PREDATION OF THE ENDANGERED BLUNT-NOSED LEOPARD LIZARD (GAMBELIA SILA) IN THE SAN JOAQUIN DESERT OF CALIFORNIA

Author: David J. Germano
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ABSTRACT—Predation can significantly affect prey populations, which could be significant for recovering species threatened with extinction. As part of a study on home ranges of the endangered blunt-nosed leopard lizard (Gambelia sila), I found lizards killed, or presumed killed, by predators. Predators that I could identify killing G. sila were the northern Pacific rattlesnake (Crotalus oreganus oreganus) and birds. The overall annual rate of predation during the active season of these lizards was 0.181, or 0.233 if lizards presumed killed are included. Based on published literature by others and other events of predation that I have published, birds and snakes seem to be the major predators of G. sila.

RESUMEN—La depredación puede afectar significativamente a las poblaciones de presas, lo que podría ser significativo para la recuperación de especies en peligro de extinción. Como parte de un estudio sobre los
Predation can have significant effects on local communities (Paine, 1966), prey population defenses and dynamics (Nordrath and Korpinäki, 1995; Hoverman and Reylea, 2012), and prey behavior and growth rates (Van Buskirk and Yurewicz, 1997). Predation could be especially harmful to prey populations that are severely limited in size (Macdonald et al., 1999), which can be the case with species threatened with extinction. In the San Joaquin Desert of California occurs the blunt-nosed leopard lizard (Gambelia sila), a lizard that is federally and state-listed as endangered. Understanding which species predate G. sila and the annual rate of predation could be relevant to recovery of this species. If predation rates are found to be high, predator control may be necessary for some populations of G. sila.

As part of a study to determine home ranges of G. sila (Germano and Rathbun, 2016), I found G. sila that were killed or presumed killed by predators. I collected information on predation of G. sila on the Lokern area of southwestern Kern County, California, located on the valley side of the San Joaquin Desert (Germano et al., 2011). The Lokern is a gently sloping (2–5%) alluvial plain at an elevation of 122–200 m, sloping up to the Elk Hills. The climate of the area is Mediterranean with hot, arid summers and cool, moist winters, with rainfall averaging only 170 mm (Germano et al., 2012). Although a wildfire occurred across a large part of the Lokern study area in 1997, by 2000 the area became dominated by nonnative grasses over portions of the area with native allscale saltbush (Atriplex polycarpa) and spiny saltbush (Atriplex spinifera) in parts, particularly to the northwest in the area of a grazing study (Germano et al., 2012). The herbaceous ground cover was dominated by the nonnative annuals red brome (Bromus rubens madritensis), Arabian grass (Schismus arabi cus), and red stem filaree (Erodium cicutarium).

From 2002 to 2004, I used model BD-2G transmitters (Holohil Systems Ltd., Carp, Ontario, Canada; www.holohil.com) on lizards (166 MHz) to determine home ranges (Germano and Rathbun, 2016), and these data also provided information on predation. I used beaded-chain collars to attach the transmitters to the lizards (Harker et al., 1999; Germano and Rathbun, 2016). My field assistants and I located lizards on foot using telemetry receivers (Model R1000; Communications Specialists, Inc., Orange, California; www.com-spec.com) and an H antenna or 3-element Yagi receiving antenna (Advanced Telemetry Systems, Isanti, Minnesota; www.atrack.com). I determined the Universal Transverse Mercator coordinates of all loci with a global positioning system receiver (GeoExplorer 3, Trimble Navigation Limited, Sunnyvale, California; www.trimble.com) with differential and real-time correction. I first located G. sila lizards by driving roads and on foot.

In 2002, I found and collared 12 males and 8 females, mostly in the southeastern portion of the Lokern and on one of four sections in the northwestern end of the Lokern used in the home range study. In 2003 and 2004, all G. sila were radio-collared in the home-range study part of the Lokern (Germano and Rathbun, 2016). In 2003, I found and collared 32 G. sila (18 males, 14 females) 5 May–23 June and 33 G. sila (18 males, 15 females) 13 April–14 June in 2004. Gambelia sila were radio-located once a day, three to five times per week until late in the adult active season (late July–early August). My assistants and I tracked G. sila during daylight, usually in the morning, and G. sila were found most often aboveground.

I compared rates of predation (including presumed death based on collars found on the ground) among years by using a contingency table (α = 0.05). I assumed that collars found on the ground after many weeks of radio-tracking G. sila were owing to predation because G. sila have small necks compared with their wide head and shoulders and the beaded chain collar does not slip off when adjusted properly (pers. observ.). Because I was cognizant of the need to eliminate accidental loss of collars, I made sure collars fit properly. Also, I did not find G. sila for which collars were found on the ground in 2002 and 2003 in subsequent years.

