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The Presence of Food Likely has no Influence on Substrate Use of Tokay Geckos (Gekkonidae: Gekko gecko)

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Abstract

Geckos and their adhesive capabilities have been thoroughly examined for the past two decades, especially in terms of adhesion and its mechanics. However, few studies have focused on how the adhesive performance of geckos influences ecologically relevant behaviors (e.g., habitat/substrate use). The limited work on the topic in the laboratory suggests that geckos spend more time on substrates in which their adhesive capabilities are superior, such as glass. In their natural habitat, however, multiple factors besides adhesive performance alone is likely to collectively impact the substrate use of geckos. The presence of food is one such factor. Here I examined whether the presence of food influenced gecko substrate use on three different substrates that differed in their surface roughness and gecko adhesive capabilities (glass, 1000-grit sandpaper, 80-grit sandpaper). The substrate use of Tokay geckos (*Gekko gecko*) was recorded in enclosures which had three different substrates and a food source (fruit purée) randomly placed throughout. Consistent with previous work, I found that geckos spent significantly more time on the glass substrate than the two sandpaper substrates, although geckos spent equal amounts of time on the sandpaper substrates. The mean time geckos spent on substrates on which food was located was about 57%. By random chance, geckos would be expected to utilize these substrates about 56% of the time, suggesting that food presence does not influence gecko substrate use in the laboratory. The result of this study can be used to generate testable hypotheses of the many factors that influence gecko substrate use in their natural habitat, which will enhance our understanding of the ecology and evolution of geckos.

Introduction

The study of geckos and their adhesive toe pads has received much attention within the past 20 years. The adhesive toe pads of geckos are composed of extended scales (scansors) which possess arrays of hair-like fibers (setae), which end in multiple tips (spatulae). Spatulae make intimate contact with surfaces, providing adhesion via van der Waals interactions (Autumn, 2006). While geckos can support their body weight on a myriad of different substrates, maximum adhesive ability often differs depending on the substrate (Stark et al. 2015; VanHooydonck et al. 2005; Stark et al. 2015). Considering the fact that geckos may experience forces reaching maximum theoretical adhesion in their natural habitat (Higham et al. 2017), geckos may use substrates non-randomly in their natural habitat with respect to adhesive performance. This makes clear sense, as using the superior substrates in a natural habitat will result in optimal use of said habitat. VanHooydonck et al. exemplify gecko adhesion differing between substrates. In their experiment, three substrates (wood, cloth, wire mesh) were used to examine locomotor capabilities of a climbing gecko (*Hemidactylus garnotii*). It was shown that the substrate with the highest available surface area for gecko adhesion (wood) proved to be what geckos performed best on. This proves to be relevant to the current study, seeing as the three substrates used (glass, 1000-grit sandpaper, and 80-grit sandpaper) all differ in their respective surface area for gecko adhesion.

Although laboratory investigations documenting substrate use in geckos are limited in scope, they can still provide information regarding the individual factors that may influence free-ranging gecko substrate use. Another study done by Wheeler and Fa (1995) found that gecko substrate use is dependent on enclosure size, as geckos inhabiting smaller vivaria tended to spend more time on glass than in hides or the floor, whereas geckos inhabiting large vivaria did the

opposite. Other, more recent, work specifically examined how gecko adhesive performance is related to substrate use on substrates varying in surface roughness (Garner et al. in preparation). Of the three substrates included in their study (glass, 80-grit sandpaper, 1000-grit sandpaper), geckos generated the highest adhesive force on glass, followed by 1000-grit sandpaper, and then 80-grit sandpaper. Geckos were also observed to be on the glass substrate the majority of the time, spending significantly lesser amounts of time on the two sandpaper substrates. Their results suggested that geckos do appear to use substrates non-randomly, and that they spend the majority of time on the substrate that they adhere best to. However, the surprising greater usage of 80-grit sandpaper (which resulted in lower adhesion forces generated than 1000-grit sandpaper) suggests that other variables not measured may influence substrate usage patterns. One such variable is food presence. Organisms such as geckos naturally compete for food, and this need for food can bring about behavioral changes in these organisms (Cole and Harris 2011). Geckos for instance may adapt different behavioral strategies in the presence of food that would allow them to maximize their possible benefit. Seeing as it is a common stimulus for the geckos, there is good reason to believe it is a good variable to examine further.

