

Response of monitor lizards (*Varanus* spp.) to a repeated food source; evidence for association learning?

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ABSTRACT — Food location times have been recorded in three captive monitor lizards (*Varanus* spp.). The results, in the form of regression equations, showed that in general the time taken to locate the food decreased with the number of times the food was offered.

LITTLE work has been carried out on learning in varanid lizards (Phillips, 1994; Horn, 1999) which is perhaps surprising given their general impression of alertness even to the casual observer. We devised a simple experiment using food as a positive reinforcer to evaluate association learning in three adult monitor lizards from three species, *Varanus niloticus ornatus*, *V. albigularis* and *V. exanthematicus*. We used monitor lizards for two reasons. Firstly there was always a good response to food as a stimulus in our research animals. The second reason was that many types of monitor lizards are intense active foraging predators (Regal, 1978) travelling large distances in their search for food (Thompson & Withers, 1997; Thompson, 1999 and Bennett, 1998 for a review). We predicted that this behaviour, combined with the interest in food, increased the probability of the experiments giving meaningful results. The work was part of a second year HND research project on animal behaviour at Huddersfield Technical College carried out by IF, MT and MR under the supervision of RM.

METHODS AND MATERIALS

A variety of assumptions must be made when selecting methods of evaluating learning in animals. The method employed here was based on

showing the lizards a food item then repeatedly placing it in the same location in an enclosure where it could not be visually observed. The time taken to locate and consume the food item was then recorded. We assumed that if the lizards were learning from experience then the time taken to locate the food should decrease with the increase in the number of trials. The trials were run from midday onwards which allowed approximately four hours for the animals to heat up and activity body temperatures to be attained. Skin surface temperatures of the lizards were measured with a non-invasive Omega OS204 Digital Thermometer immediately before the commencement and at the conclusion of each trial – i.e. just after the animal had swallowed the food. All enclosures had heating facilities to allow the lizards to bask if required but this was not observed during the trials. The experimental arenas were different for each lizard, all of which were imported into the UK as juvenile animals.

Enclosures

Varanus niloticus ornatus (male approximate length 1.2 m). The nervous disposition of this species is well known and our lizard's behaviour was no different. Therefore to avoid any unnecessary stress to the animal, the trials were

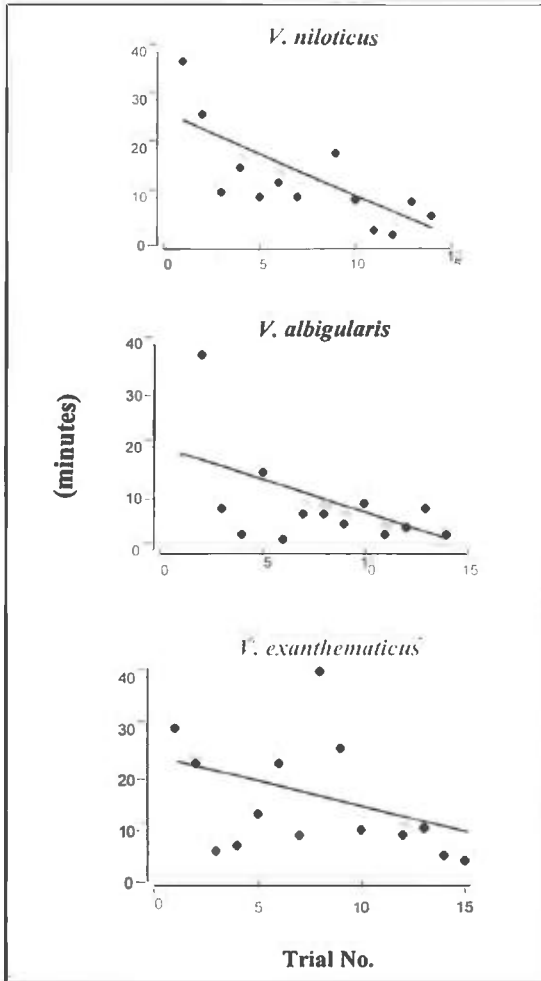


Figure 1. A graph of food location time plotted against the number of trials in three monitor lizards. The lines taken through the data are derived from the regression equations given in the text.

conducted in its permanent housing. This was a three-tiered enclosure with lengths of 3.5 m and widths of 1m in the top and bottom levels. The middle level had similar dimensions but a length of 1.3 m. A facility for passage between levels was by way of a tree trunk running vertically from the bottom to the top floor. The top floor had a 2 x 1 m pool and a series of horizontal branches, the bottom floor large rocks and a 0.6 x 0.4 m hide box. The overall height of the enclosure was 2 m. The placement of the food was carried out when the lizard was in the top floor and located at the

furthermost point of the bottom level from the point of the lizard's entry.

Varanus albigularis. (male approximate length 1.2 m). The trials for this lizard were also conducted in its regular enclosure. This had a length of 3.5 m by 1.5 m wide and 3 m high. Two hide areas, a horizontal tree trunk, and a living evergreen tree (*Ficus* sp.) whose growth reached the roof of the enclosure were the main furnishings. The food was shown to the lizard when it was in the top of the tree and placed in an area out of view on the ground.

