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Ecology and Conservation Status of the Arakan Forest Turtle, *Heosemys depressa*, in Western Myanmar

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The Arakan forest turtle (*Heosemys depressa*) is endemic to Myanmar and is regarded as one of the world's least known chelonians (Ernst and Barbour, 1989; van Dijk, 1993). From 1875, when the species was first described, to 1908 only 5 *H. depressa* were collected, all from Rakhine (formerly known as "Arakan") State, Myanmar (Iverson and McCord, 1997). These presumably originated from the Arakan Yoma Hills, although specific locality data are lacking (Iverson and McCord, 1997). More recently, at least 18 additional *H. depressa* were obtained from turtle markets in Yunnan Province, China (Iverson and McCord, 1997; P.C.H. Pritchard, *in litt.*). Given the extensive trans-border turtle trade in this region (Kuchling, 1995; Platt et al., 2000), these specimens were most likely imported from Myanmar rather than collected locally (Iverson and McCord, 1997; P.C.H. Pritchard, *in litt.*).

Heosemys depressa is classified as Critically Endangered (facing an extremely high risk of extinction in the near future; IUCN, 1994) by the IUCN due to continuing exploitation and limited distribution, and since 2003 also receives Appendix II protection under CITES (IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group, 2000; IUCN, 2002; CITES, 2003). Nothing is known concerning habitat preference, ecology, or population status of *H. depressa*, and consequently, surveys have been accorded high priority (van Dijk, 1993, 1997; Platt et al., 2000). We herein report the results of a recent survey to assess the conservation status and gather ecological data on *H. depressa* in central Rakhine State, Myanmar. Conservation recommendations based on this survey are also provided.

Study Area. — Rakhine State encompasses much of the Arakan Yoma Hill range, one of the most rugged and sparsely inhabited regions in mainland Southeast Asia (Salter, 1983). The Arakan Yoma Hills extend for 500 km along the western coast of Myanmar, and represent a southern extension of the Himalayas (Henderson et al., 1971; Salter, 1983). These hills consist of parallel north-south ridges separated by streams flowing within restricted valleys (Stamp, 1930; Henderson et al., 1971). Maximum elevation ranges from 915 to 1150 m, while valley bottoms 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, 1983). A narrow alluvial belt occurs along the coast (Henderson et al., 1971). Mean annual precipitation ranges from 4500 to 5300 mm with a pronounced wet season extending from early June to late October (Smythies, 1953; Henderson et al., 1971).

The evergreen forests of the Arakan Yoma Hills have been variously described as rainforest (de Terra, 1944), semi-evergreen rainforest (Salter, 1983), tropical semi-evergreen forest (Champion, 1936), and evergreen tropical forest (Stamp, 1924, 1930); even so, their floristic composition remains poorly documented (Salter, 1983). Extensive tracts of bamboo (*Melocanna bambusoides*) occur throughout the region, developing in response to human disturbances such as shifting cultivation, fire, or both (Stamp, 1924, 1930; de Terra, 1944). Small tracts of deciduous forest are restricted to porous soils in the foothills of the coastal

alluvial belt. This habitat is rare on the western side of the Arakan Yoma Hills and dominated by vegetation more characteristic of the central Myanmar Dry Zone (Stamp, 1930; de Terra, 1944). The coastal alluvial belt has largely been permanently converted to flooded rice agriculture (Stamp, 1930). Otherwise the region is sparsely populated by ethnic Chin people who grow upland rice under a system of shifting cultivation known as *taungya* agriculture; hillside vegetation is cleared and burned, and fields are cultivated for several seasons before being fallowed for up to 20 years, after which the cycle begins anew (Salter, 1983; Platt, 2000). Villages are typically small, consisting of 10 to 20 families (Platt, 2000). Few roads penetrate the region and travel by foreigners is generally prohibited by civil and military authorities.

