

Observations on the Influence of Seasonality, Lunar Cycles, and Weather Condition on Freshwater Turtle Activity in Sarawak, East Malaysia (Borneo)

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Abstract.- Freshwater turtles were surveyed at two sites in Sarawak: Loagan Bunut National Park and Balai Ringin. Capture results were tested against environmental factors such as lunar phase, weather and seasonality to examine differences in activity level. Proportionally, soft-shelled turtles were most active during the full moon (29.0%) and the last quarter lunar phase (29.4%). Hard-shelled turtles were active during the full moon 50.0% of the time. Both soft-shelled and hard-shelled turtles were more active during overcast periods (53.0% and 66.0%, respectively). Seasonality did not seem to affect soft-shelled turtle activity, while hard-shelled turtles were active 50.0% of the time during the dry South-west Monsoon from June to September.

Keywords.- Testudines, Malaysia, Borneo, capture success, environmental factors.

Introduction

Southeast Asia has a highly diverse freshwater turtle fauna due to a combination of factors, including the presence of major mountain massifs, some of the largest archipelago systems in the world, large tracts of lowland forests, streams and rivers, high precipitation, and tropical climate (Iverson, 1992; Lovich, 1994). Due to their cryptic nature and the presence of intense hunting in the recent past, however, these enigmatic species have been difficult to study. Consequently, there is a paucity of published information regarding the current status and basic ecology of the Southeast Asian fauna, including those populations endemic to Borneo. As part of a larger study on the ecology of *Amyda cartilaginea* (described in Jensen, 2006), the activity of freshwater turtles in Borneo in relation to environmental factors, such as lunar phase, precipitation, and seasonality, were assessed.

Materials and Methods

The primary study area was Loagan Bunut National Park (03°44' – 03°00'N, 114°09' – 114°17'E) in northern Sarawak, which is within a three hour drive to the town of Miri. Field work was concentrated at the Park, but two visits were also made to Balai Ringin (01° 03' 00"N, 110° 45' 00"E), a fishing village about two hours driving distance from Kuching. Both sites are located within peat swamp forests (Fig. 1).

Loagan Bunut National Park contains the only freshwater floodplain lake in Sarawak (Sayer, 1991), encompassing 650 ha² at its maximum diameter. The lake is completely dry during prolonged droughts. Annually, the lake completely dries between three and six times, typically in February, May, and June.

A variety of techniques were attempted to assess the most effective method for capturing *Amyda cartilaginea*. One method employed was the use of hoop traps according to techniques described by Frazer et al. (1990), Legler (1960), and Vogt (1980). Native hoop traps called 'bubu' were ineffective in trapping turtles. Another local fishing device called a 'selambau' caught a single turtle in Balai Ringin.



Figure 1. Locations of Balai Ringin and Loagan Bunut National Park in Sarawak, East Malaysia.

Table 1. Total number of individuals of freshwater turtle species caught during the present study. The asterisk refers to an unsexed carcass. Sites include: 1 = Loagan Bunut National Park; 2 = Balai Ringin; 3 = Matang Wildlife Centre; and 4 = Vicinity of Mulu National Park.

	Site 1	Site 2	Site 3	Site 4	Total
<i>Amyda cartilaginea</i>	14	5	0	1	20
Adult males	6	0	0	1	7
Adult females	6	4	0	0	10
Juveniles	2	1	0	0	3
<i>Cuora amboinensis</i>	3	0	0	0	3
Adult males	0	0	0	0	0
Adult females	0	0	0	0	0
Juveniles	3	0	0	0	3
<i>Cyclemys dentata</i>	6 (1)*	1	0	0	7
Adult males	0	0	0	0	0
Adult females	1	1	0	0	2
Juveniles	4	0	0	0	4
<i>Heosemys spinosa</i>	0	1	3	0	4
Adult males	0	0	1	0	1
Adult females	0	1	1	0	2
Juveniles	0	0	1	0	1

Manual capture, otherwise known as 'muddling' (Cagle, 1943), was an effective, albeit labor-intensive, method of collecting turtles in the surrounding forests and streams, although it was only effective during low water periods. The technique consists of wading through streams and probing areas of sand or mud and among roots with a stick, hands, or feet. Comparisons with other studies were not possible as there are no comparative studies of *Amyda cartilaginea* available.

Hard-shelled turtles were searched for in forested areas by walking 100 m transects (2 m wide) through the forest, looking under leaves, tree roots, and debris. The turtles were most frequently located as they crossed trails or other open areas.

