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PRELIMINARY OBSERVATIONS OF THE BEHAVIOR OF MALE, FLAT-TAILED HORNED LIZARDS BEFORE AND AFTER AN OFF-HIGHWAY VEHICLE RACE IN CALIFORNIA

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Animal movements are influenced by many factors, including the need for food and other resources necessary for survival; searching for mates or nest and brood sites; and response to stress, including escape from predators and environmental extremes. Although it is often difficult to determine the exact cause for particular movements by animals, movement, nonetheless, reflects an organism's response to its immediate and changing environment.

The flat-tailed horned lizard, *Phrynosoma mcallii,* is found in extreme southern California, southwestern Arizona, and northwestern Mexico. It was proposed for listing as a threatened species under the federal Endangered Species Act, but the proposal was withdrawn (USFWS[3] 1997). A variety of threats were identified in the listing proposal, including habitat destruction and direct mortality due to off-highway vehicle (OHV) activity. Large areas of habitat occupied by flat-tailed horned lizards are negatively impacted by OHV activity (Lovich and Bainbridge 1999). In addition to direct impacts, OHV activity may modify the behavior and, possibly, habitat use of this species (Wone and Beauchamp 1995, Beauchamp et al. 1998). In this paper we compare the rates of movement, activity areas, and mean vectors of movement of 3 radio-tagged, male, flat-tailed horned lizards before and after an OHV race.

The Yuha Desert study site (36°32'N, 115°51'W) is located in the western portion of the Colorado Desert (Burk 1977) of southeastern California. The area is managed

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[3] USFWS (United States Fish and Wildlife Service). 1997. Withdrawal of the proposed rule to list the flat-tailed horned lizard as threatened. Federal Register 62:37852-37860.

by the U.S. Bureau of Land Management, as an "Open Area" – a place where OHVs may travel both on and off roads and trails.

Vegetation at the study site was dominated by creosote bush, *Larrea tridentata;* burro-bush, *Ambrosia dumosa*; and scattered ocotillo, *Fouquieria splendens*. Total shrub cover was <5%. Small washes braided throughout the site and were dominated by burro-bush; galleta grass, *Pleuraphis rigida*; dyeweed, *Psorothamnus emoryi*; desert holly, *Atriplex hymenelytra*; and allscale, *A. polycarpa*. Plant cover in the washes averaged about 25%. Soils outside the washes were characterized by sand, small pebbles, and occasional cracked clay lenses. Wash soils were composed of coarse sand and gravel.

The core of the study site was bisected by a race course that is used as an OHV trail throughout the year. The race is called "24 hours of LeFud" and lasts from 0700 hours to 0700 hours the following morning (4–5 May 1996). Dune buggies, motorcycles, and other OHV's participate in this biennial event. Twenty-four hours prior to the race about 10 participants practiced the course throughout the day. The race began with approximately 50 participants traveling through the study plot about once every 20 minutes. Only 4–6 vehicles completed the race.

Before the race, 3 male, flat-tailed horned lizards were fitted with radio transmitters and released at the point of capture. The lizards weighed 13.5, 18.0, and 19.0 g and were 74, 71, and 74 mm snout-vent length, respectively. All were assumed to be adults (Turner and Medica 1982). Transmitters were attached with backpack harnesses following the method of Fisher and Muth (1995).

Lizards were monitored for 8–10 days before the race and 10 days after it. Locations of lizards were recorded at least once every other day, but usually twice per day (once before 1000 hours and once after 1500 hours) using a handheld global positioning system. Coordinates were differentially corrected to an accuracy of ±3 m. In addition to measuring distance between recaptures (meters), compass bearings were taken from the actual point of last relocation to the next relocation point. Wind speed, air temperature (1 cm above the ground), and relative humidity were measured each time a lizard was relocated.

As the time interval between relocations varied both among lizards and before and after the race, data on movement were standardized for statistical analysis to rates expressed as m/hour. A randomized-block ANOVA, blocking on individual lizards, was used to test for differences in movement rates before and after the race. Data were log-transformed to normalize them prior to analysis. Because compass direction is a circular scale variable, compass bearings between consecutive recaptures were analyzed separately using Oriana© software for circular statistics. Muth and Fisher[4] (1992) estimated that as many as 70 recaptures were required to adequately describe the home range of flat-tailed horned lizards. As relocations ranged from 10 to 16 for each lizard in each sampling interval (before or after the race), we chose the term "activity area" to describe the areas occupied by the lizards. Activity

[4] Muth, A. and M. Fisher. 1992. Development of baseline data and procedures for monitoring populations of the flat-tailed horned lizard. Final Report for Contract FG 9268, California Department of Fish and Game, Sacramento, California, USA.

area size was estimated using CALHOME shareware (Kie et al. 1996). We used the minimum convex polygon that encompassed all the observed locations for an animal during a given sampling interval (before or after the race event). Other statistical analyses were conducted using SYSTAT (Wilkinson 1988). Given the sensitive conservation status of the lizard and our small sample size, alpha was set at 0.10 to minimize the probability of "accepting" a false null hypothesis that OHV activity had no effect on lizard behavior.

