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Prey preference of the Common House Geckos *Hemidactylus frenatus* and *Hemidactylus platyurus*

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Abstract. House geckos (*Hemidactylus frenatus* and *H. platyurus*) are very common in residential areas throughout Southeast Asia. Geckos are fierce insect feeders and their role in in-home pest control is worth considering. Here a study is presented that aims to elucidate the prey choice behaviour of both gecko species. We observed wall dwelling house geckos that foraged near artificial lights in Thailand. The invested effort for each attack sequence was compared to the estimated prey size and the prey type. We found that the house geckos fed most on Diptera. However, they showed a strong preference for Lepidoptera and a slight preference for Culicidae. These results are further discussed in the context of the optimal foraging theory.

Key Words: *Hemidactylus frenatus; Hemidactylus platyurus;* Diet; Food preference; Prey choice.

Introduction

House geckos are common throughout the tropics, with some species being very well adapted to living in urban environments (Vanderduys and Kutt, 2012). The common house gecko, *Hemidactylus frenatus* Schlegel 1836, is a species that is native to Southeast Asia, but nowadays can be found in many other regions of the world as an invasive species (Hoskin, 2011). *Hemidactylus frenatus* is often found inside buildings feeding on insects that are considered to be pests (Tyler, 1961; Newbery and Jones, 2007). The foraging behaviour of *H. frenatus* has previously been studied under experimental conditions by Canyon et al. (1997). These authors studied the predation rate of *H. frenatus* and the gecko *Gehyra dubia* (Macleay, 1877) feeding on mosquitoes. Predation rates were relatively high (63 to 109 mosquitoes per day depending on prey density) in comparison to other in-home wall-dwelling mosquito predators such as daddy long leg spiders (*Crosspriza lyoni*) (Strickman et al., 1997) or jumping spiders (Salticidae) (Weterings et al., 2014). Dietary analyses based on stomach contents have shown that the diet of *H. frenatus* is very diverse (Tyler, 1961; Diaz Perez et al., 2012). Based on these results *H. frenatus* is considered to be an opportunistic generalist predator. However, dietary content by itself does not give any information with regard to prey preference.

House geckos might be considered as a pest themselves. Their faeces are often considered to be a nuisance and can even cause salmonella infection when ingested (Bockemuhl and Moldenhauer, 1970; Callaway et al., 2011). Nevertheless, the role of geckos in pest control might still be considered to be very beneficial (Canyon and Hii, 1997). Mosquitoes seem to constitute a major part of the diet of this very common species (Tyler, 1961; Newbery and Jones, 2007). From a biocontrol perspective it is thus of great interest to understand the feeding behaviour of common house geckos in more detail. In order to assess whether house geckos are suitable for biological control, it is important to understand its diet, in particular the preference for certain prey (Berryman, 1999). Here we present an observational study of prey preference in *H. frenatus* and *Hemidactylus Platyurus* (Schneider, 1792), two common house geckos that can be found throughout Southeast Asia.

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Materials and Methods

Behavioural observations

During a period of three months (November 2013 to January 2014) we observed geckos on buildings in Muang Kamphaeng Phet, Thailand. Geckos were studied from approximately 19:00 to 21:00 for a total of 34 nights. Observations were made on walls and ceilings of inhabited buildings that were provided with artificial lights. We used binoculars to observe the geckos in order to increase the distance and reduce the interference with their natural hunting behaviour. Each night we observed multiple geckos on a single wall. We noted the gecko species (*H. frenatus* or *H. platyurus*), the order (and the dipteran family Culicidae) to which a prey insect belonged, the approximate size of the prey, and the approximate distance that a gecko moved to catch a prey. Prey insects that could not be identified were noted as unknown. Size of prey insects could not be measured directly because this would interfere with the attack sequence. Therefore we estimated the size of prey by assigning it to one of the following six categories: 0-4 mm, 5-9 mm, 10-19 mm, 20-29 mm, 30-39 mm and greater than 39 mm. The attack distance, the distance moved into the direction of a certain prey, could also not be measured directly. Distance was categorized into 4 different categories. The first category contained the shortest distance and thus the least effort which consisted of only a slight movement of the head and/or tongue. The second category consisted of an attack sequence in which the gecko performed a small jump towards its prey; this category did not involve any walking. In the third and fourth category the geckos stalked their prey and walked either a distance of less than 25 cm or more than 25 cm.

