Daily basking patterns of the fresh-water turtle

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Basking activity in the turtle *Pelomedusa subrufa* L. apparently is initiated by the presence of a suitable heat source, whereas subsequent basking is largely determined by prevailing environmental temperatures as well as requirements for avoiding overheating.
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Die begin van sonbadaktiwiteite in die skilpad *Pelomedusa subrufa* L. word veroorsaak deur die teenwoordigheid van 'n geskikte hittebron, terwyl voortgesette sonbaai in 'n groot mate bepaal word deur heersende omgewingstemperature sowel as vereistes vir die bekamping van oorverhitting.
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Temperature dependent daily activity patterns occur in some terrestrial chelonians (Auffenberg & Weaver 1969; McGinnis & Voigt 1971; Voigt & Johnson 1976). These activities enable the animals to regulate their body temperatures fairly precisely, at a species specific level. Similar activity patterns have also been found in semi-aquatic chelonians (Boyer 1965). In these species activity patterns may be more complex in that they involve the animals' emergence from a relatively stable thermal environment, into one that is characterized by short-term temperature fluctuations. The thermal requirements of many semi-aquatic chelonians appear to be similar to those for terrestrial species (Mackay 1964; McGinnis & Voigt 1971; Gordon 1972; Voigt & Johnson 1976), but relatively few studies have been made of the environmental parameters influencing regulation of body temperature (Boyer 1965) and the attendant basking activity of semi-aquatic chelonians (Moll & Legler 1971).

This paper reports on activity patterns during voluntary basking by the freshwater turtle, *Pelomedusa subrufa*, under various conditions of artificial heat irradiation and natural insolation.

Materials and Methods

For experimental purposes in the laboratory, a total of three turtles were introduced individually into an asbestos tank (1,8 × 1,0 × 1,0 m) filled to a depth of 23 cm with freshwater. A single asbestos platform (25 × 25 × 25 cm) was situated at one end of the tank, allowing turtles to emerge completely from the water should they wish to bask.

A heat lamp (Philips Infraphil 240 V, 150 W; Type F/3379/F49) was positioned at varying heights above the platform (Table 1) illuminating it for 12 hours daily (06h00–18h00). A Victory (35 A1 8 (1A3)) thermistor, accurate to 0,1 °C, set in a steel, matte-black bulb (o.d. = 5 cm) and connected to a pre-calibrated wheatstone bridge monitor was used in determining black-bulk temperature at the centre of the platform. The temperature was monitored continuously for 1 d of heat/lamp illumination with animals absent and for each experimental lamp height. Black-bulb temperature stabilized at a maximum level (Tabel 1) within 10 minutes of the heat lamp being switched on.

A movie camera (Minolta Super 8, Model No. D16B), set for single-frame time lapse operation, was focused on the platform and triggered remotely (every three minutes), in synchrony with an electronic flash unit. A permanent photographic record of activity was obtained throughout the day and night.

Turtles were introduced in turn into the tank. Each individual was subjected to two trials of seven days with the heat lamp set 50 cm above the basking platform. One individual underwent two additional seven day trials for each of five different lamp heights (Table 1).

A record of emergence by basking turtles was obtained from the photographs. Separate emergences were grouped for successive two hour periods thoughout each day of lamp illumination, and summed to give a ranked value for the number of emergences at a given time of day by each individual. Ranked values were summed for all three turtles subjected to a 50 cm lamp height and plotted as a mean value for the six seven day trials against time of day, giving a basking profile for the entire experimental period.

The records obtained for the individual tested at various lamp heights were treated differently. Total basking time was calculated from the photographs and expressed as a percentage of the total period of heat lamp illumination for each lamp height.

A series of 'control' experiments were carried out for each individual. The turtles were placed in the tank as described, and behaviour photographed for one week. A standard desk-top lamp was substituted for the heat lamp and mounted high enough to illuminate but not significantly heat the platform during 06h00-18h00 daily.

