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

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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 rangos de hogar de la amenazada lagartija leopardo narigona (*Gambelia sila*), encontré lagartijas matadas, o presuntamente matadas, por depredadores. Los depredadores que pude identificar matando a *G. sila* fueron la víbora de cascabel pacífica norteña (*Crotalus o. oregano*) y aves. El total anual de la tasa de depredación durante la temporada activa de estas lagartijas fue de 0.181, o el 0.233 si lagartijas supuestamente matadas son incluidas. En base a la literatura publicada por otros y otros eventos de depredación que he publicado, las aves y las serpientes parecen ser los principales depredadores de *G. sila*.

Predation can have significant effects on local communities (Paine, 1966), prey population defenses and dynamics (Norrdahl and Korpimäki, 1995; Hoverman and Relyea, 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 arabicus*), 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.atstrack.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 ($\alpha = 0.05$). 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.

Year	Sex	ID	Date	Fate	Reference/notes
2002	Female	6.544	5 June	Eaten by rattlesnake	Germano and Brown (2003)
2002	Male	6.744	18 June	Eaten by red-tailed hawk	Germano and Brown (2003)
2002	Male	6.868	1 July	Collar broken apart on ground	
2002	Male	6.505	6 July	Collar broken apart on ground	
2002	Female	6.346	19 July	Collar intact on ground	
2003	Female	6.078	26 May	Intact body found on ground	Presumed snake predator
2003	Male	6.144	12 June	Eaten by rattlesnake	Radio on ground 4 July
2003	Male	6.782	14 June	Eaten by rattlesnake	Radio on ground 23 June
2003	Male	6.060	6 July	Collar intact on ground	
2003	Male	7.068	5 August	Antenna caught on saltbush branch: *G. sila* hanging dead in mid-air	
2003	Female	6.222	6 August	Radio on ground: no chain	
2003	Female	6.544	8 August	Eaten by rattlesnake	Radio on ground 15 August
2004	Male	4.477	17 May	Collar intact; head and tail found	Presumed bird predator
2004	Female	4.290	23 May	Collar intact on ground	
2004	Female	6.271	4 June	Collar intact on ground	
2004	Female	4.422	23 June	Collar intact on ground	
2004	Male	6.467	6 July	Collar encased in snake excrement	On *Atriplex* shrub
2004	Male	7.266	15 July	Collar intact on ground	900 m from home range; presumed bird predator
2004	Male	4.290	24 July	Partially eaten body on ground	Presumed bird predator
2004	Male	4.188	24 July	Collar intact on ground	

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 prairie falcons (*Falco mexicanus*), American kestrels (*Falco sparverius*), 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 (Jaksić 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 attempted snake predation may have accounted for the intact body of 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 bunch grass 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 (*Phrynosma*; 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 lateralus*; Jaksić et al., 1982). In total, lizards accounted for 51.1% of these reptile remains from predators (Jaksić 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*.

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