Insect sampling

To assess the presence of insects we placed one sticky trap in front of the wall at each sampling location. The sticky traps were placed 20 minutes prior to the behavioural observations and removed after we finished observing the geckos. The single-sided surface (15cm by 30cm) of the sticky traps was covered with a layer of weather proof glue, consisting of a rubber based adhesive mixed with an organic solvent. After collecting the insects the sticky traps were sprayed with permethrin, a pesticide, to kill all insects. The sticky trap was then placed into a plastic box to protect the insects from external influences during transportation. All insects apart from mosquitoes were identified to the order level; mosquitoes were identified to the family level.

Analyses

We used a Chi squared test of independence to test for differences between the observed number of prey in certain orders, and the number of insects that were present on the sticky traps. We assessed the adjusted residuals to see if there was a difference in the ratio of prey consumed from certain orders in comparison to the insects that were present. We considered an absolute adjusted residual (a.r.) value of two or higher to be different (Agresti, 2007). For this analysis we only used the data for the samples for which the insect community was considered similar according to another Chi squared test (nine nights). We also used the Chi squared test of independence to assess differences in prey preference among the two focal species and to assess the size classes for each insect order.

The effect of gecko species, insect order and insect size on hunting effort was assessed using a Cumulative Link Mixed Model (CLMM). This type of model allowed us to use an ordinal response variable in a regressional fashion (Christensen, 2012). We used the movement distance as our ordinal response variable and the insect order, insect size and gecko species as independent variables. Data violated the assumption of independence: data were clustered on different sites (34). To account for the clustering of the data we added location as a random effect to the models. We used the model inference approach described by Anderson (2008) to select the best model. Following this approach we developed a priori hypotheses that were all represented in different models. Subsequently these models were compared using the AICc score (Anderson, 2008). We calculated model weights in order to develop an averaged model based on all a priori hypothesized models. All analyses were conducted in RStudio (RStudio, 2012) built on R 3.0.0 (R Development Core Team, 2013). The 'ordinal' package (Christensen, 2012) was used to conduct the CLMM analysis.

Results

A total of 1034 attacks were observed, 523 for *H. frenatus* and 511 for *H. platyurus*. Most preyed insects belonged to the orders Diptera (36.3%) and Homoptera

Table 1. Number of insects preyed by *H. frenatus* and *H. platyurus* as frequency and percentage. The numbers of insects on the sticky traps and the total availability of insects (preyed plus sticky traps) are also included.

Prey type	*H. frenatus*		*H. platyurus*		Sticky trap		Total availability	
Coleoptera	5	1.0%	4	0.8%	57	3.8 %	66	2.6 %
Culicidae	16	3.1%	26	5.1%	14	0.9 %	56	2.2 %
Diptera	204	39.0%	171	33.5%	454	30.4 %	829	32.8 %
Heteroptera	-	0.0%	-	0.0%	89	6.0 %	89	3.5 %
Homoptera	138	26.4%	135	26.4%	528	35.4 %	801	31.7 %
Hymenoptera	21	4.0%	42	8.2%	80	5.4 %	143	5.7 %
Isoptera	-	0.0%	-	0.0%	2	0.1 %	2	0.1 %
Lepidoptera	40	7.6%	35	6.8%	3	0.2 %	78	3.1 %
Neuroptera	6	1.1%	3	0.6%	2	0.1 %	11	0.4 %
Unidentified	93	17.8%	95	18.6%	263	17.6%	451	17.9 %

Table 2. Comparison of models that looked at hunting effort. The 'order' resembles the taxonomic insect orders, 'size' is the size category of a prey and 'gecko species' is the focal species. d.f are the degrees of freedom, AICc is the corrected Aikake's Information Criterion, Δ is the difference in AIC_C score in comparison with the best model and W_i is the model weight (selection probability).