Maximum body temperatures of basking turtles were recorded using thermosensitive radio transmitters (Mini-Mitter Co., Indianapolis, U.S.A. — Model V) implanted into the abdominal cavity. Transmitter implantation and body temperature recording techniques are described in Miller (1977). Body temperatures were also recorded in two freshly killed turtles placed individually in the centre of the basking platform for one day at each lamp height.

An asbestos tank of the same dimensions as that used in the laboratory was placed outdoors in natural sunlight. Information on the emergence of turtles was collected in the same manner as described for the laboratory based trials.

Basking profiles were determined for the experimental turtles, each subjected to a single seven day trial. The platform was photographed at three minute intervals during 06h00-18h00. Black-bulb temperatures were recorded in full sunlight on an asbestos sheet close to the platform. Maximum black-bulb temperature never exceeded 45,5 °C, which was very close to the maximum (46 °C) measured under the heat lamp 50 cm above the platform in the laboratory (Table 1).

Knowing the actual area of the outdoor platform, and the magnification factor of the camera, it was possible to calculate percentage platform area under direct insolation at any one time from the photographic record. Basking emergence data and percentage platform exposure to direct sunlight were plotted relative to time of day.

One-day visits were made in each week during a year to the Fitzsimons Snake Park, Durban, where basking behaviour of a group of 25 turtles was recorded at 30 minute intervals during 09h15-16h15. The percentage frequency of basking turtles was determined with respect to the total number of individuals at each observation. The area exposed to direct insolation was assessed by eye and sketched onto a scale drawing of the snake park display. Percentage display area in direct sunlight was then calculated and recorded for each observation. Black-bulb temperatures, in full sunlight, were also recorded.

Five turtles were taken from the snake park and the same day exposed individually to the laboratory heat/light regime. Each individual underwent a seven day trial period with the heat lamp set at 50 cm. The body temperature during basking of turtles in the snake park and of snake park turtles in the laboratory were measured using a mercury thermometer accurate to 0,2 °C. The thermometer was inserted into the turtle's cloaca, and care was taken to ensure that depth of insertion was similar relative to the overall size of each individual.

Table 1 Maximum body temperature of basking *Pelomedusa* turtles in relation to various conditions of artificial heat illumination and to natural sunlight in different localities outdoors

Place of experiment	Height (cm) heat lamp above basking platform	Maximum black-bulb temperature (°C) during experiment	Maximum (°C) body temperature	
			Live animals	Dead animals
	Artificial heat illumination			
Laboratory	30	54	37	54
	35	50	36,5	50
	45	48	37	48
	50	46	37	46
	70	35,5	35,5	35,5
Animals from Snake Park in laboratory	50	37	46	46
	Illuminated by natural sunlight			
Outdoor tank	—	45,5	37	45,5
Snake Park	—	47	37	—

Results

In the laboratory, turtles exhibited a bimodal pattern of basking activity (Fig. 1). Peaks of emergence occurred during 08h00-10h00 and 16h00-18h00. However turtles in

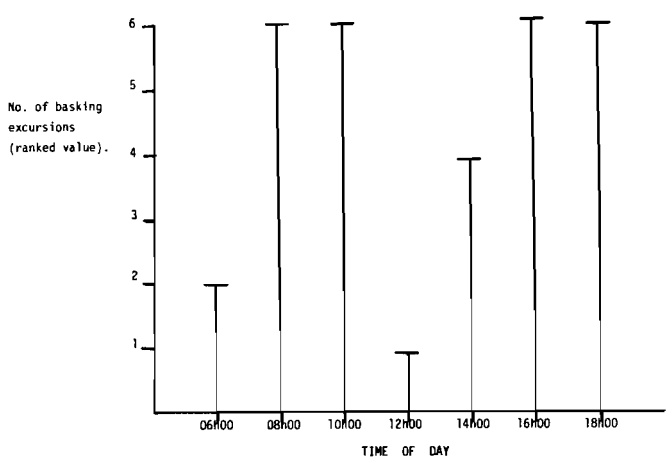

Fig. 1 Rank-ordered pattern of basking activity of *Pelomedusa* turtles kept under a constant regime of heat and light in the laboratory.

