

Figure 1. Movement (solid line) of satellite-tracked Kemp's ridley (*Lepidochelys kempii*) from Cameron, Louisiana to Rancho Nuevo, Mexico from 13 August 1994 to 16 May 1995. Nesting was recorded on 23 April 1995 and 19 May 1995.

Nuevo workers. This is the only time a Kemp's ridley has been remotely tracked to a nesting beach. The satellite transmitter was in its non-transmit mode during the first nesting, and was no longer functional during the second nesting, the last transmission having been recorded just offshore three days earlier on 16 May 1995 (Fig. 1).

A total of 121 eggs were deposited in the first nest; 103 (85%) successfully hatched on 14 June 1995. One hundred twenty-nine eggs were laid in the second nest; 98 (76%) hatchlings emerged from the nest on 5 July 1995.

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Observations on *Manouria impressa* at Phu Luang Wildlife Sanctuary, Northeastern Thailand

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The impressed tortoise, *Manouria impressa*, is one of the world's most beautiful tortoises, and at the same time one of the least known. Many authors (Günther, 1882; Boulenger, 1889, 1903; Smith, 1922, 1931; Bourret, 1941; Bour, 1980;

Obst, 1983; Crumly, 1985) have discussed its morphology and taxonomy, while Groombridge (1982) and Moll (1989) reviewed its conservation status. Only Annandale and Robinson (in Boulenger, 1903) provided some observations on this species in the wild. In recent years, exploitation of the impressed tortoise, along with other southeast Asian tortoise species, appears to be increasing considerably. Continuing deforestation and encroachment bring humans ever closer to previously inaccessible populations, and many tortoises end their lives consumed by rural people or in faraway captivity. In response to the increasing numbers of exported pet specimens, Espenshade and Buskirk (1994) recently reviewed experiences with captive maintenance of *M. impressa*. In this note we add some observations on the species in its natural habitat.

One of the few populations of *Manouria impressa* with a good outlook for survival occurs at Phu Luang Wildlife Sanctuary, covering about 800 sq. km in Loei Province, northeastern Thailand (17°20'N, 101°30'E) (Figs. 1-2). For the past three years, one of us (TC) has been working as director of Phu Luang Wildlife Research Center, located in a clearing in the hill forest inhabited by *M. impressa*; the others (KT and PPvD) visited at various times. A large enclosure (about 100 sq. m) was constructed at the forest edge and decorated with vegetation and pools to provide the major habitat features. A total of nine *M. impressa*, up to six at a time, have been kept here, permitting behavioral observations on the assumption that their behavior is not very different from animals living wild on the other side of the fence. In addition, animals were observed in the forest on about 15 occasions, either by us or by forest rangers, but no precise records were kept.



Figure 1. Location of Phu Luang Wildlife Sanctuary in Thailand.

Phu Luang is a sandstone mountain rising rather steeply from the surrounding areas (at about 400 m altitude) to its main plateau at 1200-1300 m, with a few peaks and ridges reaching over 1500 m. The climate on the mountain is influenced by the monsoon, with a rainy season from June to September, a dry, often cool period from October to February, and a hot season with occasional showers from March to May. Streams on the mountain drain to the Nam San in the north, eventually joining the Mekong, or to the headwaters of the Mae Nam Pa Sak in the west, to the Nam Loei in the central plateau and southwest, and to the Mae Nam Loei in the southeast; the latter three join outside the sanctuary to flow south into the Gulf of Thailand. Temperatures vary considerably between day and night, creating heavy fog and dew in the early morning. During the coldest months (December and January), average air temperature does not exceed 22°C and may drop as low as 9°C; in the hot season (March to May), air temperatures may occasionally rise as high as 40°C. Daylength varies seasonally from 11 to 13 hours. Annual rainfall is about 1150 mm, ranging between 900 and 1400 mm. Figures 3 and 4 show climatic trends during the year at Loei City, about 20 km distant; as Loei is at about 400 m altitude, temperatures at Phu Luang are 1-2°C cooler while humidity and precipitation are somewhat higher. The weather data were collected following meteorological standards; microclimate conditions experienced by tortoises on the forest floor can differ considerably, but unfortunately were measured in detail only occasionally. Compared to standard mid-air measurements, temperature fluctuations are more moderate at the forest floor level, while humidity remains comparatively higher.

The mountain slopes are covered mainly with hill evergreen forest (Fig. 2), a dense three-canopy community of tall, middle, and low trees, low shrubs, some herbaceous plants on the ground, and an abundance of creepers, climbers, bamboos, and epiphytes. Extensive stands of bamboo cling to the very steep southeastern slope. Most of the summit is cloaked in dense hill evergreen forest, with some open grasslands with stands of *Pinus keyisia* pine forest. Other areas of the boulder-strewn plateau bear unique upper mountain scrub forest, consisting mainly of abundant rhododendrons and numerous epiphytic and epilithic orchids, whose blooms make this and its nearby sister mountain Phu Kradung famous throughout Thailand and beyond. Phu Luang is also famed for its early Cretaceous theropod dinosaur footprints, the first to be discovered in southeast Asia (Buffetaut et al., 1985).

