An Expedition into Central Rakhine State, Myanmar

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Executive Summary

This report summarizes the results of a Wildlife Conservation Society expedition into central Rakhine State, Myanmar, conducted from 21 January to 14 February 2000. Rakhine State (formerly known as "Arakan") encompasses much of the Arakan Yoma Hill range, one of the most rugged and sparsely populated regions in mainland Southeast Asia. The primary objective of this expedition was to gather data on the conservation status and ecology of the Arakan forest turtle (*Geoemyda depressa*), considered one of the world's rarest living chelonians. *Geoemyda depressa* is known from only seven specimens; five were collected from 1875 to 1908 in Rakhine State, presumably from the Arakan Yoma Hills. However, all specimens lack specific locality data. In 1994, two additional specimens were purchased alive in Yunnan Province, China after being imported for local food markets. Virtually nothing is known concerning the ecology, habitat preference, or population status of *G. depressa*, which is currently classified as Critically Endangered on the 1996 IUCN Red List of Threatened Animals.

During our expedition we obtained 16 shells and one living *G. depressa* from villagers. These confirm the existence of *G. depressa* in the Arakan Yoma Hills and are the first specimens with specific locality data. *Geoemyda depressa* occurs in evergreen, deciduous, and bamboo forests throughout the region. We accompanied hunters to seven sites where *G. depressa* were captured during the past year. These sites were generally in evergreen forest or bamboo and associated with small streams. However, one site was located in deciduous forest along the coast and another was in a sugarcane field. Observations by hunters of feeding turtles indicate the diet is largely composed of fruit, leafy vegetation, and shoots.

Geoemyda depressa is exploited for meat and plastrons in central Rakhine. The meat is consumed locally and plastrons are sold to traders for eventual export to China. Some adult turtles are also exported alive to food markets in southern China via Mandalay. The number of *G. depressa* taken by individual hunters appears low. Hunters regard *G. depressa* as rare, although whether this reflects actual rarity or cryptic behavior remains unknown. Most *G. depressa* are captured using trained dogs, but limited numbers are collected by fire hunting and nocturnal searching using headlamps.

Despite the paucity of records, the current IUCN classification of *G. depressa* as Critically Endangered is probably unwarranted. Market demand is low, the harvest appears minimal, existing habitat is extensive and under no immediate threat, and the human population density in Rakhine State is among the lowest in Southeast Asia. However, caution is urged as *G. depressa* may become threatened by changing market demands when stocks of other turtles are depleted. Furthermore, proposals to construct a paper mill in Rakhine State based on the large-scale harvesting of *Melocanna bambusoides* could negatively impact *G. depressa* populations.

We also documented the existence of an extensive commercial harvest of other turtles in central Rakhine State. The yellow tortoise (*Indotestudo elongata*) is the primary target of hunters and harvested principally for its plastron. The regional harvest

remains unquantified, but large numbers are apparently being collected. Some hunters reported capturing as many as 300 tortoises each year. *Indotestudo elongata* was formerly harvested on a subsistence basis that was probably sustainable given the low human population of the region. However, commercial demands from markets in southern China now threaten the continued viability of tortoise populations. In addition to *I. elongata*, large numbers of Asian leaf turtles (*Cyclemys dentata*) and lesser quantities of Asian brown tortoises (*Manouria emys*) and keeled box turtles (*Pyxidea mouhotii*) are also being harvested at levels that are probably unsustainable.

Marine turtles nest at a number of sites on Ramree Island, but remain subject to egg harvest and incidental drowning in fishing nets. Interviews with egg dealers suggest nesting populations of green turtles (*Chelonia mydas*) have been declining for many years. We also documented the probable occurrence of estuarine terrapins (*Batagur baska*) on the coastal mainland.

The status of the estuarine crocodile (*Crocodylus porosus*) was investigated in central Rakhine and Ramree Island. Although formerly abundant in coastal habitats, it appears that crocodile populations are now reduced to scattered individuals. Population declines are attributed to chronic over-harvesting. While on Ramree Island we investigated the alleged massacre of nearly 1000 Japanese soldiers by crocodiles during World War II. The massacre supposedly occurred when Allied Forces invaded the island during 1945. The Japanese withdrew into the mangrove swamps separating Ramree Island from the mainland and allegedly fell victim to repeated crocodile attacks. This incident has been uncritically accepted by later writers without adequate investigation. Our interviews with long-term residents of Ramree Island and a subsequent examination of historical sources found no evidence that such a massacre ever occurred.

Incidental to our investigations of turtles and crocodiles, we gathered data on the status of large mammals in central Rakhine. Tigers (*Panthera tigris*) are extremely rare and probably approaching extinction in the Arakan Yoma Hills. A single set of elephant (*Elephas maximus*) tracks was found. According to villagers elephants rarely occur in the area we visited, but are common elsewhere in the Arakan Yomas. Gaur (*Bos gaurus*) remain common in the region and we encountered numerous tracks and well-used trails, and noted extensive browsing in abandoned *taungya* fields. Gaur are hunted for meat and horns, which are sold to traders for export to Thailand and China. The occurrence of sambar deer (*Cervus unicolor*) and barking deer (*Muntiacus muntjak*) was documented. The former is considered rare, while the latter are common. Other mammals we recorded include wild pigs (*Sus scrofa*), bear (probably *Helarctus malayanus*), binturong (*Arctictis binturong*), jackals (*Canis aureus*), and three species of primate.

In conclusion, this expedition and other studies indicate that large numbers of turtles and tortoises are being exported illegally from Myanmar into China. This trade undoubtedly threatens the continued viability of chelonian populations in many regions of Myanmar. Therefore, it is absolutely essential that authorities in Myanmar and China cooperate to drastically reduce harvest levels. As long as the wildlife markets in southern China continue to operate, turtle hunting will remain a lucrative economic proposition for

the rural inhabitants of Myanmar. Without rapid implementation of protective measures, continued population declines can be expected and many species may become critically endangered within the next 10 years.

Furthermore, additional field surveys to determine the distribution and status of *Geoemyda depressa* elsewhere in Myanmar are warranted. Priority areas for investigation include the southern Arakan Yoma Hills, Chin Hills, and suitable habitat in Kayah State. Additionally, we recommend initiating an *ex-situ* conservation program for *Geoemyda depressa* at the Yangon Zoo and facilities in the United States. Finally, crocodile and turtle surveys should be conducted in extreme western Rakhine State north of Sittwe. This area is poorly known biologically and may harbor remnant populations of gharial (*Gavialis gangeticus*). *Gavialis gangeticus* has been reported from the Kaladan River, although the basis of these records is unclear. *Gavialis gangeticus* still occurs in neighboring Bangladesh, and could potentially survive in Myanmar.

Acknowledgments

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Introduction

Rakhine State (formerly known as "Arakan") is located in western Myanmar, bordering Bangladesh in the west, Chin State and Magwe Division in the north, Ayeyarwady Division in the east, and the Bay of Bengal in the south (Figure 1). Rakhine State (Figure 2) encompasses much of the Arakan Yoma Hill range, one of the most rugged and sparsely inhabited regions in mainland Southeast Asia (Salter, 1983a). These hills rise to 3000 m and are covered with extensive tracts of forest, which may support significant wildlife populations. Brief surveys were conducted during the early 1980's in the vicinity of Tanlwe-Mae Chaung (Salter, 1983b) and Taungup Pass (Salter, 1983a), but more recent data are unavailable and the biological resources of the region remain poorly documented.

This report summarizes the results of a Wildlife Conservation Society expedition into central Rakhine State conducted from 21 January to 14 February 2000. The primary objective of this expedition was to obtain data on the conservation status, ecology, and exploitation of the Arakan forest turtle (*Geoemyda depressa*). This enigmatic species is regarded as among the worlds rarest turtles; only seven specimens have ever been collected and virtually nothing is known concerning its ecology (Ernst and Barbour, 1989; van Dijk, 1993; Iverson and McCord, 1997). Incidental to our investigation of *G. depressa*, data were collected on the status and biology of other chelonians, crocodiles, birds, and mammals.

A detailed expedition itinerary and gazetteer are presented in Appendix 1 and 2, respectively. To briefly summarize, we assembled in Yangon and traveled by road to Datun Taung, a coastal village in Rakhine State hosting a large fish and crab market. From Datun Taung we journeyed upriver by boat to the agricultural hamlet of Pada Kyaw, and then proceeded on foot into the inland hills. We visited several interior villages before returning to the coast, whence we traveled by boat to Pyin Won Village, and eventually to Ramree Island. We traversed Ramree Island by road, boarded a cargo vessel in Kyaukphyu and returned to our starting point in Datun Taung. From Datun Taung Village we traveled by road to Yangon.

Frequent reference is made in the text to the local currency (kyats) and units of weight (viss). The approximate exchange rate at the time of the expedition was US$1=300 kyats. One viss is equal to about 1.6 kg. Other measurements are presented as mean ± 1 SD.

Description of Area

The Arakan Yoma Hills (Figure 3) extend for 500 km along the western coast of Myanmar, and represent a southern extension of the Himalayas to which they are linked through the Chin Hills (Roberts et al., 1968; Salter, 1983a). The landscape is dominated by a series of parallel north-south ridges separated by streams flowing within restricted valleys (Figure 4; Stamp, 1930; Henderson et al., 1971). Mount Victoria, at 3,050 m, is

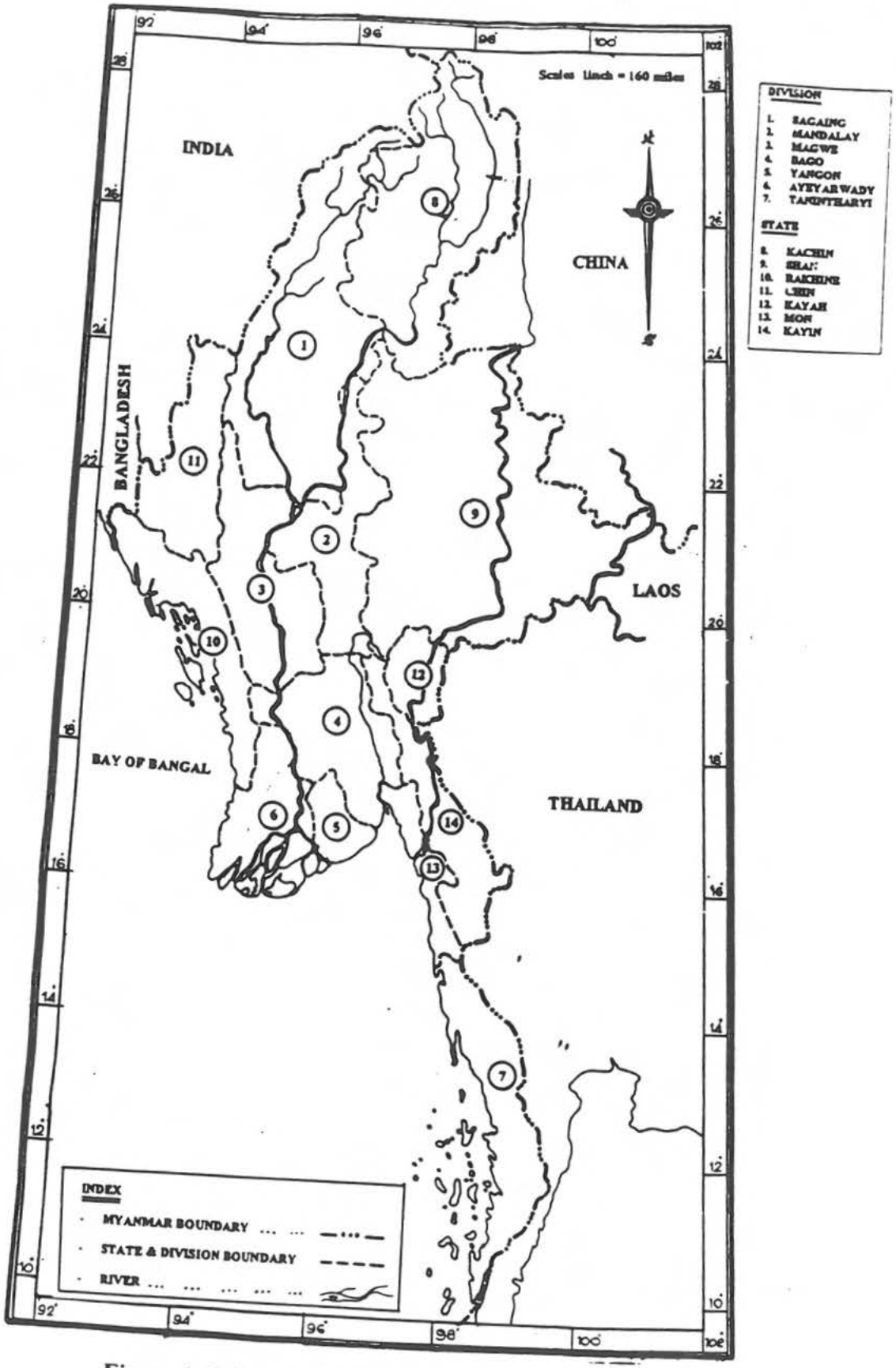

Figure 1: Political map of Myanmar (Scale: 1cm=100 km).

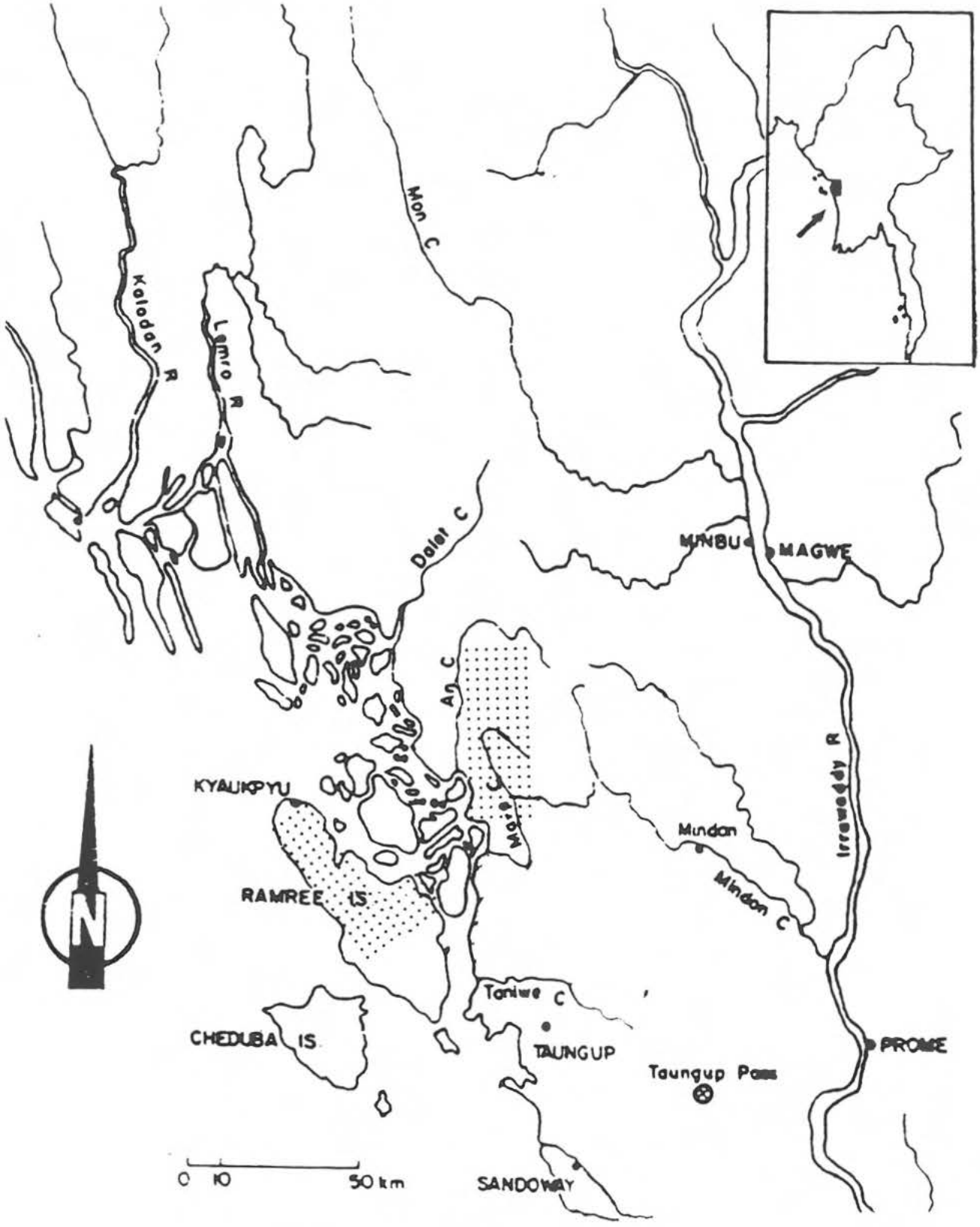

Figure 2: Map of central and western Rakhine State, Myanmar. Inset shows this region in relation to the rest of Myanmar. Shading denotes approximate area visited during WCS Rakhine Expedition (January /February 2000). Map modified from Salter (1983b).