Methods. — Fieldwork was conducted from 21 January to 14 February 2000 in the vicinity of An and Mae Chaungs [= creeks] on the western slope of the Arakan Yoma Hill Range (Fig. 1). We interviewed hunters regarding the occurrence of turtles in the surrounding area, levels of exploitation, hunting methods, and general knowledge of turtles. Available specimens were examined, measured, and photographed. Sex was determined from plastral morphology; males exhibit a pronounced concavity that is lacking in females (Iverson and McCord, 1997). To examine habitat and search for living turtles, we accompanied hunters to specific sites where *H. depressa* were captured recently (< 1 yr). Plants said to be consumed by *H. depressa* were either identified in the field or collected and later identified by botanists at the Yangon University Herbarium. Plant taxonomy follows Hundley (1987). Place names are in accordance with 1927 Survey of India topographical maps, although local names are given for villages not labeled. Coordinates were determined with a Garmin GPS 48. Elevation was calculated from 1927 Survey of India topographical maps. Mean carapace length (CL) is presented as ± 1 SD.

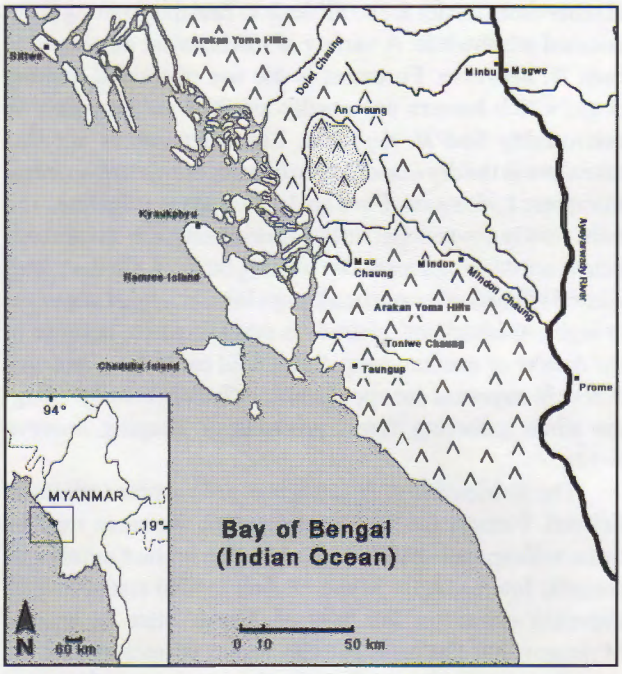

Figure 1. Map of western Myanmar. Shading denotes area visited during field work in January – February 2000. Inset shows this region in relation to the rest of Myanmar.

Results and Discussion. — We examined 16 shells (14 adults and two juveniles) and one living adult *H. depressa* during the expedition. Our sample of shells consisted of 8 carapaces with plastrons, 3 carapaces lacking a plastron, and 5 plastrons only. Specimens were obtained from Mintat (4), Pada Kyaw (1), Hmwa (1), Pyin Won (2), Let Pan (1), Ahngyin Taung (6), and Padan (2) villages (Table 1). Four plastrons from Mintat were reportedly collected approximately 30 km NE in the Arakan Yoma Hills. A carapace and a living turtle obtained from a hunter in Padan 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). According to hunters, the remaining specimens originated near the villages where we obtained them.

The living turtle was a male (CL = 22.0 cm; mass = 1300 g; 18 plastral annuli) captured in bamboo forest on 7 February 2000. The posterior region of the carapace was grossly deformed and appeared to have been crushed and then healed abnormally. Two ticks (*Amblyomma supinoi*) removed from loose skin around the right foreleg constitute the first record of an ectoparasite from *H. depressa* (Robbins and Platt, 2001).

The mean CL of 10 adult *H. depressa* was 224 ± 19 mm (range = 176–242 mm). The CL of 2 juveniles measured 109 and 132 mm. Our sample included 7 males and 7 females; two shells lacking plastrons and the shell of a juvenile could not be sexed. Although the largest specimen that could be sexed was a female, mean CL was greater in males (CL = 226 ± 11 mm; range = 209–236 mm) than females (CL = 195 ± 50 mm; range = 176–242 mm). One hunter stated that a female (CL = 230 mm) captured on 1 February 2000 contained three enlarged, but unshelled follicles.

