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Susceptibility of Reptiles at Yucca Mountain, Nevada, to Capture Using Three Sampling Methods: Noosing, Pitfall Traps, and Funnel Traps

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Studies of species diversity rely on accurate floral and faunal lists as the basis for analysis, however the adequacy of sampling designs to determine species composition and relative abundance has always been a problem (Dunn and Loehle, 1988; Miller and Wiegert, 1989; Williams, 1995, 1996), and studies continue to demonstrate that many faunal assemblages contain species variously susceptible to different sampling procedures (Brattstrom, 1996; Durtsche, 1996; Heyer et al., 1994; Legg et al., 1996; Mommertz et al., 1996; Voss and Emmons, 1996; Wilson et al., 1996) and different sampling biases (Kendall et al., 1996; Pacheco, 1996; Quang, 1991). Here we provide data on the susceptibility of certain desert reptiles to capture using three sampling methods (noosing, pitfall traps, and funnel traps) at Yucca Mountain, Nevada, a site being considered by the U.S. Department of Energy for storing high-level nuclear waste.

Yucca Mountain (36°50'N; 116°28'E) is located 150 km northwest of Las Vegas, and sits in the narrow transition zone between the Mojave and Great Basin deserts, a region with rugged mountain ranges and broad valleys. Yucca Mountain is a long, north-south ridge of volcanic origin, that ranges in elevation from approximately 950 to 1,500 m. Vegetation is dominated by Mojave Desert plant associations below approximately 1,200 m and by transitional associations composed of Mojave and Great Basin floras at higher elevations (Beatley, 1976; Hessing et al., 1996).

From 1991 to 1995, we sampled 25 1-ha study plots (Boone et al., 1997) located on the southern ridges and southeastern flanks of Yucca Mountain, and we recorded anecdotal observations throughout the region (generally within 15 km of Yucca Mountain). We sampled 3 plots using pitfall and funnel traps. These plots each contained 16 15-m-long drift fences aligned in four rows with each fence perpendicular to the next. The end of each drift fence overhung a 30-cm-wide by 50-cm-deep pitfall trap (5-U.S.-gal. plastic bucket). We shaded each pitfall trap with a plywood board raised 5 cm above the ground. In addition, we placed two shaded funnel traps along each fence, one on each side. We generally trapped 1-3 times per year for a total of 7-9 five-day sampling sessions per plot. We also sampled these 3 plots, plus an additional 22, using noosing techniques (Medica et al., 1971). We divided plots into five contiguous 20-m strips, and 1-4 biologists systematically walked each strip catching reptiles with nooses or by hand. We uniquely marked and released all animals at the point of capture. We sampled these plots using nooses from near dawn until we had made two consecutive passes across a plot without finding any new *Uta stansburiana* (side-blotched lizard; our most abundant species), and traps remained

open throughout the session. We generally noosed 1-4 times per year for a total of 1-11 four-day sampling sessions per plot. Boone et al. (1997) give additional details of the sampling procedure.

Our ability to estimate the susceptibility of reptiles to our three capture methods was complicated by differences in sampling effort. To estimate susceptibility, we standardized the number of animals caught using each sampling method by the amount of effort expended per method. We did this by dividing the total number of animals of each species captured per sampling method by the number of plot-days (1 day on 1 plot = 1 plot-day) that sampling method was used (99 days for traps and 388 days for nooses).

For species A: $\text{catch day}^{-1}_{A} = \text{total number caught}_{A} / \text{days spent sampling}$

$\text{catch day}^{-1}_{A} = \text{total number caught}_{A} / \text{days spent sampling}$ (Equation 1)

We used these numbers, the expected catch per day, to calculate the relative frequency of capture by each method per day. We calculated this by dividing the number of individuals of each species captured per method per day by the total number of individuals of each species captured per day.

$\text{Relative catch/day}_{\text{pitfall}} = (\text{\# caught/day}_{\text{pitfall}}) / (\text{\# caught/dau}_{\text{pitfall + funnel + noose}})$

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We assumed that the relative frequency of capture per method provided an index to susceptibility of capture using that method as compared to the other two methods.