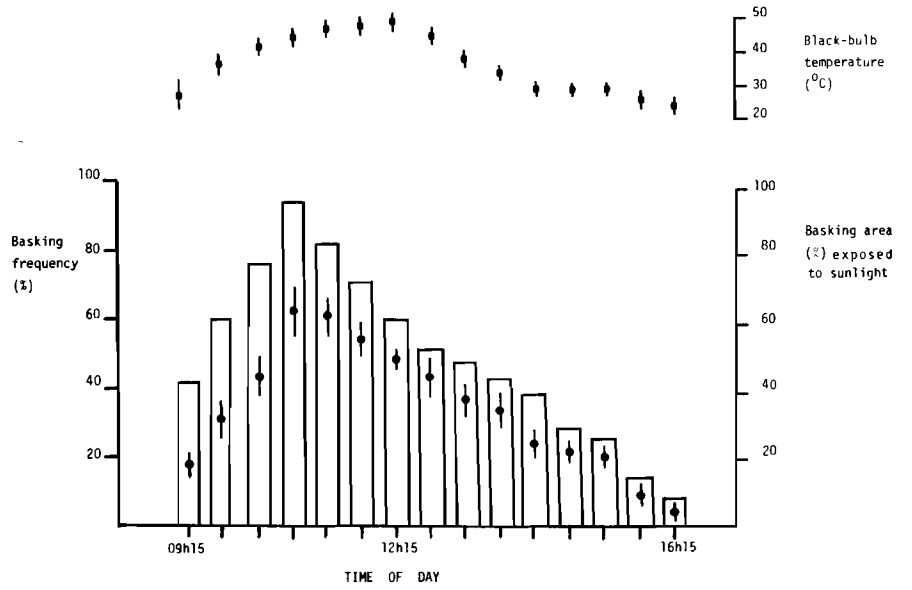

Fig. 2 Annual mean percentage basking frequency of a group of 25 *Pelomedusa* turtles in the snake park with respect to annual mean percentage basking area exposed to sunlight, annual mean black-bulb temperature and time of day.
(♦—annual mean percentage basking frequency, ± one standard deviation; □ — annual mean percentage basking area exposed to insolation; ♦ — annual mean black-bulb temperature, ± one standard deviation).

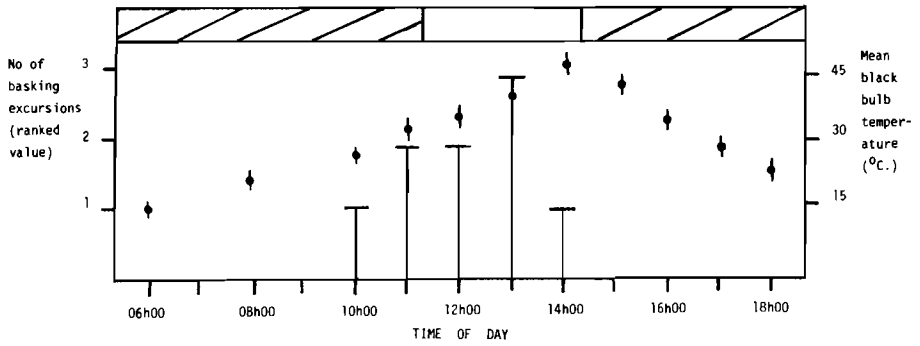

Fig. 3 Rank-ordered pattern of basking activity of *Pelomedusa* turtles removed from constant regime of heat and light in the laboratory and subjected to natural sunlight in an outdoor tank.
(T — basking excursion, ranked value; □ — basking platform exposed to sunlight; ▨ — basking platform fully shaded; ♦ — mean black-bulb temperature for duration of experimental period; ± one standard deviation).

the snake park exhibited a unimodal activity pattern with peak basking activity during 10h45-11h45 (Fig. 2). This peak in basking activity coincided with the time of maximum display area exposed to direct sunlight (10h45) and preceded time of maximum black-bulb temperature (12h45).

