05-12 Yr. 2

Why Did The Gila Monster Cross The Road?
Basic Research at Tonto National Monument

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Introduction

Gila monsters (*Heloderma suspectum*) are a flagship species of the Sonoran Desert. They are one of the more easily recognizable and charismatic reptiles living in the southwestern National Parks. In spite of this, these large lizards are rarely seen and poorly understood. Several studies have estimated that they may spend up to 95% of their active season underground (Beck 1990, 2005). Tonto National Monument (Tonto) in central Arizona is unusual in that gila monsters may be found with some predictability during the spring, especially crossing the main road near the visitor center. A program to identify individual gila monsters based on differences in dorsal pattern from photographs was begun in1994, and we have built on that research.

Our two-year study had the following objectives: 1) Initiate long-term mark-recapture studies with permanent identification of individual gila monsters using PIT-tagging; 2) continue photographing the dorsal patterns of animals and compare these and previous photos to PIT-tagged individuals to assess the efficacy of the photographic identification method; 3) surgically implant radio-transmitters in up to five adult gila monsters to assess movement patterns and habitats used, and provide basic ecological information; and 4) provide interpretive research sessions for visitors.

Methods

Capture and PIT-tagging. We searched for gila monsters in Cave Wash, the park housing, and the pumphouse area intensively in the spring (March-April) and monsoon season (July-August). Gila monsters were also captured opportunistically by park staff. Gila monsters were captured by hand or using reptile tongs, and were weighed and measured (snout-vent and tail length). We attempted to sex gila monsters using visual observation of head size and hemipene extrusion (e.g. by injecting saline into the cloaca; Dale DeNardo, pers. comm.); however, some animals could not be not accurately sexed.

For permanent identification, we gave each gila monster a unique 11-mm passive integrated transponder (PIT) tag (Fagerstone and Johns 1987). Using field-sterile techniques, the tag was injected into the muscle of the upper back leg or pelvic area of each animal (Denardo, unpubl. method). Every time a gila monster was captured we scanned it with a tag scanner to verify its identity. Each capture and release of a gila monster was used as an interpretive opportunity to explain to visitors the project's objectives, funding source, and results, as well as biology and behavior.

Photograph Comparisons. Other authors have established that snakes exhibit and retain unique individual color patterns over the course of their lives, e.g. in tail bands (Moon et al. 2004); and dorsal blotch patterns (Graham 1991; Nowak, unpubl. data). When captured initially, we photographed the back of each gila monster using digital or 35-mm cameras. Photographs were taken from the top at a distance of 3 feet or less, so the animal filled the photo frame. Photo records were printed and were archived in a notebook at the Tonto Resource Management office. Additional digital images of gila monsters taken at Tonto from 1994-1997 (Don Swann, unpubl. data) were printed and added to this notebook. Each new animal captured was compared to existing photographs using ocular estimation to determine if it had been previously caught.

Telemetry. Radio-transmitters were implanted in nine male or non-gravid female adult gila monsters. Transmitters weighed 13-20 grams (no more than 5% of each animal's body weight). Surgeries occurred in a sterile laboratory at Arizona State University. Methods for preparation and surgery followed those of Hardy and Greene (1999) for rattlesnakes and modified by Dale Denardo for gila monsters. Transmitter implantation occurred in the coelomic (gut) cavity of the lizards with the antenna wire coiled subcutaneously toward the head. After surgery, we gave the lizards an injection of saline equal to 5% of the body weight to ensure replacement of any fluids lost during surgery. There was a 2-6 hour post-operative recovery period, after which the gila monsters were returned to their original capture site. We determined their positions using telemetry at least once a week during the active period and once a month during the hibernation season. When an animal was located, we recorded its position in UTM Zone 12 NAD 27, time, date, weather conditions, microhabitat association, behavior, and whether a visual sighting was obtained. Movement patterns were mapped using ArcView GIS 3.3 (ESRI 2002) and analyzed using the ArcView extensions Animal Movement (Hooge et al. 1999) and XTools (DeLaune 2003). Activity or home ranges were estimated using the minimum convex polygon method. A geographic information system database of telemetry locations and capture data will be provided to Tonto NM.

