Foraging Patterns of the Desert Horned Lizard, *Phrynosoma platyrhinos*

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Abstract

Phrynosoma platyrhinos (Desert Horned Lizard) is a good model animal for studying the ecology of food acquisition. The daily patterns of activity of the lizard can be observed, the spatiotemporal patterns of distribution and abundance of its principal prey, ants can be measured, and the lizard's prey choice also can be accurately measured. A testable initial hypothesis is that the spatiotemporal availability of ants would be closely matched with prey choice by *P. platyrhinos.* Radio tracking of lizards in the Great Basin Desert Scrub enabled frequent documentation of lizard mesohabitat choice and also permitted palpation of lizards to check for fecal pellets (filled with ant exoskeletons) that, if present, could be expressed and collected easily, thereby providing samples for diet analysis. Moreover, fluorescent powder tracking revealed microhabitat and nanohabitat use by the lizards, and permitted researchers to determine if foraging pathways included visits to known, mapped ant colonies. Pitfall traps enabled comparisons among mesohabitats and microhabitats for spatial patterns of ant abundance. Ant colonies could be found via visual searching for only a few of the 15 ant species, whereas pitfall traps revealed strong spatial patterns of ant abundance for most of the ant species. *Pogonomyrmex spp* colonies were the most commonly found colony in all three mesohabitats, and *Pogonomyrmex spp* were among the most abundant ants on the plot, as determined by pit trapping and standardized visual surveys. *Pogonomyrmex* numerically comprised 60.5% of prey items in the fecal pellets of *P. platyrhinos*; the preponderance of this ant taxon in the diet significantly exceeded the apparent availability as determined by pitfall trapping. We infer from the diet data that *P. platyrhinos* focused a large part of their feeding efforts near the visually obvious colony entrances of *Pogonomyrex spp.* (and *F. densiventris*). Moreover, we inferred from powder tracking data that each day *P. platyrhinos* used 1) trap line foraging mode when environmental temperatures permitted lizards to move about in the open to visit colonies, and 2) ambush predation when temperatures limited the lizards to being rather sedentary in the shady retreats of perennial plants. By using both types of food acquisition modes *P. platyrhinos* are able to eat many ants daily.

Introduction

One of the challenges in ecological research is observing the distribution and abundance of predator versus prey. It can be very difficult to determine the foraging patterns of predators on prey. The Desert Horned Lizard *Phrynosoma platyrhinos*, however, is an exemplary model predator for vertebrate ecology, as its foraging patterns on ants can be easily observed. *Phrynosoma platyrhinos* is distributed throughout lower elevation deserts of California and Nevada, but the species' range extends throughout much of the Great Basin Desert Scrub, and reaches as far north as the Alvord Basin of southeastern Oregon, where we chose to study this lizard and its prey.
The Alvord Basin is an excellent location to study the basic ecology of lizard populations. This arid basin receives only about 25 cm of precipitation per year (ODFW 2006) because it is rimmed by mountains and plateaus, hence orographic rainfall occurs on the west side of the Steens Mountain range, thus causing a "rain shadow" of warm dry air over the Alvord Basin, thereby resulting in desert scrub ecosystems in the the basin. The desert scrub habitats of the Alvord Basin are simple enough to perform viable community studies.

Throughout its life, *P. platyrhinos* must face biotic and abiotic challenges when foraging. Being ectothermic, the body temperatures of *P. platyrhinos* are dependent on and are limited by the intensity of solar radiation and substratum temperatures (Levenhagen, 2004). As an ant-eating specialist, *P. platyrhinos* (Munger, 1984) may have a significant ecological role in the Alvord Basin on the ant communities in all three major mesohabitats—sandy flats, dunes and hardpan—in the basin. Opinions about the types of food acquisition modes used by *P. platyrhinos* range from trap-line foraging to ambush predation (Huey & Pianka 1981). Trap line foragers move from colony to colony, feeding on ants until they become full or until the colony becomes inactive; the predator then moves to the next colony or quits. An ambush predator waits for prey to approach, then the predator makes a short lunge or dash to capture the prey. The basic null hypothesis to begin with for this study is that *P. platyrhinos* will consume ant species in proportions similar to their relative patterns of distribution and abundance.

Methods

Ant Plots: Three examples of each mesohabitat - dune, sandy flats, and hardpan - were divided into 16-5x5m squares in two rows and numbered. The substrate was searched, then the vegetation. Scribing involved recording the plants, A (*Artemisia tridentata,* or ARTR), S (*Sarcobatus vermiculatus*, or SAVE), O (Other vegetation), and OP (Open), in correlation with the ants (*Pogonomyrmex spp, Crematogaster mormonum, Forelius mccooki, Conomyrma insana, Formica densiventris, Camponotus hyatti, Myrmecocystus pyramicus*). Ant activity at colony entrances were observed via standardized methods.