Parameters	*d.f.*	AIC_C	Δ	W_i
order + size	16	2339.1	0.0	0.74
order + size + gecko species	17	2341.2	2.1	0.26
order	11	2372.4	33.3	0.00
order + gecko species	12	2375.5	35.3	0.00
size	9	2405.8	66.7	0.00
size + gecko species	10	2407.8	68.7	0.00
null	4	2588.9	270.8	0.00
gecko species	5	2601.8	262.6	0.00

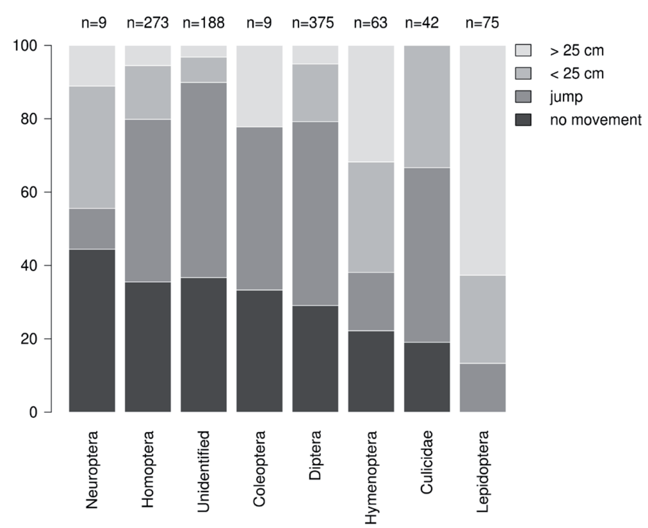

Figure 1. The hunting effort is displayed as the percentage in each class per insect order. For insect orders on the right of the graph the effort to catch a prey is lowest for insect orders on the left the effort is highest. N is the number of observed attacks of prey within each order.

Figure 2. The hunting effort is displayed as the percentage in each class per insect size. For small insects on the right of the graph the effort to catch a prey is lowest for large insects on the left the effort is highest. N is the number of attacks in each size class.

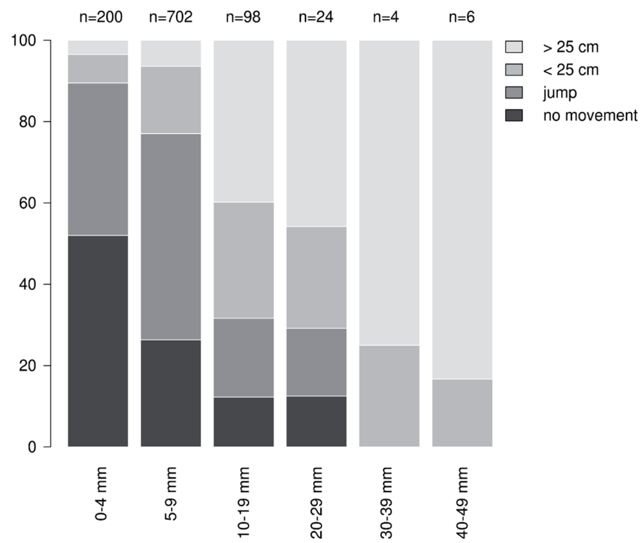

Table 3. Parameter estimates for the best model. The categories Coleoptera (insect order) and 0-4mm (prey size) are included in the threshold coefficients. In the threshold coefficients 0 represents the category with the lowest hunting effort and 3 the category with the highest effort.

Coefficients	Estimate (SE)
Threshold coefficients	
0|1	0.09 (0.70)
1|2	2.31 (0.70)
2|3	3.83 (0.71)
insect orders	
Diptera	-0.02 (0.68)
Unidentified	-0.06 (0.69)
Homoptera	0.09 (0.69)
Neuroptera	0.23 (1.02)
Culicidae	0.75 (0.73)
Hymenoptera	1.30 (0.76)
Lepidoptera	3.25 (0.78)
size	
5-9mm	0.99 (0.18)
10-19mm	1.21 (0.36)
20-29mm	0.74 (0.55)
30-39mm	3.17 (1.24)
40mm or greater	4.20 (1.18)

(26.4%) (Table 1). The insects (n=1492) caught on the sticky traps belonged to eight orders of which six also occurred in the diets of *H. frenatus* and *H. platyurus*. The Chi squared test did not show any significant differences in diets between the two gecko species ($X^2 = 13.65$, *d.f.* = 7, *p*-value = 0.06). The Chi squared test that compared diet versus the insects that were available showed that there was a significant difference ($X^2 = 96.25$, *d.f.* = 7, *p*-value < 0.001). Both species appeared to prefer Lepidoptera (a.r = 5.3), Diptera (a.r = 3.4), Culicidae (a.r = 2.8), Neuroptera (a.r = 2.6), Hymenoptera (a.r = 2.2) and avoided Heteroptera (a.r = -4.6) and Coleoptera (a.r = -3.4). All other insect orders did not differ in the ratio in which they appeared in the diet versus the sticky trap.

