

# Effects of Vegetation Loss on a Sand Dune Lizard

OMAR A. ATTUM,<sup>1,2</sup> Department of Biology, University of Louisville, Louisville, KY 40207, USA

PERRI K. EASON, Department of Biology, University of Louisville, Louisville, KY 40207, USA

(JOURNAL OF WILDLIFE MANAGEMENT 70(1):27–30; 2006)

## Key words

*Acanthodactylus longipes*, agriculture, body condition, distance from refuge, Egypt, grazing, habitat degradation, predation, thermoregulatory behavior, vegetation loss.

Habitat degradation in the form of vegetation loss often decreases the abundance of various species of reptiles (Fleischner 1994, Smith et al. 1996). Several reasons have been proposed for why vegetation loss should decrease abundance, including reduction of thermoregulatory patches, decreased prey availability, and increased predation from being in more exposed areas (Jones 1981, Norbury 2001). Vegetation loss could adversely affect lizards because they might be unable to escape lethal substrate temperatures (Adolph 1990, Carrascal et al. 1992). Vegetation loss may also decrease food availability, which could affect reptile abundance either directly or indirectly by affecting behavior. Individuals might compensate for reduced food availability by moving farther in search of prey or spending more time foraging, which might increase their susceptibility to predators (MacArthur and Pianka 1966, Hinsley 2000). Vegetation loss might additionally increase predation risk because fewer refuges are available.

We examined the effects of vegetation loss by livestock grazing and agricultural practices on the abundance of the lizard *Acanthodactylus longipes*. To investigate the differences in abundance we found, we next compared body condition, thermoregulatory behavior, and activity patterns of lizards from unprotected and protected habitats. To test the hypothesis that vegetation loss affected thermoregulatory behavior, we compared the time that *A. longipes* spent thermoregulating by postural changes in unprotected and protected habitats. We expected that lizards in habitats with less vegetation might spend more time thermoregulating at higher temperatures by postural changes, while lizards in protected habitats might use vegetation more frequently. To test whether vegetation loss affected food availability or susceptibility to predation, we examined whether lizards in habitats experiencing vegetation loss moved greater distances or spent more time moving than in protected habitats. We assumed that if food availability were decreased, lizards would compensate by moving greater distances while foraging or spending more time foraging. This analysis also assumes that more active lizards are at higher risk of predation due to greater visibility. To provide an additional assessment of predation risk, we examined the distance from vegetation at which the lizard was observed.

*A. longipes* is a common diurnal lizard that inhabits the sand dune deserts of North Africa and the Middle East; it thermoregulates by postural changes and by using vegetation (Attum 2004).

<sup>1</sup> E-mail: attumo@lpfw.com

<sup>2</sup> Present address: Center for Reptile and Amphibian Conservation and Management, Indiana–Purdue University at Fort Wayne, Fort Wayne, IN 46805

*A. longipes* is ecologically and morphologically specialized for psammophile environments (Arnold 1981, Baha El Din 2001).

## Study Area

The location of our study was Zaranik Protected Area (ZPA) in North Sinai, Egypt. The ZPA occupies 250 km<sup>2</sup> and is 30 km west of the town of El Arish along the Mediterranean Sea (31°05'N, 33°25'E). Altitude within the park ranges from sea level to 30 m, and rainfall varies between 50 and 100 mm per year. The vegetation of our study sites is characterized as an *Artimesia monosperma*–*Stipagrostis scoparia* community and is located in semistable sand dunes. The ZPA is subjected to grazing and seasonal, small-scale, and low-impact watermelon farming by the inhabitants residing within the protected area. Prior to watermelon cultivation, 1 species of vegetation, the sagebrush *A. monosperma*, is removed and the remaining vegetation is left intact; thus, the watermelon patches are not monocultures. In addition, watermelons are not treated with pesticides, watered, or maintained in any way. Livestock graze on all palatable species of vegetation, including *A. monosperma*, which is generally palatable only as seedlings.

