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HERPETOLOGICAL NOTES

TEMPERATURE PREFERENCE AND TOLERANCE IN THE GECKO, *COLEONYX VARIEGATUS*.—As data accumulate for temperature regulation in lizards it becomes apparent that mean body temperatures in the field and in a laboratory gradient may differ significantly. This is true for both diurnal (De Witt, 1967; Licht, 1968, McGinnis, 1966) and nocturnal (Bustard, 1967) species. Since preferred temperatures are often used in the evaluation of other reptilian functions such as hearing sensitivity (Campbell, 1969), thermal tolerance (Kour and Hutchison, 1970) and spermatogenesis (Licht, 1965), more studies directed towards documentation of temperature parameters seem appropriate. I have tried to determine more precisely the preferred body temperature (PBT) and temperature tolerance (critical thermal maximum and minimum, CTMax and CTMin, respectively) of *Coleonyx variegatus.*

Males and females were used in all experimental conditions in approximately equal numbers. They were housed in a large terrarium with rocks and sand which was fitted with an outdoor heating tape providing 12 hours of crudely controlled substrate heating per day. The heat was not uniformly distributed so temperature selection between approximately 26 and 33 C was available in the home cage. They were on a 12L–12D photoperiod. Mealworms, crickets and water were provided.

A circular "race track" gradient with substrate heating was built to determine the PBT. The width of the runway was 18 cm and the circumference was 2.2 m. Plexiglas sides 24 cm high contained the lizards in the gradient. A thermostatically controlled nichrome wire grid embedded in plaster was the heat source. The temperature extremes were separated by a 5 cm asbestos plug and the entire substrate was covered with sand. The minimum temperature of the gradient was dependent upon the room air temperature and was either 20 C or 22–24 C. The maximum temperature was always 45 C. The gradient was randomly rotated in relation to incident light and there was no corner effect. Lizards were introduced into the gradient at the cold end at least 4 hours and sometimes overnight before any temperatures were taken. Exploratory movements were usually initiated almost immediately and resulted in exposure to the complete range of temperatures in the first few minutes. All readings were taken between 0800 and 1700 in the light. Substrate temperatures of 45 C were not tolerated but the lizards crossed that segment of the runway several times in their initial investigations. Locomotor activity declined rapidly with time in the gradient and the lizards were usually quiescent before testing began. Six consecutive body temperature readings were obtained from each animal at half hour intervals with a Schultheis thermometer. Lizards were always replaced in the cold end of the gradient. Temperature preference of six individuals was measured under three conditions: single animals at 20 C air temperature

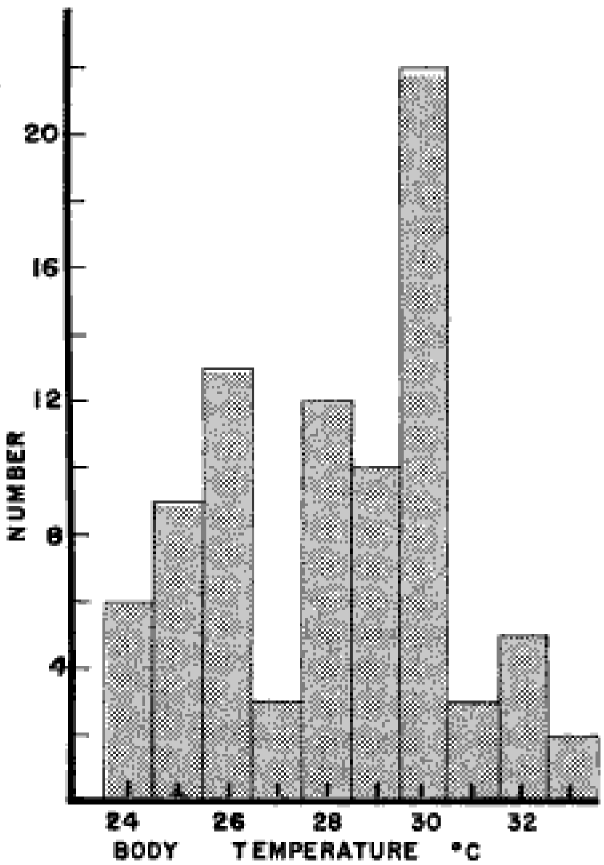

Fig. 1. Frequency distribution of body temperatures of *Coleonyx variegatus* in a thermal gradient.

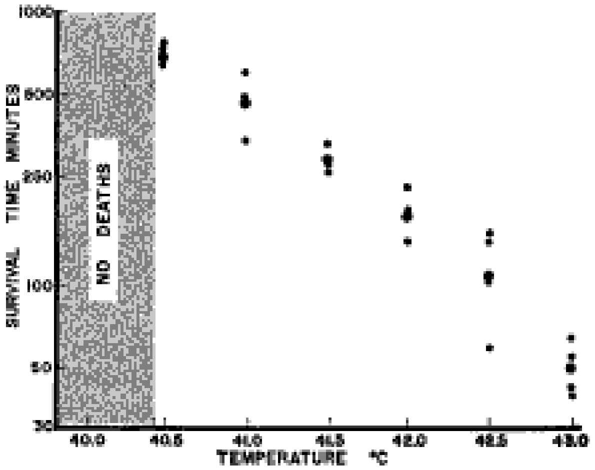

Fig. 2. Survival of *Coleonyx variegatus* at constant body temperatures. Small dots represent individuals and large dots represent means.