In this study, I introduce a static food source into the enclosures used by Garner et al. (in preparation) to examine if it influences the distribution of gecko substrate use. Competition for food can bring about behavioral changes in organisms, and these behavioral changes include the way organisms forage, their diet, when they forage and eat, etc. I hypothesize that the presence of food will influence the distribution of substrate use behavior in *G. gecko*, in which geckos spend more time on substrates that possess food.

Methods

Geckos and Enclosure Setup

For this study, 6 Tokay geckos (*Gekko gecko*) from the University of Akron Research Vivarium were used as the sample. Geckos were chosen based on their relative activity levels; geckos that were typically inactive were not used. In total, 6 different 10-gallon terraria were used. The same enclosures used in the previous study done by Garner et al. (in preparation) were used for this experimental setup. The sides of each enclosure were split into 6 equal areas, and 3 substrates (glass, 1000-grit sandpaper, and 80-grit sandpaper) were randomly assigned to 2 areas (**Figure 1)**. Glass substrate portions were covered with black paper from the outside of the enclosure, ensuring that every portion of the enclosure (besides the top, bottom, and filming side) was opaque. For a food platform, a small square was cut from cardboard, and was then glued in between two randomly selected substrates. The food dishes were placed on this platform, which sat at about ¾ the way up the side of the enclosure. Infant fruit purée was used in all 6 food dishes.

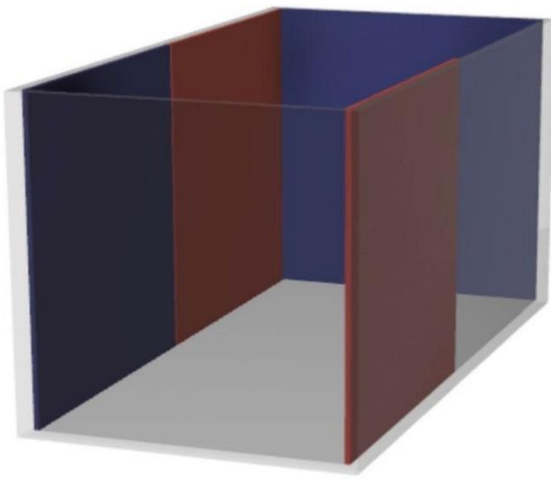

Figure 1. Substrate use enclosures. The red, blue, and clear portions mark different substrate types (glass, 80-grit sandpaper, and 1000-grit sandpaper). Food containers would be in between two substrates, right where the different colors meet. Every side of the enclosure was opaque, except for the side exposed to the camera.

Image credit: Austin M. Garner

Recording and Image Analysis

From the period of June 30, 2020 until July 5, 2020 geckos were recorded for roughly 5-8 hours per day (during the daytime) in the enclosures. MATLAB was used to run a program that would capture images of the geckos and enclosures every 30 seconds. Two enclosures were recorded by a single camera. To record substrate use data, one hour was randomly selected per gecko for each day. In some cases, the positioning of the enclosures was not ideal with respect to the camera view, so there were some instances of gecko substrate use that were uncertain. Such instances were not included in the final data. Instances in which the geckos were on the top or bottom of the enclosure were also not used. Each gecko had 94 ±5 images that were analyzed, marking which substrate they were on at the time the image was taken.

Statistical Analyses

A mixed model analysis of variance (ANOVA) was used to analyze potential differences in the proportions of time the geckos spent on the three different substrates in the presence of food. Individual gecko was modeled as a random effect in order to control for repeated measures of single individuals. A Chi-Square test of independence was then used to examine the data from Garner et al. (in preparation) and my study, to determine whether there was a significant shift in the distribution of gecko substrate use between the two studies. The major difference between the two studies (but not the only difference) was the presence of food, which was included in my study but not Garner et al. (in preparation).