## Methods

We conducted our study between September 1999 and September 2000. Lizards were sampled in 6 sites, which were 50 m × 50 m. Each site was sampled 2 to 4 times monthly. The 3 unprotected sites were not fenced and experienced vegetation loss as a result of grazing and agriculture (Attum 2004). The remaining 3 sites were protected by fences established in December 1998. Protected sites had higher vegetation cover (10% vs. 5%) and abundance than unprotected sites (Attum 2004).

We observed each lizard for 3 min. Lizards startled by the investigator's arrival, that disappeared from view, or that chased conspecifics were not included in focal samples. Once established, the human observer is unlikely to have affected the lizards' behavior: individuals often approached the observer and foraged nearby, and on occasion individuals used the observer's shade for thermoregulation (these observations were omitted from analyses). We captured lizards immediately after observation to weigh, measure, and mark them with paint markers. Body condition was estimated by weight divided by snout-vent length (SVL); abundance for each plot was the total number of marked lizards caught over the study period.

During focal observations, we recorded active time, distance moved, and duration of thermoregulatory behaviors. Active time

included time spent in any active behavior, such as moving or digging. Distance moved was the distance an individual traveled in the 3-min observation. *A. longipes* thermoregulated by postural positions and by using vegetation; postural positions included basking and stiling (Attum 2004). Basking lizards were in the sun, not moving, and their tails touched the substrate. Stiling lizards were also in the sun but had their bodies raised off the substrate and tails elevated. Lizards using vegetation either rested in its shade or atop it. Even small vegetation could provide shade and perches; *A. longipes* were never observed on top of shrubs or grasses.

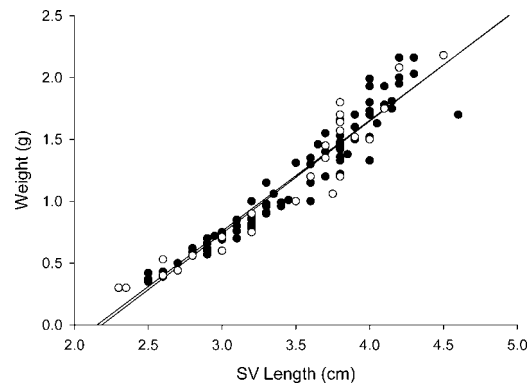
Following the focal sample, we measured substrate temperature and distance from nearest vegetation. We measured substrate temperature by pressing a thermometer flush with the substrate. Distance from vegetation was the distance from the lizard to the nearest shrub or bunch grass that provided both thermal and predator refuge; seedlings, annuals, and leaf litter were not included because they were too small to provide predator refuge, although they could provide thermal refuge.

The analysis of abundance and body condition included only marked individuals. The data for thermoregulatory and activity patterns included observations of unmarked and marked lizards. To reduce the likelihood of pseudoreplication, the only unmarked individuals included in these 2 analyses were those observed on the first day of each month; repeated observations of the same marked individuals were not included in the analysis. We made 459 observations of lizards (247 unmarked and 212 marked) in protected sites. Sixty of the unmarked and 39 of the marked lizards from protected sites were used in the analysis. Eighty-two lizard observations (38 unmarked and 44 marked) occurred in the unprotected sites. Sixteen of the unmarked and 9 of the marked lizards were used in the analysis.

We analyzed the effects of vegetation loss on abundance using a 1-way ANOVA. We used ANCOVA to analyze body condition, thermoregulation, and activity. We adjusted  $P$ -values using Bonferroni corrections and considered tests to be significant if the  $P$ -value was less than the adjusted alpha ( $\alpha_{adj}$ ). The independent variables for all analyses were substrate temperature (covariate), site (which was considered random and nested within habitat quality), and habitat quality (protected and unprotected; categorical variable). We also examined the interaction between substrate temperature and habitat quality. Due to the lack of observed thermoregulatory behavior at relatively low temperatures, the residuals had a bimodal distribution. Accordingly, to achieve a normal residual distribution, data for a behavior that did not occur were removed from the analysis, and all dependent variables were  $\log(y + 1)$  transformed.