Figure 3: Arakan Yoma Hills east of Ann, Rakhine State, Myanmar. Extensive bamboo brakes and scattered evergreen forest on slopes. Maximum elevation in this area is approximately 1100 m.

the highest peak in the Arakan Yomas. Maximum elevation in the central Arakan Yomas ranges from 915 to 1,150 m (Salter, 1983a). Valley bottoms adjacent to high ridges are often less than 100 m above sea level; thus a wide range of slope, aspect, and elevational conditions often exist within a small area (Salter, 1983a). A narrow alluvial belt known as the Arakan coastal strip lies between the Arakan Yoma Hills in the east and the Bay of Bengal in the west (Roberts et al., 1968). Ramree Island is a large (ca. 80 km long X 30 km long) island separated from the mainland by a network of estuarine rivers and mangrove swamps.

The regional climate is influenced by the southwest monsoon and exhibits three distinct seasons: a wet season extending from early June to late October, a cool dry season from early November to mid-February, and a hot dry season from late February to late May (Henderson et al., 1971). Mean annual precipitation ranges from 450 to 530 cm in the central Arakan Yomas (Roberts et al., 1968). However, the pattern of rainfall is complicated by the influence local topography (Salter, 1983a). Rainfall is highest along the coast, but mountain ridges create a create a series of successive rain shadows and total rainfall decreases rapidly along a west-east gradient (Salter, 1983a). Mean monthly temperatures in the Arakan coastal strip range from 23°C in January to 29°C in May (Salter, 1983a). Data from inland sites are unavailable, but temperatures are undoubtedly somewhat lower, particularly at high elevations (Salter, 1983a). Nighttime temperatures as low as 10°C were recorded during our expedition.

The vegetation of central Rakhine is determined by the interaction of rainfall, altitude, and aspect (Salter, 1983a). Mangrove forests occur in extensive coastal estuaries and on Ramree Island. These forests are dominated by *Rhizophora*, *Heritiera*, *Ceriops*, *Bruguiera*, and *Sonneratia* (Stamp, 1924), and appear floristically similar to those described in the lower Ayeyarwady Delta (Thorbjarnarson et al., 1999). Most of the coastal lowlands have been converted to agriculture (Figure 5); by the early 1930's, approximately 90% of the region was devoted to rice cultivation (Stamp, 1930).

Remnant forest patches are found on broken terrain unsuitable for paddy agriculture. Deciduous forests dominated by *pyinkado* (*Xylia dolabriformis*) occur on permeable soils, while less permeable soils support evergreen forests typical of inland habitats (Stamp, 1930; de Terra, 1944). The upland vegetation of Ramree Island (Figure 6) is characterized by a distinct deciduous forest type dominated by *pyinkado*, *nabe* (*Lennea grandis*), *thakut* (*Dolichandrone spathacea*), *tabauk* (*Dalbergia paniculata*), and the bamboo *tin wa* (*Cephalostachyum pergracile*) (see Appendix 3 for additional notes on bamboo).

The forests of the Arakan Yoma Hills have been variously described as rainforest (de Terra, 1944), evergreen rainforest (Henderson et al., 1971), semi-evergreen rainforest (Salter, 1983a), tropical semi-evergreen forest (Champion, 1936), and evergreen tropical forest (Stamp, 1924, 1930). The floristic composition of these forests remains poorly documented (Salter, 1983a). Sub-montane forests are found atop the highest ridges (Salter, 1983a). Extensive tracts of the bamboo, known locally as *khayin* (*Melocanna*

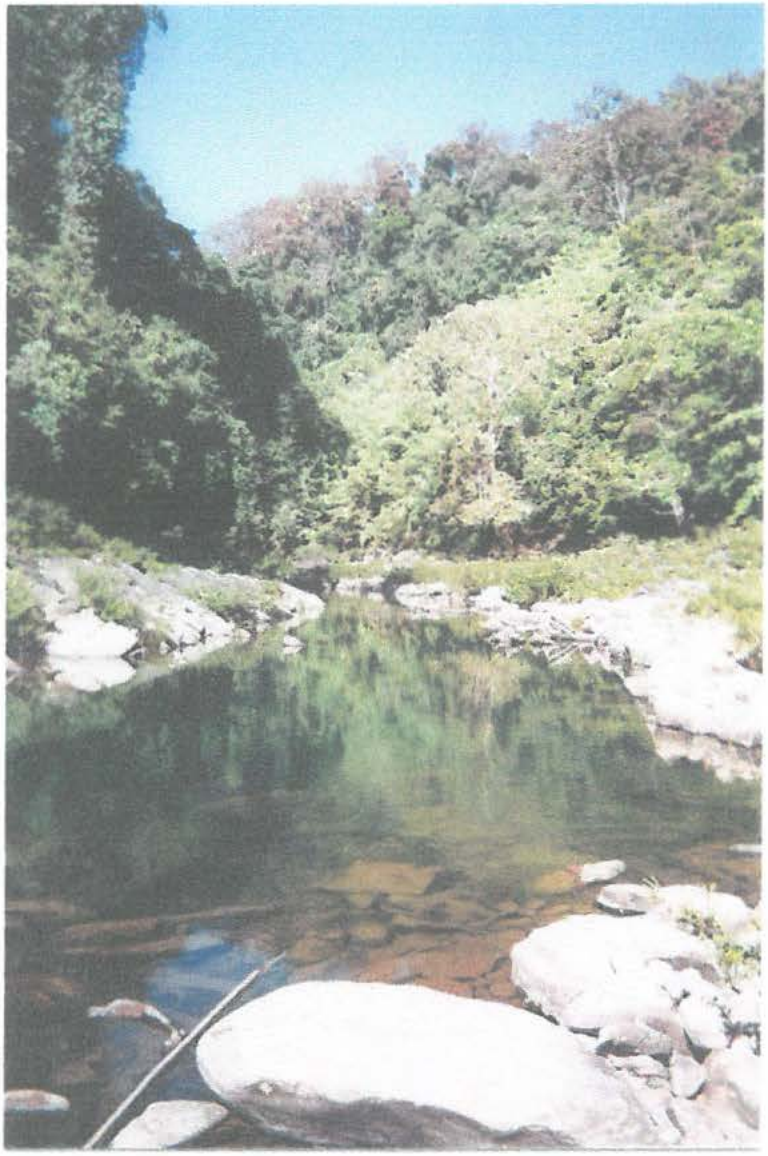

Figure 4: Pyaung Chaung in the Arakan Yoma Hills. Note bamboo brake on lower slopes and evergreen forest on upper slopes and ridge. Asian leaf turtles (*Cyclemys dentata*) are common in this river.

Figure 5: Coastal lowlands near Pyin Won Village. Most (>90%) of this region has been converted to rice cultivation. Earthen dams separate rice fields from mangrove fringe along tidal creeks.

Figure 6: Upland deciduous forest on Ramree Island.

bambusoides) occur throughout the region. Bamboo forest is considered by most authors to be an anthropogenic climax, developing in response to human disturbances such as shifting cultivation, fire, or both (Stamp, 1924, 1930; de Terra, 1944). Once established bamboo prevents the regeneration of most tree species (Stamp, 1924).

Hill forests in central Rakhine are populated largely by ethnic Chin who cultivate upland rice using a system of shifting, or *taungya* agriculture (Stamp, 1924). Forest is cleared and allowed to dry before being burned late in the dry season. Upland rice is seeded in fields immediately prior to the first rains. Farmers cultivate the same site for one to four years depending on local soil fertility. Fields are abandoned once productivity declines, and farmers then move to another site and repeat the cycle. Because human population density is low and uncultivated land is widely available, abandoned fields may remain fallow for 15 years or more before being returned to production. The Arakan coastal strip is populated by ethnic Rakhine who cultivate wet rice in permanent paddy fields.

Species Accounts

Freshwater Turtles and Tortoises

During this expedition we documented the occurrence or probable occurrence of 8 species of chelonians in central Rakhine State. Morphometric measurements, sex, locality data, and additional notes on the specimens we examined are presented in Appendix 4 to 9.

Arakan forest turtle (*Geoemyda depressa*)

The Arakan forest turtle (*Geoemyda depressa*) is endemic to Myanmar, and considered one of the world's rarest living chelonians (Ernst and Barbour, 1989; van Dijk, 1993). *Geoemyda depressa* was described by Anderson (1875), and only seven specimens are known (Table 1). Five were collected from 1875 to 1908 in Arakan State, Burma. These presumably originated from the Arakan Yoma Hills, although specific locality data are lacking (Iverson and McCord, 1997). In 1994, two additional living specimens were purchased near Po Shang in western Yunnan Province, China. Iverson and McCord (1997) suggest these were imported for the food market and regard them as extralimital. Nothing is known concerning habitat preference, ecology, or population status of *G. depressa* (van Dijk, 1993). *Geoemyda depressa* is classified as Critically Endangered on the 1996 IUCN Red List of Threatened Animals due to its limited distribution and continuing exploitation, but receives no legal protection under CITES (King and Burke, 1989; van Dijk, 1993).

During this expedition we obtained 16 shells (Figure 7) and one living *Geoemyda depressa* (15 adults and one juvenile; Appendix 4 to 6). Our sample of shells was comprised of nine complete specimens, two carapaces lacking a plastron, and five plastrons without a carapace. Specimens were obtained from Mintat (4), Pada Kyaw (1), Hmwa (1), Pyin Won (2), Let Pan (1), Ahngyin Taung (6), and Padan (2) Villages. Four

plastrons from Mintat Village were reportedly collected approximately 30 km NE in the Arakan Yoma Hills. A carapace and living turtle obtained from a hunter in Padan Village were collected on Salu Taung (=Mountain) along the western slope of the Arakan Yoma Hills (GPS coordinates unavailable; ca. 19° 10' N; 94° 20' E on Sheet No. 85, Survey of India Map). The remainder of the turtles originated near the villages where we obtained them.

The living turtle was a male (CL = 22.0 cm; mass = 1300 g) with 18 annuli captured in bamboo forest on 7 February (Figure 8). The posterior region of the carapace was grossly deformed and appeared to have been crushed and then healed abnormally. The hunter attributed this damage to trampling by a gaur (*Bos gaurus*). Two ticks were removed from folds of skin around the right foreleg. These were identified as *Amblyomma supinoi* and constitute the first record of an ectoparasite from *G. depressa* (Robbins and Platt, in prep.). The turtle was deposited in the Yangon Zoo.

Morphometric data for adult turtles is presented in Table 2. Sex was determined from plastral morphology; males exhibit a pronounced concavity that is lacking in females (Iverson and McCord, 1997). Our sample included seven males and seven females; two shells without plastrons and a juvenile (CL = 10.9 cm) could not be reliably sexed. Mean carapace and plastron lengths were larger in males (CL = 22.6 ± 1.1 cm; range = 20.9 to 23.6 cm and PL = 19.8 ± 0.7 cm; range = 19.2 to 21.3 cm) than females (CL = 19.5 ± 5.0 cm; range = 13.2 to 24.2 cm and PL = 17.7 ± 3.5 cm; range = 12.0 to 22.1 cm). However, small sample size precluded meaningful statistical comparisons. The largest specimen was a female. A hunter claimed that a female (CL = 23.0 cm) captured on 1 February 2000 contained three enlarged, but unshelled follicles. We were unable to confirm the reproductive state of this female, but obtained the carapace and heavily damaged plastron (Turtle #6; Appendix 4 to 6).

According to hunters, *G. depressa* occurs in evergreen, deciduous, and bamboo forests. Within these habitats, hunters reported finding turtles in shallow streams, among streamside stands of *Homalomena* spp., beneath leaves and other debris on hillsides, and occasionally in pangolin (*Manis* spp.) burrows. We accompanied hunters to specific seven sites where *G. depressa* had recently (<1 year) been captured. The first site (19° 32.316' N; 94° 03.153' E) was located in the floodplain of an intermittent stream near Pada Kyaw Village. The stream flows only during the wet season, but contained numerous deep pools at the time of our visit (24 January). The floodplain was dominated by second-growth evergreen forest with a moderately dense understory, while the surrounding slopes supported a mixture of bamboo and evergreen trees. Elevation along the streambed was approximately 50 m.

We inspected two capture sites near Pyaung Chaung Village (Figure 9). One was located less than 1.0 km from the village along a permanent stream (19° 32.650' N; 94° 06.700' E). The surrounding vegetation was mature evergreen forest with a dense understory of succulent herbaceous plants, vines, and creepers. Elevation was approximately 90 m. The other site (19° 33.357' N; 94° 07.125' E) was in the restricted (<100 m) floodplain of an intermittent stream where a turtle was found eating the fallen

fruit of *Artocarpus chaplasha*. The stream flows only during the wet season and contained no water at the time of our visit (2 February). Dense bamboo was growing in the floodplain and nearby slopes supported mature evergreen forest. Understory vegetation was absent beneath the bamboo and sparse on the slopes. Elevation was approximately 150 m.

A fourth capture site was located among low hills near Pyin Won Village, where a turtle was found eating *Wallichia disticha* shoots in a deep, mesic ravine (19° 22.150' N; 94° 08.969' E). The hillside (elevation ca. 30 m) is dominated by evergreen forest with moderately dense understory, and the ravine contains water only after heavy rains. Another *G. depressa* was captured in a sugarcane field near the village (19° 20.950' N; 94° 07.739' E). Villagers considered this capture unusual, and the turtle most likely wandered into the field from the surrounding forest.

Another capture site was located amidst low hills near Let Pan Village, where a turtle was found feeding on the fallen fruits of *Dillenia pulcherrima* (Figure 10). This site (19° 22.013' N; 94° 10.008' E) was on a hillside characterized by relatively open evergreen forest dominated by *D. pulcherrima* and *Strychnos nuse-blanda* with a sparse understory. The hillside was dissected by a number of deep gullies that contain water only after heavy rains. Elevation was approximately 30 m.

In contrast to other sites, a *G. depressa* found near Hmwa Village was captured in deciduous forest (Figure 11; 19° 29.131' N; 94° 02.293' E). This habitat is rare on the western side of the Arakan Yomas and restricted to porous soils in the foothills. The turtle was found buried among leaf litter on a dry slope above an intermittent stream. The surrounding forest was dominated by *Lagerstroemia villosa* and *Xylia dolabriformis*, with a relatively open canopy and an understory of scattered woody shrubs. Charring on trees and logs indicated the site is subject to periodic dry season wildfires. Elevation was approximately 45 m.