The CLMMs showed that insect order and insect size were important factors in the effort that was put into an attack sequence (Table 2). For larger prey the attack distance was highest (Figure 1) as well as for Lepidoptera, Hymenoptera and Culicidae respectively (Figure 2, Table 3). Insects of the order Lepidoptera and Hymenoptera were generally larger than expected, while Culicidae were generally smaller but did not differ from the expected values ($X^2 = 982.55$, *d.f.* = 35, *p*-value < 0.001, see Table 4 for the adjusted residuals).

Table 4. Adjusted residuals for the comparison of size for different insect orders. When values are higher than 2 or lower -2 the size is larger or smaller than the expected size.

Size	Coleoptera	Culicidae	Diptera	Homoptera	Hymeno-ptera	Lepido-ptera	Neuro-ptera	Unidentified
0-4mm	-1.48	1.15	-10.41	7.89	-4.01	-4.40	-1.48	9.52
5-9mm	1.36	0.50	13.50	-1.87	-5.78	-10.76	-2.23	-3.91
10-19mm	0.17	-1.60	-4.76	-5.51	8.89	16.74	4.74	-4.90
20-29mm	-0.46	-1.02	-3.74	-2.97	4.78	11.35	1.76	-2.34
30-39mm	-0.18	-0.41	-1.51	-1.20	3.68	3.30	-0.18	-0.94
40mm or greater	-0.23	-0.51	-1.85	-1.47	9.64	-0.69	-0.23	-1.16

Discussion

Our results clearly displayed that both focal species do not randomly select their prey. Prey items were generally larger than expected from a random selection. Lepidoptera tended to be preferred by *H. frenatus* and *H. platyurus*. There appeared to be a disfavour for Heteroptera and Coleoptera. Both gecko species showed a slight preference towards Culicidae which was reflected in both the prey choice and attack distance. Lepidoptera and Culicidae are generally much softer than Heteroptera and Coleoptera (Hackman, 1974; Evans and Sanson, 2005). Softer insects are easier to digest and apart from size this might have influenced a preference towards these insects, especially considering the fact that Culicidae are not specifically large in comparison to the other insects that were encountered. The optimal foraging theory suggests that an individual of any species aims to retrieve most energy while investing the least energy (Stephens and Krebs, 1986). Some basic predictions based on this theory are that an individual would put more energy in hunting a large prey in comparison to a small prey (Stephens and Krebs, 1986). In addition an individual would prefer an easy digestible prey over a hard to digest prey because this will cost less energy (Stephens and Krebs, 1986). Many insectivorous vertebrate species are known to choose their prey based on cuticle thickness or 'hardness' (Fisher and Dickman, 1993; Weterings and Umponstira, 2014). Our results suggest that *H. frenatus* and *H. platyurus* both forage optimally.

Previous studies regarding the diet of *H. frenatus* showed varying results. Tyler (1961) reported that the diet of the latter was mainly comprised of Diptera, Lepidoptera and Coleoptera while Diaz-Perez et al. (2012) reported a diet that comprised of Hemiptera, Hymenoptera and Coleoptera. These large differences in diets might be explained by the availability of prey which can show strong spatial and temporal variation. Also in our study area we can see large temporal variation in insect abundance. For example during the onset of the rainy season, termite alates (Isoptera) and ant alates (Hymenoptera: Formicidae) swarm in large numbers when the first rain has fallen after a long period of drought (Lepage and Darlington, 2000). House geckos can then be observed feeding ferociously on the alates (personal observations). This opportunistic feeding on alates has also been observed for other lizards in Thailand (Schaedla, 2004).

Previous studies have suggested that mosquito predation by *H. frenatus* is of considerable importance (Tyler, 1961; Canyon and Hii, 1997; Newbery and Jones, 2007). Based on our observations we can conclude that house geckos show potential as a mosquito control measure. Nevertheless, this is very dependent on the composition of the overall in-home prey community.

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References

Agresti, A. (2007): An Introduction to Categorical Data Analysis, 2nd Edition. John Wiley & Sons, Inc, Hoboken, New Jersey.

Anderson, D.R. (2008): Model Based Inference in the Life Sciences: a Primer on Evidence, 1st edition. Springer, New York.

