Vidyodaya J. of Sci, (2006) Vol. 13, pp 127-138

Activity budgets and habitat preference of land monitor, Thalagoya *Varanus bengalensis* in a residential area

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Received on : 06/01/07
Accepted on : 07/19/07

Abstract:

A study on habitat use and activity budget of the land monitor *Varanus bengalensis* was conducted from August 2004 to February 2005 inside the university premises of Sri Jayewardenepura, Nugegoda, Colombo, Sri Lanka. Activity index of the land monitors was significantly high for the time period of 0900 to 1200 hrs (2.22±0.51). Activity patterns varied during the day but remained constant among months. Time spent on basking was highest between 0900 to 1200 hrs and foraging was highest between 1200 to 1500 hrs ($P<0.05$, $x^2=187.332$). Stones were used significantly more than the other habitat types for basking while wet grounds and dumping sites were used for foraging activities. There was a significant correlation between the individual count and the ambient temperature ($P>0.05$, $Z=2.645$). Walkers, sweepers, dogs and cats did not disturb the land monitors but vehicles disturbed them. Findings of the present study suggest that the best time for locating the land monitors are from 0900 to 1200 hrs and that providing suitable basking and foraging sites and making certain areas off limits to vehicles will be helpful in increasing the land monitor populations in urban areas.

Key Words : Activity budget, habitat preferences, land monitor

1. Introduction

Sri Lanka has two of the 36 varanid lizards identified worldwide (Rathnayaka 2000). The presence of these two species of varanids in Sri Lanka was known as far back as the 17th century (Heydt 1744). Sri Lanka is also well known for its appreciable population of Land monitor *V. bengalensis* (Gaulke & De Silva 1977). Land monitor is considered a delicacy among the locals. Archeologists have found large number of land monitor bones at the site of Gedige excavation (800BC-300AD) in Anuradhapura, suggesting that the land monitors were widely consumed

(Chandrarathna 1997). Gypsies traditionally hunt land monitors both for consumption and for sale. There are also several interesting beliefs, which cause immense hardships to these monitors. Among them is the belief that if a tongue of a land monitor is eaten, a child will get a super memory (De Silva 1996), if a person eats the flesh of a land monitor he will never suffer from wheeze and that it is a good remedy for convalescence (Deraniyagala 1927). Although the Land monitor is known to occur in a wide area (Dryden & Wicramanayaka 1991) and even up to 1500 m (Auffenberg 1994) the demand for its flesh and the rapid urbanization has deprived the land monitor its former range and habitat. At present there are indications that the varanid population is decreasing even though the skin trade is banned and the varanids are protected by law (Gaulk & De Silva 1997). Today it is rarely seen in urbanized areas except in large parks and in areas like universities where hunting of land monitors is not possible. Although several important studies have been carried out on the two varanid species of Sri Lanka (Deraniyagla 1927), (Mertens 1942), (Dryden & Wikramanayake 1991), (Wikramanayake & Green 1989), (Gaulke 1997), (Silva 1994), there is a paucity of data on microhabitat utilization by *V. bengalensis.* Therefore, the objective of this study was to identify the micro-habitat utilization and to assess the tolerance level of the land monitor to disturbances in order to make predictions about what effective conservation measures can be taken to protect and increase their numbers in urban areas.

2. Methodology

Study site

The study was conducted in the university premises of Sri Jayewardenepura in Colombo, Sri Lanka from August 2004 to February 2005. Study area is relatively small (111,178 m^2 and is isolated from the surrounding community by a six foot high wall. Soils vary from loose sand to hard terrain and gravel. It has an infrastructure of tarred roads together with large open grassy areas. It also has several damp garbage dumping sites and several termite mounds which provide burrows to the Land Monitors. More than 50% of the study area is covered by buildings. Vegetation of the study site consists of a community of at least 20 plant species dominated by deciduous trees, *Casuarinas sp. Mangifera sp.*, and *Delenia retusa.* The annual rainfall is about 204 mm and the mean temperature is about 30°C. The study area has a human population of about 10,000 students, staff members and minor staff and is prone to be extremely disturbed while the university is functioning. However, during the vacations it provided an ideal sanctuary to the land monitors and numerous other wild animals.