Hunter observations indicate the diet of *G. depressa* is composed largely of vegetation and fruit. Hunters have observed *G. depressa* consuming fruits of *taung peinne* (*Artocarpus chalplasha*), *thapan* (*Ficus glomerata*), *taw thayet* (*Magnifera caloneura*), *pattagyi* (*Woodfordia fruticosa*), and *zin byun* (*Dillenia pulcherrima*). A favored hunting method is to search for turtles in the vicinity of fruiting trees. Hunters have also observed *G. depressa* consuming the foliage of *petsalut* (*Marantha caespitosa*), shoots of *khayin* (*Melocanna bambusoides*), *Musa* spp., and *let me* (*Wallichia disticha*), stems and roots of *taw pein* (*Homalomena* spp.), and several species of mushrooms. In addition to fruit and vegetation, captives readily consume earthworms and neonate mice (Iverson and McCord, 1997), suggesting *G. depressa* may be more omnivorous than suggested by hunter observations.

The number of *G. depressa* taken by individual hunters appears relatively low (Table 3). Hunters generally reported catching less than 20, and most caught less than 10 each year. An exceptionally large harvest of 40 per year was reported by a professional hunter. Meat is consumed locally and shells are purchased by traders, although the

Table 1. Summary of Arakan forest turtle (*Geoemyda depressa*) specimens known prior to the recent Wildlife Conservation Society expedition into central Rakhine State, Myanmar (January-February 2000). BMNH = British Museum of Natural History, London. UF = University of Florida, Gainesville. ZMB = Museum für Naturkunde, Berlin. ZSI = Zoological Survey of India, Calcutta. "Arakan" and "Aracan" refer to current Rakhine State. From Iverson and McCord (1997).

Museum number	Collection locality	Description/comments
ZSI 751	Burma	Skull
ZMB 8869	Arakan, Burma	Adult female in alcohol.
BMNH 1947.3.4.28	Aracan, Burma	Dried shell of an adult female.
BMNH 1947.3.5.69	Aracan, Burma	Skull, probably same turtle as BMNH 1947.3.4.28.
BMNH 87.3.30.1	Aracan, Burma	Deformed dried shell of an adult female.
BMNH 1908.12.28.11	Aracan, Burma	Subadult female in alcohol.
UF 102893	Po Shang, Yunnan Province, China.	Female purchased in 1994; original collection locality is unknown.
Living specimen	Po Shang, Yunnan Province, China	Male purchased in 1994; original collection locality is unknown; currently in collection of W. P. McCord.

Table 2. Morphometric data from adult Arakan forest turtles (*Geoemyda depressa*) examined in central Rakhine State, Myanmar (January-February 2000). One juvenile (Turtle #9; Appendix 4-6) not included in the analyses.

Attribute	n	Mean ± 1SD	Range
Carapace length (cm)	11	21.6 ± 3.6	13.2 to 24.2
Carapace width (cm)	11	15.5 ± 2.2	10.8 to 17.9
Plastron length (cm)	13	18.8 ± 2.5	12.0 to 22.1
Plastron width (cm)	8	12.2 ± 2.7	7.5 to 16.0
Shell depth (cm)	7	7.3 ± 1.1	5.2 to 8.9

Table 3. Summary of Arakan forest turtle (*Geoemyda depressa*) harvest data from several villages in central Rakhine State, Myanmar.

Village	Captures[1]	Price received for plastrons[2]	Hunting methods
Hmwa	~ 4 to 10	250	Trained dogs
Letpan-Ahngyin	~ 10	200	Trained dogs; night hunting with headlamps; search at fruiting trees.
Mae	~ 1 to 20	500	Trained dogs; fire hunting.
Mae Sadwe	~ 4 to 5	250	Trained dogs; fire hunting.
Padan[3]	~ 40	---	Trained dogs.

[1]Turtles/hunter/year.
[2]kyats/viss. 1 viss=1.6 kg.
[3]Padan Village is located on the eastern side of the Arakan Yoma Hills in the central dry zone of Myanmar, and outside of the range of *G. depressa*. A professional hunter living in this village collects *G. depressa* from the western slope of the Arakan Hills. Most are sold alive to brokers in Mandalay.

Figure 7: Arakan forest turtle (*Geoemyda depressa*) shells obtained from hunters in central Rakhine State, Myanmar (January-February 2000). Plastron in lower photograph was partially destroyed by a dog.

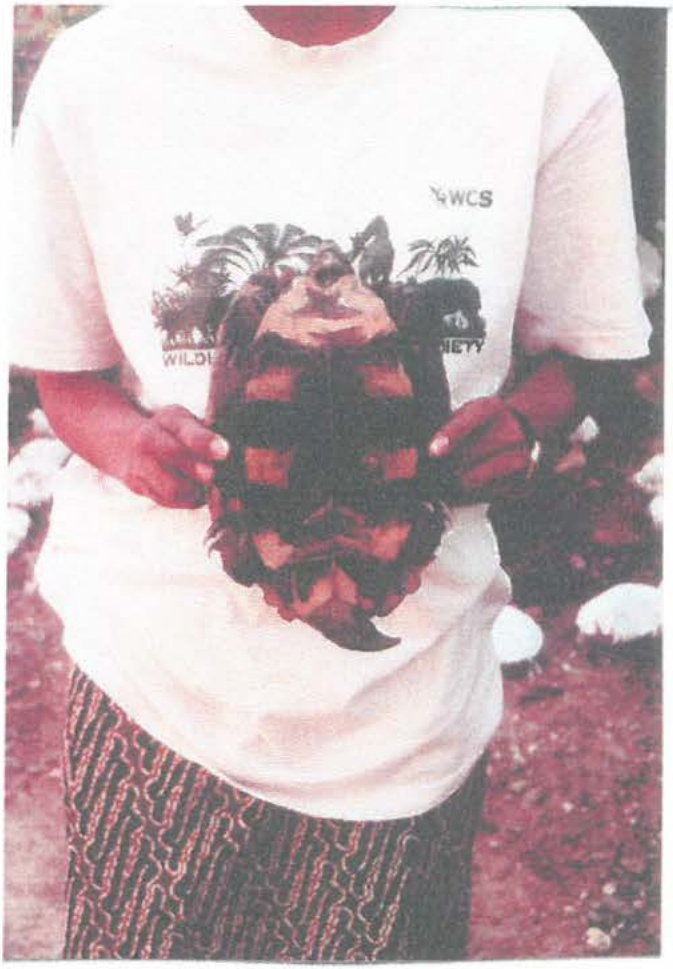

Figure 8: *Geoemyda depressa* obtained from hunter in Padan Village.

Figure 9: *Geoemyda depressa* habitat near Pyaung Chaung Village. Evergreen forest along permanent stream (above) and intermittent creek in bamboo thicket (below).

Figure 10: *Geoemyda depressa* habitat among coastal foothills near Let Pan Village. Hillside evergreen forest dominated by *Dillenia pulcherrima* and *Strychnos nuse-blanda*.

Figure 11: *Geoemyda depressa* habitat near Hmwa Village. Open deciduous forest dominated by *Lagerstroemia villosa* and *Xylia dolabriformis*. This habitat type is rare on the western side of the Arakan Yomas and confined to porous soils in the foothills. Deciduous forest is subject to dry season wildfires.

demand for the latter does not seem particularly high. Some hunters reported being unable to sell plastrons; others receive from 200 to 500 kyats/viss. One hunter received 30 kyats/viss for carapaces, but these are generally discarded. Plastrons are exported from Myanmar and have been found in Taiwanese medicinal markets (Hsien-chen Chang, pers. comm.). A professional hunter in Padan Village sells living *G. depressa* to brokers in Mandalay for 1200 kyats each. Only large adults are purchased, presumably destined for food markets in Yunnan Province, China.

Hunters consider *G. depressa* rare, although whether this reflects actual rarity or cryptic behavior remains unknown. *Geoemyda depressa* is known locally as *leik pyin* (=lazy turtle), because it is infrequently encountered and assumed to be sleeping. Most hunters regard May through July as the optimal time to search for *G. depressa*. Hunters in the coastal lowlands told us they search for *G. depressa* only during May and June when *Dillenia pulcherrima* fruit is available; at other times the turtles are so difficult to find that hunting is not deemed worthwhile. *Geoemyda depressa* are captured by a variety of methods. Hunters universally asserted that trained hunting dogs are necessary to consistently find *G. depressa*. Limited numbers are taken by fire hunting during March, April, and May (see *Indotestudo elongata* account). Hunters from coastal villages often search for *G. depressa* at night using headlamps, although this practice is rare elsewhere because of the danger of encountering gaur. A few *G. depressa* are opportunistically collected by villagers while clearing *taungya* fields and gathering forest products.

The distribution of *G. depressa* in Myanmar remains ill defined. Iverson (*in litt.*) speculated *G. depressa* may be more widespread than indicated by the limited number of museum specimens, all lacking meaningful locality data. Interestingly, Myint Maung (1976) stated that *G. depressa* also occurs in Kayah State of eastern Myanmar (Figure 1), but the basis for this report is unclear and the record remains to be confirmed. The chelonian fauna of Myanmar is the least studied in Asia (McCord, 1997; van Dijk, 1997), and it is possible that heretofore overlooked populations of *G. depressa* exist.

Despite the paucity of records, the current IUCN classification of *G. depressa* as Critically Endangered is probably unwarranted. Market demand is low, the harvest appears minimal, extensive tracts of habitat remain and are under no immediate threat, and the human population density in Rakhine State is among the lowest in Southeast Asia. However, caution is urged as *G. depressa* may become threatened by changing market demands when stocks of other species are depleted. Furthermore, proposals to construct a paper mill in Rakhine State based on the large-scale harvesting of *Melocanna bambusoides* could negatively impact *G. depressa* populations.

Yellow tortoise (*Indotestudo elongata*)

We examined 28 *I. elongata*, including 11 living tortoises and 17 shells during this expedition (Appendix 7). Our sample of shells was comprised of three complete specimens, seven carapaces lacking a plastron, and seven plastrons without a carapace. Using data from the present expedition and a previous study (Platt, 1999), a significant

positive correlation was found between plastron length (PL) and carapace length (CL) (r = 0.98; df = 1, 38; p<0.001; Figure 12). The equation CL = 1.37(PL) - 1.66 (r^2 = 0.97; p<0.001) was used to estimate carapace length for plastrons lacking a carapace. The mean carapace length of our sample was then calculated as 23.4 ± 4.4 cm (range = 13.4 to 29.5 cm; n=28). Our sample of *I. elongata* was dominated by larger tortoises with lesser numbers of intermediate size and small specimens (Figure 13).

The sex of adult tortoises was determined based on differences in plastron morphology; males exhibit a pronounced concavity that is reduced or absent in females (Ernst and Barbour, 1989). Our sample included eight males, 12 females, and eight tortoises for which sex could not be reliably determined. Most of the latter were shells without plastrons. Male carapace length (24.4 ± 3.5 cm; range = 19.0 to 29.5 cm; n = 8) was larger than mean female carapace length (22.1 ± 5.4 cm; range = 13.4 to 28.5 cm; n = 12), but the small sample size precluded statistical comparisons.

The slate-gray carapace of an apparently melanistic *I. elongata* was obtained in Hmwa Village. We are unaware of any previous reports of melanism in *I. elongata*. Fifty-two ticks identified as *Amblyomma supinoi* were collected from 10 living *I. elongata*. This tick collection comprised 50 males and two females found attached to the rear legs and among the skin folds in the inguinal region.

Indotestudo elongata is the primary target of hunters, and exploitation is ubiquitous throughout the region. Plastrons are in high demand by traders, and hunters receive from 700 to 1400 kyats/viss, the highest price paid for any species in the region. Tortoise meat is consumed or sold locally for 100 kyats/viss. Carapaces are generally discarded, although some are purchased by traders for 100 kyats/viss.

Hunters devote considerable effort to collecting tortoises and employ a variety of techniques. The use of specially trained dogs for tortoise hunting is near universal in the region. This is an extremely efficient technique that is likely to overlook few tortoises (Platt, 1999). Fire hunting is widely employed during March, April, and May to capture tortoises. This practice involves setting backfires along ridgelines, which burn slowly downslope. Tortoises flee downhill and seek cover in the streambeds below where they are intercepted by waiting hunters. This technique is most effective in dry bamboo habitats. Villagers also capture tortoise opportunistically while engaged in the collection of forest products or clearing *taungya* fields.

The regional annual harvest of *I. elongata* remains unquantified, but large numbers are apparently being collected. One hunter stated that early in the wet season (June-July) it is possible to catch one tortoise each day. Hunters in Pyin Won reported catching 60 tortoises during an eight day period in 1999. Other individuals reported annual harvests ranging from 50 to 300. All size classes, including small juveniles are collected.

Indotestudo elongata inhabits both bamboo and evergreen forests in central Rakhine. During the wet season tortoises are commonly found in bamboo stands feeding

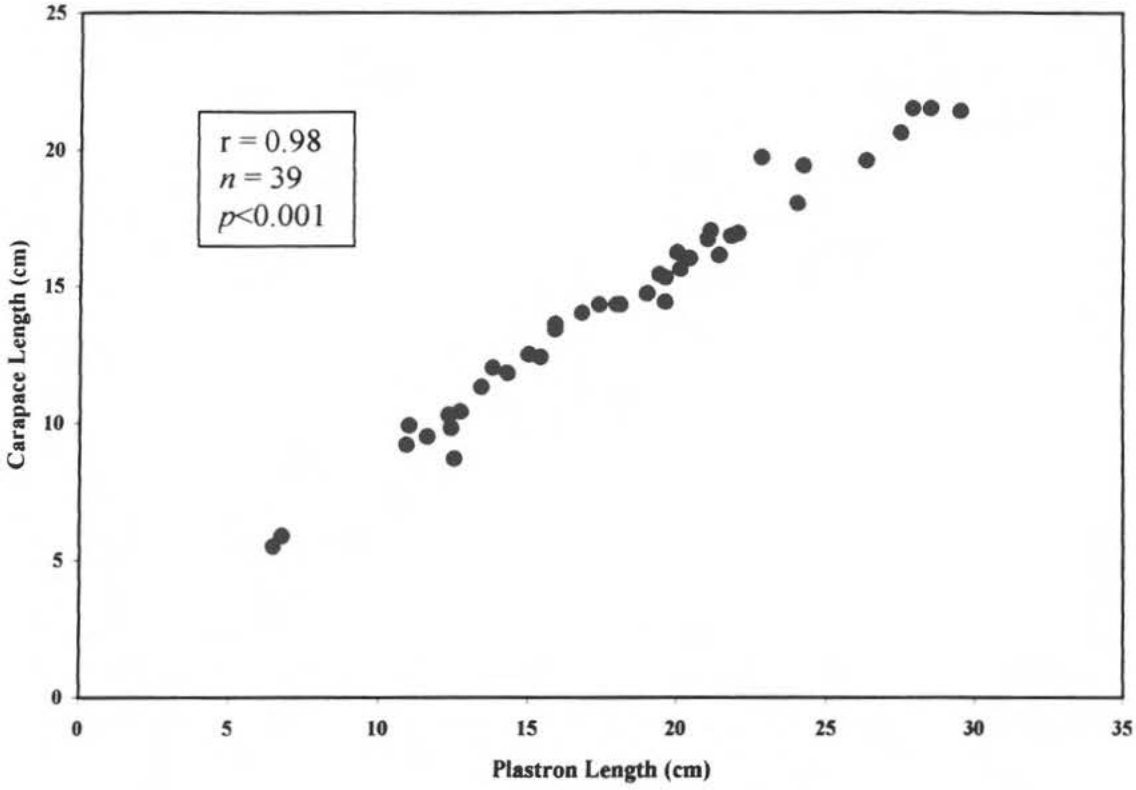

Figure 12: The relationship between plastron length and carapace length in the yellow tortoise (*Indotestudo elongata*). Data from present study and Platt (1999).