Results and Discussion

Captures. In 2004, we captured nine individual gila monsters, and one of these animals was subsequently seen five additional times. In 2005, we captured eight new gila monsters, and recaptured two animals PIT-tagged in 2004. Thus, we found a total of 17 individual gila monsters at Tonto during two years of research.

Sexing gila monsters has proven to be difficult, especially in very young animals. We estimate that we have captured nine adult males, three adult females, one subadult female, and four juveniles or subadults of unknown sex. The proportion of adult males to females at first detection is 3:1. This result is contrary to that found for 206 specimens in the University of Arizona museum collection, where the sex ratio approached 1:1 (Beck 2005). Our detections may approach a 1:1 ratio with additional years of field research.

Nine adult gila monsters were implanted with radio-transmitters; six in 2004 and three in 2005. Of these, six were likely males and three were females. We obtained a total of 255 locations of these animals in 2004 and 222 locations in 2005. One gila monster disappeared in June 2004 and we found his crushed transmitter in 2005 near his last known location in July 2005. We suspect he was killed by a large carnivore based on the damage to the transmitter.

Photograph comparisons. Using photographs taken previously, we were able to document the recapture of at least three gila monsters. The first, a telemetered male, was initially captured by researcher Don Swann (currently of Saguaro National Park) as a small adult or subadult in May 1995. The dorsal photograph taken at that time matches closely a photograph taken on April 24, 2004 (Figure 1a and b). This result is significant because it shows the potential efficacy of using non-invasive photography as a long-term mark-recapture method. As well, it gives us a longevity record of at least 12 years for a gila monster in the wild. Other gila monsters are known to have lived at least 17 years in the wild and up to 37 years in captivity (Beck 2005).

The second photographic "recapture" was a telemetered male that was captured several times in the park housing area before the present research started. He was photographed first as a small adult or subadult in 2002 and in April 2004 he was captured as an adult.

The third animal, a juvenile subsequently named "Star" by park staff, was originally captured in 2004 before PIT tagging efforts commenced. This animal was sighted at least eight times in different locations between March 20 and July 4 2004, and once in April 2005, all between the visitor center and the park housing.

Activity Periods. In 2004, gila monsters apparently began emerging from hibernation at Tonto in late March. In 2005, telemetered gila monsters began moving from hibernacula during the first two weeks in March. In both years, the major dispersal and/or activity period appeared to be the first two weeks in April, with a peak of detections between April 7 and 10. In 2004, three gila monsters were detected on the same day in early April crossing the main road in a single location just north of the visitor center parking lot and south of the pumphouse: two animals (a juvenile and an adult) were captured under the same bush less than a half-hour apart.

In both years, a few additional animals were captured during the months of March and May, and one each was captured in late June and early July. No new animals were seen during the summer monsoon period or the fall in either year. One possibly new untelemetered gila monster (possibly a male; Davis and Repp, pers. comm.) was seen sharing a hibernaculum with a telemetered male in December 2005.

Most detections of moving telemetered animals occurred in April and May, with a second peak in during the monsoon season from August to mid-September. This bimodal seasonal activity pattern has been well-established for other Sonoran desert gila monster populations (Beck 2005). As expected, these lizards were frequently underground: we did not obtain a visual fix in 69% (2005) to 73% (2004) of the locations of the telemetered animals. Telemetered gila monsters were not seen above the ground surface in July or from October through January. They were primarily nocturnal in July and August, consistent with other populations (Beck 2005; Davis, unpubl. data; Repp, unpubl. data.). In both years, telemetered gila monsters continued to move sporadically between retreat sites until early December, when the hibernation period began and movements ceased.

Habitat Use and Shelter Sites. Visual estimation based on overlaying telemetered gila monster range maps on a topographic coverage of the park seems to indicate that telemetered gila monsters used vegetation types in proportion to their occurrence on the monument, with the exception of forested riparian areas. However, more detailed habitat use analyses using a vegetation map of the park are needed. Within this gross habitat use, microhabitats used were primarily dry washes and rocky outcrops (Figures 2 and 3). Shelter sites used during the summer were typically gila monster-excavated burrows under boulders or small outcrops; while hibernation sites tended to be in alcoves or burrows under larger outcrops. These sites are consistent with those seen by other researchers (Beck 2005; Davis, unpubl. data; Repp, unpubl. data).