At Loagan Bunut National Park, 51 field days were spent during five sampling trips. Over the course of 33 evenings, two hoop nets and 60 baited hand lines were set, totaling 2,046 trap nights. At Balai Ringin, 16 field days were spent during two sampling trips; in total, 45 baited hand lines were set over 16 evenings, totaling 720 trap nights. There were 2,766 trap nights in total.

With the exception of the Balai Ringin trips, traps were set for a minimum of seven days. The baits used, chosen on the basis of availability, consisted of parts of chicken, pork, or local fishes such as Ikan Kali (*Clarius nieuhofii*), Ikan Toman (*Channa micropeltes*) or Ikan

Haruan (*Channa striatus*). If habitat conditions changed noticeably, the traps were re-located to a nearby site with at least one meter of water depth.

Lunar phase was recorded at the time of capture to test for possible differences in turtle activity level during the different phases of the lunar cycle. Turtles that were captured while physically active, as opposed to resting, were used in the present study. "Active" animals were qualified as those specimens caught with traps or lines because they must have swam or walked to the area of capture. Three *Amyda cartilaginea* were found by muddling and one *Cyclemys dentata* was found buried near the trunk of a tree. These animals were inactive at the time of capture and were not included in subsequent analyses. One *A. cartilaginea* was caught by baited line on a trip near Gunung Mulu National Park, and was included in subsequent analyses, as were any active hard-shelled turtles found in localities other than the study sites.

Lunar phase was divided into four categories; new moon, first quarter, full moon, and last quarter. New moon was defined as when the non-illuminated side is facing the Earth; at this time, the moon is not visible, except during a solar eclipse. First quarter moon was defined as the phase when one half appears to be illuminated by direct sunlight; during this phase, the illuminated fraction of the moon's disk increases. Full moon was the phase when the moon was completely illuminated by direct sunlight. Last quarter moon was defined as the phase when one half of the moon appears to be illuminated by direct sunlight; during this phase, the illuminated fraction of the moon's disk decreases. Moon phases were obtained from the U.S. Navy Astronomical Applications Department website (U.S. Navy, 2003). In the analyses, hard-shelled and soft-shelled species were pooled separately due to their presumed different behavior, capture method, and habitat use.

To determine if weather affected capture success, weather conditions at the time of collection was recorded, being divided into three categories: clear, overcast, and raining. Overcast was defined as times when the sky was completely cloudy and grey, and clear weather was defined as entirely clear to having some white cumulus clouds.

Seasonality was divided into the North-east Monsoon (wet season), the South-west Monsoon (dry season) and non-monsoonal times, which occurred during April, May and October. The North-east Monsoon prevails from November to March and the South-west Monsoon occurs from June to September. The North-east Monsoon brings the majority of precipitation to Sarawak, while the South-west Monsoon season is typically characterized by dry weather.

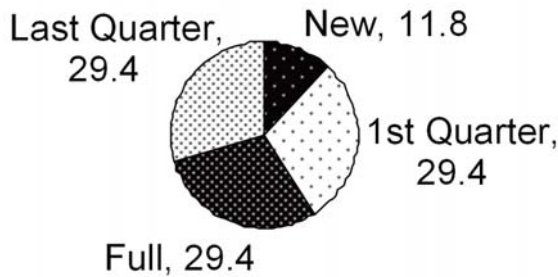


Figure 2. Percentage of *Amyda cartilaginea* collected while physically active during various lunar phases.

Twenty-two days were spent searching for turtles during the North-east Monsoon, 15 days were spent searching during the South-west Monsoon and 30 days were spent searching during non-monsoonal times.

Results

Species richness.- A total of 34 individual turtles from four species were found at the sites examined (Table 1).

Loagan Bunut National Park.- A total of five freshwater turtle species were recorded over a period of 51 field days and 2,046 trap nights. In all, 14 *Amyda cartilaginea* were captured: six males, six females and two juveniles. Six *Cyclemys dentata* were collected: one female, four juveniles and one unsexed carcass. Three juvenile *Cuora amboinensis* were collected.

Of the 14 *Amyda cartilaginea* captured at Loagan Bunut National Park, three individuals were found by muddling, and 11 were caught during the 2,046 trap nights. Of the 11 trapped animals, ten were caught on handlines with Ikan Kali and one was caught on a handline baited with Ikan Haruan. No more than a single turtle was collected per night, representing a 0.54% trap success, with only 11 out of 2,046 trap nights being successful.

Balai Ringin.- Three freshwater turtle species were collected over a period of 16 days and 720 trap nights: one female *Cyclemys dentata*, one female *Heosemys spinosa* and five *Amyda cartilaginea* (four females and one juvenile).