(N = 36), grouped animals at 20 C air temperature (N = 28), and single animals at 25 C air temperature (N = 21).

CTMax and CTMin were both defined as the temperature at which the animal was unable to right itself. The lizards were housed in plastic boxes in a refrigerator with a glass window for the CTMin experiments. They were introduced at 15 C and the temperature was lowered 1C/15 min. Torpor temperatures were measured with a Schultheis thermometer. CTMax was measured in glass flow-through cylinders 50 × 130 cm which were submerged in a water bath with an initial temperature of 39 C and a heating rate of 1 C/10 min. The temperature of the air circulating through the chambers was monitored with a recording potentiometer. Body temperature lag time, measured by simultaneous recording of cloacal and air temperatures, showed that the lizards very quickly adjusted to the air temperature and therefore body temperatures were not monitored during the experimental trials.

Another index of heat tolerance, survival time at constant temperatures, was measured in the same apparatus used for the CTMax experiments. Temperatures used were one half degree intervals between 40.0 C and 43.0 C.

There was no significant difference between the mean PBT of individuals or of groups in the three test situations ($P < .05$). The combined PBT was 28.6 ± 0.24. The single and grouped readings in the 20 C room were virtually identical. No animal voluntarily tolerated body temperatures of less than 24 C or more than 33 C (Fig. 1). *Coleonyx* apparently has no strong temperature preference within this range although more than 50% of the values lie between 28 C and 30 C.

The CTMin of 14 animals showed little variability, ranging from 6.9 C to 8.4 C. The mean CTMin was 7.7 ± 0.42 C. Five CTMax measurements ranged from 42.5 C to 45.0 C with a mean of $44.0 \pm .041$ C. Panting was not observed in any of the high temperature tests.

Survival times at high temperature are shown in Fig. 2. The highest temperature tolerated "indefinitely" was 40.0 C. After 12 hours at this temperature the lizards showed no sign of stress and remained healthy afterwards in the laboratory for several weeks. Extension of the survival curve estimates a survival time of 20 to 30 minutes at the CTMax (44.0 C) which indicates that both measures of heat tolerance establish similar limits.

These studies show that *Coleonyx* has a very broad range of temperature tolerance and that temperatures recorded in the field are significantly different from temperatures in the laboratory. The range of thermal tolerance (36 C) is between the tolerance ranges reported by Kour and Hutchison (op. cit.) for narrow and wide temperature tolerant species. The high thermal tolerance is comparable to that of thermophilic Australian geckos studied by Licht, et al. (1966).

The minimum field temperature recorded for *C. variegatus* is 15.0 C (Brattstrom, 1965) and the maximum is 37.0 C (Mayhew, 1968). A significant percentage of Mayhew's field temperatures lies outside the range of temperatures selected in the thermal gradient and the shape of the temperature curve generated from his field data does not suggest temperature selection. Apparently circadian rhythms control emergence and initiation of activity in *Coleonyx* but the length of the activity period is temperature dependent at both high and low environmental temperatures (Evans, 1966, Mayhew, op. cit.). Field temperatures above 34 C and below 24 C are probably "tolerated" rather than "selected". *Coleonyx* thus conforms with the pattern of other reptiles which are active outside their preferred temperature range to take advantage of some other aspect of their environment (Bartholomew, 1966; Bustard, 1967; DeWitt, 1967; Licht, et al., 1966; Regal, 1966). Severe restrictions on the possible days of activity would result if activity were limited to nights when temperatures selected in the temperature gradient are available. The PBT may be related to habitat temperatures in their secreted daytime environment as was shown for the Australian gecko *Gehyra variegata* (Bustard, op. cit.).

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T-MAZE BEHAVIOR OF THE TUATARA (*SPHENODON PUNCTATUS*).—Behavioral experimentation has demonstrated learning ability in reptiles, but no direct comparisons have been possible due to a lack of uniform testing conditions. Few workers have overcome the problem of adequate reward in instrumental conditioning. Turtles have been used frequently with success (Spigel, 1963; Wise and Gallagher, 1964; Kirk and Bitterman, 1965). In most cases change in elapsing time with exposure to a task was used as the criterion for learning (Crawford and Alkov, 1964; Crawford and Bartlett, 1966). Such data are difficult to interpret and compare with other groups of vertebrates. Ectotherms because of their low metabolic rates, do not respond as well as endotherms when placed on a program whose reward is based on food intake. However, lizards, like mammals, demonstrate territoriality as part of their behavior (Carpenter, 1962; Northcutt and Heath, 1971). Using this information, we designed a maze in which return to home area was the reward.

Two tuataras, a 470 gram male (Specimen 1) and a 197 gram female (Specimen 2) were