Climatic conditions were similar before and after the race. Air temperatures ranged from 21 to 49°C and were not significantly different before and after the race (F = 0.32; df = 1,68; P = 0.58). Rates of movement before the race (n = 36) ranged from 0 to 21.2 m/hour with a mean of 3.6 m/hour (SD = 5.4). After the race, movements (n = 40) ranged from 0 to 16.5 m/hour with a mean of 2.4 m/hour (SD = 3.6). Mean log-transformed rates of movement before and after the race (1 case deleted due to no movement) differed significantly (P = 0.085), after blocking for the significant effect (P <0.001) of individuals (Table 1). Distances moved between consecutive relocations varied with no obvious pattern related to the race. Activity area size increased for lizard #266, decreased for lizard #936, and remained about the same for lizard #17 following the race (Table 2). Rates of movement were not significantly correlated with wind speed or relative humidity, but were significantly correlated with air temperature (r = –0.289, P = 0.083).

Direction of movement between relocations before and after the race also varied significantly (Watson's F-test for 2 circular means, F = 15.6, df = 74, P <0.01). Prior to the race, movements were almost uniform, as shown by a wide 95% confidence interval (65.3° clockwise to 15.4°) for a mean vector of 220.3°. After the race, movement directions were still highly variable, but the 95% confidence

Table 1. Randomized-block ANOVA for log-transformed data on rates of movement (m/hour) of 3 radio-tagged, male, flat-tailed horned lizards before and after (treatment) an off-highway vehicle race. Blocking is on individuals.

Source	Sum of squares	DF	Mean square	F-ratio	P
Block	39.790	2	19.895	13.887	<0.001
Treatment	4.384	1	4.384	3.060	0.085
Error	101.717	71	1.433		

Table 2. Summary of movements of male, flat-tailed horned lizards before and after an off-highway vehicle race. Activity areas are based on minimum convex polygons. Sample sizes are given in parentheses.

	Mean distance (m) between sequential recaptures		Activity area size (m^2)	
Lizard ID #	Before	After	Before	After
17	71.7 (14)	53.8 (12)	14,450	11,190
266	32.6 (11)	131.7 (10)	2,708	65,390
936	18.3 (15)	6.3 (15)	3,776	75

interval (255.7° clockwise to 118.3°) was reduced and the mean vector of movement shifted to 7°.

OHV activity impacts desert animals (Webb and Wilshire 1983, Brooks 1995) in various ways, including hearing loss in some lizards (Brattstrom and Bondello 1983). Others have noticed decreased abundance of desert reptiles in areas used by OHVs (Busack and Bury 1974, Bury et al. 1977). Vollmer et al. (1976) compared areas in which they repeatedly drove a 4-wheel-drive truck with control areas and noted differing responses of various lizard species. Side-blotched lizard, *Uta stansburiana*, and whiptail lizard, *Cnemidophorus tigris* densities were similar before, during, and after the experiment. However, counts of zebra-tailed lizards, *Callisaurus draconoides*, were much lower in the driven area.

Our small sample of male, flat-tailed horned lizards exhibited reduced rates of movement following disturbance from OHVs. This, coupled with the fact that flat-tailed horned lizards are often sighted on roads (Norris 1949, Turner and Medica 1982), may make them especially susceptible to mortality from vehicle strikes. While driving a vehicle, Wone and Beauchamp (1995) observed that the majority (86%) of the flat-tailed horned lizards they encountered fled for short distances and stopped, sometimes under shrubs, and sometimes on OHV trails. Thus, flat-tailed horned lizards may attempt to avoid OHVs, although road mortalities have been observed when lizards fail to move out of the way of oncoming traffic (Muth and Fisher[4] 1992).

Our results for activity area size were equivocal, as some increased and others decreased after the race. Turner and Medica (1982) reported that the mean home range size of 5 male, flat-tailed horned lizards, as measured with convex polygons, was 1,287 m^2 (range 804–2,112 m^2). The activity areas we observed (Table 2) were generally much larger, but we used almost twice as many recaptures as Turner and Medica (1982).

Avoiding OHV activity may not protect flat-tailed horned lizards from lethal effects. Muth and Fisher[4] (1992) observed dormant flat-tailed horned lizards at soil depths from 2.5 to 10 cm (mean = 5.6, n = 6). As motorcycle tires are capable of increasing soil density (soil compaction) to depths of 30–60 cm (Webb 1983), OHV activities may kill immobile subterranean animals (Stebbins 1995).

The consequences of moving at different rates and directions after a disturbance may be negative or positive. If these changes fail to take the animal away from the area of impact, or the movements are energetically costly, the consequences may be negative. If the movements decrease the probability of an animal being struck by an OHV, then the consequences are potentially positive. While our analysis is preliminary because of small sample size, these data are the first to suggest that OHV activity affects movement of flat-tailed horned lizards.

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