FOOD HABITS OF THE BLUNT-NOSED LEOPARD LIZARD (*GAMBELIA SILA*)

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ABSTRACT—We quantified the food habits of the endangered blunt-nosed leopard lizard (*Gambelia sila*), an endemic species of the San Joaquin Valley, California. Based on analyses of stomach contents and prey remains in scats, we determined that this species is an opportunistic predator that eats large numbers of orthopterans, coleopterans, and hymenopterans, with dipterans, hemipterans, and lizards taken in lesser numbers. These data are similar to the qualitative or unpublished data of previous studies, and also are similar to the food habits of the congeneric *Gambelia wislizenii*.

RESUMEN—Cuantificamos los hábitos alimenticios de la lagartija leopardo narigona (*Gambelia sila*) clasificada en peligro, una especie endémica del Valle de San Joaquín, California. Basados en el análisis del contenido estomacal y restos de presas en heces, determinamos que esta especie es una depredadora oportunista que come muchos ortópteros, coleópteros, e himenópteras, con dípteras, hemípteros, y lagartijas en cantidades menores. Estos datos son semejantes a los datos cualitativos o no publicados de estudios previos, y son también semejantes a los hábitos alimenticios de la congénere *Gambelia wislizenii*.

Determining the diet of a species can be important for understanding the trophic level it occupies and the structure of habitat necessary for its survival. If the species is a predator and it uses an active mode of foraging, then it might survive better in a more open habitat structure that does not impede its movements. Of course, if the species has preferred prey, then the prey must also be abundant, or relatively so, in open areas. Understanding food habits can be especially important for species that are declining so that any management actions undertaken do not negatively affect food supply.

The blunt-nosed leopard lizard (*Gambelia sila*) is a predatory lizard of the San Joaquin Valley, California, that has been listed as an endangered species since 1967 (U.S. Fish and Wildlife Service, 2005). It is known to eat invertebrates and lizards (Meek, 1905; Montanucci, 1965, 1967), including its own young (Montanucci, 1965; Germano and Williams, 1994); however, quantified food analyses have not been published. *Gambelia sila* is one of a number of species in the San Joaquin Valley whose habitat has been greatly modified by invasive annual grasses and might benefit from management actions that would keep habitats open (Germano et al., 2001). Another possible impact to this species is the regular spraying of native habitat in the San Joaquin Valley to control the sugarbeet leafhopper (*Circulifer tenellus*), an introduced agricultural pest (California Department of Food and Agriculture, unpublished report). Quantifying food habits of *G. sila* would help determine if managing for habitat structure or pest control would affect the prey base for the lizard.

We assessed the diet of *G. sila* from stomach contents and scats. Most stomachs were collected in the early 1990s from salvaged lizards from the southern San Joaquin ecosystem of Kern, Kings, Tulare, and San Luis Obispo counties, California (see Appendix for specific locations). We removed viscera from individual lizards and stored them separately in vials containing 70% ethanol until contents were removed. We also collected scats from 3 locations in the southern San Joaquin ecosystem: 19 scats were collected in 1994 from the Elkhorn Plain, San Luis Obispo County; 42 scats were collected in 1992 from the Kern Front Oil Field, just north of Bakersfield, Kern County; and 73 scats (10 in 2005, 63 in 2006) were collected from the Lokern Natural Area, Kern County. To collect scats, we held leopard lizards in bags or buckets. We analyzed

TABLE 1—The number of animal items (% of total items, % frequency of stomachs) found in stomachs of male and female *Gambelia sila* from the southern San Joaquin ecosystem of California. Entries for the insect orders are the totals for each order. The *n* value denotes the number of stomachs examined.

