Does habitat structure affect foraging success in the Mediterranean house gecko, *Hemidactylus turcicus?*

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ABSTRACT - The effects of structural habitat complexity on predator foraging success has been seldom investigated in lizards. We studied a population of the gecko *Hemidactylus turcicus* in Northern Cyprus to examine how structural habitat complexity can alter the behavioural patterns of foraging geckos. In Northern Cyprus *H.turcicus* are found in both urban and natural environments, however urbanised areas provide a simple habitat structure which could benefit foraging success. Although light levels and prey density are factors in their success, foraging success could also be a factor as to why these geckos are often found in urbanised areas. We hypothesised that increased structural complexity of the habitat will have a negative influence on *H.turcicus* foraging success because of visual impairment. The results support our hypothesis that in a simple habitat foraging will be more successful with a significantly lower number of strike attempts, fewer failed feeding bouts and a significantly larger strike distance in a simple habitat compared to a more complex one. However the time taken to start hunting prey showed no significant difference, which was not predicted. The results from this study show that the foraging success of *H.turcicus* is increased in simple habitats, therefore we propose that foraging success could be a part of the driver for the successful colonisation into urbanised areas.

INTRODUCTION

The gecko, *Hemidactylus turcicus*, commonly occurs in built up areas, often associated with human-mediated dispersal events. It is often thought that the main cause of the dispersal is a result of human introduction (Carrenza & Arnold, 2006), a claim that is supported by the distribution being associated with the US highway network (Davis, 1974). However in North Cyprus it is not known how or when *H. turcicus* arrived but the species is nonetheless more commonly found in urbanised areas but also occurs in natural habitats. *H. turcicus* utilises adapted toes that enable them to climb walls (Hennig & Dunlap, 1977; Carrenza & Arnold, 2006) and other flat surfaces. Climbing walls is beneficial because geckos can move to high places where most forms of disturbance can be avoided, such as predation. (Carrenza & Arnold, 2006). *H. turcicus* often perches on walls near lights, presumably to prey on insects attracted to the lights in human habitations, providing a higher prey density. (Carrenza & Arnold, 2006; Williams & McBrayer, 2007; Rato et al., 2011).

The walls of buildings are often simple compared to natural rock habitats. In a structurally more complex environment, prey location may be more difficult because objects can break the line of sight (Petren & Case, 1998), whereas in a simple habitat there should be greater opportunities for a gecko to observe and catch prey, and to procure prey more quickly (Short & Petren, 2007). The line of sight between predator and prey is important for predators to locate prey, which is another advantage of a high perch as it often removes visual impairment (Andersson et al., 2009).

In this study we compared the foraging success of *H. turcicus* in simple and complex environments. We hypothesised that simple habitats could yield higher foraging success and could alter how the gecko procures prey. Behavioural observations were used to test these hypothesises, by recording the strike success, distance and time of each strike.

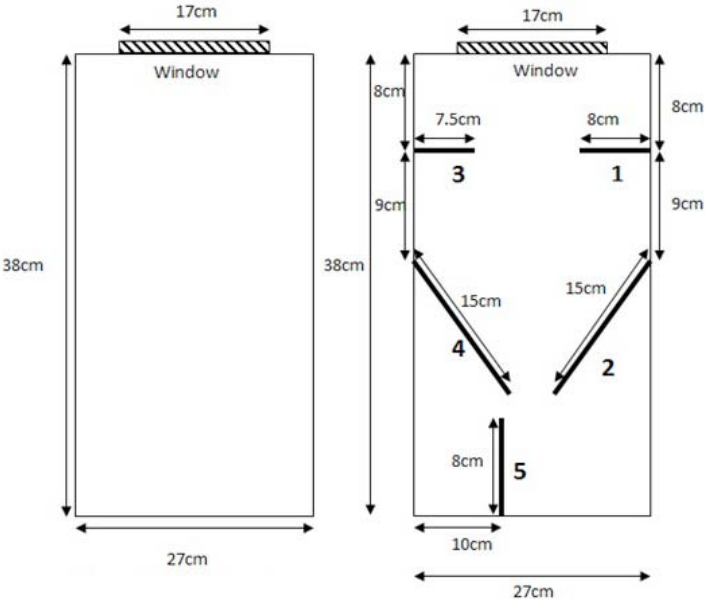

Figure 1. Layout of simple habitat enclosure. Open plan area with no internal walls to impair visibility providing simple habitat. Window at the front used as insertion point for prey.