Movement Patterns and Range Size. The number of days between locations of gila monsters (i.e. the inter-tracking interval) averaged 4.3 days in 2004 and 8.3 days in 2005 (telemetered gila monster Channel 52 was excluded from this analysis because he was prone to disappearing for long time periods). The average distance moved during tracking intervals for the active season of March to mid-December was 185.5 m in 2004 and 165.9 m in 2005 (Table 1). The doubling of the inter-tracking interval in 2005 compared to 2004 did not result in an increase in the average distance moved between locations. It was not uncommon for individuals, especially males, to move 200-400 meters between inter-tracking intervals in the spring and monsoon seasons. It appears that females made smaller movements during inter-tracking intervals than males in both years; however we do not have enough females to permit statistically robust comparisons.

Activity ranges as estimated by the minimum convex polygon method are shown in Figure 2. Telemetered gila monsters had larger activity (home) ranges in 2004 than in 2005: average activity range size was 36.2 ha in 2004 and 22.6 ha in 2005 (Table 2). This apparent difference may be due more to fewer locations of telemetered animals in 2005 compared to those in 2004. However, given that the average distance moved per day is also smaller in 2005, the difference may be due to environmental variables, such as increased annual rainfall in 2005 compared to 2004 (Western Regional Climate Center, unpubl. data). Increased rainfall may have resulted in increased abundance of prey species (rabbits, rodents, and birds), resulting in decreasing movement distances required to find prey. In both years, males tended to have larger activity ranges than females, a pattern also generally noted by Beck (2005) and seen by Repp (unpubl. data).

A striking pattern for animals tracked over the two-year study period is the overlap of activity ranges between years (Figure 2). Not only did individual animals reuse the same general geographic areas, they also re-used favored shelter sites, both during the active season and in hibernation. These patterns are consistent with those seen for other gila monster populations (Beck 2005; Davis, unpubl. data; Repp, unpubl. data).

Prey and Water Use. We have observed gila monsters with hair around their mouths, and we assume that they have been eating young cottontail rabbits (Davis, unpubl. data). One animal regurgitated a freshly-eaten, unbroken clutch of six gambel quail eggs. These dietary results are consistent with those of Beck (2005), who also documented reptile eggs, rodent pups, and other bird nestlings and eggs being consumed.

One of the telemetered gila monsters was found drinking from a leaking hose in the housing area in 2004. This observation is important as it shows that this species will drink free water, and that individuals are using human-modified habitats and features to obtain basic ecological needs.

Behavior. We did not observe any interactions between gila monsters with the exception of two animals sharing a hibernaculum. An unexpected behavioral interaction with human researchers is that telemetered animals exhibited a range of defensive behaviors when located (Table 3). Of 123 visual observations, the most common behavior seen (55% of observations) was the animal retreating deeper into a burrow, moving under cover, or running away, especially if encountered in the open; followed by no visible reaction (29%); freezing then fleeing (9%); and freezing without moving (5%). In addition to these behaviors, gila monsters commonly tongue-flicked (27%), hissed (9%), or showed the inside of the mouth through gaping (4%). Hissing and gaping were most often used when the animal was being captured for measuring.

Why did the gila monster cross the road? We suspect that gila monsters are commonly seen near the visitor center area along the road in early spring as they are dispersing from hibernation sites higher up in the cliffs. This area parallels Cave Wash and tends to be covered by dense vegetation and have high relative humidity. Gila monsters have been documented to seek out humid microsites for retreat sites during the active season (Beck 1990, 2005), so it is possible that by following Cave Wash they are staying within preferred microclimates. In addition, gila monsters are known to eat rabbit pups and quail eggs, and this area of the park appears to be favorable for these prey species (Amyann Madara and Nowak pers. obs.). It is also possible that the gila monsters are following a traditional social migration routes used over generations (e.g. Ford 1986). By following the scent trails of others, adults could increase chances of finding mates and juveniles could increase chances of finding areas with rich food resources. To our knowledge the role of pheromone trails in the social behavior of gila monsters has not been studied.