Survey of land monitors

The day was divided into four time periods as 0600-0900, 0900-1200, 1200-1500 and 1500 -1800 hr. All individuals studied were marked with different color patterns. Also their distinct skin marks and patterns were used to identify the individuals and to avoid double counts. Standard paths crossing the whole study site

was determined and they were traversed thrice in each time period for three days and the count was taken in each hour. Activity index was determined to find out the most active time of the monitors by the method of Bhatt (1991) using the equation AI=S/n (AI=Activity Index, S=Total number of monitors sighted on a standard path in a particular time class, n=Number of runs on a standard path for that particular time class). After determining the highest Activity Index, time period from 0900 to 1200 hrs was selected to record the population. The standard paths were traversed for 26 days (once a week) for the whole study period and the individuals observed were recorded using the Visual Encounter Survey Technique (Heyer et al. 1994). Ambient temperature was recorded at the time of encountering the monitors using a mercury thermometer.

Activity Budgets

The activity of *V. bengalensis* was recorded using the scan sampling (Altman, 1974). Each individual land monitor was observed for a period of 15 minutes every week using the 15~60x25 spotting scope in the time periods of 0900-1200 hr and 1200-1500 hrs. This time period was selected after observing that these are the most active time periods of the land monitors. Activity was divided into four categories as basking (seeking heat in open area or lying with limbs outstretched on relatively warmer substrates), foraging (actively searching for food or feeding), resting (avoiding heat in shaded areas or lying with limbs outstretched in cooler substrates) and non-foraging (walking, agonistic behavior, avoiding predators and disturbances) (Pandav & Choudhury 1996). Time spent on each activity was recorded together with the microhabitat they used for each behavior. A lizard's immediate physical environment in which it was observed was considered the microhabitat. Four successive observations from the same month were combined to yield a single observation. These data was used to calculate the activity budgets of the land monitors for each month.

Food availability & identification

Foraging sites were located by observing the land monitors closely using the 15-60x25 spotting scope. After locating the foraging sites, soil samples were taken to a depth of six inches using a 2'x 2' quadrate. Four samples were taken per feeding site. Food items were separated using a sieve set. The collected food items were preserved in 70% alcohol in the field. They were sorted, counted and identified against a white background without magnification at the laboratory (Maher 1984). Stomach flush of a single land monitor was taken and undigested food items were identified using a dissecting microscope.

Disturbances

Any event causing the land monitors to modify their activity was identified as a disturbance. Number of walkers, sweepers, vehicles, cyclists, dogs, cats, hawks, and mongoose were identified as likely to disturb the monitors. There numbers were recorded during the period in which the monitors were observed.

3 Results

Mean activity index of land monitors were significantly high for the time period of 0900-1200 hrs compared to other time periods (AI=2.22±0.51, ANOVA, F= 5.65, $p<0.05$, df=3). Lowest activity indexes was observed for the time period of 0600-0900 hrs and the highest activity index was observed for the time period of 0900-1200hrs. Mean activity index among the three days was not significantly different (ANOVA, F= 1.637, fp=0.2475, df=2) (Table 1).

Table 1. Activity index (AI=S/n) of the *V.bengalensis* in different time periods inside the university premises of Sri Jayewardenepura. ANOVA was used to determine the difference of activities between time periods. Post-hoc test (Fisher's PLSD) was used to see where the differences originated.

Day	Time Period				
	0600-0900	0900-1200	1200-1500	1500-1800	MeaniSD
Day 1	1.00	2.67	1.67	1.67	1.75±0.69[C]
Day 2	0.00	1.67	0.67	1.00	0.84±0.69[C]
Day 3	0.67	2.33	1.00	0.67	1.17±0.79[C]
Mean±SD	0.56±0.51*[A]	2.22±0.51[B]	1.11±0.51[A]	1.11±0.61[A]	

*Time periods sharing the same letter are not different (P>0.05).