Taxon	Males (n = 9)	Females (n = 16)	Combined (n = 26)*
Coleoptera	9 (31.0%, 77.8%)	13 (33.3%, 50.0%)	22 (31.0%, 57.7%)
Carabidae	3 (10.3%, 22.2%)	1 (2.6%, 6.3%)	4 (5.6%, 11.5%)
Scarabidae		2 (5.2%, 12.5%)	2 (2.8%, 7.7%)
Tenebrionidae		1 (2.6%, 6.3%)	1 (1.4%, 3.8%)
Adult	2 (7.0%, 22.2%)	9 (23.1%, 25.0%)	11 (15.5%, 23.1%)
Larvae	4 (13.8%, 33.3%)		4 (5.6%, 11.5%)
Diptera	4 (13.8%, 44.4%)	2 (5.2%, 6.3%)	6 (8.5%, 19.2%)
Adult	3 (10.3%, 33.3%)		3 (4.2%, 11.5%)
Larvae	1 (3.4%, 11.1%)	2 (5.2%, 6.3%)	3 (4.2%, 7.7%)
Hemiptera		3 (7.8%, 6.3%)	3 (4.2%, 3.8%)
Unidentified		3 (7.8%, 6.3%)	3 (4.2%, 3.8%)
Hymenoptera	6 (20.7%, 44.4%)	2 (5.2%, 6.3%)	8 (11.3%, 19.2%)
Apidae	3 (10.3%, 22.2%)		3 (4.2%, 7.7%)
Vespidae	3 (10.3%, 22.2%)		3 (4.2%, 7.7%)
Unidentified		2 (5.2%, 6.3%)	2 (2.8%, 3.8%)
Orthoptera	9 (31.0%, 66.7%)	18 (46.2%, 75.0%)	30 (42.3%, 73.1%)
Acrididae	7 (24.1%, 44.4%)	18 (46.2%, 75.0%)	28 (39.4%, 65.4%)*
Gyrillidae	1 (3.4%, 11.1%)		1 (1.4%, 3.8%)
Unidentified	1 (3.4%, 11.1%)		1 (1.4%, 3.8%)
Lizard	1 (3.4%, 11.1%)	1 (2.6%, 6.3%)	2 (2.8%, 7.7%)
Total items	29	38	71

* Includes contents from stomach of lizard of unknown sex.

contents from stomachs and scats separately and identified items to family when possible. For stomachs, we analyzed contents by sex, but for scats, we analyzed by area. In both cases, we determined the percentage of each taxon by number of items and by the frequency of occurrence of each taxon per stomach or scat.

Orthopterans and coleopterans were the most abundant taxa in stomachs of male and female *G. sila* (Table 1). Both taxa accounted for >30% of the items identified, and orthopterans were present in 67 to 75% of stomachs and coleopterans were present in 50 to 78% of stomachs (Table 1). Most orthopterans in stomachs were grasshoppers. Bees and wasps (hymenopterans) were the next most abundant item in male lizards and were present in 44% of stomachs (Table 1). Dipterans also were present in 44% of male stomachs. In females, hymenopterans, dipterans, and hemipterans were generally equally represented, but were not abundant. Parts of lizards were found in one male and one female lizard (Table 1). Although present, small amounts of plant matter and pebbles were not quantified.

From scats, we found that coleopterans comprised a large percentage of items (69 to 71%) and were present in a majority of scats (67 to 95%) from the Elkhorn Plain and Lokern Natural Area (Table 2). Orthopterans were a much lower percentage of items at these 2 sites compared to the Kern Front Oil Field, although they still were present in 37 to 53% of scats. In contrast, orthopterans accounted for 86% of items and were present in 95% of scats from the Kern Front Oil Field (Table 2). Coleopterans, dipterans, and hymenopterans accounted for only a small percentage of the diet at Kern Front. On the Elkhorn Plain, ants accounted for 11% of items in scats, and hymenopterans, in general, were present in >26% of scats (Table 2). No hymenopterans were present in scats from the Lokern. Differences in diet between sites might be due to year of collection, season, or differences in habitat composition. In the large sample of scats from

TABLE 2—The number of animal items (% of total items, % frequency of scats) found in scats of *Gambelia sila* from the Kern Front Oil Field and the Lokern Natural Area, Kern County, and the Elkhorn Plain Natural Area, San Luis Obispo County, California. Entries for the insect orders are the totals for each order. The *n* value denotes the number of scats collected per area.