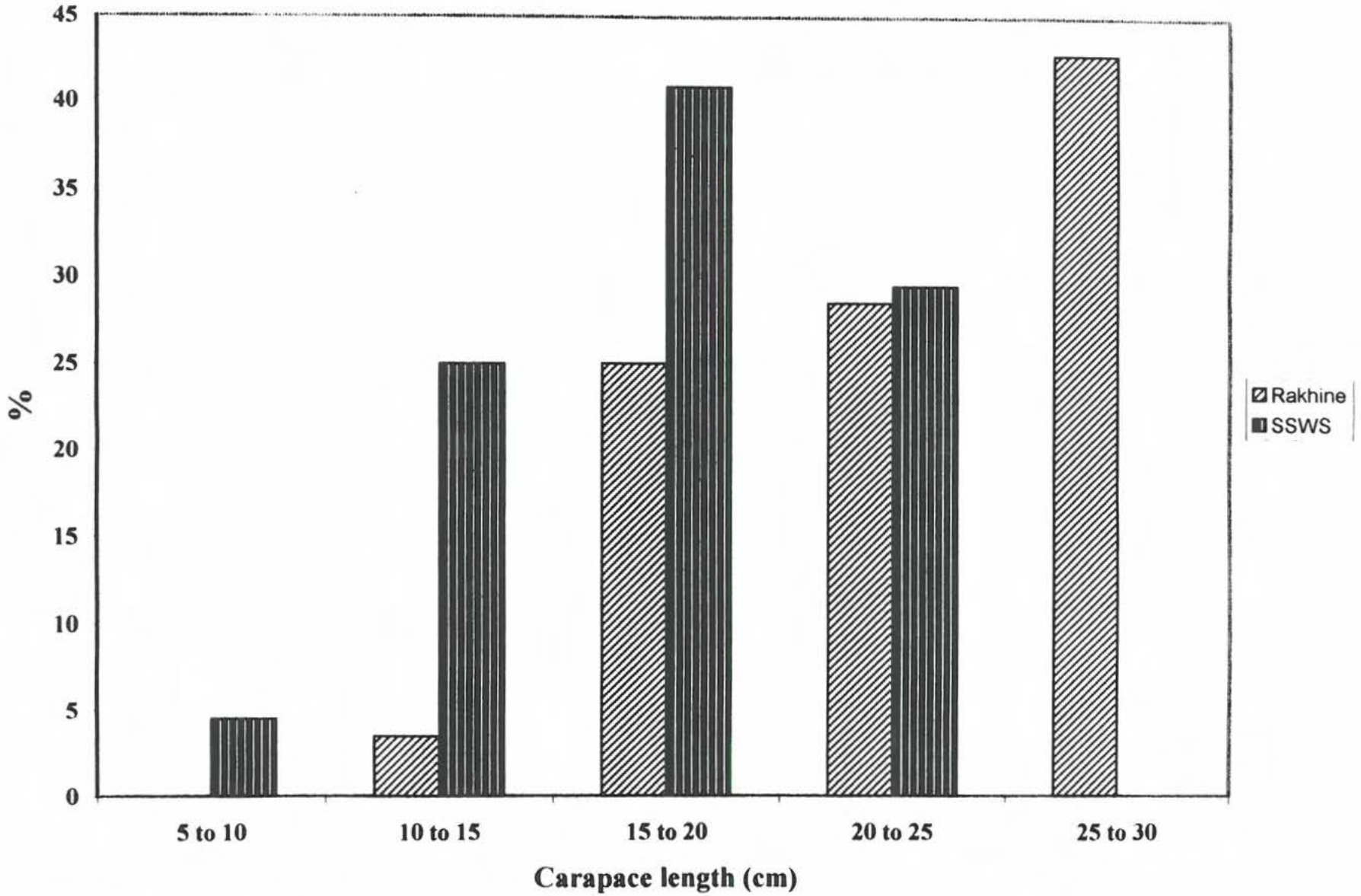

Figure 13: A comparison of the size distribution of yellow tortoises (*Indotestudo elongata*) from a relatively unexploited population in the Arakan Yoma Hills (n = 28), and a heavily exploited and declining population in Shwe Settaw Wildlife Sanctuary (n = 43). Data from Shwe Settaw Wildlife Sanctuary from Platt (1999).

on abundant mushrooms. Hunters contend that *I. elongata* remains common in the region and still occurs in close proximity to villages despite escalating harvest pressure. The large numbers of tortoises that are readily collected is certainly suggestive of a relatively unexploited population. Furthermore, the mean carapace length in central Rakhine (23.2 ± 4.4 cm) is significantly larger than that of tortoises from a heavily exploited population in Shwe Settaw Wildlife Sanctuary (17.1 ± 4.2 cm; Platt, 1999) (ANOVA; $F = 150.2$; $df = 1, 69$; $p<0.001$). Similarly, Close and Seigel (1997) found the mean carapace length of *Trachemys scripta elegans* from protected populations was significantly larger than in exploited populations. Van Dijk (1993) noted that the carapace length of *I. elongata* in a heavily exploited population near Mandalay never exceeded 25 cm. Moreover, a comparison of the size distribution from the two regions (Figure 13) shows the heavily exploited and declining population at Shwe Settaw to be dominated by intermediate size tortoises with larger animals notably absent. Conversely, the largest size class dominated the sample from central Rakhine.

The continued abundance of *I. elongata* in central Rakhine is attributable to several factors. First, although tortoises have always been harvested for local consumption, other wildlife resources were abundant and tortoise meat comprised only part of a varied diet; thus there was little reason to harvest large numbers. Additionally, and perhaps most importantly, the human population of central Rakhine is low resulting in a correspondingly minor subsistence harvest. Finally, the current commercially driven harvest is a relatively recent phenomenon, and it is likely that significant negative impacts are simply not yet obvious.

Market demands have commercialized what was formerly a subsistence harvest, and hunters are now motivated by economics to collect as many tortoises as possible. This harvest has probably attained a level that threatens the continued regional viability of tortoise populations. Life history traits of long-lived organisms such as tortoises severely constrain the ability of populations to respond to chronic over-harvesting (Congdon et al., 1993). For example, an annual harvest of only 10% resulted in a 50% reduction of a snapping turtle population (*Chelydra serpentina*) population within 15 years (Congdon et al., 1993). Furthermore, there is no evidence of a compensatory response in juvenile survivorship to increased adult mortality (Brooks et al., 1991). Therefore, the ability of turtle populations to withstand even moderate levels of increased mortality remains doubtful (Klemens and Moll, 1995), and it is questionable whether any harvest can be considered truly sustainable (Thorbjarnarson et al., 2000). Tortoise populations in central Rakhine can thus be expected to decline unless rigorous measures are implemented to regulate the trans-border wildlife trade between China and Myanmar. As long as turtle markets in southern China continue to operate, tortoise hunting will remain a lucrative proposition for villagers and exploitation will continue until the resource is exhausted.

Asian leaf turtle (*Cyclemys dentata*)

Cyclemys dentata remains common in Rakhine, and large numbers are regularly captured in the vicinity of villages (Figure 14). We examined 13 specimens (7 living turtles and 6 shells; Appendix 8) with a mean carapace length of 17.4 ± 3.8 cm (range = 6.8 to 20.7 cm; n = 11). Our sample of living turtles included two males, four females, and one turtle that we were unable to confidently sex. Males exhibited long, narrow tails, while females had relatively short, thickened tails. Sex could not be determined based solely on shell characteristics. Two nematodes, later identified as female *Falcaustra* spp. (Dr. Charles Bursey, *in litt.*) were recovered from the feces of a living *C. dentata*. *Cyclemys dentata* is found in a wide variety of habitats, including rivers, creeks, evergreen forest, and bamboo.

On 26 January we captured a juvenile (CL = 6.8 cm) in a small forest stream flowing into Pyaung Chaung (19° 34.091' N; 94° 08.151' E). The turtle was found basking on the edge of a deep pool (+2 m) at the base of a waterfall. Water temperature at the time of capture was 16°C. Feces collected from the turtle were composed primarily of filamentous green algae, which was growing abundantly on submerged rocks.

Cyclemys dentata is heavily exploited and individual hunters reported catching from 30 to 300 turtles annually. These are consumed locally, but the disposition of the plastron varies. Some traders reportedly do not purchase *C. dentata* plastrons, while others pay 500 kyats/viss. Hunters employ dogs to locate *C. dentata* in forest and bamboo habitats. Along rivers, hunters search exposed holes and overhanging banks where turtles seek refuge during the dry season (Figure 14).

Cyclemys dentata are also taken on riverbanks in elaborate bamboo traps built at the base of fruiting *mau* trees (*Anthocephalus indica*). Traps are constructed on sandbars during October and November when turtles emerge from the river to feed on fallen fruits. The trap consists of two wings, each about 5 m long and 30 cm high, constructed of split bamboo. These wings function as a "drift fence" angling inwards towards the tree and directing foraging turtles into a "pitfall" (ca. 45 cm wide X 30 cm deep) excavated in the sand. Vertical pieces of split bamboo line the walls of the pitfall to prevent captured turtles from climbing out.

Asian brown tortoise (*Manouria emys*)

We examined the carapaces of three adult *Manouria emys* (CL = 34.1 to 56.8 cm) in Mae Village on 7 February (Appendix 9). *Manouria emys* occurs throughout central Rakhine, in both bamboo and evergreen forests. *Manouria emys* is heavily exploited for meat and plastrons and does not appear common. Captured tortoises are consumed locally and the plastrons sold to traders for eventual export. Individual hunters reported capturing from one to 10 tortoises annually, and all size classes are harvested, including small juveniles. However, the species is not in particularly high demand with traders,

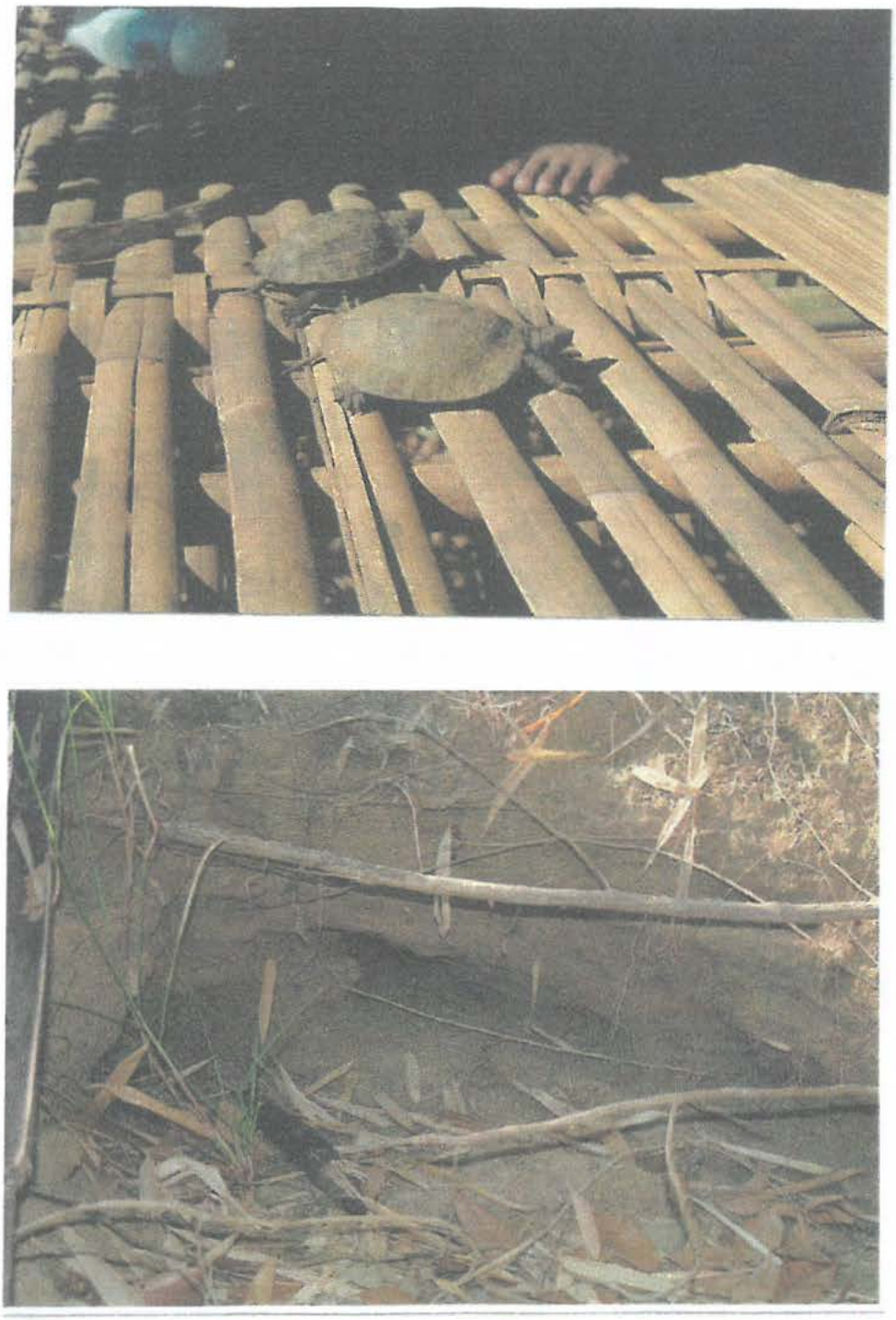

Figure 14: Asian leaf turtles (*Cyclemys dentata*) in Mae Sadwe Village (above). Hole in undercut bank exposed by low water levels in Pyaung Chaung (below). Hunters often find *C. dentata* in these holes during the dry season.

and hunters typically receive about 500 Kyats/viss for plastrons, somewhat less than paid for *Indotestudo elongata* plastrons. Most *M. emys* are opportunistically captured when hunters are searching for *I. elongata*.

Keeled box turtle (*Pyxidea mouhotii*)

A single *P. mouhotii* carapace was obtained from a hunter in Padan Village (Appendix 9). The turtle was collected from Bogyi Mauk Taung in the Arakan Yomas during May 1999. This specimen constitutes the first record of *Pyxidea mohoutii* from Rakhine State (Iverson, 1992). Previous records exist for Shan and Chin State (van Dijk, 1993). According to the hunter, *P. mohoutii* is uncommon, and occurs in evergreen forest on upper slopes and ridgelines.

Estuarine terrapin (*Batagur baska*)

The estuarine terrapin formerly nested in large numbers on islands at the mouth of the Ayeyarwady River (Maxwell, 1911). However, this population is no longer extant (Thorbjarnarson et al., 1999), and verified records from elsewhere in Myanmar are lacking (Iverson, 1992). Interestingly, villagers told Salter (1983b) that large river turtles occasionally nest on sandbanks along the Tanlwe Chaung in central Rakhine State. Although an adequate description of this species could not be obtained, Salter (1983b) speculated these reports referred to *B. baska*.

Likewise, we also received reports of a large hard-shelled turtle in coastal Rakhine. A hunter in Pyin Chaung stated he encountered nine or ten large turtles in mangrove creeks during the last 10 years. Another person reportedly recovered about 25 eggs from a dead female, each approximately the size of a domestic duck egg. These large turtles are known locally as *pyin tha*, a name also applied to *Chelonia mydas*. However, villagers stated that unlike *C. mydas*, these turtles were capable of completely withdrawing into their shells. Furthermore, when presented with photographs, villagers were able to distinguish between *B. baska* and *C. mydas*, and indicated the former as the species they occasionally encountered. Together these reports strongly suggest that a small population of *B. baska* may occur along the Rakhine coast. Specific information regarding nesting was unavailable, but villagers believed the turtles nest on nearby Ramree Island.