Individuals previously conditioned to the laboratory environment altered their activity to a unimodal pattern when placed outdoors (Fig. 3). Peak basking activity coincided with maximum insolation (13h00). Turtles taken to the laboratory from the snake park, where they exhibited a unimodal activity pattern (Fig. 2), adopted a bimodal pattern (Fig. 4) with peak activity occurring during 08h00-10h00 and 16h00-18h00. Furthermore peak morning activity (08h00-10h00) by individuals in the laboratory preceded that of the same individuals in natural sunlight at the snake park (10h45-11h45) by some 45 minutes.

Body temperature of basking turtles did not exceed 37 °C (Table 1) in the laboratory, in the outdoor tank or in the snake park. On the other hand, maximum black-bulb temperatures and body temperatures of dead turtles were consistently higher in the laboratory (Table 1). Similarly, black-bulb temperatures were higher in the snake park and in the outdoor tank. However, when the heat lamp was located 70 cm above the platform in the laboratory, maximum body temperature of basking turtles and black-bulb temperature were the same (Table 1).

The time spent basking by laboratory turtles decreased proportionately with increased heat load (Fig. 5), as represented by a lowering of the heat lamp. No basking activity was observed with the heat lamp absent.

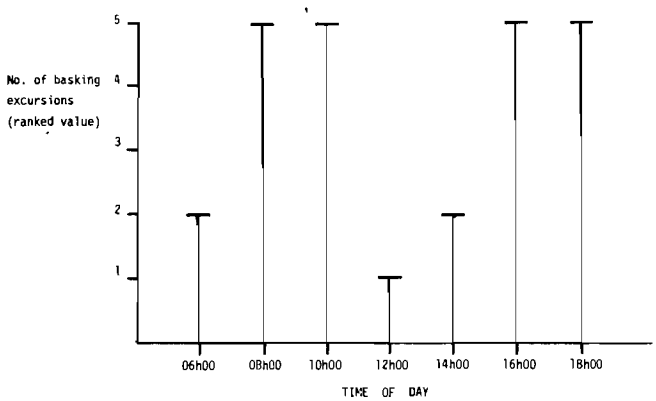

Fig. 4 Rank-ordered pattern of basking activity of *Pelomedusa* turtles removed from sunlight in the snake park and placed in conditions of constant heat/light illumination in the laboratory.

Discussion

The bimodal basking activity pattern shown by turtles under continuous heat illumination in the laboratory may represent an endogenous rhythm in *P. subrufa*. If this is true, similar activity patterns might be expected under different heat/light conditions. However, the unimodal patterns demonstrated (Figs. 2-4) suggest that this may not necessarily be so and that basking in *P. subrufa* is in fact a flexible activity.

Activity patterns of snake park turtles and of turtles outdoors indicate that peak basking was coincident with maximum exposure of suitable basking areas to sunlight (Fig. 2). This is upheld by the observation that although a single basking activity peak was apparent in both cases, these peaks occurred at different times, which coincided with maximum insolation of basking areas. Observations outdoors on cloudy days and in the laboratory on heat lamp absence showed that turtles would not bask without a suitable heat source present.

From the results it is also apparent that during basking maximum body temperature of turtles in the laboratory never rose above 37 °C even when black-bulb temperatures exceeded the preferred limits for the species (31-37 °C) (C.W. Sapsford, pers. comm. and unpublished data). However temperatures in dead turtles equilibrated with black-bulb temperatures at all heat levels. Only at a maximum black-bulb temperature (35,5 °C, lamp height 70 cm) well within the preferred limits was this observed for live turtles. In addition it could be seen that as environmental heat loads increased (i.e. lamp height dropped) basking activity in laboratory turtles decreased (Fig. 5).

