# The role of running in predation and antipredation by the leopard lizard, *Gambelia wislizenii*

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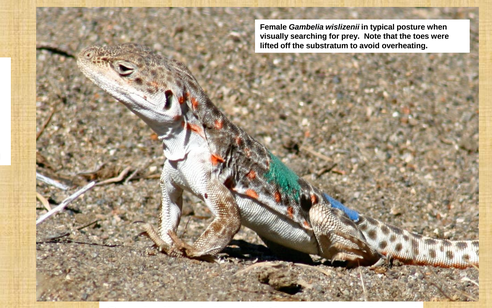
***Gambelia wislizenii*:**
- Lives in desert scrub
- Is an ambush predator
- Remains still as it visually seeks prey
- Often stations itself near a shrub
- Captures mobile prey as they approach

| Lizard Body Temperatures | mean | SD | N |
|---|---|---|---|
| AT emergence, pre-activity | 36.4 | 1.9 | 14 |
| GW Emergence, pre-activity | 34.3 | 2.9 | 35 |
| AT during activity period | 40.1 | 0.84 | 81 |
| GW during activity period | 39.0 | 1.05 | 201 |
| AT in raceway | 40.1 | 1.3 | 260 |
| GW in raceway | 39.1 | 1.1 | 41 |



Female *Gambelia wislizenii* in typical posture when visually searching for prey. Note that the toes were lifted off the substratum to avoid overheating.

***Gambelia wislizenii,* the Leopard Lizard**

## INTRODUCTION

Locomotory behavior is assumed to be an integral component for meeting the ecological challenges of food acquisition, mate seeking, predator evasion, refugium seeking and dispersal in vertebrates. There have been neither comprehensive studies of locomotory capablilities for any taxon of terrestrial vertebrate, nor adequate observation and testing of locomotory capabilities in the field. Terrestrial lizards in desert scrub are useful model systems for studying locomotory adaptedness because they perform well in the lab and they can be observed easily in the field as they forage, seek mates and evade predators.

The long-nosed leopard lizard, ***Gambelia wislizenii***, as a mesopredator, preys on on highly mobile insects and lizards and is potential prey for raptors and snakes. We sought to determine how leopard lizards use running to evade predators and pursue prey. We expected that anti-predatory responses of ***Gambelia wislizenii*** would depend on the type of predator, the type and speed of approach, and in which microhabitat. We also expected that its locomotory pursuit methods would differ among prey items (ie running and leaping after grasshoppers and sprinting after lizards, such as the elusive prey, the western whiptail lizards, ***Aspidoscelis tigris***)

The research site is in the Great Basin desert scrub, in the Alvord Basin, southeast of Steens Mt, in Harney Co, OR

Among ten available 20x20m quadrants (on a 1 ha map of the plot) with the largest open patch beginning in each quadrant, (and no open patch repeats) the mean maximum straight-line distance without encountering any plants, was 16.8 ± 13.3 m, with a range of 5–56 m and a median of 10.4 m (note raceway lengths). The lime green shrubs are greasewood and the gray-green shrubs are basin big sage. There is a dune on the upper right; the flat area in foreground is hardpan. Most of the plot is sandy flats (out of this view).


## Focal observations were performed prior to experiments

To document the undisturbed behavior of *Gambelia wislizenii* and its ecological context, we conducted 68 focal observations (mean = 21min/focal) in the first half of July in 2003-09.

Most *G. wislizenii* spent 89% of the time during focal observations in sedentary positions in the sunlit open or near shrub perimeters (see *Artemisia* below) during mid-morning as they visually searched for prey.

Body temperatures of undisturbed lizards captured at the end of focals and captured opportunistically at other times were typical for diurnal, field-active lizards in deserts (see table above).

Lizards were relatively unwary when approached by walking humans (see table below).

With the knowledge derived from focal observations we were able to devise efficacious, ecologically realistic experiments on predatory and antipredatory locomotion of *G. wislizenii.*

| Evasion patterns of 19 *Gambelia* pursued by humans in the field | | |
|---|---|---|
| ***Field Pursuit Measures*** | **Evasion Distance (m)** | **Evasion Velocity (m/sec)** |
| Mean | 7.4 | 2.3 |
| Range | 0.74 - 44 | 1 - 5.2 |
| SD | 9 | 1 |

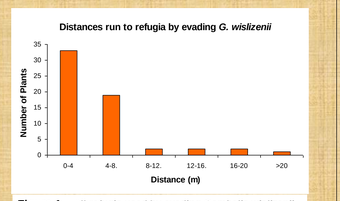



**Figure 1.** All refugia used by evading *Gambelia wislizenii* were shrubs. Although most refugia chosen by these human-pursued *G. wislizenii* were within 8m, over 10% of evasions were long distance runs. The mean distance to the nearest available shrub was 2.5 m, but mean distance to the chosen shrub-refugium by *G. wislizenii* was 4.9 m ± 9 m. N = 60 chased *G. wislizenii* in 2001, 2004, and 2007). For comparison, 12 *A. tigris* were similarly chased: mean distance to refugium was 7.3 ± 6.3 m, median was 4.5 m and range was 1.9 - 23m, and 7 of 12 ran through a shrub enroute to another shrub used as the refugium.