Giant Asian softshell turtle (*Amyda cartilaginea*)

On 14 February we examined three living *Amyda cartilaginea* at a trading establishment in Min Tone Village (Appendix 9). The turtles were reportedly obtained from villagers who captured them locally in Min Tone Chaung. This creek is on the eastern side of the Arakan Yoma Hills and within the central dry zone of Myanmar, and as such, it constitutes an eastward range extension for *A. cartilaginea*. Previous records from the dry zone are lacking (Iverson, 1992). According to Annadale (1912), *A. cartilaginea* is restricted to the Arakan Hills and mountainous areas of eastern and peninsular Myanmar.

Amyda cartilaginea is in great demand for export markets and commands a relatively high price among traders (Saw Tun Khaing, pers. comm.). According to the trader in Min Tone Village, his monthly purchase of *A. cartilaginea* has declined from 480 kg in 1999 to less than 100 kg in 2000, strongly suggesting local populations are being rapidly depleted. Villagers in Pyaung Chaung and Mae Sadwe also reported harvesting softshells for local consumption. These were presumably *A. cartilaginea*, but specimens for verification were unavailable during our visit.

Marine Turtles

Salter (1983b) provides the only information on the status and occurrence of marine turtles along the central Rakhine Coast. During the early 1980's green turtles (*Chelonia mydas*) and olive ridleys (*Lepidochelys olivacea*) nested from November through February at several sites on Ramree Island (Gonchwen, Minbyin, Thomas Point, and Zatatpyin), and on Cheduba, Hpaungya, Sagu, and Leikpyin Islands (Salter, 1983b). Turtle eggs were opportunistically collected and consumed locally, although some were sent to markets in Taungup and Kyaukphyu. Small numbers of hawksbills (*Eretmochelys imbricata*) occurred in offshore waters, but nesting was unreported. Salter (1983b) also noted that a relatively large number of marine turtles, primarily *L. olivacea*, accidentally drowned each year in shrimp nets.

A limited amount of data on marine turtles was collected during our visit to Ramree Island. Fishermen reported two principal nesting beaches on Ramree Island; one located about 10 km south of Zin Chaung Village, and another in the vicinity of Min Pyin Village. Marine turtles also nest on Tancrow Taung Island. According to fishermen, *C. mydas* is the only species that currently nests on Ramree Island, although *E. imbricata* are occasionally caught in offshore waters. We obtained the carapace of an immature *E. imbricata* in Min Pyin Village that drowned in a fishing net (Appendix 9).

Villagers continue to collect marine turtle eggs for consumption and sale. Eggs are sold in markets of Zin Chaung and Kyaukphyu, and some are sent from Kyaukphyu to Yangon via air. According to egg dealers the daily harvest of marine turtle eggs has declined each year. One dealer said that 10 years ago he could find 7 to 8 nests each day, while now he is fortunate to find even one per day. None of the egg dealers had ever found *Batagur baska* eggs, which would prove readily distinguishable from marine turtle eggs by their larger size. Marine turtles are not deliberately harvested for food, but those drowning in fishing nets are salvaged and eaten. One fisherman stated that he recovers about one turtle each month from lobster and tiger prawn nets. Given the large number of fishermen operating in the area, this incidental harvest undoubtedly constitutes a significant source of mortality for local marine turtle populations.

Crocodiles

Historic accounts indicate estuarine crocodiles (*Crocodylus porosus*) were once common, and probably occurred throughout coastal wetlands in Rakhine State (Table 4). Smart (1917) stated that crocodiles were abundant in estuarine habitats near Aykab (now known as Sittwe), and according to Tydd (1912), although uncommon, crocodiles occurred in river deltas and mangroves in the vicinity of Sandoway. Maxwell (1911) mentions crocodile predation of loggerhead turtles (*Caretta caretta*) along the Arakan coast. Salter (1983b) noted that *C. porosus* remained common during the 1960's in mangrove swamps separating Ramree Island from the mainland, and nesting was recorded from several rivers. However, by the early 1980's commercial skin hunting and collection of juveniles for sale to crocodile farms resulted in drastic population declines throughout coastal Rakhine (Salter, 1983b). Salter (1983b) was unable to locate evidence of recent nesting or observe crocodiles, noted illegal hunting continued, and concluded only scattered individuals remained in the area.

We conducted crocodile surveys in the vicinity of Pyin Won Village from 6 to 8 February (Figure 15). A combination of diurnal surveys and nocturnal spotlight counts were used to census crocodiles (Bayliss, 1987). Survey methodology employed in coastal habitats of Myanmar is described in Thorbjarnarson et al. (1999). A detailed description of each survey route is presented in Appendix 10. We surveyed 33.5 km during the day, and 55.4 km during spotlight counts, but observed no crocodiles or crocodile sign.

Nonetheless, it is probable that the area harbors a remnant population of *C. porosus*. According to villagers, two juveniles (TL ca. 60 and 120 cm) were killed and three adult crocodiles were sighted during 1999; a large adult readily distinguished by a missing eye and two smaller individuals. We also examined a captive crocodile (TL = 107 cm) hatched from an egg collected in 1997, and visited two crocodile nest sites in a nearby mangrove swamp. Hunters found one nest along Hnan Chaung in 1997 (19° 22.948' N; 94° 07.083' E). We located the remains of a nest mound about 20 m from the creek in a dense thicket of *Acrostichum aureum* and *Acanthus ilicifolius* with no overhead tree canopy (Figure 15). The mound was positioned about 1.5 m from a wallow where hunters found the female, and constructed of mud and *A. aureum* fronds. The hunters chased the female from the nest and collected 32 eggs. Hunters found a second nest in 1998 along a tributary creek of the Hnan Chaung (19° 22.581' N; 94° 07.629' E), about 0.5 km from the 1997 nest site. We were unable to locate the old nest mound, but the site was in a dense thicket of *A. aureum*. This nest also contained 32 eggs according to the hunters. Given the close proximity of the two sites, and the reported identical clutch sizes, it is probable the nests represent the reproductive efforts of a single female.

A professional crocodile hunter was interviewed in Aha Wa Taung Village on Ramree Island. This individual begin commercial hunting about 1970 and ceased in 1990 when crocodiles became too scarce to justify his efforts. He killed approximately 300 crocodiles during this 20-year period. Crocodiles were hunted at night by teams of three

Table 4: Summary of locality records for estuarine crocodiles (*Crocodylus porosus*) in Rakhine State, Myanmar.

Location	Comments
An Chaung	Last reported in early 1960's near Sakanmaw Village[1]
Akyab (Sittwe)	Common in estuarine habitats[2]
Dalet Chaung	Nesting near river mouth[1]
Hnan Chaung	Three adult crocodiles observed in 1998-1999. Single nests found in 1997 and 1998[3]
Lamu Chaung	Last observed in the early 1960's; nesting[1]
Mae Chaung	Last reported near Saton Village in 1979[1]
Pyin Won Village	Two subadult crocodiles killed in 1999[3]
Ramree Island	Common in mangroves[1]
Sabyin Chaung	Last reported near Sabyin Village in 1979; nesting[1]
Sandoway	Uncommon in river deltas and mangroves[4]
Staton Village	Nesting reported in nearby lake[1]
Tanlwe Chaung	Two sighted near Kindaunggyi Village in 1982[1]
Taungup Chaung	Last reported ca. 1981[1]
Wunbaik Reserved Forest	Nesting reported[1]

[1]Salter, 1983b
[2]Smart, 1917
[3]This survey
[4]Tydd, 1912

Figure 15: *Crocodylus porosus* habitat near Pyin Won Village (above), and a 1997 nest site (below). Crocodiles have been largely extirpated from this region.

to four men using headlights and harpoons. Crocodile meat was sold for local consumption and traders purchased skins. Hunters received 40 to 50 kyats for each skin, or the equivalent of US$60 to 75 at the contemporary exchange rate. The largest crocodile the hunter killed was 18 feet (5.4 m) long, although he was uncertain if he actually measured the specimen. Hunters also collected and ate crocodile eggs. Crocodiles were last seen on Ramree Island in 1990, and the hunter attributed the decline to chronic over-harvesting.

Ramree Island was the scene of an alleged massacre of Japanese soldiers by *Crocodylus porosus* during World War II. The incident supposedly occurred during February 1945 when Allied forces invaded the island as part of their drive to recapture Rangoon (now known as Yangon). Securing the airfields at Kyaukphyu was considered an essential phase of the offensive, and an Allied amphibious assault force landed at the northern tip of Ramree Island on 21 January 1945 (Owen, 1946; Hickey, 1998). The Japanese garrison on the island numbered about 1000 men. Expecting an assault south of Kyaukphyu, the Japanese constructed a strong defensive position at Yanbank Chaung (Owen, 1946). The British executed a wide flanking maneuver, bypassed this strongpoint, and attacked towards Ramree Town (Owen, 1946). The Japanese position was now untenable and they fled into the mangrove swamps on the eastern side of the island, planning to withdraw across the river to the mainland. However, a Royal Navy flotilla quickly blocked their escape and trapped the Japanese in the swamp (Owen, 1946; Slim, 1956; Hickey, 1998).

It was in this swamp that the Japanese soldiers were allegedly massacred by repeated crocodile attacks. According to Bruce Wright (1962), a member of the British forces who witnessed the incident,

> "that night [19 February 1945] was the most horrible that any member of the M.L. [Marine Launch] crews ever experienced. The scattered rifle shots in the pitch black swamp punctured by the screams of wounded men crushed in the jaws of huge reptiles, and the blurred worrying sound of spinning crocodiles made a cacophony of hell that has rarely been duplicated on earth. ... Of about one thousand Japanese soldiers that entered the swamps of Ramree, only about twenty were found alive."

This incident has been uncritically accepted by later authors and recounted in a number of popular (Capstick, 1977, 1981) and semi-technical (Guggisberg, 1972; Pooley, 1989) works. Guggisberg (1972) further embellished the original account, by stating that while "some Japanese were certainly killed by gunfire, [and] others drowned, the *majority* seem to have been eaten by crocodiles" [italics added]. Only Campbell and Winterbotham (1985) have expressed skepticism concerning the scale of the massacre. Man-eating by *C. porosus* is well documented (Neill, 1971; Webb et al., 1978; Kar and Bustard, 1983; Edwards, 1989), but the magnitude of the Ramree Island massacre is exceptional and a critical reexamination of the incident is therefore warranted.

There is little evidence in historical accounts of the Ramree Island campaign to suggest that a large-scale massacre of Japanese troops by crocodiles actually occurred. A number of campaign histories contain no reference to the alleged massacre (Romanus and Sunderland, 1956; Moser, 1978; Allen, 1984). Others are ambiguous or suggest that only a limited number of soldiers were taken by crocodiles. In his memoirs of the Burma campaign, Lieutenant General William Slim (1956), commander of the Allied forces, stated the retreating Japanese "fell victims to naval patrols – and the sharks – as they attempted ... to reach the mainland." However, these events are not mentioned in a later, abridged edition of his memoirs (Slim, 1961). According to Hickey (1998), the Japanese "were forced into one corner of the island where, amongst crocodile-infested swamps, most of them died from drowning, disease or starvation. Only 20 ever surrendered." The only account suggesting crocodiles were responsible for some Japanese casualties is provided by Owen (1946) who stated that "... prey to flies, mosquitoes, scorpions, and most horrible, the crocodiles, and without food or water, the Japanese died in the hundreds ... Many were drowned or else crocodiles got them... No more than 20 ever surrendered."

Furthermore, we interviewed a number of older Ramree Island residents, and our results cast additional doubt on the magnitude of the alleged massacre. These individuals ranged from 67 to 86 years old, and all lived on Ramree Island during World War II. Several had billeted Japanese soldiers in their homes, and most were conscripted as porters by the Japanese Army. These individuals all related a similar version of events, and none were aware of a large-scale massacre of Japanese soldiers by crocodiles. According to our informants, the Japanese forces retreated into the mangrove swamp and rapidly exhausted their rations. Freshwater was unavailable and the soldiers were forced to drink brackish swamp water, resulting in severe dehydration. Dysentery and other diseases were rampant among the Japanese, and many soon succumbed to these privations. The only crocodile-related deaths occurred when 10 to 15 soldiers were killed attempting to ford Min Chaung, a tidal creek near Ramree Town. Our informants unanimously discounted any suggestion that large numbers of Japanese fell prey to crocodiles. Moreover, an informant who conducts regular tours for visiting Japanese veterans stated his clients often recount their experiences, but have never mentioned crocodile attacks.

In summary, there is little evidence that crocodiles were responsible for a massacre of Japanese soldiers on Ramree Island during World War II. That nearly 1000 Japanese died is well documented and undisputed. Nor is it surprising that only 20 Japanese emerged from the swamp to surrender for these soldiers followed the samurai code of bushido; death in battle or even suicide was preferable to the dishonor of surrender (Bergerud, 1996). Indeed, the bag of 20 prisoners from an initial force of 1000 is noteworthy, for Japanese typically surrendered at a ratio of only 1 per 120 dead (Chang, 1997; by comparison Allied soldiers surrendered at the rate of 1 per 3 dead). The question is whether the Japanese fell victim to crocodile attack or succumbed to a variety other causes. In this the historical accounts and our interview data are emphatic; nearly 1000 Japanese soldiers died from combat, disease, starvation, and even shark

attack, but only a small fraction of this total were devoured by crocodiles. Crocodiles alone certainly did not decimate this Japanese force.

Birds and Mammals

Eighty-one species of birds were recorded during the expedition. A checklist is presented in Appendix 11. Nomenclature follows Boonsang and Round (1991). An annotated checklist of the avifauna in coastal Rakhine and the nearby foothills is also provided by Christison et al. (1946). Observations of mammals encountered during the expedition are discussed below.

Tiger (*Panthera tigris*)

Tigers were abundant in the Arakan Yomas prior to World War II, and the region was long a favored destination of big game hunters (Thom, 1934a; Marshall, 1947). As recently as the early 1980's tigers remained common (Salter 1983a and b). Salter (1983a) regarded the Arakan Yomas as one of the major remaining strongholds for tigers in Southeast Asia, and stated that "[tigers] ... certainly occur throughout the area and may be quite numerous." Somewhat ominously, Salter (1983a) further noted that tigers were regularly taken by poachers.

No evidence of tigers was found during our expedition and villagers unanimously agreed that tigers no longer occurred in the area. Declines were attributed to widespread poaching beginning about 1990. Most villagers said they would not live in the forest if tigers inhabited the area. One group of hunters in Mae Sadwe Village told us they recently encountered fresh tiger tracks about one days walk east of the village. They also reported finding tiger tracks in the same area during 1999.

Other carnivores

A large hole we found on a hillside near Pyaung Chaung Village was attributed by our guides to the excavation of a subterranean bee nest by a bear (probably *Helarctus malayanus*). Villagers kill one or two bears each year; the meat is eaten, and the gall bladder and skin sold to traders. The tail of a recently killed binturong (*Arctictis binturong*) was obtained in Mae Sadwe Village. Asiatic jackals (*Canis aureus*) were heard vocalizing in farmland surrounding Pada Kyaw Village. Villagers stated jackals are common in the area, and occasionally enter town and attack domestic dogs.