Mean time spent on different activities by the land monitors differed significantly (Kruskal-Wallis, H=21.215, p0.000l). Basking (Mean±SD, 49.5±10.65) and foraging (Mean±SD, 42.68±15.7) was the major activities of the land monitors from August 2004 through February 2005 (Table 2).

Table 2. Percentage time spent on different activities by *V.bengalensis* in the university premises of Sri Jayewardenepuara from August 2004 to February 2005. Kruskal - Wallis test was used to determine the difference of activities between months. Manr - Whithey u test was used to see where the differences originated.

Month	Behaviour			Non-Foraging
	Basking	Foraging	Resting	
August	51.48	31.48	0	17.04
September	62.50	25.00	12.5	0
October	52.78	41.67	0	5.55
November	28.57	71.43	0	0
December	48.57	48.09	0.95	2.38
January	46.30	50.00	0	3.70
February	56.44	31.11	0	12.44
Mean±SD	49.5±10.65*[A]	42.68±15.7[A]	1.922±4.68[B]	5.87±6.5[B]

Seventy-five land monitors were observed for a period of 1062 minutes in the time period of 0900-1200 hrs and 62 land monitors were observed for 813 minutes in the time period of 1200-1500 hrs. Land monitors spend most of their time basking in the time period of 0900-1200 hrs and foraging in the time period of 1200-1500 hrs throughout the study period. Time spent on basking was significantly low in the afternoons while the time spent on foraging was significantly low in the morning ($x^2 = 187.33$, $P<0.05$) (Table 3). There was a significant relationship with the mean individual count of the land monitors and the mean ambient temperature (Spearman rank correlation, $Z= 2.645$, $p<0.05$) (Table 4). Four microhabitats, namely stones, dry ground, wet ground, dump sites and grass were identified as important to these lizards. Kruskal-Wallis test revealed that there was a significant difference among the microhabitats used for foraging ($H=24.999$, $P<0.0001$) and basking ($H=24.182$, $P<0.0001$). Resting ($H=1.333$, $p = 0.8557$) and non-foraging ($H=2.852$, $p = 0.583$) did not show such a difference. Stones were used significantly more than the other micro habitats by the land monitors for basking while grass was the least preferred micro habitat for basking. When stone cover was not present land monitors preferred basking in the dry ground. Wet ground and the dump sties were never used for basking. Dump sites and wet grounds were used significantly more than the other habitats by the land monitors for foraging (Mann-Whitney U test) (Table 5).

Table 3. Percentage time spent on different activities by *V.bengalensis* within periods of day from August 2004 to February 2005.

	Behaviour			
Time period	Basking	Foraging	Resting	Non Foraging
0900-1200(1062), n=75	94.4	0.62	0.17	4.17
1200-1500(813), n=62	0	88.60	3.22	8.17

n = No of individuals observed. Number of minutes observed is given within brackets

Table 4 . Monthly variation of the mean individual count of *V. bengalensis* in relation to the temperature in the university premises of Sri Jayewardenepura

Month	Mean Count	Mean Temp °C
August	3.25±0.96 (n=4)	30.0 (n=4)
September	3.25±0.50 (n=4)	30.0(n=4)
October	2.00±1.41(n=5)	29.4±0.89 (n=5)
November	1.25±0.45(n=4)	28.9±0.25 (n=4)
December	1.75±1.25(n=4)	29.0±0.45 (n=4)
January	4.25±0.54 (n=5)	30.0±0.70 (n=5)
February	3.25±0.50 (n=4)	30.25±0.5 (n=4)

Table 5 . Mean time percentages spent in different habitats by *V. bengalensis* in the university premises of Sri Jayewardenepura from August 2004 to February 2005. Kruskal-Wallis test was used to determine the difference of time spent in different habitats. Mann-Whitney U test was used to see where the differences originated.