Figure 2. Layout of complex habitat enclosure. A more complex area containing 5 walls at variable sizes to obscure vision. Window at the front used as insertion point for prey.

MATERIALS AND METHODS

The study was carried out on a population of *H.turcicus* geckos in Northern Cyprus between 29th June and 27th July 2010. Comparative observations were made on the predation behaviour of individual geckos in simple and complex chambers within a basic field laboratory on a work bench (Fig.1 and Fig.2). The simple structured habitat was an empty grey plastic box arranged horizontally 38 cm long, 27 cm wide and 15 cm high, providing an open space to represent the simple habitat found in human habitations (Fig. 1). Hardboard partitions were used to create the complexity of the second habitat type, acting as barriers to reduce the geckos' visual range (Fig. 2). Partitions one and five were 8 cm x 8 cm at a 90∫angle from the wall and were elevated off the floor by 7 cm. Partitions two and four were 15 cm x 7.5 cm lying long ways on the floor at a 45∫angle from the wall. The final partition (partition number three) was 15 cm x 7.5 cm standing up against the left wall at a 90∫angle from the wall.

Both of the habitat types were divided into a three dimensional grid with each grid section being 7.6 cm deep x 5.4 cm across x 5 cm high. The grid was used to record the exact location of the gecko when the first sign of hunting was observed and where the gecko captured the prey.

All caught geckos were sexed and any gravid females were immediately released back where they were caught; no experimentation was conducted on them because in many reptilian species gravid females are known to have a reduced consumption rate (Johnson et al., 2010). Only geckos with a snout to vent length of 44 mm or greater were used because this is the average size of an adult *H. turcicus* gecko (Selcer, 1986). Fifteen adult *H. turcicus* geckos in total were caught from the wild and randomly placed into either a complex or simple enclosure for a 7 day period regardless of sex or size.

Following Hitchcock & McBrayer (2006), each gecko was left undisturbed for 20 hours to acclimatise after being placed into the test enclosures. Observations were made under a red light to minimise disturbance between 20:00 and 00:00 (Hennig & Dunlap, 1977). On each occasion an adult flour moth (*Ephestia kuehniella*) was released into the enclosure at the same location (the front window) for each assay and the time was recorded. The time of each strike was recorded as well as the grid reference (the central point of the grid section) of the gecko when it first started to hunt. The grid reference of where the prey was situated when the gecko struck was also recorded. Since a failed first strike would shorten the distance between hunting initiation and a successful strike, only data from first strikes were used to compare distances travelled to strike at prey. The success of each strike was recorded and if successful the observation was concluded for that night. If the strike was unsuccessful the gecko observations continued and all other attempts recorded in the same way until a successful strike was made. After 60 minutes, if the gecko had not made a successful strike the moth was removed and observation was concluded for the night.

Observations were repeated for seven consecutive days, after which the gecko was moved into the other habitat type and left for another 20 hour acclimatisation period before repeating the study. Therefore, each gecko had the opportunity to feed for 7 consecutive days with a 20 hour acclimatisation period before another 7 consecutive days in the opposite habitat type.

We used Pearson's chi-squared analysis to assess whether there was a difference in the amount of successful feeding bouts compared to unsuccessful feeding bouts in both simple and complex habitats. While a Paired t-test was used to test the null hypotheses that there is no difference between the distance to strike, the number of attempts, and time to strike in both habitat types.

RESULTS

The Pearson's chi-squared analysis showed that there is a significant difference between a successful feeding bout and an unsuccessful feeding bout in simple and complex habitats (χ^2 = 5.1079, df = 1, p = 0.024). The results show that in a simple habitat foraging is more successful as there were fewer failed attempts than in the complex habitat.