Numerous deadfall traps were noted along forest streams throughout the area we visited. The traps targeted a small carnivore known locally as *kyaung letme*, or "black-handed cat," an animal described as weighing about 4.0 kg, with dark stripes and black feet and legs. We were unable to obtain a skin for identification, but the black-handed cat is likely a species of civet. Black-handed cats are common and widely hunted for food, and each village takes five to 10 per month. The animals are cooked by roasting the whole carcass and burning off the fur, hence our inability to obtain a skin for identification. The black-handed cat is said by hunters to follow streams and feed on

crustaceans, which it excavates from burrows. The traps we inspected were baited with prawns, reflecting this dietary preference.

Elephant (*Elephas maximus*)

Salter (1983a and b) noted elephants were common in parts of the Arakan Yomas, and the region was long a source of captives for domestication. However, little evidence for the occurrence of wild elephants was noted within the area we visited. The only exception were the tracks of a solitary elephant found near Pyaung Chaung Village. According to our guide the tracks were made following the last significant rainfall (ca. late November 1999). Hunters in Mae Sadwe Village reported finding elephant fresh elephant tracks about one days walk east of the village. Nine people were reportedly killed by elephants near Yu Village (GPS coordinates unavailable; an approximately two day walk east of Mae Sadwe) about four years ago. Villagers stated that elephants were common in the vicinity of Mae Sadwe until about three years ago, but moved elsewhere in response to increasing levels of human activity. According to villagers there is little or no hunting of elephants in the area.

Gaur (*Bos gaurus*)

The abundance of gaur in the Arakan Yomas was often commented on by big game hunters of the colonial era (Thom, 1934b). More recently, Salter (1983a and b) found gaur "common and widespread" and concluded the region provided important habitat for conservation of the species. Based on the prevalence of tracks and other sign, gaur appeared common in the areas we visited. Numerous tracks and well used trails were found in the vicinity of Pyaung Chaung and Mae Sadwe Villages, along the river between the two villages, and in the forest between Pyaung Chaung and Hinwyet Villages. At Pyaung Chaung Village we found fresh tracks and a heavily used river crossing within 250 m of the village. Although somewhat speculative, gaur populations may be increasing in response to the near extirpation of tigers in the region.

Gaur sign was found in both evergreen forest and bamboo habitats, and was particularly evident along small forest streams. Abandoned *taungya* fields with regenerating *Melocanna bambusoides* provide important habitat for guar, and extensive browsing of regenerating bamboo foliage, shoots, and stems was noted. According to hunters, gaur remain concealed during the day in bamboo thickets or other dense cover, and most activity is nocturnal or crepuscular.

Gaur are hunted locally for both meat and horns. Meat is consumed by villagers, while horns are sold to traders who pay the equivalent of about US$15.00 per pair. The horns are reportedly exported to China and Thailand, where they are highly regarded as trophies. Villagers lack firearms and take gaur either by trapping with snares or hunting with spears and dogs. Snares are set along game trails and indiscriminately capture either sex. We found two gaur skeletons in the forest near Pyaung Chaung Village; both were captured in snares and the skulls were missing. One was taken in 1998, but our guide

was uncertain when the other was killed. Hunters employing dogs typically target males. Dogs are used to corner animals, which are then speared at close range. Gaur spears consist of a locally produced steel blade (ca. 30 cm long) lashed to a bamboo pole approximately two meters long. Hunting in this manner presumably involves considerable risk to the hunter, as cornered or wounded gaur have a reputation for ferocity (Thom, 1934b; Marshall, 1947). Hunters estimated that each village takes two or three gaur annually, although one professional hunter in Padan Village claimed to have killed 16 (15 males, 1 female) during 1999. Police and military personnel from Ann reportedly hunt gaur with automatic weapons in the vicinity of Mae Sadwe Village; some meat is sold the remainder is used to supplement their rations.

Other Ungulates

Several sets of sambar (*Cervus unicolor*) tracks were found at widely scattered locations near Pyaung Chaung Village, but hunters regard this species as rare. Salter (1983a) considered *C. unicolor* common at higher elevations in the Arakan Yomas, and noted these large deer were frequently killed by hunters. We found numerous barking deer (*Muntiacus muntjak*) tracks and droppings, and often heard vocalizations at night. One barking deer was even heard vocalizing in agricultural habitat on the outskirts of Pada Kyaw Village. Hunters consider barking deer common, and we examined the antlers of two recently killed animals. Evidence of wild pigs (*Sus scrofa*) was ubiquitous throughout forested areas.

Primates

We recorded three species of primate during this expedition. A group of six to seven Rhesus macaques (*Maca mulatta*) were encountered in evergreen forest near Pyaung Chaung Village. Dusky leaf monkeys (*Presbytis obscura*) were observed in the same area, and a female was shot for food by our police escort. We found *P. obscura* in both evergreen and bamboo habitats. An undetermined number of crab-eating macaques (*Maca fasicularis*) were encountered in streamside mangroves during crocodile spotlight surveys near Pyin Won Village. Additionally, our porters reported observing a group of "bee monkeys" in thick riverine vegetation along Pyaung Chaung. These small monkeys are said to be common, but we were unable to locate an individual for species identification.

Butterflies

Although we did not record or collect butterflies during the expedition, annotated checklists are available for central Rakhine and Ramree Island (Gladmen, 1946; Emmet, 1948). Both authors served with the Allied forces during the campaigns of 1944-45, and collected extensively in the region despite ongoing battles. Gladman (1946) even mentions collecting butterflies while engaged in a raid behind Japanese lines.

Conclusions and Recommendations

1. The current study and others (Kuchling, 1995; van Dijk, 1997; Platt, 1999) indicate that large numbers of turtles and tortoises are being exported illegally from Myanmar into China. This trade undoubtedly threatens the continued viability of chelonian populations in many regions of Myanmar. The limited distribution of endemic species, such as the Burmese star tortoise (*Geochelone platynota*), Burmese roofed turtle (*Kachuga trivittata*), and perhaps the Arakan forest turtle renders them particularly vulnerable to over-exploitation. Therefore, it is **absolutely essential that authorities in Myanmar and China cooperate to drastically reduce trade levels**. As long as the wildlife markets in southern China continue to operate, turtle hunting will remain a lucrative economic proposition for rural inhabitants in Myanmar. Without rapid implementation of protective measures, continued population declines are expected and it is probable that many species will become critically endangered within the next 10 years.

2. Conduct additional field surveys to determine the distribution and status of *Geoemyda depressa* elsewhere in Myanmar. Priority areas for investigation include the southern Arakan Yoma Hills, Chin Hills, and suitable habitat in Kayah State. The elevational distribution of *G. depressa* in the Arakan Yoma Hills needs to be established.

3. Initiate *ex-situ* conservation program for *Geoemyda depressa*. Because *G. depressa* inhabits a restricted distribution, the species remains vulnerable to increased levels of exploitation and habitat destruction. Captive groups should be established while living specimens are still readily obtainable. *Ex-situ* programs should focus on developing methods of husbandry and propagation. Captive groups should be established at the Yangon Zoo and facilities in the United States.

4. Crocodile and turtle surveys are warranted in extreme western Rakhine State north of Sittwe. This area is poorly known biologically and may harbor remnant populations of gharial (*Gavialis gangeticus*). The only confirmed specimen of *G. gangeticus* from Myanmar was collected in 1927 from the Shweli River, a northern tributary of the Ayeyarwady River (Barton, 1928). However, *G. gangeticus* has been reported from the Kaladan River in Rakhine State (Smith, 1931; Symns, 1942), although the basis of these records is not stated. Platt (1999) discusses a recent anecdotal report of a *G. gangeticus* skull that supposedly originated in Rakhine State. *Gavialis gangeticus* still occurs in neighboring Bangladesh (Groombridge, 1987), and remnant populations could potentially survive in Myanmar.

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Appendix 1: Expedition itinerary

19 January	Arrive in Yangon.
20 January	Attend to logistics in Yangon.
21 January	Travel from Yangon to Shwe Settaw Wildlife Sanctuary.
22 January	Travel by road from Shwe Settaw Wildlife Sanctuary to Rakhine State. Stop in Ann to secure permission from State authorities for Further travel. Proceed to Datun Taung Village and spend the night.
23 January	Travel by boat from Datun Taung Village to Hinwyet Village (12.6 km) along Ann Chaung. Stop enroute at Mintat Village and inspect turtle shells. Travel overland from Hinwyet Village to Pada Kyaw Village and establish bivouac.
24 January	Travel overland from Pada Kyaw Village to Pyaung Chaung Village (0830-1330 hrs; ca 12.8 km). Establish basecamp at Pyaung Chaung Village.
25 January	Pyaung Chaung Village. Two hunters with dogs dispatched to search for turtles. Remainder of the team inspected habitat and searched forest surrounding basecamp for large mammal sign (0830-1330 hrs).
26 January	Win Ko Ko departs for Mae Sadwe Village. Remainder of team conducts biological reconnaissance in hills surrounding Pyaung Chaung Village.
27 January	Win Ko Ko in Mae Sadwe Village. Remainder of team continues biological survey of hills surrounding Pyaung Chaung Village.
28 January	Win Ko Ko in Mae Sadwe Village. Remainder of team continues biological survey of hills surrounding Pyaung Chaung Village.
29 January	Win Ko Ko in Mae Sadwe Village. Remainder of team moves overland (0915-1530 hrs) and establishes forward operating base in Mae Village. Interview hunters.
30 January	Team consolidated in Mae Sadwe Village. Survey of surrounding forest conducted (1400-1630 hrs.). Interview hunters.
31 January	Mae Sadwe Village. Conduct biological reconnaissance of surrounding forest (1000-1630 hrs.). Visit Myo Village and interview inhabitants.
1 February	Win Ko Ko remains in Mae Sadwe Village. Remainder of team returns to basecamp at Pyaung Chaung Village.
2 February	Win Ko Ko returns to Pyaung Chaung Village. Remainder of team inspects *Geoemyda depressa* habitat (1000-1300 hrs) or conducts vegetation sampling (1000-1700 hrs).
3 February	Measure and examine tortoises obtained from hunters in Mae Sadwe Village. Dismantle basecamp in Pyaung Chaung Village. Team returns overland to Pada Kyaw Village (0930-1600 hrs).
4 February	Pada Kyaw Village. Visit Yematheim and Hmwa Villages (0900-1500 hrs). Obtain shells and accompany hunters to sites where *Geoemyda depressa* was collected.

Appendix 1 (continued).

5 February	Move overland to boat landing along creek (0830-0930 hrs). Travel by boat to Pyin Won Village and establish basecamp.
6 February	Visit Pyin Chaung and examine captive crocodile (0930-1330 hrs). Conduct spotlight survey for crocodiles near Pyin Won Village (1600-2200 hrs).
7 February	Pyin Won Village. Three team members visit *Crocodylus porosus* nest sites along Hnan Chaung (0900-1330 hrs). Remainder of team visits Let Pan and Ahngyin Taung Village, obtain turtle shells and interview hunters (0900-1350 hrs). Team reassembles and accompanies hunter to *Geoemyda depressa* habitat (1530-1745 hrs). Crocodile survey conducted near Pyin Won Village (1700-2100 hrs).
8 February	Pyin Won Village. Visit Let Pan and Ahngyin Taung Villages. Accompany hunters into surrounding hills and inspect *Geoemyda depressa* habitat (0700-1400 hrs). Dismantle basecamp and travel by boat to Ramree Island (1530-2400 hrs).
9 February	Ramree Town, Ramree Island. Visit Tha Ze Pyin and examine flowering bamboo (0900-1300 hrs). Return to Ramree Town and interview elderly residents regarding alleged massacre of Japanese soldiers by crocodiles during World War II (1330-1530 hrs). Visit nearby Ah Wa Taung and interview elderly crocodile hunter (1530-1700 hrs).
10 February	Travel by road from Ramree Town to Kyaukphyu (0900-1330 hrs). Stop enroute and gather data on sea turtles at Zin Chaung and Min Pyin Village.
11 February	Kyauphyu. Visit fish market and interview turtle egg vendor (0830-0930 hrs). Team given liberty at beach near town in preparation for arduous return journey to Yangon.
12 February	Travel by boat from Kyaukphyu to Datun Taung Village (0900-1300 hrs). Inspect fish market in Datun Taung Village.
13 February	Travel by road from Datun Taung Village to Shwe Settaw Wildlife Sanctuary (0900-1830 hrs). Stop enroute at Padan Village and obtain living *Geoemyda depressa* from hunter.
14 February	Travel by road from Shwe Settaw Wildlife Sanctuary to Yangon 0930-2300 hrs). Stop enroute at Min Tone and visit turtle trader.
15 to 16 February	Attend to logistics and travel arrangements in Yangon.
17 February	Depart Yangon and return to United States.

Appendix 2: Expedition gazetteer: Latitude and longitude of locations listed in text. Coordinates determined with Garmin GPS 48. Locations listed alphabetically.

Location	Latitude (N)	Longitude (E)
Ah Wa Taung	19° 06.06'	93° 53.86'
Ahngyin Taung Village	19° 20.94'	94° 09.58'
Ann	19° 46.09'	94° 01.50'
Datun Taung Village	19° 33.89'	93° 56.05'
Hnan Chaung	19° 22.94'	94° 07.08'
Hinwyet Village	19° 30.69'	94° 02.06'
Hmwa Village	19° 29.01'	94° 01.74'
Kyaukphyu	19° 26.16'	93° 32.65'
Let Pan Village	19° 20.39'	94° 09.46'
Mae Village	19° 37.33'	94° 08.80'
Mae Village	19° 20.64'	94° 08.33'
Mae Sadwe Village	19° 37.19'	94° 09.23'
Min Pyin Village	19° 17.26'	93° 31.69'
Min Tone	19° 20.97'	94° 44.31'
Mintat Village	19° 31.67'	93° 58.24'
Myo Village	19° 37.34'	94° 08.43'
Pada Kyaw Village	19° 31.13'	94° 01.89'
Padan Village	19° 58.60'	94° 32.63'
Pyaung Chaung	19° 32.64'	94° 06.70'
Pyin Chaung	19° 22.78'	94° 07.66'
Pyin Won Village	19° 20.94'	94° 07.73'
Ramree Town	19° 05.57'	93° 51.72'
Tha Ze Pyin	19° 02.33'	93° 49.82'
Yemathiem Village	19° 30.09'	94° 01.57'
Zin Chaung Village	19° 08.76'	93° 38.11'

Appendix 3: Notes on bamboo encountered during an expedition to central Rakhine State, Myanmar (20 January to 14 February 2000).

Tin Wa (*Cephalostachyum pergracile*)

On 9 February we examined a stand of *Cephalostachyum pergracile* approximately 1 km NE of Tha Ze Pyin Village (19° 02.026' N; 93° 49.389' E) on Ramree Island. The bamboo was growing in an open deciduous forest dominated by *Lennea grandis*, *Dalbergia panniculata*, *Dolichandrone spathacea*, and various leguminous trees. A second species of bamboo, *thaik wa* (*Bambusia burmanica*), also occurred in the area. *Cephalostachyum pergracile* initiated flowering during the 1998 dry season and continued until 1999. At the time of our inspection flowering clumps were dead, but numerous dried panicles were present. A few clumps that reportedly failed to flower remained alive. According to older residents *C. pergracile* last flowered about 40 years ago (circa 1960). A dense carpet of seedlings was growing beneath dead clumps of *C. pergracile*. According to our guides, these seedlings germinated following wildfires of the previous dry season (March to June 1999). Villagers observed rats, red junglefowl (*Gallus gallus*), small passerines, pigeons, and tree squirrels feeding on bamboo seeds. Seeds were also collected for human consumption and prepared by boiling; the taste was said to be similar to rice. Dead panicles were collected and later deposited in the herbarium of the Campbell Museum, Clemson University, Clemson, South Carolina.