Impressed tortoises occur almost exclusively in the evergreen forest on the mountain slopes, where they hide in accumulations of leaf litter and undergrowth (Fig. 2). While the upper leaves of the litter layer dry out during the day, lower layers remain permanently moist. Small streams, sometimes drying out in the dry or hot seasons, yet occasionally torrential in the wet season, occur in every valley and gully, and moist patches remain in depressions in otherwise dry areas. Some of the larger streams contain water throughout the year, and provide a dry season refuge for the fresh-



Figure 2. Top left: adult female *Manouria impressa* (carapace length 283 mm, weight 3.7 kg) in natural evergreen forest habitat, Phu Luang Wildlife Sanctuary, Thailand. Top right: close-up of same female. Bottom left: general topography and hill evergreen forest habitat of *M. impressa* at Phu Luang. Bottom right: forest floor and understory of hill evergreen forest microhabitat of *M. impressa* at Phu Luang. All photos by P.P. van Dijk, March 1994.

water turtles *Platysternon megacephalum* and *Cyclemys dentata*. A few tortoises also occur on flat mountain top areas, but there is insufficient data to speculate whether this is a seasonal occurrence. Some tortoises have also been reported from bamboo forests on the mountain slopes. The natural lower altitude limit is unknown; deforestation of the lowlands, forest fires, and hunting on the lower slopes have left no tortoises below the sanctuary boundary at about 600 m.

The animals kept in the enclosure show that the cold winter months force *M. impressa* at Phu Luang to hibernate. They usually enter hibernation during November and emerge after the first substantial rains, which usually fall in late February (Fig. 4). During this hibernation period, no animals were observed in the wild.

The geographic or ecologic separation between *M. impressa* and *M. emys* remains intriguing. *Manouria emys* ranges from northeastern India through parts of Myanmar, Thailand, and Malaysia to Sumatra and Borneo; *M. impressa* is known to occur in localized areas of Myanmar, Thailand, Laos, and peninsular Malaysia. Both species inhabit similarly structured evergreen forest and are broadly sympatric in the range of mountains stretching from Shan State (eastern Myanmar) south to peninsular Malaysia; at least in the Umphang region of western Thailand (16°N, 99°E) both

species occur in the same hills (Thirakhupt and van Dijk, 1995), which range between 600 and 1000 m, but each species' exact altitude, vegetation, and other microhabitat preferences remain poorly known. *Manouria emys* is absent from the Phu Luang region, yet the robust health of a 23 kg adult female originally from Kanchanaburi, western Thailand, kept outdoors as a pet at Ban Pong Chi (near Phu Luang, at about 600 m altitude) for the last seven years suggests that the absence of *M. emys* is not due to climatic reasons alone.

Incidental observations of feeding by *M. impressa* in the wild, as well as dietary preferences of tortoises kept at Phu Luang Wildlife Research Center, indicate a natural diet composed almost exclusively of several species of forest mushrooms. Tortoises leave distinct large smooth triangular bite-marks on mushroom caps, which were observed in the forest on several occasions. Mushroom species known to be included in the diet are particularly *Pleurotus cornucopiae*, *Amanita vaginata*, *Auricularia auricularis*, and *Termitomyces* spp., and in lesser quantities *Tricholoma crassum*, *Russula foetans*, *Russula* sp., and *Favolus* sp. Animals in the enclosure will eat boiled rice; they were not observed to consume vegetation or fruits. Impressed tortoises do not readily defecate when disturbed and feces have not been found in the wild; thus, no scats could be examined to evaluate these preferences.

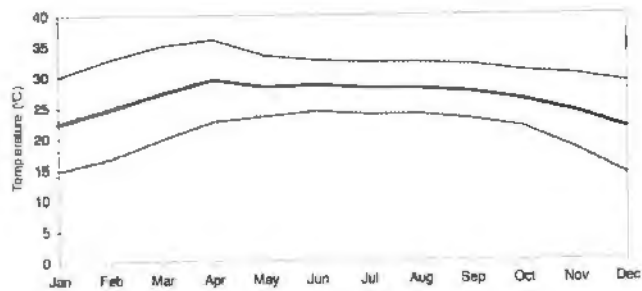


Figure 3. Average mean, maximum, and minimum monthly temperatures at Loei City, Thailand, during the period 1984–93; temperatures in °C.