Combined, our reptile sampling efforts resulted in 6,959 captures of 3,405 individuals and documented the presence of 23 species (10 lizards, 12 snakes, and 1 tortoise). However, each sampling method produced a different list of species; and combined, these techniques missed 5 species (2 lizards, and 3 snakes) that we detected using other methods. We caught 17 species in funnel traps, 12 species in pitfall traps, and 17 species using nooses (Table 1).

Using funnel traps, we caught 8 lizard species and 9 snake species (Table 1). These included one *Callisaurus draconoides* (zebratail lizard), one *Eumeces gilberti* (Gilbert's skink), and four *Hypsiglena torquata* (night snake) that we captured only in funnel traps. Using pitfall traps, we caught 6 species of lizards and 6 species of snakes. These included five *Tantilla hobartsmithi* (southwestern blackhead snake) that we captured only in pitfall traps. Using noosing techniques (noosing and hand capture), we caught 7 species of lizards, 9 species of snakes, and 1 species of tortoise. These included one *Sauromalus obesus* (western chuckwalla), one *Masticophis taeniatus*

(striped whipsnake), and many *Gopherus agassizii* (desert tortoise), species that we never captured in traps.

In addition to sampling, we made anecdotal observations and collected road kills that documented the presence of five species that we never captured on the 25 1-ha plots. These included *Dipsosaurus dorsalis* (desert iguana), *Sceloporus occidentalis* (western fence lizard), *Arizona elegans* (glossy snake), *Diadophis punctatus* (ringneck snake), and *Phyllorhynchus decurtatus* (spotted leafnose snake).

Species differed in their susceptibility to capture methods (Table 1). Lizards were generally more susceptible to capture in funnel traps or by noosing than by pitfall trapping, and we more often caught a given species with nooses or funnel traps, rather than by both methods equally. We never caught three species of lizards with nooses (*Callisaurus draconoides*, *Coleonyx variegatus*, and *Eumeces gilberti*), but we only captured two others (*Crotaphytus insularis* and *Sauromalus obesus*) using this method. We captured *Sceloporus magister* and *Cnemidophorus tigris* most often in traps, and we captured *Phrynosoma platyrhinos* and *Uta stansburiana* most often while noosing. These results may also have been influenced by a general decline in the number of lizards in 1994 and 1995. While the decline may have been due to natural changes in these populations, the decline also may have been due to inadvertent habitat modification while sampling or to other sampling effects, and it is unclear whether this decline affected our results.

Snakes were generally most susceptible to capture in funnel traps and, except for *Chionactis occipitalis* and *Tantilla hobartsmithi*, least susceptible to capture in pitfall traps. We never noosed or captured three species of snake (*Chionactis occipitalis*, *Hypsiglena torquata*, and *Tantilla hobartsmithi*), and we never trapped two species (*Masticophis taeniatus*, and *Crotalus cerastes*). We captured some species of snake only in pitfall (*Tantilla hobartsmithi*) or funnel traps (*Hypsiglena torquata*). However, the number of snakes captured in the pitfall traps was probably influenced by the depth of the bucket: because our traps were only 50 cm deep, large snakes probably escaped.

In addition to differences in susceptibility to capture using various methods, some species were not captured in numbers that reflect their apparent true abundance at Yucca Mountain. We recorded anecdotal observations of reptiles during nighttime road surveys, while traveling at night, and while working on other projects (spotlight surveys, radiotracking tortoises, sampling vegetation, and driving to and from our field sites). These observations invite the speculation that while we caught only one each of *Callisaurus draconoides* and *Sauromalus obesus*, they were relatively common in some habitats at Yucca Mountain, and that *Crotalus cerastes* (sidewinder) and *Phyllorhynchus decurtatus* were not uncommon. Also, despite our lack of capture records during plot sampling, *Sceloporus occidentalis* (captured) and *Arizona elegans* (road kill) were present at Yucca Mountain. Other species may have been present at Yucca Mountain, but were never recorded using any method. *Leptotyphlops humilis* (western blind snake) and *Trimorphodon biscutatus* (lyre snake) were probably present, but rare, in our area (Stebbins, 1966; Tanner, 1969; Tanner and Jorgensen, 1963).