Of the turtles captured at Balai Ringin, three were caught using handlines baited with Ikan Kali, one was found in a selambau and one was caught in a bubu. The trapping success rate was 0.69%.

Additional species.- An adult *Amyda cartilaginea* was caught in the vicinity of Mulu National Park (4° 1' 15" N, 114° 54' 2" E). Three *Heosemys spinosa* (one male,

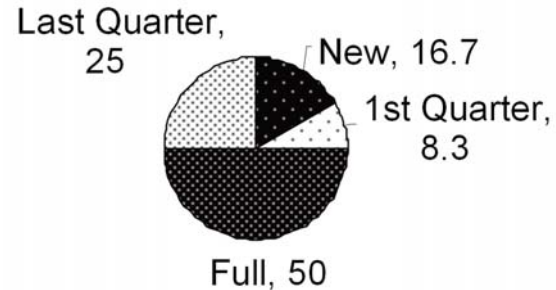


Figure 3. Percentage of hard-shelled turtles collected while physically active during various lunar phases.

one female, and one juvenile) were also found by various Universiti Malaysia Sarawak personnel while performing wildlife surveys at Matang Wildlife Centre (01° 36' 398" N, 110° 11' 33" E).

Effects of lunar phase on capture success.- During the new moon phase, traps and lines were set for 8 days; two adult *Amyda cartilaginea* (one male, one female) were captured. During the first quarter moon phase, traps and lines were set for 18 days; five adult *A. cartilaginea* (one male, four females) were captured.

During the full moon phase, traps and lines were set for 14 days; five *A. cartilaginea* were captured (four females, one juvenile). During the last quarter phase, traps and lines were set for nine days; five *A. cartilaginea* were captured (two males, one female, two juveniles). These data are shown in Figure 2. The active hard-shelled turtle species captured were *Heosemys spinosa* (four individuals), *Cuora amboinensis* (three individuals) and *Cyclemys dentata* (five individuals, one of which was inactive). During the new moon lunar phase, one juvenile *Cuora amboinensis* and one juvenile *Cyclemys dentata* were collected over a period of three days. During the first quarter lunar phase, 10 days were spent searching for turtles with only one female *Heosemys spinosa* (8.3% of the total) captured. During the full moon lunar phase, collections over 11 days produced one female and one juvenile *Heosemys spinosa*, one juvenile *Cuora amboinensis*, and one female and two juvenile *Cyclemys dentata*. During the last quarter lunar phase, collections over five days yielded one male *Heosemys spinosa*, one juvenile *Cuora amboinensis* and one juvenile *Cyclemys dentata* (Fig. 3).

Results for both soft-shelled and hard-shelled turtles indicate that lunar phase may not have an influence on their activity patterns. A larger sample size with at least one radio-tagged species would provide more significant results.

Effects of weather on capture success.- During clear weather, three *Amyda cartilaginea* (one male, two juve-

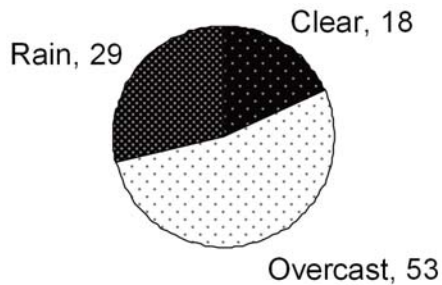


Figure 4. Percentages of *Amyda cartilaginea* collected during different weather conditions.

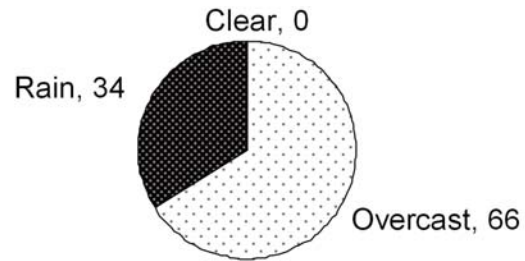


Figure 5. Percentages of hard-shelled turtles collected during different weather conditions.



Figure 6. Percentages of all *Amyda cartilaginea* collected based on seasonality.

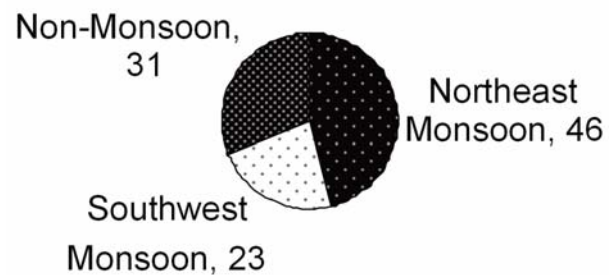


Figure 7. Percentages of all hard-shelled turtles collected based on seasonality.

niles) were collected, nine individuals were captured during overcast weather (three males, six females), and six individuals were captured when it was raining (four females and one juvenile) (Fig. 4).