Taxon	Kern Front (n = 42)	Elkhorn (n = 19)	Lokern (n = 73)	Combined (n = 134)
Coleoptera	4 (8.0%, 9.5%)	38 (69.0%, 94.7%)	149 (71.0%, 67.1%)	191 (60.6%, 45.5%)
Carabidae		6 (10.9%, 21%)	103 (49.0%, 32.9%)	109 (34.6%, 20.9%)
Cucurlionidae			18 (8.6%, 16.4%)	18 (5.7%, 9.0%)
Scarabidae		5 (9.1%, 15.8%)		5 (1.6%, 2.2%)
Tenebrionidae		13 (23.6%, 15.8%)	1 (0.5%, 1.4%)	14 (4.4%, 3.0%)
Unidentified	4 (8.0%, 9.5%)	14 (25.5%, 42.1%)	27 (12.9%, 16.4%)	45 (14.3%, 17.9%)
Diptera	1 (2.0%, 2.4%)		2 (1.0%, 2.7%)	3 (1.0%, 2.2%)
Muscidae	1 (2.0%, 2.4%)			1 (0.3%, 0.7%)
Unidentified			2 (1.0%, 2.7%)	2 (0.6%, 1.5%)
Hemiptera		1 (1.8%, 5.3%)		1 (0.3%, 0.7%)
Unidentified		1 (1.8%, 5.3%)		1 (0.3%, 0.7%)
Hymenoptera	2 (4.0%, 4.8%)	9 (16.4%, 26.3%)		11 (3.5%, 5.2%)
Formicidae	1 (2.0%, 2.4%)	6 (10.9%, 10.5%)		7 (2.2%, 2.2%)
Vespidae		2 (3.6%, 10.5%)		2 (0.6%, 1.5%)
Unidentified	1 (2.0%, 2.4%)	1 (1.8%, 5.3%)		2 (0.6%, 1.5%)
Orthoptera	43 (86.0%, 95.2%)	7 (12.7%, 36.8%)	59 (28.1%, 53.4%)	109 (34.6%, 61.9%)
Acrididae	30 (60.0%, 66.7%)	1 (1.8%, 5.3%)	58 (27.6%, 52.1%)	89 (28.3%, 47.8%)
Unidentified	13 (26.0%, 28.6%)	6 (10.9%, 31.6%)	1 (0.5%, 1.4%)	20 (6.3%, 14.8%)
Total items	50	55	210	315

the Lokern in 2006, we found that all scats collected in May only contained coleopterans, but orthopterans (grasshoppers) accounted for >95% of the diet in June and July. Lizards did ingest items other than animals. Although we only recorded non-animal items in scats in 2006 from the Lokern, we found that about 20% of scats contained pebbles as large as 5 mm, 3 scats contained molted lizard skin, and 1 scat had plant matter.

The crotaphytid lizards (*Gambelia* and *Crotaphytus*) as a group are predatory carnivores that eat invertebrate and vertebrate prey, mainly insects and lizards (Conant and Collins, 1991; McGuire, 1996; Stebbins, 2003). *Gambelia sila* shares this diet. Depending on the area, or perhaps year, we found that orthopterans (mainly grasshoppers) and coleopterans (various groups of beetles) comprised the bulk of the prey items for *G. sila*. Hymenopterans (bees, wasps, and ants) and dipterans made up a smaller, but significant, portion of the diet of this lizard. We also found evidence of *G. sila* eating hemipterans and lizards, but both taxa comprised only a small portion of the diet. We did not observe much difference in preference of prey items between males and females.