Sampling method was important because estimates of presence-absence, relative abundance, and density differed among sampling techniques. For example, the list of uncommon species differed among methods: noosing techniques documented the presence of four species that were never trapped, trapping techniques documented the presence of five species that were never noosed, and both techniques missed some species known to occur in the study area. In addition, estimates of abundance based on any method suggest that both *Uta stansburiana* and *Cnemidophorus tigris* were relatively common, but data from only noosing or only trapping suggest different relative abundances. In view of the biases introduced by sampling method, we recommend that researchers carefully consider their sampling methods relative to the objectives of their study and the species they expect to capture. By applying a variety of biased sampling strategies (including several sampling techniques and anecdotal observations) to the question of species presence at Yucca Mountain, we produced a robust list of reptiles, little biased by differences among methods, that accounted for almost all species thought to occur in the area.

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Table 1. Susceptibility of reptiles to three sampling methods used between 1991 and 1995 at Yucca Mountain, Nevada. The total number captured using each method was standardized by effort (99 days each of funnel and pitfall trapping; 388 days of noosing) to determine mean number captured per day and relative frequency of capture per method. Cases with small sample sizes should be interpreted carefully.

Species	Common Name	Total Number Captured	Mean Number Captured per Day	Relative Frequency of Capture		
				Funnel	Pitfall	Noose
Testudines	turtles					
Testudunidae						
Gopherus agassizii	desert tortoise	[a]	[a]			
Sauria	lizards					
Crotaphytidae						
Crotaphytus insularis	desert collared lizard	37	0.10	0.00	0.00	1.00
Gambelia wislizenii	longnose leopard lizard	42	0.19	0.26	0.32	0.42
Iguanidae						
Sauromalus obesus	western chuckwalla	1	<0.01	0.00	0.00	1.00
Phrynosomatidae						
Callisaurus draconoides	zebratail lizard	1	0.01	1.00	0.00	0.00
Phrynosoma platyrhinos	desert horned lizard	94	0.36	0.22	0.22	0.55
Sceloporus magister	desert spiny lizard	25	0.21	0.71	0.24	0.06
Uta stansburiana	side-blotched lizard	5465	18.49	0.18	0.14	0.68
Gekkonidae						
Coleonyx variegatus	western banded gecko	50	0.51	0.56	0.44	0.00
Teiidae						
Cnemidophorus tigris	western whiptail	1031	7.77	0.48	0.41	0.12
Scincidae						
Eumeces gilberti	Gilbert's skink	1	0.01	1.00	0.00	0.00
Serpentes	snakes					
Colubridae						
Chionactis occipitalis	western shovelnose snake	6	0.06	0.17	0.83	0.00
Hypsiglena torquata	night snake	4	0.04	1.00	0.00	0.00
Lampropeltis getula	common kingsnake	6	0.03	0.66	0.00	0.34
Masticophis flagellum	coachwhip	49	0.38	0.87	0.03	0.10
Masticophis taeniatus	striped whipsnake	1	<0.01	0.00	0.00	1.00
Pituophis melanoleucus	gopher snake	15	0.10	0.82	0.00	0.18
Rhinocheilus lecontei	longnose snake	28	0.28	0.92	0.07	0.01
Salvadora hexalepis	western patchnose snake	8	0.07	0.92	0.00	0.08
Sonora semiannulata	ground snake	28	0.26	0.66	0.31	0.03
Tantilla hobartsmithi	southwestern blackhead snake	5	0.05	0.00	1.00	0.00
Viperidae						
Crotalus cerastes	sidewinder	1	<0.01	0.00	0.00	1.00
Crotalus mitchellii	speckled rattlesnake	4	0.03	0.61	0.31	0.08

[a] *Gopherus agassizii*, the focus of separate studies, was detected but not counted during the lizard and snake surveys.