Myin Wa (*Dendrocalamus strictus*)

On 14 February we examined flowering clumps of *Dendrocalamus strictus* along the road to Min Tone Village (18° 19.068' N; 94° 45.784' E). Several dead clumps of *D. strictus*, which flowered previously (1999) were also noted. However, most of the bamboo clumps along this road remained in the vegetative phase. Clumps flower and seed from December through April and then die. Lay Lay Khine (pers. comm.) has found scattered flowering clumps of *D. strictus* at Shwe Settaw Wildlife Sanctuary every dry season since 1993. These observations contrast those of Janzen (1976) who stated that synchronous flowering occurs in *D. strictus* every 15 to 47 years. However, according to McClure (1966) sporadic flowering in parts of a continuous population and even on different culms within a single clump, is a frequent occurrence in this species.

No bamboo regeneration was evident beneath flowering or dead clumps. However, the area was intensively grazed by cattle and little forage remained. Thus, any seedlings that germinated would undoubtedly be quickly consumed. During our visit we observed a mixed species flock of small minivets (*Pericrocotus cinnamomeus*) and red-breasted parakeets (*Psittacula alexandri*) feeding on bamboo seeds. Flowering specimens were collected and deposited in the herbarium of the Campbell Museum, Clemson University, Clemson, South Carolina.

Khayin (Melocanna bambusoides)

Melocanna bambusoides is a monopodial bamboo with erect culms arising from rhizomes and growing to a height of 15 to 20 m. Extensive monotypic stands, known as bamboo brakes, occur throughout the Arakan Yoma Hills (Stamp, 1930; de Terra, 1944). Bamboo brakes develop under regimes of moderate to intense anthropogenic disturbance, particularly shifting cultivation and fire (Stamp, 1924, 1930; de Terra, 1944). Salter (1983a) attributes the widespread occurrence of this plant community in the region to centuries of shifting cultivation.

We determined culm density and diameter of *M. bambusoides* in a representative bamboo brake near Pyaung Chaung Village. Six 100 m transects were established perpendicular to terrain contours, with 1 m^2 quadrats positioned at 5 m intervals. Within each quadrat, all living and dead culms were counted. The DBH (diameter breast height; ca. 1.3 m) of each culm was measured to the nearest 0.1 cm using large forestry calipers. Additional living culms surrounding each quadrat were randomly selected until a total of 10 living culms had been measured. The mean density of living culms was $3.2 \pm 2.5/m^2$ (range = 0 to 13; n = 120) or 320 ± 250/ha. Densities as high as 25,935 living culms/ha have been reported in cultivated stands (Farrelly, 1984). The mean density of dead culms was $2.2 \pm 2.0/m^2$ (range = 0 to 9; n = 120) or 220 ± 200/ha. The mean diameter of living culms was 4.3 ± 0.9 cm (range = 2.4 to 6.5 cm; n = 80).

Melocanna bambusoides is a monocarpic bamboo exhibiting prolonged vegetative growth followed by mast seeding (synchronized production of seeds within a population; Janzen, 1976), and subsequent culm die-off (Chatterjee, 1960). The intermast period ranges from 7 to 51 years (Janzen, 1976). According to villagers, *M. bambusoides* last produced seed from 1958 to 1960. Mast seeding was also reported during the same years among *M. bambusoides* brakes in the Mizo Hills of Assam, India (Chatterjee, 1960; Vaid, 1962). *Melocanna bambusoides* produces the largest fruit of any bamboo, which unlike other species contains a liquid endosperm that hardens as the fruit matures (Chatterjee, 1960). Seeds may germinate while still hanging on the parent plant (Farrelly, 1984). Villagers told us they collect mature fruits and prepare by boiling or roasting. However, most people did not seem particularly fond of eating bamboo seeds.

Next to rice, *M. bambusoides* is probably the most important plant to the indigenous cultures of central Rakhine, and the uses of bamboo are myriad. Houses are constructed almost entirely of bamboo, the only exception being the palm thatch used for roofing. Bamboo fences exclude free ranging pigs from garden plots. Dried bamboo is used as a quick burning fuel for cooking. Split culms are woven into mats, baskets, and fish traps. During the wet season, bamboo shoots are harvested for food. Thom (1935) observed that the hill tribes suffered greatly when the bamboo forests died after flowering, depriving them of building materials and food. The villagers we interviewed were unaware of any medicinal uses for *M. bambusoides.*

We traversed several large bamboo brakes that had burned within the past two years. Fire hunting is widely practiced in the region, and brakes are burned late in the dry season to flush game. Hunters set backfires along ridgelines, which burn slowly downslope. Animals moving ahead of the flames are intercepted by hunters waiting in streambeds below. This technique is especially effective for capturing *Indotestudo elongata*. Villagers also attribute ignition to winds, which cause dry culms to rub together for a sustained period. The resulting friction could be sufficient to cause ignition under certain conditions. Recently burned brakes are characterized by standing or fallen dead culms and an almost impenetrable understory of resprouting culms. Living culms are killed by fire, but resprout quickly from rhizomes. Villagers often fell and burn bamboo to plant upland rice, but rhizomes remain intact and resprout following field abandonment. Villagers stated that a bamboo brake matures 8 to 10 years after a field is abandoned.

Bamboo brakes are important habitat for a number of large mammals. Sumatran rhinoceros (*Sondaicus sumatrensis*) were once frequently encountered in bamboo, and consumed foliage, shoots, flowers, and fruits, being especially fond of the latter (Thom, 1935; Christison, 1945; Ansell, 1947). Gaur (*Bos gaurus*) use brakes as cover (Thom, 1934b), and we noted extensive browsing of regenerating bamboo in abandoned *taungya* fields. Banteng (*Bos banteng*) also inhabit bamboo brakes and browse foliage (Vernay, 1924; Thom, 1944). Elephants (*Elephas maximus*) utilize bamboo for browse and cover (Thom, 1933; Salter, 1983b). The smaller fauna of bamboo brakes is not well documented. Hunters reportedly capture *Indotestudo elongata*, *Manouria emys*, *Geoemyda depressa*, and *Cyclemys dentata* in bamboo brakes. Smith (1936) describes the nest of a king cobra (*Ophiophagus hannah*) constructed of dried bamboo leaves and twigs in a bamboo brake. We observed Kalij pheasants (*Lophura leucomelana*) and tree squirrels (*Callosciurus* spp.) in bamboo. Red junglefowl (*Gallus gallus*) and various rodents consume *M. bambusoides* seeds (Thom,1935; Chatterjee, 1960).

Appendix 4: Arakan forest turtles (*Geoemyda depressa*) examined in Rakhine State, Myanmar from 19 January to 14 February 2000. Dates presented as month/day. Sex: M = male; F = female; J = juvenile, sex could not be reliably determined. CL = carapace length; CW = maximum carapace width; PL = plastron length; PW = plastron length; SD = shell depth. Shell attributes given in cm; mass in grams.

Number	Date	Sex	CL	CW	PL	PW	SD	Mass	Annuli	Location/Notes
1	01/20	F	24.2	17.4	22.1				11	Mintat Village
2	" "	M			21.3					Mintat Village; plastron only.
3	01/23	F			20.6					Same as #2.
4	" "	M			19.7					Same as #2.
5	" "	F			17.5				10	Pada Kyaw Village; plastron only; caught about 2 km NE of village.
6	02/04	F	23.0	17.9					22	Hmwa Village; extensively chewed by dog; found in deciduous forest.
7	02/07	F	17.6	13.1	16.1	7.5	6.8		8	Pyin Won Village
8	" "	F			18.3	10.7			10	Let Pan Village; plastron only.
9	" "	J	10.9	9.2	9.8	8.3	4.1		5	Ahngyin Taung Village; found by dog in evergreen forest.
10	" "	F	13.2	10.8	12.0	9.6	5.2		9	Same as #9.
11	" "	?	24.2	16.7					17	Same as #9; carapace only.
12	" "	M	23.4	17.6	20.2	16.0	8.9		18	Same as #9; found by dog.
13	" "	M	23.6	15.9	19.2	13.5	7.9		18	Same as #9; fire (?) damage to marginals and vertebrals; found in deciduous forest.
14	" "	M	23.3	13.6	19.9	13.6	7.5		18	Same as #9; carapace damaged
15	" "	M	20.9	16.4	19.2	14.0	7.4		17	Pyin Won; found in sugarcane field
16	02/13	M	22.0	15.2	19.3	13.2	8.0	1300	18	Living specimen obtained from hunter in Padan; caught at Salu Taung, Rakhine State in bamboo.
17	" "	?	22.3	16.7					20	Same as #16; carapace only.

Appendix 5: Plastron attributes of Arakan forest turtle (*Geoemyda depressa*) shells examined in Rakhine State, Myanmar from 19 January to 14 February 2000. Numbers correspond to turtles listed in Appendix 4 and 6. PLM = maximum plastron length. DN = depth of plastral notch. Interplastral seams: G = gular; H = humeral; P = pectoral; Ab = abdominal; F = femoral; An = anal. PFW = plastral forelobe width; PHW = plastral hindlobe width. Plastron attributes given in millimeters. Asterisk denotes specimens for which plastrons were unavailable.

			Interplastral seam length						Bridge length			
Number	PLM	DN	G	H	P	Ab	F	An	Right	Left	PFW	PHW
1	233	11.2	25.4	27.4	49.9	58.4	37.4	27.5	95.9	95.6	104.3	124.8
2	229	13.3	28.8	24.0	47.0	54.0	36.0	29.0	86.0	85.7	100.9	125.1
3	220	11.8	25.1	22.9	44.6	57.4	37.8	26.7	90.3	93.1	103.9	120.7
4	215	16.6	24.8	23.3	41.5	50.5	40.5	25.6	78.3	76.6	94.3	114.6
5	191	13.3	24.4	25.8	33.1	45.0	30.3	24.2	74.9	75.2	82.8	96.7
6[1]					43.3	56.4						
7	170	9.0	20.1	21.6	30.2	41.4	31.0	18.8	68.1	67.6		
8	183	12.0	22.9	27.7	35.7	36.5	33.0	21.5	78.9	77.8	83.1	93.7
9	102	4.3	13.2	12.4	18.1	26.8	19.3	12.4	46.1	45.8	48.1	56.0
10	128	7.9	15.6	19.9	20.5	32.0	24.0	14.9	55.7	53.6	58.5	70.4
11*												
12	214	12.0	23.2	25.9	43.5	51.5	39.1	22.9	82.9	80.7	87.8	111.1
13	208	16.0	28.2	23.0	40.5	46.2	38.6	21.7	79.5	80.0	90.5	111.7
14	209	10.0	24.5	26.5	39.8	48.1	36.8	27.7	84.7	84.1	88.7	116.6
15	203	11.0	24.6	25.1	43.5	45.2	33.3	25.6	77.7	77.1	89.9	112.6
16	205	12.0	19.9	29.1	41.5	47.6	37.2	23.6	81.0	79.8	91.0	107.6
17*												

[1]Most of plastron destroyed by dog.

Appendix 6: Carapace scute measurements from Arakan forest turtle (*Geoemyda depressa*) shells examined in Rakhine State, Myanmar from 19 January to 14 February 2000. Numbers correspond to Appendix 4 and 5.

	Cervical scute (mm)		Vertebral scute length (mm)				
Number	Length	Width	1	2	3	4	5
1	11.3	7.3	46.1	47.6	44.5	42.9	40.1
2*							
3*							
4*							
5*							
6	10.2	6.0	46.7	43.5	41.6	46.0	42.8
7	6.0	5.4	34.9	33.2	30.9	34.7	32.7
8*							
9	6.6	3.8	22.1	22.3	21.2	20.3	28.5
10	7.2	6.0	26.6	26.7	26.9	25.7	22.5
11	12.1	6.1	46.1	41.1	40.5	41.5	51.8
12	12.8	13.4	46.8	45.4	39.9	40.4	41.0
13	13.1	8.4	45.5	42.5	34.9	44.0	51.0
14	13.1	5.0	40.9	41.5	39.1	39.7	46.8
15	11.9	16.7	M	M	37.7	37.0	M
16	10.1	10.6	41.5	40.2	39.8	38.4**	46.5
17	11.8	10.7	44.9	40.0	34.1	42.9	38.2

* Only plastron available.

** Malformed scute.

Appendix 7: Elongated tortoises (*Indotestudo elongata*) examined in Rakhine State, Myanmar from 19 January to 14 February 2000. Dates presented as month/day. Sex: M = male; F = female. CL = carapace length; CW = carapace width; PL = plastron length; PW = plastron length; SD = shell depth. Shell attributes given in cm; mass in grams.

Number	Date	Sex	CL	CW	PL	PW	SD	Mass	Annuli	Location/Notes
1	01/23	F	25.2*		20.1	17.0				Plastron only.
2	" "	M	27.6*		21.3	16.9				Plastron only.
3	" "	F	26.6*		20.7	16.4				Plastron only.
4	" "	M	21.1	14.2	17.0	11.2	8.8		9	Pada Kyaw Village.
5	" "	F	18.1*		14.4	10.7				Mintat Village.
6	01/27	F	18.9*		15.0	11.0				Mae Sadwe Village; Plastron only.
7	01/31	M	24.2	16.2	19.4	14.5	11.1	2500	18	Mae Sadwe Village; evergreen forest in pangolin burrow.
8	01/31	M	27.5	18.1	20.6	15.5	10.8	3000		Same as #8.
9	" "	M	22.8	15.0	19.7	13.7	9.0	1500	18	Same as #8.
10	" "	M	24.0	15.8	18.0	14.5	9.7	2100	17	Mae Sadwe Village; found by dog.
11	02/03	F	27.9	20.0	21.5	18.2	12.4	3250		Pyaung Chaung Village; found in bamboo forest.
12	" "	M	29.5	18.5	21.4	16.7	10.7	3000		Same as #11.
13	" "	F	26.3	17.9	19.6	15.3	11.0	2250	21	Same as #11.
14	" "	F	28.5	18.1	21.5	16.3	11.7	2750		Same as #11.
15	" "	F	15.9	12.1	13.4	10.2	8.0	800	14	Same as #11.
16	" "	F	20.0	13.8	16.2	12.0	9.0	1200	14	Same as #11.
17	02/04	?	26.0	12.1						Hmwa Village; carapace only.
18	" "	?	25.9	17.0						Hinwyet Village; carapace only.
19	" "	F	16.8	13.0	14.0	10.3			12	Hinwyet Village.
20	" "	?	28.4	18.6					21	Same as #18.
21	" "	?	22.3	14.8						Yemathein Village; carapace only.

Appendix 7: (continued).

Number	Date	Sex	CL	CW	PL	PW	SD	Mass	Annuli	Location/Notes
22	" "	?	25.3	17.0					15	Hmwa Village; carapace only; found eating mushrooms.
23	" "	?	23.7	15.9					12	Same as #22.
24	02/07	?	19.5*		15.4	9.8				Thetyin Chaung; plastron only.
25	" "	M	19.0	13.0	14.7	11.9	8.3		9	Pyin Won Village.
26	" "	F	13.4	10.5	11.3	9.2	6.7	400	5	Datun Taung Village; found eating mushrooms.
27	02/14	F	27.6*		21.3	13.0				Min Tone Village; plastron only.
28	" "	?	18.8	11.7						Min Tone Village; collected in mountains; carapace only.

*Carapace length (CL) determined from plastron length (PL) by the formula: CL = 1.377 (PL) – 1.660.

Appendix 8: Asian leaf turtles (*Cyclemys dentata*) examined in Rakhine State, Myanmar from 19 January to 14 February 2000. Dates presented as month/day. Sex: M = male; F = female. CL = carapace length; CW = carapace width; PL = plastron length; PW = plastron length; SD = shell depth. Shell attributes given in cm; mass in grams.