The time taken to initiate hunting did not differ significantly between the two habitats (t (71)= -0.845; P = 0.401). The average number of grid squares travelled to make a successful strike was greater in a simple (mean number of grid squares=2.79, SD= 1.66) compared to a complex (mean number of grid squares=2.18, SD=1.35) habitat (t (61) = -2.537; P = 0.013). Similarly the distance travelled to make a strike, whether successful or not, was also greater in the simple (mean number of grid squares=3.08, SD=1.55) compared to a complex (mean number of grid squares=2.51, SD1.31) habitat (t (71) = -2.524; P = 0.014). Fewer attempts were needed to make a successful strike in the simple (mean=1.40, SD=0.69) compared with the complex (mean =1.71, SD=0.91) habitats (t (69) = 2.036; P = 0.046).

DISCUSSION

We have shown that *H. turcicus* is more successful at catching prey in a simple habitat than in a more complex one, with fewer strikes before capturing a live food item and the small number of unsuccessful feeding bouts in simple habitats. The ability to catch prey from a longer distance in comparison to a more complex habitat also shows how habitat complexity alters foraging. However the time that is taken to initiate a response to the prey showed no significant difference between simple and complex habitats. Overall, simple habitats provide a more suitable area for a more efficient feeding bout. Combined with the increased prey density from lights in anthropogenic environments, it is reasonable to suggest that a simple habitat is an extra benefit for foraging.

Any feeding bout can be divided into four stages: prey search, subjugation (handling), ingestion and digestion. However the energetic cost of prey handling and ingestion has been shown to be trivial in lizards (Cruz-Neto et al., 2001). Generally speaking the time taken to find the prey will be longer than the time taken to procure and ingest prey. Strike success then becomes more important to avoid having to find and procure another prey item, therefore a higher capture efficiency would minimise energetic costs. *H. turcicus* is more successful at capturing prey in a structurally simple habitat as

shown by a significantly lower number of attempts needed to catch the prey. Having a higher capture efficiency in simple habitats will reduce the energetic costs and decrease handling time of the prey; this could be a reason for *H. turcicus* being more common in urbanised areas, which is simpler than a natural habitat.

The strike range of *H. turcicus* is another important factor to be considered when comparing how successful the species is in either simple or complex habitats. The results show that the distance travelled between the gecko and prey for both the first strike and for a successful strike in a simple habitat is greater than in a complex habitat. A possible reason for this might be that the simple habitat is providing *H.turcicus* with a greater line of sight and it is therefore able to stalk prey over a longer distance (Fernandez-Juricic et al., 2011). However, when the gecko fails to capture the prey on the first attempt the gecko will quickly have a second attempt while the prey is close, meaning that this could bias the distance of the successful strike (if all strikes are measured) as geckos in complex habitats require more attempts to catch prey. Despite this, the results from the first strike show that habitat structure does affect the strike distance of *H.turcicus*. Although travelling a greater distance to capture prey has a higher energetic cost, the higher success rate balances the cost/benefits from travelling a longer distance. A simple habitat structure could lead to a higher foraging efficiency, which would increase fitness in a structurally simple habitats such as that used in this experiment. Although it has been shown in *H. frenatus* that increased prey density resulting from the presence of artificial lights is a driver for success in urban areas, the results from this study suggest that an increased foraging success has an extra impact on the success of urbanised geckos.

There was no significant difference between the time taken for a gecko to initialise hunting between simple and complex habitats. A possible reason for this could be that geckos in complex habitats can safely position themselves closer to the entry point, therefore negating the advantage of an open vantage point. However the number of failed feeding bouts is greater in complex habitats suggesting that visual obstructions do prevent the geckos locating their prey.

This study has been able to provide some understanding of the foraging behaviour of *H.turcicus*. It showed that habitat structure can influence foraging success and that the gecko is able to benefit from simple structures increasing foraging efficiency. The research has suggested that the availability of foraging areas that are unimpeded by physical barriers could be a possible factor in the species' successful establishment in an urbanised area. Higher prey density caused by insects being attracted to artificial lights and high foraging success work simultaneously to further increase their successful integration into urban areas.

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