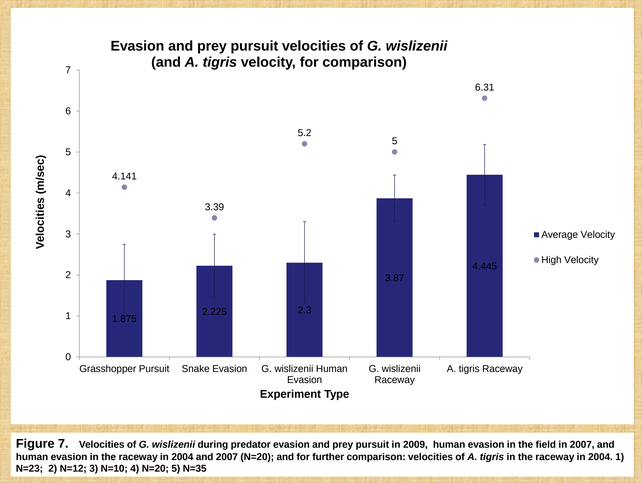



**Figure 7.** Velocities of *G. wislizenii* during predator evasion and prey pursuit in 2009, human evasion in the field in 2007, and human evasion in the raceway in 2004 and 2007 (N=20); and for further comparison: velocities of *A. tigris* in the raceway in 2004. 1) N=23; 2) N=12; 3) N=10; 4) N=20; 5) N=35

### Methods for velocities, distances and evasion pathways run by *G. wislizenii:*

- ***Gw*** chased in unrestricted field conditions
- **Gw** chased in raceways by "predators."
- ***Gw*** attempting to capture grasshoppers in the field.
- ***Gw*** pursuing model prey in unrestricted field conditions.
- ***Gw*** evading bird model
- Velocities of prey and predators were also measured.

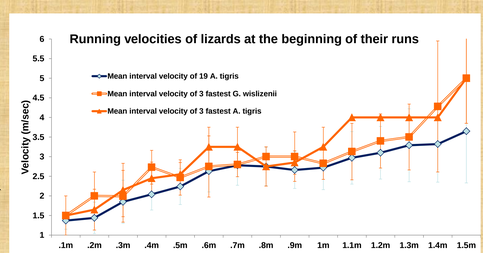



**Figure 6.** Running velocities of lizards measured for each 0.1m interval in the first 1.5 m on a natural sand raceway. Samples include the fastest starts for 19 *A. tigris*, the bests starts for the 3 fastest *A. tigris* and the best starts for the 3 fastest *G.wislizenii* (the *only* ones with good starts) in July 2004.

### Raceway Methods

20m raceways had natural sand substratum; barrier walls were constructed with aluminum flashing.

Lizards were held in a portable incubator and maintained at field active body temperatures (39-40ºC), so that body temperature was obviated as a source of variation in sprinting performance.

Lizards were released at one end and chased by a human in the raceway toward a refugium at the far end.

Five to six video cameras were used to document acceleration and velocity over separate 1- 1.4 m sections along the raceway.

Stopwatches were used to measure average velocity over the entire raceway and over large subsections of the raceway.

***Gambelia wislizenii* were often seen near or in the dappled shade of *Artemisia tridentata*, the basin big sage when in stationary position, visually searching for prey.**

| GW tolerate Human Approach | |
|---|---|
| **Type of Reaction by GW** | **Distance from Human when GW reacted** |
| **1st Reaction, N =15** | **2.0 ± 1.8 m** 0 - 7.0 m |
| **2nd Reaction, N = 6** | **1.3 ± 0.5 m** 0 - 1.45 m |
| **Turn-to-Look, N = 11** | **2.1 ± 1.0 m** 0.96 - 7.0 m |
| **Begin-to-Flee, N = 10** | **0.8 ± 0.6 m** 0 - 1.35 m |

***Gambelia wislizenii* frequently used the larger individuals of *Sarcobatus vermiculatus*, the greasewood as a refugium in the "evading humans" experiments.**

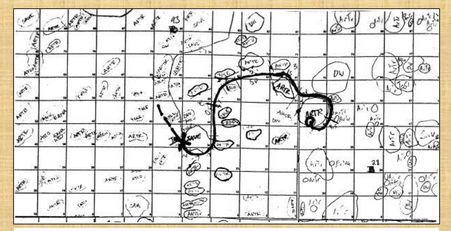


**Figure 2.** A map depicting one example of the anti-predation behavior of *G. wislizenii* when pursued by human. This was an evasive run by a *G. wislizenii,* and as was typical, it included running along perimeters of shrubs. The X signifies the point at which the pursuit of the lizard began. The dotted line shows the path of the pursuer. The circle is the point where the lizard stopped, after it already had evaded the pursuer. Each square is 1m per side.