Number	Date	Sex	CL	CW	PL	PW	SD	Mass	Annuli	Location/Notes
1	01/26	?	6.8	6.1	5.8	4.0		41	1	Captured in stream near Basecamp.
2	01/27	?	16.8	12.5	15.2	9.9	6.2	500		Mae Sadwe Village.
3	01/30	?			16.2	10.7				Mae Sadwe Village; plastron only.
4	" "	?	20.6	14.7	19.7	12.2	7.2			Mae Sadwe Village
5	" "	?	12.1	11.0	11.5	7.8	4.4			Mae Sadwe Village; carapace not completely ossified.
6	" "	?	18.1	13.1	15.8	10.7				Mae Sadwe Village.
7	" "	?	18.2		16.4	10.0	6.5			Same as #5; extensive damage.
8	01/31	M	11.5	9.6	10.2	7.2	5.0	172		Mae Sadwe Village; found on streambank.
9	" "	M	12.6	10.6	12.0	8.1	5.0	265	8	Same as #8.
10	" "	F	20.7	15.4	19.4	13.5	8.2	1250		Mae Sadwe Village; found in bamboo forest.
11	" "	F	23.0	15.7	20.1	12.9	7.8	1650		Same as #10.
12	02/03	F	18.2	12.9	16.5	10.2	6.0	750	11	Pyaung Chaung; bamboo forest.
13	" "	F	20.2	14.7	18.8	12.1	6.9	1000	14	Same as #13.
14	02/14	?			18.1	11.0				Trader in Min Tone; plastron only; captured in Arakan Yoma Hills.

Appendix 9: Other turtles examined in Magwe Division and Rakhine State, Myanmar from 19 January to 14 February 2000. Dates presented as month/day. Sex: M = male; F = female. CL = carapace length; CW = carapace width; PL = plastron length; PW = plastron length; SD = shell depth. Shell attributes given in cm; mass in grams.

Number	Date	Sex	CL	CW	PL	PW	SD	Mass	Annuli	Location/Notes
Amyda cartilaginea										
1	02/14	?	24.6	24.2						Trader in Min Tone Village; collected locally in Min Tone Chaung; carapace only.
2	" "	F	39.9	29.7	32.2	29.7	10.9			Same as #1.
3	" "	F	17.1	13.9	13.3		4.3			Same as #1.
Eretmochelys imbricata										
1	02/11	?	26.6	21.8						Min Pyin Village, Ramree Island; caught in 1999; carapace only.
Manouria emys										
1	02/07	?	34.1	32.0					30	Mae Village; carapace only; found in bamboo forest.
2	" "	?	49.9	35.1					22	Mae Village.
3	" "	M	56.8	41.6	50.4	38.5	23.6		28	Same as #3.
4	02/14	F			39.7	31.1				Trader in Min Tone Village; collected in Rakhine State.
Melanochelys trijuga										
1	01/22	F	22.9	15.7	19.9	13.7	9.1	1100	11	Trader in Padan Village; captured in Rakhine State.
Pyxidea mouhotii										
1	02/13	?	27.9	20.3					19	Hunter in Padan; collected in Rakhine State; evergreen forest; carapace only.

Appendix 10: Description of crocodile survey routes. Coordinates determined with Garmin GPS 48. Place names correspond to Survey of India topographical maps (1927). Locals names used if location not labeled on topographical maps.

6 February 2000
Weather: Clear, no rain, high temperature ca. 32° C, low temperature ca. 12° C.
Survey route: Begin at confluence of Hnan and Sane Chaungs (19° 23.025'N; 94° 05.624' E). Proceed upstream to mouth of Pyin Chaung (19° 22.556' N; 94° 07.399' E). Follow Pyin Chaung until no longer navigable and return to Hnan Chaung. Follow Hnan Chaung upstream until no longer navigable (19° 22.004' N; 94° 07.708' E). Return to starting point at confluence of Hnan Chaung and Sane Chaung. Enter Kyauk Gyi Pauk Chaung (19° 22.998' N; 94° 05.590' E) and follow to confluence of Mae Chaung (19° 21.721' N; 94° 05.741' E). Follow Mae Chaung to Pyin Won Village (19° 20.947' N; 94° 07.738' E).
Approximate distance: 15.2 km.
Results: Spotlight survey, no crocodiles observed. Crab-eating macaques (*Maca fasicularis*) encountered.

Survey route: Begin at confluence of Hnan and Sane Chaungs (19° 23.025'N; 94° 05.624' E). Follow Sane Chaung upstream until no longer navigable. Return to starting point and follow Kyauk Gyi Pauk Chaung to Mae Chaung (19° 21.721' N; 94° 05.714' E). Follow Mae Chaung to Pyin Won Village (19° 20.947' N; 94° 07.738' E).
Approximate distance: 14 km.
Results: Spotlight survey, no crocodiles observed.

7 February
Weather: Clear, no rain, high temperature ca. 32° C, low temperature ca. 12° C.
Survey route: Begin at Pyin Won Village (19° 20.947' N; 94° 07.738' E). Follow Mae Chaung to Kyauk Gyi Pauk Chaung (19° 21.721' N; 94° 05.714' E). Proceed upstream to Hnan Chaung (19° 23.025' N; 94° 05.624' E). Continue upstream until reaching crocodile nest sites (19° 22.948' N; 94° 07.083' E). Return along same route.
Approximate distance: 16 km.
Results: Daylight survey, no tracks, slides, or crocodiles observed. Nest sites from 1997 and 1998 examined. No signs of recent nesting activity.

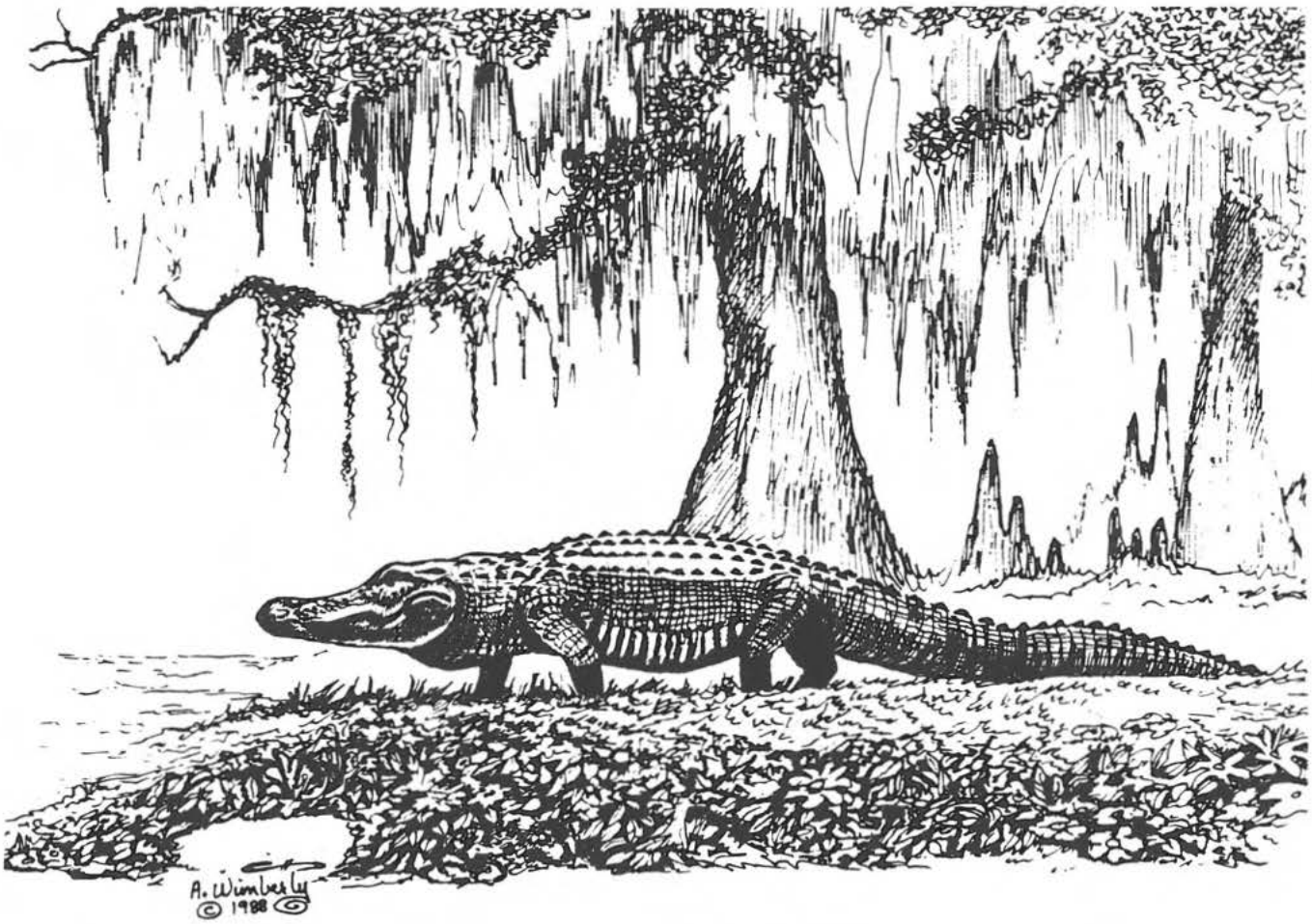
Survey route: Begin at confluence of Mae Chaung and Sapyin Chaung (19° 21.420' N; 94° 06.380' E). Follow Sapyin Chaung upstream until no longer navigable (19° 20.587' N; 94° 06.448' E). Return by same route. Follow Mae Chaung to Pyin Won Village (19° 20.947' N; 94° 07.738' E).
Approximate distance: 11.25 km.
Results: Spotlight survey, no crocodiles observed.

8 February
Weather: Clear, no rain, high temperature ca. 32° C, low temperature ca. 12° C.
Survey route: Begin survey at Mae Village (19° 20.649' N; 94° 08.331' E). Follow Mae Chaung into Kalemdang River. Follow Kalemdang River to confluence of Tan Chaung (19° 05.775' N; 94° 57.410' E).

Appendix 10: (continued).

Approximate distance: 17.5 km.
Results: Daylight survey, no tracks, slides, or crocodiles observed.

Survey route: Begin at confluence of Tan Chaung and Kalemdang River (19° 05.775' N; 94° 57.410' E). Proceed upstream to Ah Wa Taung (19° 06.066' N; 93° 53.864' E).
Approximate distance: 15 km.
Results: Spotlight survey, no crocodiles observed.



Appendix 11: Checklist of birds encountered in Central Rakhine State, Myanmar from 22 January to 14 February 2000. List compiled by Lay Lay Khine.

Common Name	Scientific Name
1. Great hornbill	*Buceros bicornis*
2. Red-headed trongo	*Harpactes erythocephalus*
3. Mountain imperial pigeon	*Ducula badia*
4. Thick-billed pigeon	*Treron pompadora*
5. Spotted dove	*Streptopelia chinensis*
6. Red turtle dove	*Streptopelia tranquebarica*
7. Emerald dove	*Chalcaphaps indica*
8. Long-tailed sibia	*Heterophasia picaodes*
9. Kalij Pheasant	*Lophura leucomelana*
10. Red junglefowl	*Gallus gallus*
11. Large-tailed nightjar	*Caprimulgus macrurus*
12. White wagtail	*Motacilla alba*
13. Grey wagtail	*Motacilla cinerea*
14. Forest wagtail	*Dendronanthus indicus*
15. Streak-throated woodpecker	*Picus xanthopygaeus*
16. Grey-headed woodpecker	*Picus canus*
17. Bamboo woodpecker	*Gacinulus granfia*
18. Laced woodpecker	*Picus vittatus*
19. White-throated bulbul	*Criniger glaveolus*
20. Olive-winged bulbul	*Pycnonotus plumasus*
21. Black-crested bulbul	*Pycnonotus melanicterus*
22. Red-whiskered bulbul	*Pycnonotus jocosus*
23. Sooty-headed bulbul	*Pycnonotus aurigaster*
24. Black bulbul	*Hypsipetes madagascariensis*
25. Green magpie	*Cissa chinensis*
26. Large-billed crow	*Corvus macrorhynochos*
27. Dollarbird	*Eurystomus orientalis*
28. Indian roller	*Coracias benghalensis*
29. Sultan tit	*Melanochlora sultanea*
30. Common myna	*Acridotheres tristis*
31. Hill myna	*Gracula religiosa*
32. Jungle myna	*Acridotheres fuscus*
33. White-vented myna	*Acridotheres javanicus*
34. Vinous-breasted starling	*Sturnus burmannicus*
35. Asian fairy bluebird	*Irena puella*
36. Black-hooded oriole	*Criolus xanthornus*
37. Greater racket-tailed drongo	*Dicrurus paradiseus*
38. Hairy-crested drongo	*Dicrurus hottentottus*
39. Black drongo	*Dicrurus macrocercus*
40. Bronzed drongo	*Dicrurus aeneus*
41. Ashy drongo	*Dicrurus leucophaeus*

Appendix 11: (continued).

Common Name	Scientific Name
42. Asian emerald cuckoo	*Chrysococcyx maculatus*
43. Drongo cuckoo	*Lugubris surniculus*
44. Pied cuckoo	*Clamator jawbinus*
45. Green iora	*Aegithina viridissima*
46. Dark-necked tailorbird	*Orthotomus atrogularis*
47. Two bar warbler	*Phylloseopus plumbeitarsus*
48. Pale-legged warbler	*Phylloseopus tenellipes*
49. Scarlet minivet	*Pericrocotus flammeus*
50. Small minivet	*Pericrocotus cinnamomeus*
51. Rosy minivet	*Pericrocotus roseus*
52. Great reed-warbler	*Acrocephalus arundinaceus*
53. Black-naped monarch	*Hypothymis azurea*
54. White-browed piculet	*Sasia ochracea*
55. Striped tit babbler	*Marconous gularis*
56. White-browed scimitar babbler	*Pomatorhinus schisticeps*
57. Lesser necklaced laughing thrush	*Monileger surrulax*
58. Bar-winged flycatcher shrike	*Hemipus picatus*
59. Brown shrike	*Lanicus cristatus*
60. Chestnut-headed bee-eater	*Merops leschenaulti*
61. Brown fulvetta	*Alcippe brunneicauda*
62. Green-billed malkoha	*Phaenicophaeus tristis*
63. Stork-billed kingfisher	*Halcyon capensis*
64. White-throated kingfisher	*Halcyon smyrnensis*
65. Pied kingfisher	*Ceryle rudis*
66. Blue-eared kingfisher	*Alcedo meninting*
67. Black-capped kingfisher	*Halcyon pileata*
68. Asian palm swift	*Cypsiurus balasiensis*
69. House swift	*Apus affinis*
70. Vernal hanging parrot	*Loriculus vernalis*
71. Red-breasted parakeet	*Psittacula alexandri*
72. Black kite	*Milvus migrans*
73. Crested serpent eagle	*Spilornis cheela*
74. Brahminy kite	*Haliastur indus*
75. Intermediate egret	*Egretta intermedia*
76. Chinese pond heron	*Ardeola speciosa*
77. Wooly-necked stork	*Ciconia episcopus*
78. Little egret	*Egretta gargetta*
79. Purple heron	*Ardea purpurea*
80. Racket-tailed treepie	*Crypsirina temia*
81. Rufous treepie	*Dendrocitta vagabunda*

Appendix 11: (continued).

Common Name	Scientific Name
82. Golden-fronted leafbird	*Chloropsis aurifrons*
83. Asian barred owlet	*Glaucidium cuculoides*
84. Osprey pandion	*Pandion haliaetus*
85. Wood sandpiper	*Tringa glareola*
86. Hoopoe	*Upupa epops*
87. Richards pipit	*Antus rovaesseelardiee*
88. Indian shag	*Phalacrocorax fusciollis*