			Basking		
Month	Stone	Dry ground	Wet ground	Dump, site	Grass
August	68.64	31.36	0.00	0.00	0.00
September	69.23	23.08	0.00	0.00	7.69
October	89.29	10.71	0.00	0.00	0.00
November	100.00	0.00	0.00	0.00	0.00
December	78.43	21.57	0.00	0.00	0.00
January	72.97	24.32	0.00	0.00	2.703
February	60.22	31.49	0.00	0.00	8.287
Mean±SD	76.97±13.6*[A]	20.36±11.38[B]	0.00[C]	0.00[C]	2.669±3.77[C]
			Foraging		
Month	Stone	Dry ground	Wet ground	Dump, site	Grass
August	0.00	0.00	45.95	54.05	0.00
September	0.00	0.00	50.00	33.33	16.67
October	0.00	0.00	52.63	47.37	0.00
November	0.00	0.00	57.14	42.86	0.00
December	0.00	0.00	16.90	•61.97	21.13
January	0.00	0.00	41.67	58.33	0.00
February	0.00	0.00	26.09	73.91	0.00
Mean±SD	0.00*[A]	0.00[A]	41.48±14.74[B]	53.12±13.35[B]	5.399±9.31[A]
			Resting		
Month	Stone	Dry ground	Wet ground	Dump, site	Grass
August	0.00	0.00	0.00	0.00	0.00
September	0.00	0.00	0.00	0.00	100
October	0.00	0.00	0.00	0.00	0.00
November	0.00	0.00	0.00	0.00	0.00
December	0.00	0.00	0.00	0.00	100
January	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	0.00
Mean±SD	0.00	0.00	0.00	0.00	28.57±48.
			Non- foraging		
Month	Stone	Dry ground	Wet ground	Dump, site	Grass
August	37.25	13.73	49.02	0.00	0.00
September	0.00	0.00	100	0.00	0.00
October	100	0.00	0.00	0.00	0.00
November	0.00	0.00	0.00	0.00	0.00
December	0.00	0.00	80.00	20.00	0.00
January	0.00	0.00	0.00	0.00	100
February	7.89	55.27	23.68	0.00	13.16
MeaniSD	24.19±39.85[A]	11.5±22.13[A]	42.12±41.76[A]	3.33±8.16[A]	18.86±40.1[A]

* Means sharing the same letter are not different (P>0.05)

Walkers, sweepers, vehicles, dogs and cats were identified as possible disturbances to the land monitors. However, only the vehicles caused the land monitors to alter their behavior (Table 6). Food availability differed among months. Annelids and

white ants were the most abundant food items recorded in the foraging habitats of the land monitors (Tabel 7).

Table 6. Type and frequency (number per minute) of possible disturbances to *V.bengalensis* recorded at the university premise of Sri Jayewardenepura, from August 2004 to February 2005. Mean actual disturbances are given inside brackets.

Month	Walkers	Sweepers	Cyclists	Vehicles	Cause of disturbance Dogs		Cats	Hawks	Mongoose	Other
August	0.28	0.03	0.00	0.06	(0.04)	0.05	0.00	0.00	0.00	0.00
September	0.33	0.03	0.00	0.05	(0.01)	0.07	0.00	0.00	0.00	0.00
October	0.32	0.03	0.00	0.03		0.05	(0.01) 0.00	0.00	0.00	0.00
November	0.38	0.01	0.00	0.03		0.07	0.00	0.00	0.00	0.00
December	0.33	0.01	0.00	0.06	(0.02)	0.05	0.00	0.00	0.00	0.00
January	0.37	0.01	0.00	0.04		0.03	0.00	0.00	0.00	0.00
February	0.43	0.01	0.00	0.02	(0.01)	0.08	0.01	0.00	0.00	0.00
Mean±SD	0.35±0.05	0.016±0.009	0.00	0.04±0.01		0.058±0.017	0.001±0.002	0.00	0.00	0.00

Table 7. Benthic and surface invertebrate taxa recorded at the feeding sites of *V-bengalensis* from August 2004 to February 2005.