Varanus exanthematicus. (female, approximate length 0.6 m). The trials for this animal involved its transfer from rather small housing conditions to an enclosure 10 m in length by 5 m wide. Ten wooden boxes were placed at equal distances on both the right and left hand sides of the unit to act as visual barriers. The food item was then shown to the animal and located at the opposite end of the enclosure.

RESULTS

Body temperatures of *V. niloticus ornatus* during the trials were from 27-35°C, mean = 31.6°C, in *V. albigularis* from 18-34°C, mean = 27.0°C and in *V. exanthematicus* from 18-34°C, mean = 32.0°C. Figure 1 shows the amount of time taken for the lizards to locate the food in respect to the number of times the food was offered (trial number). The lines taken through the data are derived from regression equations of the form $y = b + mx$ with the time taken to locate the food treated as the dependent variable y and trial number as the independent variable x . Coefficients of determination (r^2) have been attached to each equation to estimate the amount of variation in food location time that can be explained by the increasing number of trials. The results produced negative slopes in all three data sets with the following relationships:

V. niloticus ornatus:

Location time = $25.9 - 1.71 \text{ trial number}$, $r^2 = 55.2\%$.

V. albigularis:

Location time = $18.7 - 1.27 \text{ trial number}$, $r^2 = 31.7\%$.

V. exanthematicus:

Location time = $23.1 - 1.00 \text{ trial number}$, $r^2 = 16.7\%$.

The negative slopes indicate shorter food location times with the increasing number of trials. If there had been no improvement in the times taken to find the food regression coefficients of 0 would have been found. To test for departures from this hypothetical value, a *t*-test at *n*-2 degrees of freedom was applied to the regression coefficients (Bailey, 1981). The results showed significant departures from 0 in *V. niloticus ornatus* ($t = -3.84$, $p = 0.002$, d.f. = 12) and *V. albigularis* ($t = -2.35$, $p = 0.03$, d.f. = 12) but not in *V. exanthematicus* ($t = -1.62$, $p = 0.13$, d.f. = 13). The latter statistic is probably due to the initial slower location time (greater scatter) in this animal up to trial 10 (see Fig. 1).

DISCUSSION

The learning capabilities of the monitor lizards used in this study are perhaps not unexpected. Consider the problems of a hungry monitor lizard, a foraging predator faced with a series of alternative foraging routes, one of which gives a better food reward than the others. Clearly, if the lizard behaves optimally it should follow the route that gives the better food reward but how is the animal to find this out? In theory it has to spend time sampling all foraging routes before settling down to exploit the best one which is essentially what our results appear to show, with the initial lengthy foraging periods (of around 40 minutes) gradually reducing to lapsed times of as little as 2-3 minutes. The apparent slower learning response in *V. exanthematicus* is readily explained by what we considered a more difficult learning task at the commencement of the experiments than for the other lizards, i.e. the trials were carried out in a larger enclosure that was not used for the animals regular housing. However continuation of the trials in this lizard would perhaps have improved the r^2 values and given a significant departure from the 0 hypothetical coefficient.

The results of this study provide good evidence that our monitor lizards learned with experience, which is in agreement with learning experiments involving other types of reptiles in mazes. These

have included *V. albigularis* (Phillips, 1994) where a gradual reduction of running latency was observed – the time from entering to the time of exiting a maze box (Burghardt, 1977), and auto-shaping experiments on *V. bengalensis* where, after initial training, the lizards solved problems correctly 85% of the time (Loop, 1976). Horn (1999) proposed that an intensive foraging lifestyle is a precondition for complex data collecting in animals and that many monitor lizard species fall into this category; large (and hence complex) home ranges and elaborate behaviours increase the volume and range of information that needs to be processed for storage and retrieval by the brain during daily movements. The brain therefore evolves in association with these constraints and the whole process is a basis for the evolution of higher order decisions and associations. A foraging lifestyle places much greater demands, for example, on the problem solving requirements of sit-and-wait predators with limited home ranges (Harvey & Bennett, 1983) and even cruising foragers (Horn, 1999). This relationship between lifestyle and brain morphology has been observed even in closely related lizards, for instance the relative size of the hippocampus is larger in the active foraging *Acanthodactylus boskianus* than in its sit-and-wait congener *A. scutellatus* (Day et al., 1999).

Although temperature effects were not recorded in our study, we recognise that this is a potentially important aspect for learning in reptiles. For example, in a study of learning in Desert Iguanas (*Dipsosaurus dorsalis*) it was found that lizards with high body temperatures learned mazes significantly quicker than lizards with low body temperatures (Krekorian et al., 1968), whilst other lizard species have demonstrated operant responses to thermal rewards (Regal, 1971). These findings suggest, at the very least, that learning studies involving reptiles should ensure that the animals are able to operate within normal activity body temperatures for the results to be meaningful.

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