We pooled our data with measurements of 15 adult *H. depressa* (2 males, 13 females) in the collection of the Chelonian Research Institute (P.C.H. Pritchard, unpubl. data). The mean CL of the pooled sample was 236 ± 18 mm (range = 176–270 mm; $n = 25$). Although the largest specimen was a male, there was no significant difference ($t = 0.34$; $df = 21$; $p > 0.05$) between the mean CL of males (234 ± 18 mm; range = 209–270 mm; $n = 7$) and females (237 ± 19 mm; range = 176–259 mm; $n = 16$) in the pooled sample.

Table 1. Coordinates of villages mentioned in the text and Table 2. Names in accordance with 1927 Survey of India topographical maps. Local name used if village not labeled on map.

Village	Latitude (N)	Longitude (E)
Ahngyin Taung	19°06.06'	93°53.86'
Hmwa	19°29.01'	93°32.65'
Let Pan	19°20.39'	94°09.46'
Mintat	19°31.67'	93°58.24'
Pada Kyaw	19°31.13'	94°01.89'
Padan	19°58.60'	94°32.63'
Pyaung Chaung	19°32.64'	94°06.70'
Pyin Won	19°20.94'	94°07.73'

Table 2. Coordinates, elevation, and habitat description of sites where hunters recently (≤ 1 yr) captured *Heosemys depressa*.

Coordinates	Nearest Village	Elevation (m)	Habitat Description
19°29.131'N; 94°02.293'E	Hmwa	45	Dry slope above intermittent stream; open canopy deciduous forest dominated by *Lagerstroemia villosa* and *Xylia dolabriformis*; sparse understory of shrubs; subject to dry season wildfires.
19°22.013'N; 94°10.008'E	Let Pan	30	Hillside with open evergreen forest dominated by *Dillenia pulcherrima* and *Strychnos nuse-blanda*; sparse understory.
19°32.316'N; 94°03.153'E	Pada Kyaw	50	Second-growth evergreen forest along floodplain of intermittent stream; moderately dense understory.
19°32.650'N; 94°06.700'E	Pyaung Chaung	90	Evergreen forest along permanent stream; dense understory of creepers and fleshy herbaceous plants.
19°33.357'N; 94°07.125'E	Pyaung Chaung	150	Dense bamboo along restricted floodplain of intermittent stream; evergreen forest on adjacent slope; understory vegetation absent beneath bamboo and sparse on slope.
19°22.150'N; 94°08.969'E	Pyin Won	30	Mesic ravine on hillside dominated by evergreen forest; moderately dense understory.
19°20.950'N; 94°07.739'E	Pyin Won	25	Sugarcane field.

Heosemys depressa occurs in evergreen, bamboo, and deciduous forests. We accompanied hunters to seven sites where turtles had recently been captured (Table 2). Capture sites ranged in elevation from 25 to 150 m, and most were located in evergreen or bamboo forest along small permanent and intermittent streams (water absent or confined to deep pools during dry season). However, *H. depressa* is not restricted to riparian habitats, as one turtle was captured in deciduous forest and another in a sugarcane field. Hunters considered the latter unusual, and the turtle most likely wandered into the field from the surrounding forest. Hunters reported finding turtles in shallow streams, among streamside stands of elephant ears (*Homalomena* spp.), beneath leaves and other debris on hillsides, and occasionally in pangolin (*Manis* spp.) burrows. We found nothing to indicate *H. depressa* excavates burrows as suggested by Ernst and Barbour (1989).

According to hunters, the diet of *H. depressa* is composed largely of vegetation and fruit. Hunters have observed turtles consuming several species of mushrooms; fruits of *Artocarpus chalplasha* (Moraceae), *Ficus glomerata* (Moraceae), *Mangifera* spp. (Anacardiaceae), *Woodfordia fruticosa* (Lythraceae), and *Dillenia pulcherrima* (Dilleniaceae); shoots of *Melocanna bambusoides* (Poaceae), *Musa* spp. (Musaceae), and *Wallichia disticha* (Arecaceae); and stems and roots of *Homalomena* spp. (Araceae). According to Iverson and McCord (1997), captives readily consume earthworms and neonatal mice in addition to fruit and vegetation, indicating *H. depressa* may be more omnivorous than suggested by hunter observations.