Taxon	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mean
Sieved Soil samples (No/1000cm3)								
Arthropoda								
Blattoidea								
Periplanata	0.00	1.25	2	1	1.75	0.75	1.75	1.21±0.69
Isoptera		1.25	2	1	1.75	0.75	1.75	1.21±0.69
Termite	3.25	3.25	4	2.25	2.75	3.25	0.00	2.68±1.29
Hymanoptera								
Ants	12	9	10.5	12.25	9.5	11.75	9.5	10.64±1.35
Annalida								
Pheratima	5.75	3.25	2.35	6.25	5.75	8.25	4	5.25±1.87
Mollusca								
Phylla	1.75	1.25	2.25	2.75	2.25	1.75	4	2.28±0.89

4. Discussion

V. bengalensis is a poikilothermic and their body temperature adopts the temperature of their surroundings. It is known that during the night their body temperatures drop below ambient and that in the following day, they have to raise it

by basking before commencing foraging and other activities. When their body temperature increases excessively, they move to shade. Thus thermoregulation strongly influences the behavior and the choice of habitats of *V. bengalensis.* As activity indices. indicate they were most likely to be detected between 0900-1200 a.m. when they spent most of their time basking to increase their body temperature. During the evenings they are more active and engage in foraging and other activities. Emergence from borrows normally began 2 - 3 hrs after sunrise tending to be earlier in some months. They are least active during 0600-0900 hrs period because their body temperature has to reach the ambient temperature before commencing their activities. Therefore, active lizards were seen in low numbers in the early mornings (0600-0900 hrs). Thus the present study shows that the time period between 0900-1200 hrs is the best time for detecting these animals when they can be observed basking in suitable habitats to increase their body temperatures. Similar findings were made by Ibrahim (2000) in which he observed that *V. griseus* of North Sinai, Egypt is most active between 0900 to 1000 hrs and were lowest between 0700 to 0800 hrs and by Pandav & Choudhury 1996 who observed that there is a significant variation in activity levels within a 12-hour time class.

Pandav & Choudhury 1996 observed that there was a seasonal difference in activity patterns for *Varanus salvator*. However, no seasonal difference in activity patterns for *Varanus bengalensis* could be observed in the present study. This can be interpreted as response to the environmental conditions. It is known that the activity is more dependent on the occurrence of operative environmental temperature in time and space (Grant & Dunham, 1988). No drastic variation in temperature was observed in the study area during the study period and the mean temperature varied between 28.9 to 30.25 °C. This may explain the lack of seasonal variation in the activity pattern of the *V.bengalensis* in the present study compared to other varanid species (eg. *V.gouldii,* King 1980; *V. komodoensis,* Auffenberg, 1981). Several studies have shown that in a relatively less variable climate, a uniform pattern is expected unless it is controlled by other factors such as availability of food and activity of prey species (Porter et al., 1973; Huey & Slatkin, 1976). It was observed that basking was the major activity of the *V.bengalensis* from August 2004 through February 2005 except in November. In November 2005 data was collected during three rainy days. Only a few land monitors could be observed during the mornings in rainy days. In two days of the month of November no land monitors observed in their usual basking sites due to heavy rain. Comparatively higher numbers could be observed in the afternoons when the temperature had risen. Those that were observed in the afternoon was mostly foraging while the few land monitors observed in the mornings in November were basking. Therefore, the observed differences in their behavior in November 2004 compared to other months was due

to the rain which prevented land monitors from coming out of their borrows to bask in the mornings and was not due to a change in their behaviour. Further, during the heavy rains of November annelids came out of their borrows to avoid getting drowned. Hence, the availability of the annelids was high during the month of November. Also the flying white ants came out of the termite mounds. This also biased the land monitors to be observed spending more time on foraging activities during the month of November. Slight variations of the time spent on foraging activities among the months could be due the differences in the availability of food items in the environment. Availability of hymenopterans, mollusks and the annelids were low during the month of September. Hence, they may have spent less time searching for these food items during these months and could have spent more time on hunting larger prey such as frogs. However, only a single land monitor was observed feeding on a frog during the study period.