For hard-shelled turtles, 12 individuals were found on the forest floor or on forest trails when it was clear, while only four were found when it was raining (one female, one male and one juvenile *Heosemys spinosa* and one female *Cyclemys dentata*). When it was overcast, eight turtles were found (one female *Heosemys spinosa*, three juvenile *Cuora amboinensis*, and four juvenile *Cyclemys dentata*) (Fig. 5).

Effects of seasonality on capture success.— *Amyda cartilaginea* capture success was examined between seasons. As might be expected, the water levels of both the lake and its tributaries at Loagan Bunut National Park and the riparian habitats in Balai Ringin were lower in the dry season. Consequently, three of the 20 individuals captured were found buried in the mud. During the wet season, six female *Amyda cartilaginea* were captured, while in the dry season, only seven soft-shelled turtles (three males, two females, and two juveniles) were captured. During the non-monsoon seasons, seven soft-shelled turtles (four males, two females, one juvenile) were captured, representing 41% of the total (Fig. 6).

Thirteen hard-shelled turtles were collected. One female *Cyclemys dentata* was found buried under the hollowed trunk of a tree, and although inactive at the

time of capture, was included in this component of the analysis since we were looking at the overall effects of capture and seasonality. Six of these turtles were collected during the wet season (one female *Heosemys spinosa*, two juvenile *Cuora amboinensis*, and three juvenile *Cyclemys dentata*). Three of the turtles were found during the dry season (one juvenile *Heosemys spinosa*, one juvenile *Cuora amboinensis*, and one juvenile *Cyclemys dentata*). Four turtles were captured during non-monsoon times (one male and one female *Heosemys spinosa*, and two female *Cyclemys dentata*) (Fig. 7).

All four turtles found buried in mud or hidden in a tree hollow were collected in the dry season. During the North-east Monsoon, these localities would have been covered by at least two meters of water.

Discussion

Capture rates for both *Amyda cartilaginea* and hard-shelled turtles were low, (0.54% and 0.69%, respectively), indicating that the populations of these species may be at critically low levels, although this is difficult to substantiate considering the paucity of historical data for southeast Asia.

Turtle capture rates were tested against three environmental factors: lunar phase, weather, and season. In the lunar phase analysis, it appeared that a new moon may have some influence on the movements of *Amyda cartilaginea*. At a capture rate of 11.8% (compared to

29.4% for all other phases), the darkness of the sky may have an effect on the foraging capabilities of this species. Other predatory species have also been noted as having increased foraging activity with increased moonlight (Brigham and Barclay, 1992). A capture rate of 50.0% during the full moon phase indicated that hard-shelled turtles may need lunar illumination for foraging activity.

The effects of lunar phase on changes in animal behavior are well known. Tigar and Osborne (1999) hypothesized that fewer predaceous arthropods were active during full moons than new moons, possibly because of the increased risk of vertebrate predation. Álvarez-Castañeda et al. (2004) concluded that fewer rodent remains were present in barn owl (*Tyto alba*) pellets during full moons, indicating that rodent activity may be decreased during this phase, which is supported by other studies that have found rodent activity to be linked to lunar phase. O'Farrell (1974) found that the most important factors affecting rodent activity was the amount of time between sunset and sunrise, as well as lunar phase. Price et al. (1984) reported that bright moonlight reduces the overall activity of nocturnal rodents. Church (1960a), concluded that ovulation of the common Asian toad (*Duttaphrynus melanostictus*) was correlated with the lunar cycle in Java. Church (1960b) also found this to be the case with the crab-eating or mangrove frog (*Fejervarya cancrivora*) in Java.

In the present study, 53.0% *Amyda cartilaginea* collections occurred during overcast weather, 29.0% occurred during rain events, and 18% occurred when the skies were clear. A total of 66.0% of hard-shelled turtles captured during overcast conditions, 34.0% were captured during rainy conditions and none were captured during clear weather, indicating that turtles may favor overcast weather for moving and foraging. Seasons did not have a dramatic affect on the capture rate of turtles, however, more information is necessary to make this determination with any confidence. Clearly, a large amount of effort is required to examine the behavior of turtles, as well as other animals, especially when conducted across multiple seasons, lunar phases, weather conditions, or even years. This paper thus presents preliminary information on the influences of environmental factors on turtle behavior in Borneo.

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