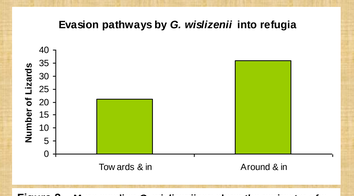



**Figure 3.** More evading *G. wislizenii* ran along the perimeter of a shrub before entering (both *around & in* and *towards, around, & in*) than ran straight into shrub (towards & in). N = 60 lizards chased by humans, in 2001, 2004, and 2007. Sufficiently accurate distance measures in 2004 revealed the mean distance to the chosen shrub refugium was 4.9 + 9m, but runs along perimeters resulted in the mean total distance run to be much higher, at 9.0 + 6.8 m (range = 1.4-28 m). See also Figures 1 and 2.

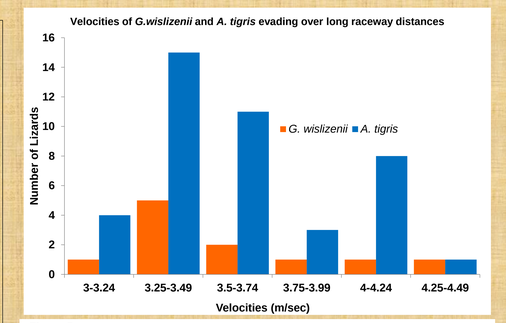
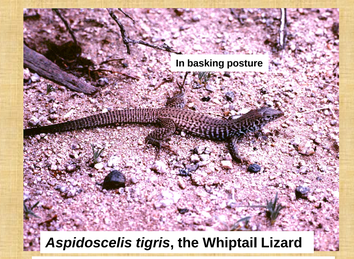



**Figure 5.** Velocities of *G. wislizenii* and its fastest running prey, the western whiptail lizard, *Aspidoscelis tigris.* Lizards were pursued by humans for 18-20m runs in a natural sand raceway. Samples include at least three long run trials per lizard; times were measured with stopwatch. Velocities over 3.5 m/sec were all bipedal. Sample sizes are 11 *G. wislizenii* (2000 & 2004) and 47 *A. tigris* (2004). Average *A. tigris* speed is 3.57 m/s when running virtually the entire distance (18-20m) on the 20.5m raceway (N=47) and 4.10 m/s for the last 7.5 m of raceway (N=31).




***Aspidoscelis tigris*, the Whiptail Lizard**

- Lives in desert scrub
- Is a wide, intensive forager
- Almost always on the move
- Crosses open ground often
- Seeks hidden prey under shrubs
- Is the fastest prey eaten by *Gambelia*

***Gambelia wislizenii*, the long-nose leopard lizard is the predominant predator of the speedy *Aspidoscelis tigris,* the western whiptail lizard. In this photo, an adult female *G. wislizenii* was eating an adult female *A. tigris*.**

**Approach by aerial predator:**

When approached by a model of an aerial predator, most *G. wislizenii* responded by moving at least one body length in an attempt to evade the "predator."

Leopard lizards in the open usually sought refuge under shrubs when approached by our aerial "predator."

Individuals in the open moved significantly further than those that were already under cover of shrubs ( p < 0.05 level, t-test).

| Location of GW | Bird Evasion Distances |
|---|---|
| **Open** N = 12 | **1.0 ± 1.1** range 0 - 4.0 |
| **Shrub Perimeter** N = 17 | **0.2 ± 0.2** range 0 - 0.6 |

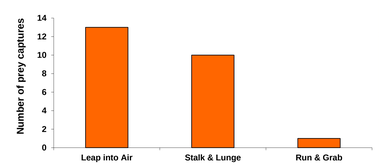



**Figure 4.** We witnessed *G. wislizenii* pursuing 111 prey items, catching 27 of them, and most by cat-like behavior. N = 68 lizards in nearly 24 hours of focal observations (21 min/ focal) in the first half of July in 2003-09.

## Conclusions

***Gambelia wislizenii* is adept at rapid leaps and lunges to capture prey and is capable of rapid acceleration and bipedal running velocities virtually equivalent to its fastest prey, *Aspidoscelis tigris*.**

The antipredation locomotion of *G. wislizenii* was primarily quadrupedal, and the evasion pathway wherein they went around shrubs and out of sight seems quite effective; the chaser was often left uncertain as to where the lizard went.

Other features of locomotory capabilities in *G. wislizenii,* as predator, and *A. tigris,* as prey yet need to be studied, such as 1) how far the lizards can run fast, 2) how often they can repeat fast runs, and 3) agility during fast runs. Intensive efforts to study locomotor adaptedness also are needed for lizards from other taxa, with other food acquisition modes, and in different habitats. Once these data are obtained, we then may begin to venture satisfactory answers to the basic and profound questions about the relative ecological challenges faced by animals and how those challenges are met by the complex of morphotype, physiotype, and behavior that comprises locomotory adaptedness.