In 2002, I found 5 of 20 G. sila (25.0%) were killed by predators or presumed killed (Table 1). In 2003, I found 6 of 32 (18.8%) radio-collared G. sila predated, and in 2004, I found 8 of 33 (24.2%) radio-collared G. sila that were eaten or presumed eaten by predators (Table 1). The differences between years were not significant (all: $\chi^2 = 0.388$, df = 2, $P = 0.824$; without radios found on ground: $\chi^2 = 0.601$, df = 2, $P = 0.740$). Radio signals of G. sila were coming from rattlesnakes in three instances in 2003, and I found the still transmitting radios defecated out of snakes 9–22 days later (Table 1). In 2004, I found a radio on an Atriplex shrub encased in snake excrement. I found three instances of presumed bird predation in 2004: two where I found partially eaten bodies, and in another case, I found a radio on the ground 800–900 m from the home range of the G. sila (Table 1). I also found one G. sila in 2003 hanging dead from an Atriplex by the
Table 1—Blunt-nosed leopard lizards (*Gambelia sila*) found dead or eaten or their collars were found on the ground on the Lokern Natural Area, Kern County, California, 2002–2004. See text for reasons I considered a collar on the ground a predation event.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>ID</th>
<th>Date</th>
<th>Fate</th>
<th>Reference/notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Male</td>
<td>6.868</td>
<td>1 July</td>
<td>Collar broken apart on ground</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>Male</td>
<td>6.505</td>
<td>6 July</td>
<td>Collar broken apart on ground</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>Female</td>
<td>6.346</td>
<td>19 July</td>
<td>Collar intact on ground</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>Female</td>
<td>6.078</td>
<td>26 May</td>
<td>Intact body found on ground</td>
<td>Presumed snake predator</td>
</tr>
<tr>
<td>2003</td>
<td>Male</td>
<td>6.144</td>
<td>12 June</td>
<td>Eaten by rattlesnake</td>
<td>Radio on ground 4 July</td>
</tr>
<tr>
<td>2003</td>
<td>Male</td>
<td>6.782</td>
<td>14 June</td>
<td>Eaten by rattlesnake</td>
<td>Radio on ground 23 June</td>
</tr>
<tr>
<td>2003</td>
<td>Male</td>
<td>6.060</td>
<td>6 July</td>
<td>Collar intact on ground</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>Male</td>
<td>7.068</td>
<td>5 August</td>
<td>Antenna caught on saltbush branch:</td>
<td>G. sila hanging dead in mid-air</td>
</tr>
<tr>
<td>2003</td>
<td>Female</td>
<td>6.222</td>
<td>6 August</td>
<td>Radio on ground: no chain</td>
<td>Radio on ground 15 August</td>
</tr>
<tr>
<td>2004</td>
<td>Female</td>
<td>6.544</td>
<td>8 August</td>
<td>Eaten by rattlesnake</td>
<td>Radio on ground</td>
</tr>
<tr>
<td>2004</td>
<td>Male</td>
<td>4.477</td>
<td>17 May</td>
<td>Collar intact; head and tail found</td>
<td>Presumed bird predator</td>
</tr>
<tr>
<td>2004</td>
<td>Female</td>
<td>4.290</td>
<td>25 May</td>
<td>Collar intact on ground</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Female</td>
<td>6.271</td>
<td>4 June</td>
<td>Collar intact on ground</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Female</td>
<td>4.422</td>
<td>25 June</td>
<td>Collar intact on ground</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Male</td>
<td>6.467</td>
<td>6 July</td>
<td>Collar encased in snake excrement</td>
<td>On Atriplex shrub</td>
</tr>
<tr>
<td>2004</td>
<td>Male</td>
<td>7.266</td>
<td>15 July</td>
<td>Collar intact on ground</td>
<td>900 m from home range;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>presumed bird predator</td>
</tr>
<tr>
<td>2004</td>
<td>Male</td>
<td>4.290</td>
<td>24 July</td>
<td>Partially eaten body on ground</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Male</td>
<td>4.188</td>
<td>24 July</td>
<td>Collar intact on ground</td>
<td></td>
</tr>
</tbody>
</table>

An unsheathed antenna that was coiled around the branch. I did not include this death in predation statistics.