The first report of the food habits of *G. sila* found that all stomachs examined contained grasshoppers (Meek, 1905). Montanucci (1965, 1967) also found the contents of stomachs mainly contained orthopterans, such as crickets (*Acheta assimilis*) and locusts (*Trimeratopis californica* and *Melanoplus*), as well as cicadas (*Okanagana triangulata*). He also found occasional lizards (*Uta stansburiana*), bees, coleopterans, lepidopteran larvae, and plant matter. Quantitative data for the diet of *G. sila* from a site on the floor of the San Joaquin Valley (Delano) and from a site in the Kettleman Hills showed similar results to what we found, although several other taxa were present (Table 3). Based on contents from stomachs, coleopterans, orthopterans, and hymenopterans were generally the most abundant prey, but hemipterans constituted almost 40% of prey items at the Delano site (Table 3). Additionally, 3 other insect orders were found at these sites, although each was only a single item, and spiders, mites, and scorpions were also found in low abundance (Table 3). A comparison of diet based on scat data showed that *G. sila*

TABLE 3—A comparison of the number of items (% of total items, % frequency of stomachs) found in stomachs (n) for this study (n = 26) and of *Gambelia sila* from Delano, Kern County (n = 14), and the Kettleman Hills, Kings County (n = 16), California (Tollestrup, 1979).

Taxon	This study	Delano	Kettleman Hills
Coleoptera	22 (31.0%, 57.7%)	20 (16.1%, —)	14 (20.6%, —)
Diptera	6 (8.5%, 19.2%)	4 (3.2%, —)	5 (7.4%, —)
Hemiptera	3 (4.2%, 3.8%)	49 (39.5%, —)	2 (2.9%, —)
Homoptera		1 (0.8%, —)	
Hymenoptera	8 (11.3%, 19.2%)	14 (11.3%, —)	12 (17.6%, —)
Isoptera		1 (0.8%, —)	
Lepidoptera			1 (1.5%, —)
Orthoptera	29 (42.3%, 73.1%)	35 (28.2%, —)	28 (41.2%, —)
Araneae			4 (5.9%, —)
Acarinans			1 (1.5%, —)
Scorpionids			2 (2.9%, —)
Insect eggs		1 (0.8%, —)	
Lizard	2 (2.8%, 7.7%)		
Total items	70	124	68

from the Elk Hills also ate more hemipterans and considerably fewer coleopterans than what we found (Table 4). No dipterans were present in scat of lizards from the Elk Hills, although lizard remains were found, which we did not find in scats. Some diet information based on scats also exists for lizards that are hybrids between *Gambelia wislizenii* and *G. sila* (Palmero, 1983). These data showed that hybrid lizards ate about the same diet as pure *G. sila*, although flying insects (hymenoptera and diptera were not separated) made up a much larger portion of the diet of hybrids (Table 4).

Similar dietary results have been found for the congeneric *G. wislizenii*. Orthopterans and coleopterans comprise a large portion of the diet of *G. wislizenii*, with hymenopterans and dipterans making up a lesser proportion and a variety of other insects (including eggs and larvae) and other arthropods generally found in low numbers (Pack, 1922; Knowlton and Thomas, 1936; McCoy, 1967; Turner et al., 1969; Tanner and Krogh, 1974; Essghaier and Johnson, 1975; Parker and Pianka, 1976; Lemos-Espinal et al., 2000). Like *G. sila*, the diet of *G. wislizenii* includes lizards, such as *Aspidoscelis tigris, Callisaurus draconoides, Sceloporus undulatus, S. graciosus,* and *U. stansburiana* (Pack, 1922; Knowlton and Thomas, 1936; McCoy, 1967; Tanner and Krogh, 1974; Parker and Pianka, 1976; Lemos-Espinal et al., 2000), but can also include small rodents (Pietruska et al., 1981). Small amounts of plant matter generally are found in stomach contents of *G. wislizenii*, and at the Nevada Test Site, it ate the berries of the shrub *Lycium andersonii* when berries were available (Turner et al., 1969; Tanner and Krogh, 1974).

In general, *G. sila* seems to be an opportunistic predator that eats whatever is most abundant and it is able to catch. However, what has not been done in this study, or any study of *Gambelia*, is to quantify the prey base and compare the diet of the species to what is available. This could be important to determine if impacts to prey resources affect this endangered lizard. The California Department of Agriculture (unpublished reports) regularly sprays Malathion on native vegetation peripheral to cropland to kill overwintering sugarbeet leafhoppers. Spraying could also impact predatory insects (such as beetles) and parasitic insects (Hymenoptera) that might attack the leafhopper. The majority of the diet of *G. sila* consists of insects, and although Malathion spraying might have negligible effects on the overall prey base of *G. sila*, that determination has not been made. The endangered status of this species warrants the study of any potential impacts.