Present study also revealed that there is a significant variance of the behaviors in the mornings and afternoons. The land monitors did not spend any time at all basking during the time period of 1200 to 1500 hrs. Most of their time was spent on foraging related activities and the rest was spent on resting or non-foraging activities including avoiding disturbances, agonistic behavior and walking. Since their body temperature is already high by this time the need to increase their body temperature by basking did not arise. They spent very little time on foraging related activities during the time period of 0900 - 1200 hrs. Since temperatures are low during this time period, heat seeking behaviour or basking was more pronounced. Once their body temperatures had risen there was no need to bask in the evenings. Hence, to observe their different behaviors it is important that the animal be observed during different time periods of the day and not among different months. This significant difference, observed in the activity of monitors between the morning and afternoon hours, could be attributed to their poikilothremic activities as observed by Wikramanayake & Green (1989). Present study also revealed that the mean individual count increased significantly with the increasing ambient temperature ($P<0.05$). This also could be attributed to their poikilothermic behavior. Population counts of these monitors can be made only when they are out of burrows and are easily observable. However, in the afternoon they tend to forage more and hence are less likely to be observed. Therefore, this study revealed that the best time to make a count of these monitors were when they are out of their borrows and when basking.

Higher number of *V. bengalensis* was seen in microhabitats such as stones and dry ground. Heat absorbed by the stones during the day remains through out the night and into the morning (Dryden & Wikramanayaka 1991). Dry ground heat up more rapidly than other substrates. By basking in such microhabitats when the ambient temperature is low, the monitors absorb heat both from the substrate and from solar radiation as observed by Pandav & Choudhury (1996). The fact that the lizards were

not observed basking in the wet grounds and damp dump sites further confirms our findings that the stones and the dry grounds are the preferred habitat of the land monitors for basking. It was apparent that the stones and the dry grounds did not contain their prey. Hence, they were not observed foraging in these habitats. Most foraging in *V.bengalensis* took place in wet ground and dumpsites. The difference of the time spent foraging in wet ground and the dump sites among different months could have been due to the difference in the availability of their prey items in these habitats. Although adult land monitors have few natural enemies, hawks, cats, mongooses and even stray dogs are known to feed on the juveniles. Therefore, the land monitors could have preferred the grassy areas for resting where they were less visible to the predators. Wikramanayake & Dry den (1993) observed that inactive animals seek refuges, which are cooler than ambient air temperatures or remain inactive in microhabitats that afford some cover.

Land monitors were disturbed only by vehicles. Approaching vehicles made the land monitors to seek shelter in order to avoid getting crushed. It is not uncommon to observe land monitors run over by the vehicles inside the study area. Therefore, the land monitors could have sensed that the vehicles meant danger. Most of the observed land monitors were adults. They may have got acclimatized to the other forms of disturbances found inside the university premises including the walkers, sweepers, dogs and cats. Observed behaviour of the land monitors could also be due to the fact that since they not hunted inside the university premises they had no reason to be wary of the humans. However the young and the juveniles could still be disturbed by the possible disturbances observed.

Land monitors are known to feed on a verity of prey such as lizards, insects, invertebrates etc (Schmidt & Marx 1957, Atkan 1971, Stanner & Mendelssohn 1987, Tsellarius et al. 1991). During this study monitors were also observed feeding on amphibians. Dumping sites provide the monitors with a rich food supply. The university dumping sites provided shady damp areas which were suitable for their prey including insects and invertebrates. Hence, when the temperatures increased these sites were used heavily by the monitors for foraging activities. Findings of this study suggest that that providing suitable basking and foraging sites and making certain areas off limits to vehicles would be helpful in increasing the land monitor populations in urban areas.

5. Acknowledgments

We are grateful to Mr. Anslem De Silva for his critical advice encouragement and guidance. We are grateful to Mr. Nimal Rathnayaka for his assistance in gathering the relevant literature.

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