Management Implications

Gila monsters are a species of concern in Arizona and at Tonto NM. In the spring, placing cautionary signs along the park road before and after the known crossing zone (south of the picnic area) might help decrease road mortality and raise visitor awareness. On peak emergence days in early April, a volunteer working the crossing zone could assist with detections and successful crossings. Park staff should be sensitive to the potential for illegal poaching, as gila monsters command a high price on the black market (Randy Babb, pers. comm.). The importance of free water to gila monsters and the large number of gambel quail that frequent the housing area (pers. obs.) may help explain their presence in this area during the active season. Photo comparisons have been shown to be a reliable method for documenting recaptures of gila monsters over time, even over 10 years or more. We highly recommend that this practice be continued, and be adopted by other southwestern parks as a non-invasive method for monitoring populations.

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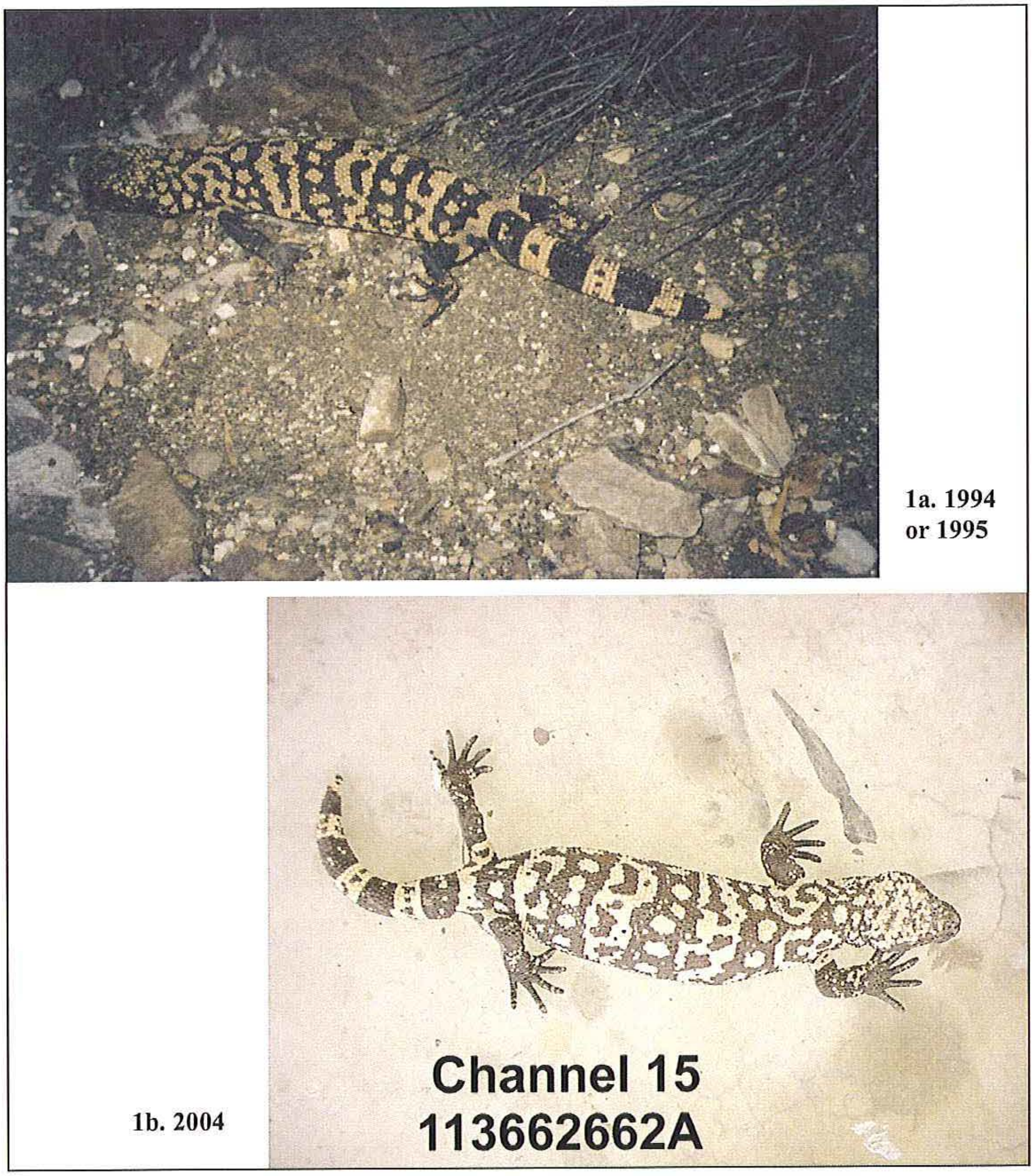

1a. 1994 or 1995

1b. 2004

Figure 1a-b. Photographs of a male gila monster captured at Tonto National Monument, Arizona in 1994 or 1995 (1**a**) and recaptured during WNPA-funded surveys in 2004 (**1b**). Animal was originally captured as a subadult by Don Swann in 1995.