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TABLE 4—A comparison of the number of items (% of total items, % frequency of scats) found in scats (n) for this study (n = 134) and of *Gambelia sila* from the Elk Hills, Kern County, California (n = 16; Kato et al., 1987, in litt.) and for hybrid *G. sila* × *G. wislizenii* from Ballinger Canyon, Santa Barbara County, California (n = 21; Palmero, 1983). Entries for orders and higher taxa are the totals for each taxon.

Taxon	This study	Kato et al. (1987)	Palmero (1983)
Coleoptera	191 (60.6%, 45.5%)	3 (4.5%, 19%)	11 (13.8%, —)
Carabidae	109 (34.6%, 20.9%)		
Cucurlionidae	18 (5.7%, 9.0%)		
Scarabidae	5 (1.6%, 2.2%)		
Tenebrionidae	14 (4.4%, 3.0%)		
Unidentified	45 (14.3%, 17.9%)	3 (4.5%, 19%)	
Diptera	3 (1.0%, 2.2%)		
Muscidae	1 (0.3%, 0.7%)		
Unidentified	2 (0.6%, 1.5%)		
Hemiptera	1 (0.3%, 0.7%)	11 (16.7%, 13%)	2 (2.5%, —)
Unidentified	1 (0.3%, 0.7%)	11 (16.7%, 13%)	2 (2.5%, —)
Hymenoptera	11 (3.5%, 5.2%)	13 (19.7%, 50%)	
Formicidae	7 (2.2%, 2.2%)	1 (1.5%, 6%)	
Vespidae	2 (0.6%, 1.5%)	12 (18.2%, 44%)	
Unidentified	2 (0.6%, 1.5%)		
Orthoptera	109 (34.6%, 61.9%)	36 (54.5%, 81%)	20 (25.0%, —)
Acrididae	89 (28.3%, 47.8%)	36 (54.5%, 81%)	
Unidentified	20 (6.3%, 14.8%)		20 (25.0%, —)
Hymenoptera + Diptera	14 (4.4%, 7.5%)		31 (38.8%, —)
Arthropod			12 (15.0%, —)
Insect			2 (2.5%, —)
Lizard		3 (4.5%, 19%)	1 (1.3%, —)
Total items	315	66	80

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APPENDIX—Locations of salvaged blunt-nosed leopard lizards (*Gambelia sila*) from which stomachs were examined.

Kern County: just east of Arvin; T31S, R30E, NW¼ Sec. 28; 1 female found dead 27 June 1990.

Kern County: just south of Arvin at edge of golf course; T32S, R30E, SW edge Sec. 6; 1 male found dead 26 April 1993.

Kern County: just south of Highway 166; T11N, R23W, NW¼ Sec. 24; 1 female found dead 16 June 1992.

Kern County: Kern Front Oil Field; T28S, R27E and R28E; 1 female, 1 male, and 1 sex not recorded found dead June 1992 in open pipeline trench.

Kings County: Kettleman Hills; T23S, R19E, Sec. 20; 1 female found dead 19 July 2006 on dirt road.

Tulare County: Pixley National Wildlife Refuge; T23S, R24E, Sec. 23; 2 males found dead 29 May and 11 June 1991, 1 female found dead 26 August 1993.

San Luis Obispo County: Elkhorn Plain Ecological Reserve; T32S, R22E, NE¼ Sec. 20; 6 females and 3 males found dead September 1991–April 1994.

San Luis Obispo County: Elkhorn Plain; T32S, R22E, Sec. 18; 2 females found dead 15 August 1989 and 11 September 1991.

San Luis Obispo County: Dead on Elkhorn Plain Road; 1 female 2.4 km SE of Elkhorn Plain Ecological Reserve (EPER) 20 August 1992, 1 female 2.4 km NW of EPER 28 September 1992, and 1 female 4.8 km SE of EPER 6 May 1993.