## Results

*A. longipes* were  $>3$  times as abundant in protected sites as in unprotected sites ( $F_{1,4} = 19.28$ ,  $P = 0.0012$ ;  $X \pm SE$ ; protected:  $29 \pm 4.2$ ; unprotected:  $9 \pm 2$ ). However, neither body condition nor weight of lizards significantly differed between unprotected and protected sites ( $F_{1,107} = 0.37$ ,  $P = 0.55$ ;  $F_{1,111} = 0.62$ ,  $P = 0.43$ ; Fig. 1). As expected, weight was significantly affected by SVL, as longer lizards weighed more ( $F_{1,107} = 940.85$ ,  $P < 0.0001$ ). There was also significant variation in weight of lizards among the different sites ( $F_{4,107} = 2.55$ ,  $P = 0.043$ ).



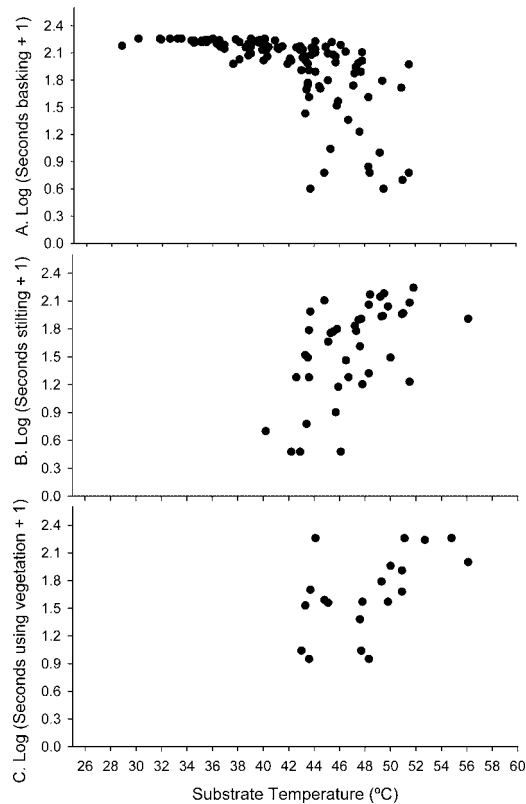
**Figure 1.** Body condition of *A. longipes* in protected (solid circles) and unprotected sites (open circles).

As expected, basking decreased as substrate temperature increased ( $F_{1,106} = 27.46$ ,  $P < 0.0001 < \alpha_{adj}$ ; Fig. 2A); basking began to decline above 42°C. In contrast, stiling increased as substrate temperature increased (Fig. 2B;  $F_{1,35} = 12.29$ ,  $P = 0.001 < \alpha_{adj}$ ), only occurring above 40°C. Similarly, the use of vegetation increased as substrate temperature increased (Fig. 2C;  $F_{1,14} = 12.88$ ,  $P = 0.003 < \alpha_{adj}$ ), only occurring above 43°C. However, none of these 3 thermoregulatory variables were significantly affected by habitat protection (basking:  $F_{1,108} = 0.022$ ,  $P = 0.883$ ; stiling:  $F_{1,35} = 0.22$ ,  $P = 0.639$ ; vegetation use:  $F_{1,14} = 2.20$ ,  $P = 0.160$ ), site (basking:  $F_{4,106} = 1.622$ ,  $P = 0.174$ ; stiling:  $F_{4,35} = 1.40$ ,  $P = 0.254$ ; vegetation use:  $F_{3,14} = 5.03$ ,  $P = 0.686$ ), or the interaction between habitat protection and substrate temperature (basking:  $F_{1,106} = 0.024$ ,  $P = 0.876$ ; stiling:  $F_{1,35} = 0.18$ ,  $P = 0.672$ ; vegetation use:  $F_{1,14} = 1.90$ ,  $P = 0.190$ ).

