Influence of Temperature on Burrow Use by the Monitor Lizard *Varanus panoptes* of the Coastal Dunes at Fog Bay, Northern Australia

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Abstract.- An increase in the number of *Varanus panoptes* burrows appearing among the sand dunes at Fog Bay in northern Australia was noticed during the dry season (June to August). Entrances of marked burrows were smoothed, and their interiors investigated using a burrowscope, to determine the monthly number of foraging and retreat burrows appearing over a 12 month period. In the dry season, increased numbers of both types of burrows were found. A temperature data logger was used to record temperatures of the sand surface, and at a depth of 50 cm. Burrow depths were measured as how far the burrowscope could be lowered into each burrow. There was a positive correlation between the number of retreat burrows and burrow depths. There was a negative correlation between the number and depth of retreat burrows and the minimum sand-surface temperature and the maximum sand temperature at 50 cm. The number of foraging burrows was independent of sand temperatures. The results indicate a likely thermoregulatory use of retreat burrows with more and deeper burrows prevalent when overnight surface and subterranean sand temperatures decrease.

Key words.- Reptilia, Varanidae, *Varanus panoptes*, Australia, Northern Territory, fossorial, thermoregulation

Introduction

Burrows serve many ecologically important purposes to many animals (Hansell, 1993). Lizards expend less energy throughout the day if a large portion of time is spent in burrows (Bennett and Nagy, 1977). Monitor lizards (*Varanus* spp.) utilise burrows for a variety of purposes such as thermoregulation (Cowles and Bogert, 1944), reducing water loss (Green, 1972), finding prey (Pianka, 1969), and for oviposition and retreat (Cowles and Bogert, 1944; Auffenberg, 1983).

In a recent study of the monitor lizard *Varanus panoptes* (Fig. 1) inhabiting the coastal dunes at Fog Bay, Northern Territory, Australia (12°42'S; 130°20'E), I detected a seasonal change in the number of burrows present. A greater number of burrows appeared among the dunes in June-August (dry season) compared to the rest of the year. These burrows also seemed quite deep compared to those seen in the wet season.

Figure 1. *Varanus panoptes* in the coastal dunes at Fog Bay, Northern Australia.

Use of these burrows for oviposition is unlikely since *Varanus panoptes* produces eggs during the wet season. Free access to other water sources might rule out conservation of water loss. Overnight temperatures in the area often drop below 15°C in the dry season. A likely explanation may be that the monitors retreat into burrows at a depth where sand temperatures remain high to conserve overnight body temperature, as has been found for some other monitors (Cowles and Bogert, 1944; Auffenberg, 1983). The monitors at Fog Bay inhabit the dunes and forage on the beach and dunes (Blamires, 1999). Increased foraging activities may be another explanation for the number of burrows seen in the dry season. The aim of this investigation was to determine whether changes in the number of burrows between the wet and dry seasons is a result of foraging, thermoregulation, retreat or a combination of these, or other, influences.

Material and Methods

The area of the investigation is approximately 5 km of beach along the northern-most mainland beach at Fog Bay (12°42'S, 130°20'E), approximately 80 km from Darwin, Northern Territory, Australia. The area is privately owned and closed to the public. The sandy dunes are immediately backed by grassland dominated by spinifex vegetation and dispersed *Pandanus* trees. Black soil plains, mangroves and salt flats back the grassland. The dunes of the southern-most 1 km stretch of beach are backed by monsoon forest. The entire 5 km of beach, and the grassland and monsoon forest backing the dunes, was walked twice monthly over a 12 month period.

All burrows encountered were marked with a depth of surveyor's tape tied to nearby vegetation (Fig. 2). To estimate visitation rates the entrances were smoothed and checked, on revisiting, for varanid tracks leading into it.

A small video-camera device, called a "burrow-scope" (Dyer and Hill, 1991; Dyer and Aldworth, 1998) was used to investigate the inside of burrows. The model I used was a modified version of that of Dyer and Aldworth, (1998). A small black and white CCD, 38mm x 38mm, camera (Samsung MOD-BW 204), now popular for home security systems (Capel, 1993) encased in a 375 ml jar was used. Infrared lighting was used to illuminate the burrow for the camera, provided by 10 high intensity light emitting diodes fitted on a piece of Vero board. A small black and white video monitor (260 mm; 5.8 kg) was used for viewing, operated directly from a 12V battery. The wiring from the camera to the monitor was approximately 2 m long and encased in a garden hose. The depth of each burrow was determined by measuring the depth of hose that fed into the burrow to reach its end.

Burrows were assumed to be for foraging when were noted to intersect the burrow of a potential prey item (crab, skink or bird). The number of foraging burrows was totalled each month. Occupied burrows, and those with tracks appearing from the entrance after smoothing, not identified as foraging burrows, were classified as retreat burrows. The number of retreat burrows observed was totalled monthly.

A temperature data logger (model 6003A, Unidata Australia, Perth) was placed on top of one of the dunes with two probes extruding from the logger's case. One of the probes was placed 1 cm below the sand surface, while the other was buried at 50 cm

Figure 2. Burrow of *Varanus panoptes*.

below the surface. A digital temperature reading was taken by the logger every 30 minutes. The data were downloaded and compiled at the end of every month.