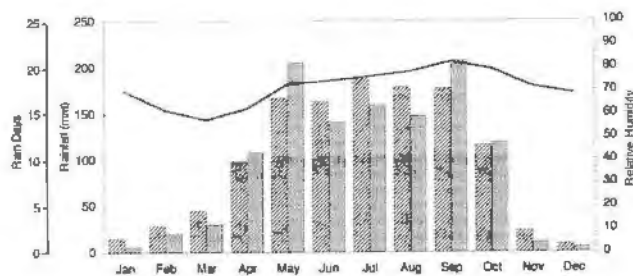


Figure 4. Average monthly number of rain days (striped columns on left, far left scale), average monthly rainfall (dotted columns on right, left scale, in mm), and average monthly relative humidity (line, scale on right, in percent); based on data collected at Loei City, Thailand, during 1984–93.

The largest of nine *M. impressa* we measured was a female of 302 mm straight carapace length (CL) weighing 3.7 kg; two other females were 283 and 175 mm. Five males measured 199–279 mm CL, averaging 232 mm CL. Scute annuli were worn smooth or very closely spaced at the seams in several of the animals; their number has not been conclusively correlated to annual growth, thus, no age classes can be defined beyond subjective assessments of juvenile, small, and large old adults. Some but not all males at Phu Luang develop a relatively darker head, while all females and juveniles have a yellow upper head (Fig. 2). The most reliable character to differentiate the sexes is the relative size of the tail, which is longer and has a heavier base in males. In addition, it appears that in the male the ventral scales of the tail are placed pairwise and make regular contacts in the midline, forming a small groove, but in females the ventral tail scales are staggered and form a zig-zag line of contact. Males also have a proportionally slightly larger anterior projection of the gular scutes, the scales on the lower front legs are offset and pointed, and the male plastron may or may not develop a slight concavity at the level of the abdominal-femoral scutes; these characters need further confirmation from a larger series of specimens to determine whether they are reliably sexually dimorphic or individually variable between individuals. The depth or angle of the anal notch does not appear diagnostic.

Glimpses of courtship and mating behavior were observed among the captive animals from mid-March to September. The male approaches the female from the front and displays his head by moving it up and down while simultaneously opening and closing his mouth. In response, the

female invites copulation by raising her body high, whereupon the male moves to her rear to mount. If the female lowers herself again before the male is in position, the male moves to face the female again and repeats his head display. During copulation, the male assumes the usual tortoise mating posture, stretching his neck and groaning. There appears to be no butting or biting of the female at any stage of courtship, but such aggressive interactions apparently occur between males (P. Youngprapakorn, *pers. comm.*).

A single observation indicates that the female digs only a very shallow nest and finishes nesting by gathering leaves with her hind legs to cover the eggs. No information is available about the duration of incubation in the wild.

A juvenile *M. impressa* from Phu Luang (preserved in the research station collection) has a CL of 102 mm and shows three distinct growth annuli. The retained original areoli on the scutes allow us to calculate its size at hatching as 50.6 mm CL.

In view of the greatly increasing trade in this species for the hobbyist market and especially to the Vietnamese and southern Chinese foodmarkets (Duc and Broad, 1995; Jenkins, 1995; J. Buskirk, A. Lindström, P. Pritchard, *pers. comm.*) and greatly increased local hunting pressures, it is imperative that *M. impressa* be effectively protected. Thailand has already recognized it as one of its priority species, has banned all trade and exploitation, and is enforcing this ban. In Myanmar the species is nominally protected by the general prohibition of commercial trade in wildlife products, but collection for personal consumption is allowed. This, together with the absence of wildlife law enforcement and the unstable political situation in most of the border regions, results in little or no effective protection in Myanmar. Neither Laos nor Vietnam currently protects the species. Specimens of *M. impressa* recently reported from Vietnam, Yunnan, Hainan, and elsewhere in China (Buskirk, 1989; Zhao and Adler, 1993; Espenshade and Buskirk, 1994; Kuchling, 1995) generally become known via foodmarkets and, irrespective whether locally caught or smuggled from nearby Myanmar, Laos, or Vietnam, this does not bode well for natural populations. The general rarity of the species, even in localized areas where it is confirmed to occur, and the extremely slow recovery of disturbed populations argue for urgent upgrading of conservation efforts for this species. Studies of the natural diet, habitat selection, home range and possible seasonal movement patterns, population structure and densities, growth rate, and recruitment are all required. Results of such studies must be incorporated in sanctuary management practices. An assessment of illegal tortoise collection concomitant with legal collection of mushrooms, palm fruits, and other forest produce from Phu Luang Wildlife Sanctuary is essential. Glimpses of the life history of this morphologically primitive tortoise show an animal that has developed complex behavioral patterns to adapt to its rich forest habitat; it is our duty to ensure the perpetual survival of this stunningly beautiful species and its mountain forest habitat.

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