In unprotected sites, *A. longipes* were 1.6× more active ( $F_{1,105} = 8.29$ ,  $P = 0.005 < \alpha_{adj}$ ; Fig. 3) and found almost twice as far from vegetation ( $F_{1,118} = 7.89$ ,  $P = 0.006 < \alpha_{adj}$ ; Fig. 3) than lizards in protected sites. However, habitat protection had no significant effect on distance moved ( $F_{1,105} = 4.05$ ,  $P = 0.047 > \alpha_{adj}$ ), which suggests that individuals in unprotected habitats moved faster than individuals in protected habitats. None of the activity indices were affected significantly by substrate temperature (move duration:  $F_{1,105} = 3.05$ ,  $P = 0.084$ ; distance moved:  $F_{1,105} = 0.579$ ,  $P = 0.448$ ; distance from vegetation:  $F_{1,115} = 0.25$ ,  $P = 0.618$ ), site (move duration:  $F_{4,105} = 1.15$ ,  $P = 0.084$ ; distance moved:  $F_{4,105} = 1.31$ ,  $P = 0.271$ ; distance from vegetation:  $F_{4,115} = 2.56$ ,  $P = 0.042 > \alpha_{adj}$ ), or the interaction between substrate temperature and habitat quality (move duration:  $F_{1,105} = 7.19$ ,  $P = 0.009 > \alpha_{adj}$ ; distance moved:  $F_{1,105} = 3.20$ ,  $P = 0.076$ ; distance from vegetation:  $F_{1,115} = 6.67$ ,  $P = 0.011 > \alpha_{adj}$ ).

## Discussion

Protecting the habitat significantly increased the abundance of *A. longipes*. The reduced abundance of *A. longipes* in unprotected habitats may be due to increased susceptibility to predators and reduced food availability. Past studies have shown that insect abundance is lower in arid habitats with less vegetation, and presumably our unprotected sites similarly have lower insect abundance (Robinson 1981, Sanchez and Parmenter 2002). However, the body condition of *A. longipes* did not significantly

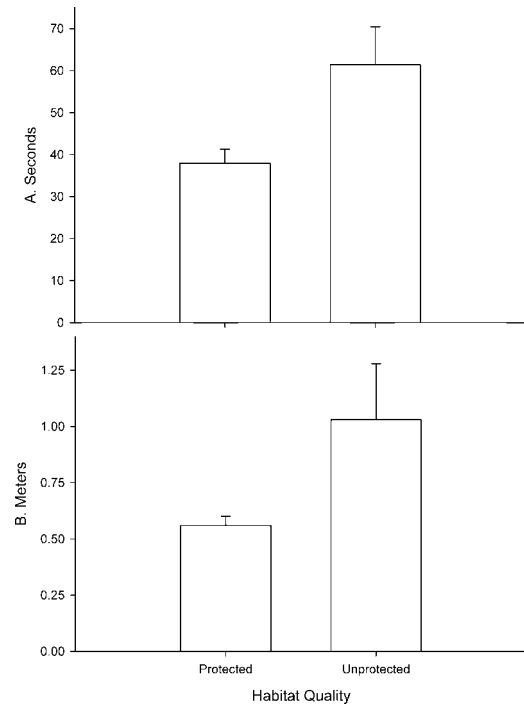


**Figure 2.** The relationship between substrate temperature and thermoregulatory behavior. (A) The relationship between Log (seconds basking + 1) and substrate temperature,  $n = 114$ . (B) The relationship between Log (seconds stiling + 1) and substrate temperature,  $n = 43$ . (C) The relationship between Log (seconds using vegetation + 1) and substrate temperature,  $n = 21$ .

differ between protected and unprotected sites. This suggests that individuals in unprotected habitats are not facing a food shortage and thus that the decreased insect abundance might limit the carrying capacity.