Berryman, A.A. (1999): The Theoretical Foundations of Biological Control. In: Theoretical Approaches to Biological Control, p. 3–21. Hawkins, B.A., Cornell, H.V., Ed. Cambridge University Press, Cambridge.

Bockemuhl, J., Moldenhauer, D. (1970): The importance of house lizards (Geckonidae) for the epidemiology of salmonellosis in South East Asia. Zeitschrift fur Tropenmedizin und Parasitologie **23**: 307–312.

Callaway, Z., Thomas, A., Melrose, W., Buttner, P., Speare, R. (2011): Salmonella Virchow and Salmonella Weltevreden in a Random Survey of the Asian House Gecko, *Hemidactylus frenatus*, in Houses in Northern Australia. Vector-Borne and Zoonotic Diseases **11**: 621–625.

Canyon, D.V., Hii, J.L.K. (1997): The gecko: an environmentally friendly biological agent for mosquito control. Medical and Veterinary Entomology **11**: 319–323.

Christensen, R.H.B. (2012): A Tutorial on fitting Cumulative Link Mixed Models with the Ordinal Package. Pages 1–9.

Diaz Perez, J.A., Davila Suarez, J.A., Alvarez Garcia, D.M., Sampedro Marin, A.C. (2012): Dieta de *Hemidactylus frenatus* (Sauria: Gekkonidae) en un area urbana de la region Caribe Colombiana. Acta Zoologica Mexicana **28**: 613–616.

Evans, A.R., Sanson, G.D. (2005): Biomechanical properties of insects in relation to insectivory: cuticle thickness as an indicator of insect “hardness” and “intractability”. Australian Journal of Zoology **53**: 9-19.

Fisher, D.O., Dickman, C.R. (1993): Diets of insectivorous marsupials in arid Australia: selection for prey type, size or hardness? Journal of Arid Environments **25**: 397–410.

Hackman, R.H. (1974): Chemistry of the Insect Cuticle. In: The Physiology of Insecta, Volume 6. p. 216–270. Rockstein, M., Ed. Academic Press Inc., New York.

Hoskin, C.J. (2011): The invasion and potential impact of the Asian House Gecko (*Hemidactylus frenatus*) in Australia. Austral Ecology **36**: 240–251.

Lepage, M., Darlington, J.P.E.C. (2000): Population Dynamics of Termites. In: Termites: Evolution, Sociality, Symbioses, Ecology, Part 2, p. 333–361. Abe, T., Bignell, D.E., Higashi, M., Ed. Kluwer Academic Publishers, Dordrecht, NL.

Newbery, B., Jones, D.N. (2007): Presence of Asian House Gecko *Hemidactylus frenatus* across an urban gradient in Brisbane: influence of habitat and potential for impact on native gecko species. Royal Zoological Society of New South Wales Forum Proceedings, 59–65

R Development Core Team. (2013): R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

RStudio. (2012): RStudio: Integrated development environment for R (Version 0n.96.331). Boston, MA.

Schaedla, W.H. (2004): Anomalous (?) nocturnal feeding by the agamid lizard *Calotes emma* in Northeastern Thailand. Asiatic Herpetological Research **10**: 295–297.

Stephens, D.W., Krebs, J.R. (1986): Foraging Theory. Page 247, 1st edition. Princeton University Press, Princeton, NJ.

Strickman, D., Sithiprasasna, R., Southard, D. (1997): Bionomics of the spider, *Crosspriza lyoni* (Araneae, Pholcidae), a predator of dengue vector in Thailand. Journal of Arachnology **25**: 194–201.

Tyler, M.J. (1961): On the diet and feeding habits of *Hemidactylus frenatus* (Dumeril and Bibron) (Reptilia; Gekkonidae) at Rangoon, Burma. The Transactions of the Royal Society of South Australia. **84**: 45–49.

Vanderduys, E.P., Kutt, A.S. (2012): Is the Asian house gecko, *Hemidactylus frenatus*, really a threat to Australia’s biodiversity? Australian Journal of Zoology **60**: 361–367.

Weterings, R., Umponstira, C. (2014): Bodyweight-forearm ratio, cranial morphology and call frequency relate to prey selection in insectivorous bats. Electronic Journal of Biology **10**: 21–27.

Weterings, R., Umponstira, C., Buckley, H.L. (2014): Predation on mosquitoes by common Southeast Asian house-dwelling jumping spiders (Salticidae). Arachnology **16**: 122–127.

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