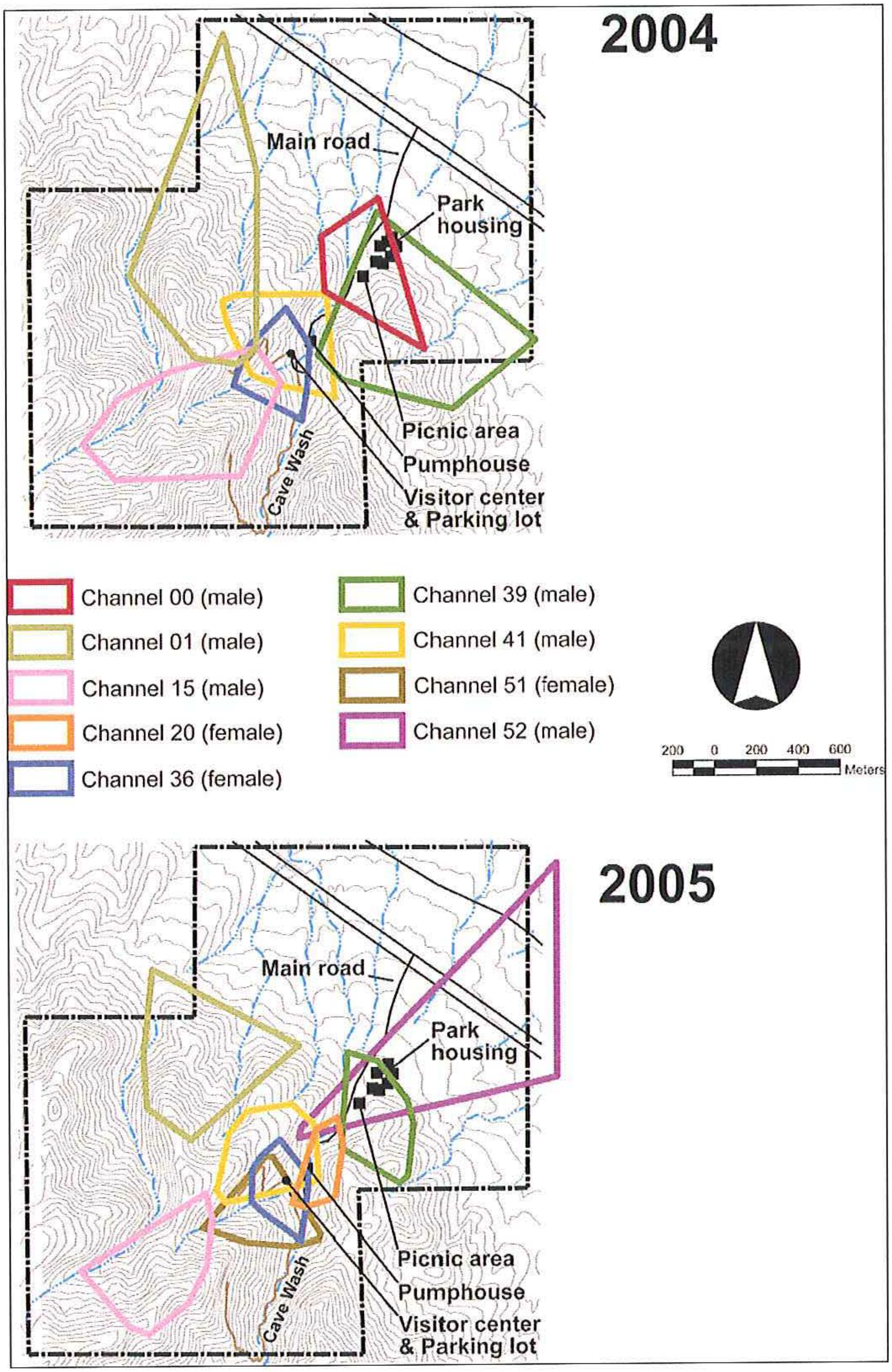

Figure 2. Activity ranges (as estimated by the minimum convex polygon method) for three adult telemetered gila monsters at Tonto National Monument, Arizona, tracked in 2004 (top) and 2005 (bottom). Channels 00, 15, 36, 39, and 41 were tracked in both years.