Pitfall Traps: Plastic pit trap vials were placed, in pairs, in the ground until the lip of the vial was flush with the surface. The vials were two and a half inches in diameter by three and a half inches deep. Location of the pit trap burials were based on the dominant vegetation of the area. Sandy flats included traps in the open, under large SAVE's, and under small, medium, and large ARTR's. Hard pan pit traps were located in the open. Dune traps were located in the open and under large SAVE's. The pit traps were left open, 50cm apart with a large flag between the traps. The traps under vegetation, at least 50cm apart and in N-S orientation, and in the open were filled with propylene glycol (antifreeze) to one third full, and placed into the ground, left for precisely one week. After collection, identification was written on the lid. In the lab, the contents of the pit traps were analyzed; invertebrates identified and counted using dissecting microscopes. Arthropods were sorted and identified at the order level, but ants were identified to the species level.

Radio Telemetry: Eighteen *P. platyrhinos* were chosen for radio telemetry based on size, sex, and mesohabitat of capture. An equal number of medium to large sized male and female lizards were used. Lizards marked for radio telemetry were, after processing, fitted with a small 150 MHz radio transmitter of a set frequency. The transmitter, 1.5x .5x .4cm with a 15.3cm whip antenna, was attached to the lizards' backs with super glue. The lizard was released at the coordinates of original sighting. At determined times, two antennae attached to radio receivers, with the appropriate frequencies entered, beeped when aimed in the direction of the transmitter, and increased in volume. A small set of frequency bars on the receiver's screen grew as the tracker neared. Once found and caught, all pertinent information was recorded. If possible, a fecal pellet was expressed. A circle of 5m radius was then searched for ant colonies in the vicinity of the lizard, and all information was recorded, and a piece of white flagging tape was scribed with the necessary identification information and was tied to the nearest tall plant, attempting for at least 25 way points on each lizard. Time constraints and egg-laying of some females lowered or raised the number of certain individuals' way points, so a fifth search time at 8:30 was added the last week of the study.

Powder Tracking: Ten 10 lizards had rabbit fur glued to their stomachs, and fluorescent powder heavily applied to the fur twice a day during radio tracking. The path left behind from the released lizards would then be found at night using the radio tracking coordinates, and followed using a battery powered black light by a team of two. At every change in direction, a numbered flag was placed. The following day, 4 of us would use 2 stationary 100m measuring tapes along two sides of the flagged path, one stretched in between that would be moved in 5m increments, and a 5m pull tape to map the path on a grid.

Mapping Ant Colonies within 5m of Powder Tracks: Any ant colony within 5m of the path of a powder tracked lizard was mapped on a gridded circle showing a radius of 5m, with all proportionate vegetation, the path, and any other pertinent information.

GPS Instructions: Trimble GeoExplorer 3® Global Positioning System (GPS) units were utilized to obtain and store GPS positions for radio tracked *P. platyrhinos*. GPS positions were acquired and logged during every radio tracking session for each lizard. Data was stored in GPS units using a generic data dictionary setting, and positions were logged as point features. GPS positions were transferred from GPS units to computers for analysis using Pathfinder® Office (version 2.9) software. GPS locations were plotted on latitude/longitude grids individually and combined using the World Geographic Survey 1984 (WGS 1984) coordinate system to determine the movements and home ranges of *P. platyrhinos*.

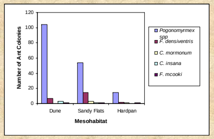

Figure 1 Number of ant colony sightings on plot for each of the five main species found in each mesohabitats.

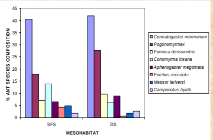

Figure 2 The proportion of different ant species in large saves in sandy flat and dune mesohabitats.

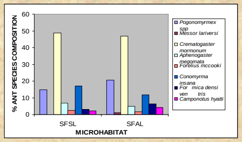

Figure 3 The proportion of different ant species in sandy flat mesohabitat in large *Artemesia tridentata* and *Sarcobatus vermiculatus* microhabitat.

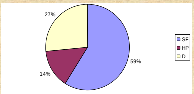

Figure 4 The proportion of lizard observations in the sandy flat, dune and hardpan mesohabitats

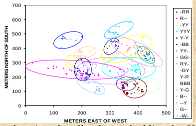

Figure 5 Plot coordinate locations for all radio tracked lizards. Home ranges are circled in corresponding colors.