Snakes and birds have been found to prey on *G. sila*. A northern Pacific rattlesnake (*Crotalus oreganus oreganus*) ate an adult *G. sila* at a site to the north of the Lokern (Germano et al., 2015). Other snake species known to eat *G. sila* are San Joaquin coachwhips (*Masticophis flagellum ruddocki*), gopher snakes (*Pituophis catenifer*), and long-nosed snakes (*Rhinocheilus lecontei*; Montanucci, 1965; Germano and Saslaw, 2015; Germano et al., 2015). Birds known to have eaten *G. sila* include peregrine falcons (*Falco peregrinus*), loggerhead shrikes (*Lanius ludovicianus*), burrowing owls (*Athene cunicularia*), and roadrunners (*Geococcyx californianus*; Montanucci, 1965; Tollestrup, 1979; Germano and Carter, 1995; Germano et al., 2015). The likely mammalian predators on the Lokern that might consume *G. sila* are coyotes (*Canis latrans*) and San Joaquin kit foxes (*Vulpes macrotis mutica*), but reptiles make a very small percentage of prey eaten by both species (Jakiś et al., 1982; White et al., 1995; Cypher and Spencer, 1998; Kozlowski et al., 2008).

I found that a *C. o. oreganus* ate an adult *G. sila* in 2002 and three adults in 2003, and I found one transmitter encased in snake excrement in 2004. A possible attempt to eat an adult female that I found on the ground without any other marks or injuries in 2003. In 2002, I found the signal of a radio transmitter from an adult male *G. sila* coming from the nest of a red-tailed hawk (*Buteo jamaicensis*) located high (20–25 m) in a tower of a high-tension line (Germano and Brown, 2003). In 2003 and 2004, I judged that some *G. sila* were eaten by birds when I found only a few body parts or mangled bodies on tops of shrubs or hundreds of meters from their last location.

Radio-tracking *G. sila* allowed me to estimate predation rates, at least during the active season. I found that 22.3% of *G. sila* that I radio-collared were killed or presumed killed by predators annually (0.223 mortality rate; averaging rates from 2002 to 2004). If the intact collars that I found on the ground were not because of predation of the *G. sila*, then the average rate of predation across years was 0.181 annually. Rates of mortality (presumed predation) have been estimated as 0.48 for side-blotched lizards (*Uta stansburiana*) from Texas (Tinkle, 1967) and 0.304–0.590 for *U. stansburiana* from spring to summer at five sites along the Pacific coast of North America (Wilson, 1991). Tinkle and Ballinger (1972) estimated rates of mortality for adult eastern fence lizard (*Sceloporus undulatus*) males as 0.58–0.67 and females as 0.44–0.63 for three sites (excluding a site in Texas that had very low sample sizes), whereas Ferguson et al. (1980) estimated a 0.90 mortality rate for *S. undulatus* in Kansas. For bunchgrass lizards (*Sceloporus scalaris*), Ballinger and Congdon (1981) estimated an average mortality rate over three seasons of 0.619 for adult males and 0.764 for adult females. These species are considerably smaller than *G. sila*, and their higher annual mortality rates are likely because of their small size. For the congener long-nosed leopard lizard (*Gambelia wislizenii*), estimates of mortality...
in southern Nevada (averaged over three sites) were 0.38 for adult males and 0.57 for adult females (Turner et al., 1969) and 0.50 for both adult males and females at a site in Utah (Parker and Pianka, 1976). For all these species, estimates of mortality were based on following year returns from censusing and not from following radio-tagged lizards. I suspect that the higher rate found for *G. wislizenii* in Utah is because some of these lizards moved off the plot being censused. In Nevada, plots were surrounded by fences that did not allow *G. sila* to move off, so these rates of mortality may mean an actual higher mortality rate than what I estimated for *G. sila*.

Snakes could have a major impact on *G. sila* populations and are known to eat a variety of lizards, including side-blotched lizards, earless lizards (*Holbrookia*), spiny lizards (*Sceloporus*), whiptail lizards (*Aspidoscelis*), and horned lizards (*Phrynosoma*; McKinney and Ballinger, 1966). Major predators of reptiles in California were Cooper’s hawks (*Accipiter cooperii*) and red-tailed hawks, accounting for 64.3 and 21.6% of all vertebrate remains in these raptors, respectively. Reptiles accounted for 9.2–57.1% of the vertebrate prey remains of gopher snakes, western rattlesnakes (*Crotalus viridis*), California kingsnakes (*Lampropeltis californiae*), and striped racers (*Masticophis lateralis*; Jakić et al., 1982). In total, lizards accounted for 51.1% of these reptile remains from predators (Jakić et al., 1982). Based on predators that I was certain or fairly certain ate *G. sila*, predatory birds and snakes likely exert the greatest control on population numbers of this lizard. Based on a review of predation papers, however, Macdonald et al. (1999) believed that predators can limit population size in some instances, but generally do not drive prey populations to extinction. Although much more data on the impact of predation is necessary, the mortality rates I have found for *G. sila* by using radio-telemetry are considerably lower than for other lizard species, including *G. wislizenii*, indicating that predation is not a significant factor depressing numbers of the endangered *G. sila*.

**Literature Cited**


Associate Editor was Charles Matthew Watson.