The number of *H. depressa* taken by individual hunters appears relatively low. Reported captures ranged from 1 to 20 turtles/yr, although most hunters caught less than 10 turtles/yr. One professional hunter reported an exceptionally large harvest of 40/yr. This contrasts markedly with the regional harvest of *Indotestudo elongata*, where the high price paid for plastrons (US$ 1.43 to 2.80 per kg) has resulted in intense exploitation, and individual hunters reported catching up to 300 tortoises/yr (Platt, 2000).

Heosemys depressa meat is consumed locally, and plastrons are purchased by traders, although demand does not seem particularly high. Some hunters reported being unable to sell plastrons, while others received the equivalent of US$ 0.38 to 1.00 per kg. Plastrons are exported and have later been found in Taiwanese medicinal markets (Hsien-chen Chang, *pers. comm.*). Hunters generally discard carapaces. A professional hunter in Padan sells living *H. depressa* to brokers in Mandalay for the equivalent of US$ 4.00 each. Only large adults are purchased, presumably destined for food markets in Yunnan Province, China.

Hunters consider *H. depressa* rare, although whether this reflects actual rarity or cryptic behavior remains unknown. *Heosemys depressa* is known locally as "*leik pyin*" (= lazy turtle) because it is infrequently encountered and assumed to be sleeping or resting. Hunters regard May through July as the optimal time to search for *H. depressa*. In the coastal lowlands *H. depressa* are hunted only during May and June when *Dillenia pulcherrima* fruit is available; at other times turtles are so difficult to find that hunting is not deemed worthwhile. A variety of methods are employed to hunt *H. depressa*. Foremost is the use of trained hunting dogs, which hunters universally asserted are necessary to consistently find *H. depressa*. Limited numbers are also taken late in the dry season when hunters burn bamboo forest to capture *I. elongata*. Fires are ignited along ridgelines and burn slowly downslope; turtles seeking cover in streambeds below are then intercepted by waiting hunters. Hunters from coastal villages often use headlamps to search for *H. depressa* at night, although this practice is rare elsewhere because of the danger of encountering Asian wild cattle (*Bos gaurus*). A few *H. depressa* are opportunistically collected by villagers when gathering forest products or clearing *taungya* fields.

The distribution of *H. depressa* in Myanmar remains ill defined. Iverson (*in litt.*) speculated *H. depressa* may be more widespread than indicated by the limited number of records. Interestingly, Myint Maung (1976) stated that *H. depressa* occurs in the hills of Kayah State in eastern Myanmar, but the basis for this report is unclear and the record remains to be confirmed. *Heosemys grandis* occurs throughout the Thai-Myanmar border region, and *H. depressa* specimens from eastern Myanmar may represent

misidentified *H. grandis* (P.P. van Dijk, *pers. comm.*). However, the chelonian fauna of Myanmar is the least studied in Asia (McCord, 1997; van Dijk, 1997; Platt et al., 2000), and given the cryptic nature of this species, it is possible that heretofore overlooked populations of *H. depressa* exist.

Despite the paucity of records, the current IUCN classification of *H. depressa* as Critically Endangered may be unwarranted. Market demand appears low, harvest levels are minimal, extensive tracts of habitat remain which are under no immediate threat, and the human population density in Rakhine State is among the lowest in mainland Southeast Asia. However, we urge caution as the ability of turtle populations to withstand even moderate levels of increased mortality remains doubtful, and it is questionable whether any harvest can be considered truly sustainable (Brooks et al., 1991; Congdon et al., 1993, 1994; Klemens and Moll, 1995; Thorbjarnarson et al., 2000). Furthermore, the limited distribution of *H. depressa* renders it particularly vulnerable to overexploitation. Populations could rapidly become threatened if harvest levels increase in response to changing market demands, especially as stocks of other Asian chelonians are depleted. Additionally, road construction and large-scale bamboo harvesting associated with a proposed paper mill in Rakhine State would probably negatively impact *H. depressa* populations.