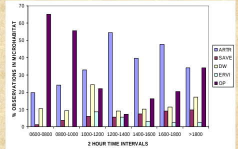

Figure 6 The proportion of lizard observations in various microhabitats at 2 hour time intervals from 0600 to >1800.

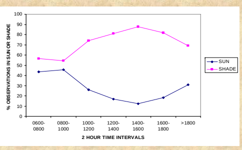

Figure 7 The proportions of radio tracked lizard observations in sun versus shade.

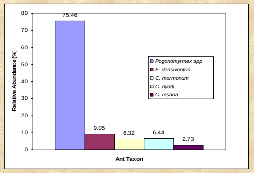

Figure 8 Proportions of ant species found in fecal pellets taken from *P. platyrhinos*. radio tracked in the sandy flat mesohabitat.

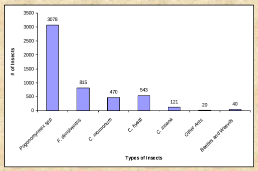

Figure 9 Abundance of prey items found in *P. platyrhinos* fecal pellets.

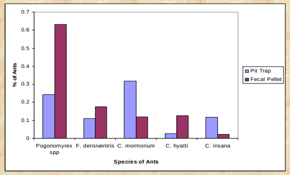

Figure 10 Percentage of ant species found in pit traps and fecal pellets

Results

According to ant colony sightings, *Pogonomyrmex spp* colonies were the most frequent colony in all three mesohabitats. Sandy flats had the highest species diversity of all three mesohabitats (Figure 2).

Crematogaster mormonum comprised the largest proportion of ant species in both sandy flat and dune mesohabitats, mostly in large *Sarcobatus vermiculatus* microhabitats. The second most abundant ants were *Pogonomyrmex spp*. *Pogonomyrmex spp* was found in higher proportions in dune mesohabitat *S. vermiculatus* relative to sandy flat mesohabitat. *Conomyrma insana* was found in larger proportions in sandy flat mesohabitat (Figure 9).

C. mormonum exhibited the highest percent composition in both the sandy flat large ARTR and the SAVE. Both plant species exhibited similar percent patterns of ant species composition. Statistcal analysis indicated that p>.05 for *Pogonomyrmex spp, C. insana, C. mormonum, Camponotus hyatti, Formica densiventris* (Figure 10).

Radio tracked lizards were observed more frequently in sandy flat mesohabitats compared to hardpan and dune mesohabitats. More than half of lizard observations were made in the sandy flats (59%), and nearly twice as many lizard observations were on dunes compared to hardpans (Figure 11).

The home range for radio tracked lizards had an average radius of approximately 100 meters. Radio tracked lizard's home ranges overlapped extensively (Figure 12).

Radio tracked lizards occupied ARTR more than any other vegetative microhabitat during every 2 hour time period. The proportion of lizards observed in ARTR progressed from 0600 to 1400, and it peaked at 1200-1400. During the afternoon (1400->1800), the proportion of observed lizards occupying ARTR decreased (Figure 14).

Radio tracked *P. platyrhinos* were found more frequently in shade at every hour interval compared to sun. The proportion of lizard observations in the sun peaked in the morning and late afternoon and was lowest at 1400-1600. The proportion of lizard observations in the shade showed low proportions in the morning and late afternoon, and peaked at 1400-1600 (Figure 16).

In the sandy flat mesohabitat, *Pogonomyrmex spp* made up 75.5% of ants found in fecal pellets, followed by *F. densiventris, C. hyatti., C. mormonum.,* and *C. insana* (Figure 19).*Pogonomyrmex spp* made up 60.5% of prey items found in the pellets. The next most abundant prey items were *F. densiventris*, followed by *C. hyatti*, *C. mormonum., C. insana,* beetles and weevils, and other ants (Figure 20).

C.mormonum was the most common ant species found in the pit traps and the third most common found in the *P. platyrhinos* fecal pellets. *Pogonomyrmex spp* was the most common ant species found in the fecal pellets and the second most common ant species found in the pit traps. *F. densiventris* was the third most common ant species in the fecal pellets. The percentage of *C. insana* in the pit traps was greater than in the fecal pellets. The percentage of *C. hyatti* found in the fecal pellets was greater than in the pit traps (Figure 21).