Table 1. Average tracking interval (number of days between locations) and average movement distance (in m) between tracking intervals for telemetered gila monsters during the active season (March to mid-December) at Tonto National Monument, Gila County, Arizona in 2004 and 2005. An "X" indicates the animal was not tracked during that year. The average number of locations and average activity range size (± SD) are summarized by year for all gila monsters, excluding Channel 52.

Channel (sex)	2004		2005	
	Average Tracking Interval	**Average movement (m)**	**Average Tracking Interval**	**Average Movement (m)**
00 (male)	4 ± 3	247.2 ± 108.7	X	X
01 (male)	5 ± 4	234.0 ± 211.9	8 ± 5	224.4 ± 184.0
15 (male)	4 ± 2	247.5 ± 199.0	10 ± 6	164.5 ± 165.8
20 (female)	X	X	9 ± 6	125.0 ± 103.8
36 (female)	4 ± 2	130.6 ± 89.5	8 ± 5	123.0 ± 81.3
39 (male)	4 ± 3	159.6 ± 195.8	8 ± 7	175.1 ± 129.8
41 (male)	5 ± 3	94.2 ± 141.6	8 ± 6	189.8 ± 139.8
51 (female)	X	X	7 ± 4	159.4 ± 121.5
52 (male)	X	X	15 ± 19	384.6 ± 563.3
Average	**4.3 ± 0.5**	**185.5 ± 66.4**	**8.3 ± 0.9**	**165.9 ± 35.7**

Table 2. Activity range size for telemetered gila monsters (by channel number) at Tonto National Monument, Gila County, Arizona in 2004 and 2005. An "X" indicates the animal was not tracked during that year. The average number of locations and average activity range size (± SD) are summarized by year for all gila monsters, excluding Channel 00, who died in mid-summer 2004.

Channel (sex)	2004		2005	
	# Locations	**Activity Range Size (ha)**	**# Locations**	**Activity Range Size (ha)**
00 (male)	12 (died)	18.1	X	X
01 (male)	52	57.5	21	33.2
15 (male)	47	39.3	25	22.3
20 (female)	X	X	25	6.3
36 (female)	52	11.7	33	8.5
39 (male)	55	52.3	34	15.0
41 (male)	44	20.0	31	16.9
51 (female)	X	X	31	13.1
52 (male)	X	X	19	65.8
Average	**50 ± 4.4**	**36.2 ± 19.9**	**27 ± 5.6**	**22.6 ± 19.4**

Table 3. Defensive behaviors exhibited by telemetered gila monsters (by channel number) at Tonto National Monument, Gila County, Arizona in 2004 and 2005. Listed are: total number of observations for each animal, number of times each animal was seen, and its behavior if seen. Primary behaviors include: no visible reaction ("none"), escape or retreat, freeze, and freeze then escape. Associated behaviors included hissing, tongue-flicking, and opening the mouth to show the inside color ("gape").

Channel (sex)	Total Obs.	Tot. Seen	No Reaction	Escape/ Retreat	Freeze	Freeze-Escape	Hiss	Tongue-flick	Gape
00 (male)	12	6	1	5	0	0	0	2	0
01 (male)	71	13	2	9	0	4	0	4	0
15 (male)	70	17	6	7	0	1	3	6	0
20 (female)	25	6	1	2	0	2	1	2	0
36 (female)	79	21	6	10	5	1	2	4	2
39 (male)	84	27	5	18	0	1	2	3	1
41 (male)	69	21	11	13	1	1	1	7	1
51 (female)	31	8	2	4	0	1	1	4	0
52 (male)	14	4	2	0	0	0	1	1	1
Total	**455**	**123**	**36**	**68**	**6**	**11**	**11**	**33**	**5**