Correlation analysis was done between the number of foraging and retreat burrows counted each month and the mean burrow depth. Correlation analysis was also done between the number of foraging burrows, retreat burrows and burrow depths and monthly maximum and minimum sand temperature at the surface and at 50 cm depth.

Results

Overall 93 burrows were identified as either retreat or foraging burrows. Fifty-one were identified as foraging burrows and 42 as retreat burrows, three of the retreat burrows were identified as such because they were occupied by a monitor lizard. The numbers of retreat and foraging burrows observed each month are shown in Figure 3. There was a peak in the number of retreat burrows in July with a steep drop in August and September. The number of foraging burrows observed peaked in April, although the number stays high until July when the number drops. The number of retreat burrows exceeded the number of foraging burrows between May and September.

There was a positive correlation between the number of retreat burrows and the burrow depths recorded each month ($r = 0.67$; $P = 0.017$; Table 1).

Table 1. Correlation coefficients between the number of retreat and foraging burrows and burrow depths.

* denotes a significant correlation

	r	P
Retreat Burrows	0.67	0.017*
Foraging Burrows	0.097	0.763

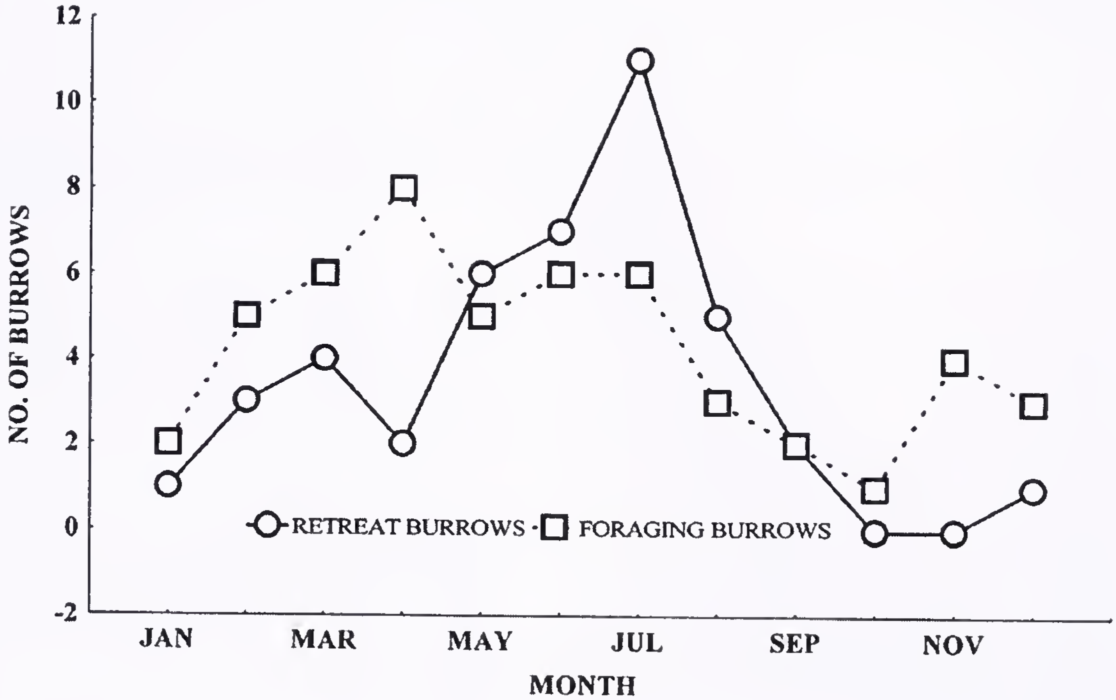

Figure 3. Monthly number of foraging and retreat burrows of *V. panoptes* at Fog Bay.

However, the number of foraging burrows is not correlated to burrow depths (Table 1). The number of retreat burrows are negatively correlated with the minimum sand-surface temperatures ($r = 0.463$; $P = 0.024$) and the maximum sand temperature at 50 cm ($r = -0.616$; $P = 0.033$; Table 2). Burrow depths were also negatively correlated to the minimum sand surface temperature ($r = -0.789$; $P = 0.002$) and the maximum sand temperature at 50 cm ($r = -0.64$; $P = 0.033$; Table 2). The number of foraging burrows was unaffected by sand surface temperature and sand temperature at 50 cm (Table 2). This equates to more and deeper retreat burrows being dug, the cooler the sand temperature at the surface and at 50 cm.

Discussion

The field experiments herein were the first attempt with this modified design of burrow viewing equipment and an assessment of its effectiveness is warranted to justify the results. The only problem encountered was when the original silicon glue (a metal sealant), used to hold the camera to the jar casing, was suspected of having a corrosive effect on the camera. The camera stopped working within a short time and, when inspected, small white spots were seen on the solder of the circuit board. The camera worked properly when the spots were cleaned off and a non-corrosive sealant (glass/window sealant) was used. From then on, the system provided clear images, with effective viewing of monitor lizard presence in burrows and the depth, width and curvature of all burrows. The narrower, rounder burrows of other animals were easily identifiable at the bottom of foraging burrows.