Results

A mixed model analysis of variance (ANOVA) revealed that the geckos spent significantly different amounts of time on the three substrates (DF=2, 96.0, F=14.8, P < 0.0001; **Figure 2.**). The proportion of time that the geckos spent on glass was significantly greater than that on 1000-grit sandpaper (P < 0.0001), as well as that on 80-grit sandpaper (P < 0.0001). It was also found that there was no significant difference in the proportion of time spent on 1000-grit sandpaper and 80-grit sandpaper (P = 0.9953). Geckos spent 57 ± 0.08% of the time on substrates that possessed food.

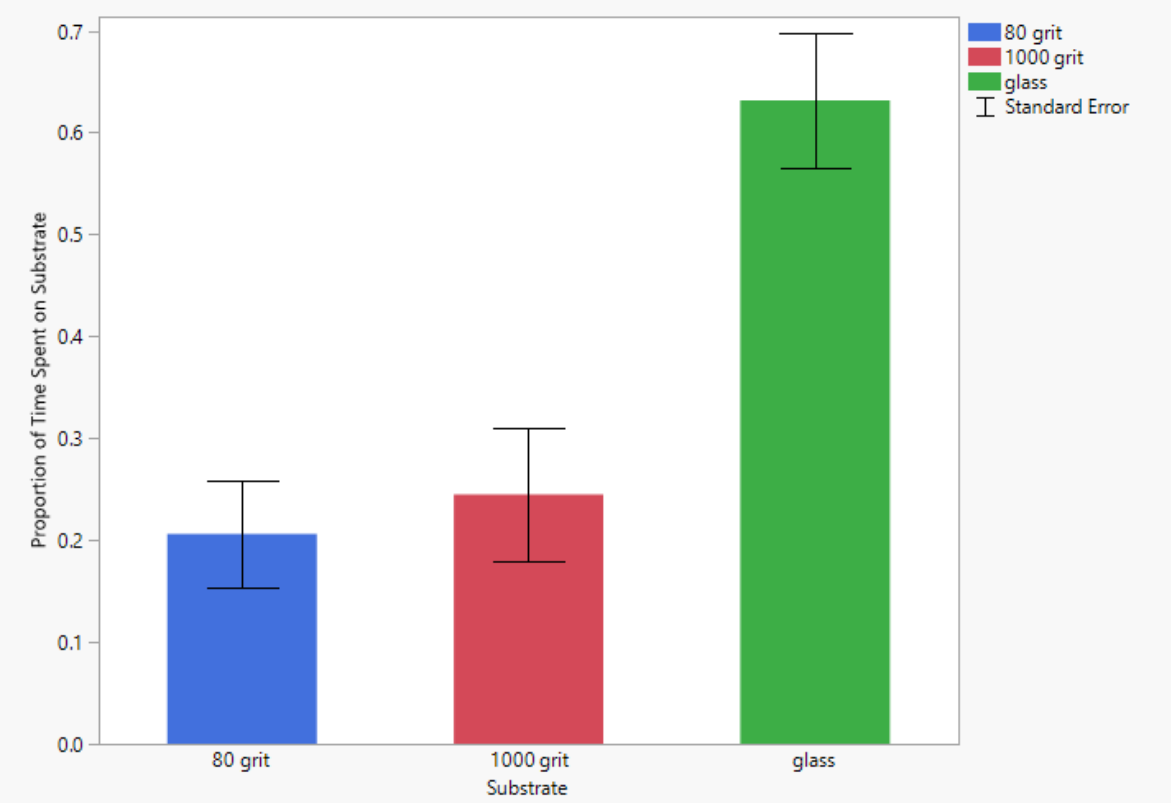

Figure 2. Mean proportion of time spent on each substrate in the enclosure. Time spent on 80-grit and 1000-grit did not statistically differ (P < 0.0001), while geckos spent significantly more time on glass (P = .9953).