We therefore recommend further surveys, especially within protected areas, to locate additional populations of *H. depressa*. Priority regions include the Chin Hills, southern Arakan Yoma Hills, and hill areas of Kayah State. Additionally, an *ex situ* conservation program should be initiated for *H. depressa* at facilities in Myanmar and elsewhere. Such a program should be established while living specimens are still readily obtainable, and focus on developing appropriate methods of husbandry and propagation as insurance against extinction in the wild. Accordingly, *H. depressa* was recently designated as a priority species for assurance colony establishment by the IUCN Turtle Survival Alliance (K.A. Buhlmann, *in litt.*). Finally, it is imperative for authorities in China and Myanmar to drastically curtail the massive transborder turtle trade, which potentially threatens most species of chelonians in Myanmar, including *H. depressa*, with extirpation (Platt et al., 2000).

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Comparative Ultrastructural Carapace Morphology in Three Freshwater Turtles

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Several researchers have reviewed the topographic features of the outermost layer of reptile scale epidermis (Hutchinson and Larimer, 1960; Maderson, 1965; Monroe and Monroe, 1967; Porter, 1967; Ruibal, 1968; Dowling et al., 1972; Stewart and Daniel, 1972, 1975; Burstein et al., 1974). This outermost layer, termed the Oberhautchen, is approximately 1 µm thick and is composed of distinctive ß-keratin, in comparison to subsequent layers (Stewart and Daniel, 1972). In hard shelled turtles, the shell (carapace and plastron) is composed of dermal bony plates covered with keratinized epidermal scales (Zangerl, 1969). The ultrastructural surface features, denoted as microornamentations, that are derived from such epidermal modifications have recently become useful taxonomic tools, as well as ecological indicators for some species. Although several squamate taxa have been examined, the literature fails to thoroughly examine the microornamentation of chelonians. Zangerl (1969) examined the morphological variation in the epidermal and dermal shields of the carapace, but based comparisons primarily on patterning and organization. Proctor (1958) noted that the growth of epizoophytic algae (*Basicladia* spp., Cladophoraceae) was primarily due to carapace morphology. Although the lamellar surface features of *Graptemys, Chrysemys, Pseudemys,* and *Deirochelys* spp. were distinct in comparison to *Chelydra* and *Kinosternon* spp. (Proctor, 1958), the ultrastructural microornamentation of these taxa was not examined. This study was designed to examine the ultrastructural carapacial microornamentation of three freshwater turtles and to ascertain its potential usefulness as a diagnostic tool for taxonomy and ecological significance within this group of reptiles.

Materials and Methods. — Twenty-five turtles (*Chelydra serpentina* [$n = 10$], *Chrysemys picta* [$n = 10$], and *Emydoidea blandingii* [$n = 5$]) were collected from pond systems located at the Chippewa Nature Center, Midland County, Michigan, during the summers of 1997 and 1998. Using a scalpel, carapace surface samples (ca. 1 cm^2) of the epidermal laminae were extracted from the right fourth costal scute of each turtle (if damaged, an adjacent scute was used). Samples were stored in 2% glutaraldehyde and refrigerated. The samples were later dehydrated by graded four minute ETOH washes of 30, 70, 95, and 100% (3x). Once dehydrated, samples were dried in a critical-point dryer at 1200 psi and mounted on scanning electron microscope (SEM) stubs with double-sided carbon tape. Samples were subsequently sputter-coated with 25 nm of gold and stored in a dessicator until examination.

Prepared samples were viewed using a JSM-840A scanning electron microscope. The exterior layers of the laminae were examined for microornamentation, both in terms of distinct ultrastructure and relative surface area. Electron micrographs of the ultrastructure were quantitatively compared for the relative densities of pronounced features (i.e., ridges and canals) in a randomly chosen 1 μm^2 area. Although canals are a direct product of pronounced ridges, they were scored independently because both represent microornamentation and past studies have shown that canals or fissures can be present without ridges (Stewart and Daniel, 1975). The quantified amount of ultrastructure within this given area, or total ultrastructural value (TUV), was averaged for each species and compared using a Kruskal-Wallis test.

Results. — All turtles examined exhibited some form of carapacial mircroornamentation. Most of these structures were visible as ridges and adjacent canals that were irregular in orientation. *Chelydra serpentina* samples possessed a loose stratification of laminae in the upper layers; beneath this layer the lamellae were tightly compacted and possessed pronounced microornamentation (Fig. 1).

Examination at higher magnification (10000x) revealed that each species possessed distinctive microornamentation