Discussion

Data do not support the hypothesis that the diet of *P. platyrhinos* simply reflects the relative abundance of ants. Home range use by *P. platyrhinos* is greatest in the sandy flats (Figure 4). The relative abundances of ants eaten (as seen in the fecal pellets) and ants available (as seen from the pit traps, Figure 10) reveals a significant difference between prey availability to *P. platyrhinos* and prey use by *P. platyhinos* in the sandy flat mesohabitat. *P. platyrhinos* eat much higher proportions of *Pogonomyrex spp.* than are available throughout the sandy flats. We infer from these data that *P. platyrhinos* prefer *Pogonomyrex spp.* over other ants species that are more abundant in the sandy flat mesohabitat. For example the pit trap data (Figure 10) reveal that *C. mormonum* may be the most abundant ants in the sandy flats. These ants, however, were only the fourth-most abundant ant species in the fecal pellets (Figures 8, 10). Hence, we infer from these data that *P. platyrhinos* focus a large part of their feeding efforts on colonies, more specifically, *Pogonomyrex spp.* and *F. densiventris* colonies, which happen to be the most visually obvious colonies on plot (Figure 1). Support for this inference comes from the powder tracking maps, which show *P. platyrhinos* making stops at *Pogonomyrex spp.* and *F. densiventris* colonies. The inference about *P. platyrhinos* foraging is also supported by the fact that *Pogonomyrex spp.* and *F. densiventris* were the two most abundant ant species found in the fecal pellets (Figures 8,9,10). These colony visits occurred during morning and evening hours when the temperatures were cool enough (compared to the hot mid-day) for lizards to move about in the open (Figure 6). This type of foraging is likely to be the classic "trap-lining" (as described for other *Phrynosoma*) wherein the predator moves among ant colonies to feed.

Some possible explanations for prey preferences of *P. platyrhinos* have been suggested (Rissing 1981, Whitford and Bryant 1979). For example, horned lizards are relatively tolerant to hymenopteran stings and some ant species are less aggressive than others and thus may be eaten more (Rissing 1981). Ant species that tend to be individual foragers, such as *Pogonomyrmex desertorum* may be preferred prey over column foragers (Whitford and Bryant 1979).

The fecal pellet data show that *P. platyrhinos* consumes significant amounts of *C. mormonum* and *C. hyatti* (Figures 8 and 9), which, according to pitfall data, are closely associated with the dominant perennial plants (ARTR and SAVE, Figures 2 and 3). This is significant because the data from radio telemetry (Figures 6 and 7) show that a large portion of midday spent by P. platyrhinos in the shade of ARTRs. Although remaining in the shade of ARTRs during the heat of the day is most likely for thermoregulation, it can also be assumed that *P. platyrhinos* are feeding on *C. mormonum* and *C. hyatti* during these times. This idea would be consistent with ambush predation proposed for *P. platyrhinos.*

All animals, including *P. platyrhinos,* occupy habitat based on reproductive sites, food availability and optimal thermal conditions (Newbold, 2005). We infer from out data that *P. platyrhinos* use both trap-line foraging and ambush predation each day. While most of the ant consumption comes from ant colonies during the active parts of the day, it makes sense to forage on ants that are available during times of low activity in the cover of shaded vegetation. Feeding during the midday helps maximize food intake (adding as much as 20% of the diet, assuming all *C. mormonum* and *C. hyatti* are eaten under plants during the heat of the day). Over the course of the lizard's activity season, getting a significant amount of alternative prey via ambushing under plants may reduce some of the predation pressure on those two species of ants that are apparently trap-lined in the open microhabitat. Hence, harvesting the maximum amount of prey, while maximizing the probability the prey population will maintain itself as a food resource (Slobodkin, 1961) can be considered a sort of "optimal predation strategy". By using both types of food acquisition modes, *P. platyrhinos* may be able to maximize rate of food intake on its home range throughout the activity season.

Future research should continue to collect fecal pellets of radio-tracked and powder-tracked lizards because this combination of field methods permits one to know exactly where the lizards have been and what they have been eating. Facility with ant species identification is essential for identifying ant colonies and individual ants in the field. It also may be valuable to take a closer look into behavioral patterns *C. mormonum* and *C. hyatti.* How much time these ants spend on the ground versus in the vegetation is still unknown, and this could have a direct effect on their prevalence in the diet of *P. platyrhinos.*

Conclusion

Phyrnosoma platyrhinos did not display any single food acquisition mode, but may alternate between ambush predation and trap-line foraging. According to powder tracking, the lizards moved from colony-to-colony, which was more of a trap-line foraging strategy. Characteristic of ambush predators, however, *P. platytrhinos* ate mobile prey and possessed camouflage and secretive behavior (Huey and Pianka, 1981). Hence, ants and other mobile arthropods are eaten by *P. platyrhinos* when the lizards are sedentary under shrubs (Figures 8, 9, 10; RAA, personal observations). This excellent model system for study of food acquisition should provide a rich panoply of research opportunities for future students enrolling in Ecological Methods and Research in Reptile Ecology.

Acknowledgments

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