*A. longipes* did not significantly alter its thermoregulatory behaviors as a result of vegetation loss. This may be because *A. longipes* can use very small vegetation for shade or perching, and such vegetation is present even in unprotected habitats. Alternatively, this species may be able to escape the thermal effects of vegetation loss because it commonly uses stiling to thermoregulate at high substrate temperatures. Stiling allows *A. longipes* to position the body off the warmer substrate and into the boundary layer of cooler air to prevent body temperature from rising (Stevenson 1985b, Shine and Kearney 2001). The long limbs of this species (Baha El Din 2001) may further enhance stiling's effectiveness as a thermoregulatory strategy. Though traditionally considered a trait that increases sprint speed in organisms occupying open areas (Pianka 1969, Melville and Swain 2000), long limbs are also a beneficial trait for stiling because they position the body farther off the substrate (Medvedev 1965, Broza et al. 1983). Postural changes may also be especially beneficial for smaller organisms (adult *A. longipes* weigh between 0.8 and 2.4 g) because they have higher surface area/volume ratios that promote faster heat exchange to equalize body and air temperature (Stevenson 1985a).

Stiling should be particularly effective in open areas—such as



**Figure 3.** The effect of habitat quality on time moving and distance from nearest vegetation. (A) The effect of habitat quality on time moving (seconds), mean  $\pm$  SE. Protected  $n = 99$ , Unprotected  $n = 25$ . (B) The effect of habitat quality on distance found from nearest vegetation (m), mean  $\pm$  SE. Protected  $n = 98$ , Unprotected  $n = 25$ .

our study sites—which have little vegetation cover and typically higher wind velocity than heavily vegetated areas (Stevenson 1985b); it also utilizes the most abundant microhabitat, open ground. Stiling may be a behavior that allows species to exist in habitats with little vegetation, where there are typically high substrate temperatures and few thermal refuges (Adolph 1990). Therefore, vegetation loss may not affect *A. longipes* as it would species that depend on vegetation to escape higher substrate temperatures (Fleischner 1994, Attum 2004).

Vegetation loss appears to alter the activity of *A. longipes*. Lizards in unprotected habitats spend significantly more time moving and were found further away from vegetation. These longer moving durations may be the result of having to compensate for reduced availability of resources by more intensively searching for food (MacArthur and Pianka 1966, Huey and Pianka 1981).

*A. longipes* in unprotected habitats may be more susceptible to predation as a result of being more conspicuous and attracting the attention of predators while being further away from vegetation. Vegetation often serves as a retreat, and *Acanthodactylus* burrows are often found near vegetation; the reduced abundance of vegetation in the unprotected sites reduces the availability of these safe refuges (Norbury 2001, Zaady and Bouskila 2002). Thus, we suggest that the unprotected habitats are more dangerous, open areas typically associated with increased predation risk (Brown et al. 1988, Kotler et al. 1991, Vasquez et al. 2002). It is, however, possible that the higher risk of being attacked by any predator present in unprotected sites is ameliorated by a lower abundance of predators compared to protected areas (Attum 2004).

## Management Implications

Habitat protection by fencing increased the abundance of *A. longipes* by more than 3 times its abundance in unprotected areas. This result is somewhat surprising because *A. longipes* is considered a sand dune, desert specialist that can occupy relatively bare habitat. For this particular species, habitat protection did not appear to affect thermoregulatory behavior; rather, the increased vegetation in protected sites may increase carrying capacity. This species responded quickly to habitat protection, with abundance increasing in less than 2 years after the establishment of fences; further research on other desert species is needed to see whether this is part of a general pattern in this region. The protected sites in this study were relatively small and yet were successful in supporting more lizards. This is encouraging because managers with few funds or limited capability to protect large expanses may still be able to protect small areas scattered through a zone experiencing vegetation loss; those small islands of protected land