The number of foraging burrows was independent of depth or temperature influences. However, the greater the number of retreat burrows dug, the greater their depth. The number and depth of retreat burrows was also negatively correlated to minimum sand-surface temperature each month. This is indicative of an increased need for the lizards to burrow to an increasing depth as the overnight temperatures cooled.

Cooler sand temperatures at 50 cm also caused an increase in the number and depth of retreat burrows. Since thermal diffusion in sand is slow, sand temperature at 50 cm heats and cools slowly (Packard and Packard, 1988). The sand temperature at 50 cm at Fog Bay was the highest overnight when the sand surface is lowest (Guinea, 1994). Thus, monitors may be burrowing more in the dry season to exploit the warmer overnight internal sand temperatures. Maximum internal sand temperatures fall during the dry season and the monitors therefore dig further to find even warmer temperatures. Foraging burrows were also responsible for increasing the number of burrows seen in the dry

Table 2. Correlation coefficients between the number of retreat and foraging burrows and burrow depth and sand surface (T_{S0}) minimum and maximum temperatures and sand at 50 cm depth (T_{S50}) minimum and maximum temperatures. * denotes a significant correlation.

	Retreat burrows		Foraging burrows		Burrow depth	
	r	P	r	P	r	P
Min. T_{S0}	-0.643	0.024*	0.18	0.576	-0.789	0.002*
Max. T_{S0}	0.316	0.317	0.227	0.478	0.722	0.008*
Min. T_{S50}	-0.296	0.351	-0.145	0.653	-0.086	0.79
Max. T_{S50}	-0.616	0.033*	0.026	0.937	-0.646	0.033*

season, but their depths were constant, and independent of temperature.

Of other possible reasons for an increase in monitor lizard burrowing in the dry season, egg ovipositing is unlikely, as no eggs were ever observed within burrows and *V. panoptes*. Burrow use to conserve water loss has been proven important for some arid zone monitor lizards (Green, 1972, Vernet et al., 1988). This has not been demonstrated for tropical monitor lizards, although there is a considerable difference in humidity and rainfall between the wet and dry seasons in Australia's wet-dry tropical region (Bureau of Meteorology, 1989). Water loss in lizards increases with decreasing ambient humidity (Hillman and Gorman 1977) and without physiological adaptations to prevent water loss, burrowing to moist sand may be utilised to prevent desiccation by *V. panoptes* when ambient humidity decreases. More needs to be investigated on the water economies, and uses of other water sources, in this monitor to determine if water loss is influential in increasing burrowing during the dry season at Fog Bay.

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Literature Cited

Auffenberg, W. 1983. The burrows of *Varanus bengalensis*: characteristics and use. Records of the Zoological Survey of India. 80:375-385.

Bennett, A. F. and K. A. Nagy. 1977. Energy expenditure in free ranging lizards. Ecology 58:697-700.

Blamires, S. J. 1999. Quantifying predation on sea turtle nests by varanids at Fog Bay. MSc Thesis. Northern Territory University.

Bureau of Meteorology. 1989. Climate of Australia. Morphett Press, Canberra.

Capel, V. 1993. Security Systems and Intruder Alarms. Newnes, Oxford. 267 pp.

Cowles, R. B., and Bogert, C. M. 1944. A preliminary study of the thermal requirements of desert reptiles. Bulletin of the American Natural History Museum 83:261-296.

Dyer, P. K., and G.J.E. Hill. 1991. A solution to the problem of determining the occupancy status of wedge-tailed shearwater *Puffinus pacificus* burrows. Emu 91:20-25.

Dyer, P. K., and K. Aldworth.. 1998. The "burrowscope": modifications to burrow viewing equipment. Emu 98:143-146.

Green, B. 1972. Water loss of the sand monitor lizard (*Varanus gouldii*) in its natural environment. Ecology 53:452-457.

Guinea, M. L. 1994. A possible model to explain winter nesting by the flatback turtle, *Natator depressus* at Fog Bay, Northern Territory. Pp.154-155. In R. James (ed.), Australian Marine Turtle Conservation Workshop. Queensland Department of Environment and

Heritage, Australian Nature Conservation Agency, Gold Coast.

Hansell, M. H. 1993. The ecological impact of animal nests and burrows. Functional Ecology 7:5-12.

Hillman, S. S., and G. C. Gorman. 1977. Water loss, desiccation tolerance and survival under desiccating conditions in two species of Carribean *Anolis*. Oecologia 29:105-116.

Packard, G. C., and M. J. Packard. 1988. The physiological ecology of reptilian eggs and embryos. Pp. 523-605. In C. Gans and R. B. Huey (eds.), Biology of the Reptilia, Vol. 16. Alan Liss, New York.

Pianka, E. R. 1969. Habitat specificity, speciation and species density in Australian desert lizards. Ecology 50:498-502.

Vernet, R., M. Lemire, and C. Grenot 1988. Field studies on activity and water balance of a desert monitor *Varanus griseus* (Reptilia: Varanidae). Journal of Arid Environments. 15:81-90.