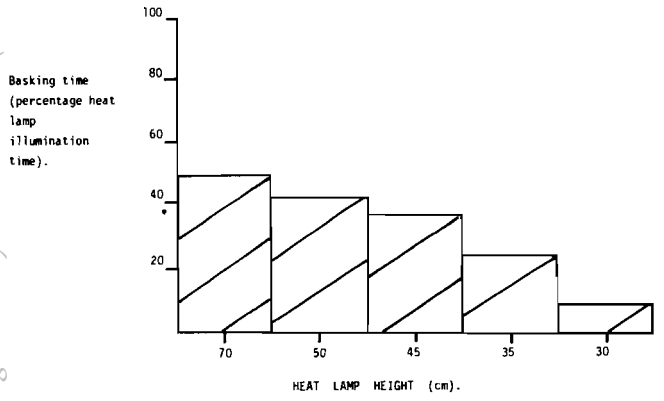

Fig. 5 Changes in basking time of *Pelomedusa* turtles exposed to varying heat loads, represented by different heights of a heat lamp above a basking platform, in the laboratory.

These observations would suggest that once basking activity had been initiated, length of exposure was determined by environmental heat levels.

Therefore the bimodal activity pattern displayed by turtles in the laboratory may also represent a response for avoiding build up of a potentially lethal heat load during basking. Individuals returned to water to avoid overheating and since a suitable heat source was continuously available, emerged for a second time once body temperature had dropped sufficiently to reinitiate basking.

Similar patterns of activity have been demonstrated for the desert tortoises, *Gopherus berlandieri* and *G. agassizii* (Auffenberg & Weaver 1969). It is suggested that maximum activity in these species occurs in the early morning and late afternoon when heat loads resulting from exposure would be minimal (McGinnis & Voigt 1971; Voigt & Johnson 1976).

In contrast, in both the outdoor tank and the snake park exposure to direct sunlight apparently initiated the single basking peak. Presumably basking activity would be reduced as heat loads became critical for each individual, but insolation, a suitable heat source for basking, was absent to reinitiate basking in the afternoon when body temperatures had dropped. It would be of interest to determine the basking activities of turtles exposed to sunlight for greater periods during the day. Predictably such exposure would result in a bimodal activity pattern similar to that seen in the laboratory and analogous to that reported for desert species.

Moll and Legler (1971) suggested that one of the primary functions of basking in ectothermic reptiles is to raise body temperature to a species specific preferenda. Logically, both a suitable heat source and tolerable ambient temperature levels would be important in determining basking activity. In conclusion, it seems probable that in *Pelomedusa subrufa* this is initiated by the presence of a suitable source and that subsequent basking activity is largely determined by prevailing environmental temperatures and a requirement for avoiding overheating.

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References

AUFFENBERG, W. & WEAVER, A.K. 1969. *Gopherus berlandieri* in Southern Texas. *Bull. Fla. State Mus. Biol. Sci.* 13: 1-203.

BOYER, D.R. 1965. Ecology of the basking habit in turtles. *Ecology, Durham* 46: 99-118.

GORDON, M.S. 1972. Animal Physiology (Principles and Adaptions). McMillan, New York.

MACKAY, R.S. 1964. Galapagos tortoise and marine iguana, deep body temperature by radio telemetry. *Nature Lond.* 204: 355-358.

MCGINNIS, S.M. & VOIGT, W.G. 1971. Thermoregulation in the desert tortoise *Gopherus agasizii*. *Comp. Biochem. Physiol.* 40A: 119-126.

MILLER, D.G.M. 1977. A preliminary investigation of behavioural thermoregulation in the Cape terrapin, *Pelomedusa subrufa* (Linnaeus). Unpublished M.Sc. Thesis, University of Natal.

MOLL, E.O. & LEGLER, J.M. 1971. The life history of the slider turtle *Pseudemys scripta* (Schoepff) in Panama. *Bull. Los Angeles Mus. Nat. Hist. Science* No. 11: 69-70.

VOIGT, W.G. & JOHNSON, C.R. 1976. Aestivation and thermoregulation in the Texas tortoise *Gopherus berlandieri*. *Comp. Biochem. Physiol.* 53A: 41-44.