The Chi-Square test of independence showed that there was a significant shift in the distribution of gecko substrate use (ChiSquare = 149.9, $P < 0.0001$). This appeared to be driven by geckos in my study spending a higher proportion of time on glass and a lower proportion of time spent on 80-grit sandpaper than what was observed in Garner et al. (in preparation). The mean proportion of the time that geckos spent on substrates where food was located was found to be 0.57 ± 0.08.

Discussion

Consistent with previous work (Garner et al. in preparation), geckos spent significantly more time on the glass substrate compared to the two sandpaper substrates; this result is consistent with the interpretation that geckos tend to spend more time on substrates that they adhere better to (Garner et al. in preparation). The findings from my study also align with those of Wheeler and Fa (1995), in which geckos in small vivaria (~8-gallon enclosures) tended to spend more time on glass rather than in hides or on the enclosure floor. While my study and that of Wheeler and Fa (1995) are very different and use different species of gecko (Wheeler and Fa used Round Island Geckos [*Phelsuma guentheri*]), it is still worth noting a similar outcome.

Interestingly, a Chi-Square test of independence revealed that there was a significant shift in the distribution of gecko substrate use between Garner et al. (in preparation) and my study, primarily driven by geckos using glass more often and 80-grit sandpaper less often in my study. While the major difference between my study and the previous was the presence of food, the mean proportion of the time geckos spent on substrates where the food was located was found to be about 57%. From the setup of the enclosures and how food was placed (in between two substrates at once), the proportion of time geckos spent on the substrates where food was located due to random chance alone was found to be 56%. Considering the observed mean was nearly identical to the expected mean by random chance, it is unlikely that the presence of food explains

the significant shift in gecko substrate use. A number of other differences between my study and that of Garner et al. (in preparation) could have resulted in the shift in the distribution of gecko substrate use. First, the two studies were completed two years apart from one another, and they were conducted during different seasons (Garner et al. in preparation was completed in winter, whereas mine was completed during the summer). Second, my study had a sample size of 6 geckos, while the previous study had a sample size of 18 geckos. Recording for the previous study took place 24 hours a day, for 6 days, whereas in my study recording took place for roughly 5-8 hours, for 6 days. Also, in the previous study geckos were randomly placed in the bottom of their tanks every three hours (Garner et al. in preparation). Thus, there are a myriad of other factors that could have explained the differences in results between the two studies.

This study was not at all without limitations. The manner in which some cameras were angled resulted in some images that could not feasibly locate the gecko and which substrate it was located on during that image. Along with images in which the gecko was located on the top or bottom of the enclosure, the images that were uncertain were not used in the data analysis. This might have resulted in a significant shift in the obtained results. If a future study is to be undertaken, a much longer time frame (study and recording period lengths), larger gecko sample size, and improved image capturing would be ideal. Future work could more definitively investigate the influence of food on gecko substrate use by introducing two separate groups of geckos, one being in the presence of food and one lacking food, to make direct, valid comparisons. Varying the location of the food or even the type of food could also be of interest and implement relevant behavioral theory such as Optimal Foraging Theory or Risk Allocation.

This study is a good example of integrating across multiple sub-disciplines of biology (behavioral, ecology, biomechanics) to examine a relatively understudied topic. Although

considerable progress is being made, there is still much to learn about the factors that influence gecko substrate use, especially in natural circumstances. Studies of the behavioral tendencies and mechanisms of geckos can lead to a better understanding of their evolution and ecology.

Conclusion

In this study, I examined the influence of food on laboratory substrate use of Tokay geckos. Consistent with previous work, I found that geckos spend the majority of time on glass, the substrate which they adhere best to. Furthermore, I found that the distribution of gecko substrate use differed significantly than that from the previous study (Garner et al. in preparation) without food, but geckos did not preferentially use the substrates on which food was located. Thus, food was likely not a factor influencing gecko substrate use, but more highly controlled studies are necessary to determine this definitively. This area of study has the potential to enhance our understanding of the ecology and evolution of the gecko adhesive system, and geckos in general.

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