## Literature Cited

- Adolph, S. C. 1990. Influence of behavioral thermoregulation on microhabitat use by two *Sceloporus* lizards. *Ecology* 71:315–327.
- Arnold, E. N. 1981. Competition, evolutionary change and montane distributions. Pages 217–228 in P. L. Forey, editor. *The evolving biosphere*. Cambridge University Press, Cambridge, United Kingdom.
- Attum, O. 2004. The ecology and effects of habitat degradation on sand dune reptiles. Dissertation, University of Louisville, Louisville, Kentucky, USA.
- Baha El Din, S. M. 2001. The herpetofauna of Egypt: species, communities, and assemblages. Dissertation, University of Nottingham, Nottingham, United Kingdom.
- Brown, J. S., B. P. Kotler, and R. J. Smith. and W. O. Wirtz. 1988. The effects of owl predation on the foraging behavior of heteromyid rodents. *Oecologia* 76:408–415.
- Broza, M., M. P. Pener, and A. Borut. 1983. On the adaptive significance of leg length in diurnal Tenebrionid beetles of the genus, *Adesmia* (Coleoptera: Tenebrionidae). *Annals of the Entomological Society of America* 76:821–824.
- Carrascal, L. M., P. Lopez, J. Martin, and A. Salvador. 1992. Basking and antipredator behavior in a high altitude lizard: implications of heat-exchange rate. *Ethology* 92:143–154.
- Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology* 8:629–644.
- Hinsley, S. A. 2000. The costs of multiple patch use by birds. *Landscape Ecology* 15:765–775.
- Huey, R., and E. R. Pianka. 1981. Ecological consequences of foraging mode. *Ecology* 62:991–999.
- Jones, B. 1981. Effects of grazing on lizard abundance and diversity in western Australia. *Southwestern Naturalist* 26:107–115.
- Kotler, B. P., J. S. Brown, and O. Hasson. 1991. Factors affecting gerbil foraging behavior and rates of owl predation. *Ecology* 72:2249–2260.
- MacArthur, R. H., and E. R. Pianka. 1966. On optimal use of a patchy environment. *American Naturalist* 100:603–609.
- Medvedev, G. S. 1965. Adaptations of leg structure in desert darkling beetles (Coleoptera: Tenebrionidae) *Entomological Review* 44:473–485.
- Melville, J., and R. Swain. 2000. Evolutionary relationships between morphology, performance, and habitat openness in the lizard genus *Niveoscincus* (Scincidae: Lygosominae). *Biological Journal of the Linnean Society* 70:667–683
- Norbury, G. 2001. Conserving dryland lizards by reducing predator-mediated apparent competition and direct competition with introduced rabbits. *Journal of Applied Ecology* 38:1350–1361.
- Pianka, E. R. 1969. Habitat specificity, speciation and species density in Australian desert lizards. *Ecology* 50:498–502.
- Robinson, J. V. 1981. The effect of architectural variation in habitat on the spider community: an experimental field study. *Ecology* 62:73–80.
- Sanchez, B. C., and R. R. Parmenter. 2002. Patterns of shrub dwelling arthropods diversity across a desert shrubland–grassland ecotone: a test of island biogeographic theory. *Journal of Arid Environments* 50:247–265.
- Shine, R., and M. Kearney. 2001. Field studies of reptile thermoregulation: how well do physical models predict operative temperatures? *Functional Ecology* 15:282–288.
- Smith, G., G. Arnold, S. Sarre, M. Abensperg-traun, and D. Steven. 1996. The effect of habitat fragmentation and livestock grazing on animal communities in remnants of gimlet *Eucalyptus salubris* woodland in the western Australian wheatbelt. II Lizards. *Journal of Applied Ecology* 33:1302–1310.
- Stevenson, R. D. 1985a. Body size and limits to the daily range of body temperature in terrestrial ectotherms. *American Naturalist* 125:102–117.
- Stevenson, R. D. 1985b. The relative importance of behavioral and physiological adjustments controlling body temperature in terrestrial ectotherms. *American Naturalist* 126:362–386.
- Vasquez, R. A., L. A. Ebensperger, and F. Bozinovic. 2002. The influence of habitat on travel speed, intermittent locomotion, and vigilance in a diurnal rodent. *Behavioral Ecology* 13:182–187.
- Zaady, E., and A. Bouskila. 2002. Lizard burrows association with successional stages of biological soil crusts in an arid sandy region. *Journal of Arid Environments* 50:235–246.

Associate Editor: Ribic.