

Habitat Use and Food Preferences of the Desert Tortoise, *Gopherus agassizii*, in the Western Mojave Desert and Impacts of Off-Road Vehicles

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ABSTRACT: The desert tortoise, *Gopherus agassizii*, and its habitats in the western Mojave Desert and elsewhere are negatively affected by off-road vehicles (ORVs). Data from a study conducted at the Desert Tortoise Research Natural Area during 1992 provide insights into why ORVs are likely to affect tortoises. To determine habitat use and food preferences, 18 large immature and adult tortoises were observed. The study site contained four subhabitats or strata: washes (comprising 7.9% of the area), washlets (2.4%), hills (42.3%), and flats (47.4%). The tortoises used the four habitat strata differentially, spending significantly more time (92%) in washes, washlets, and hills throughout spring than in the flats (8%). They were observed to take bites from 2,423 individual plants of at least 43 plant species (37 annual, 6 perennial). They showed preferences for native plants (95.3% of bites) compared to non-native plants. Some of the ten most-preferred food plants were uncommon to rare in the environment. Three of the ten most-preferred food plants occurred largely in the wash strata, and an additional four species were found only in hill strata. Users of recreational vehicles also prefer washes and hills in this region, where they are more likely to encounter tortoises, increasing the possibility of direct mortality, and where they are more likely to have a greater impact upon preferred forage and habitats.

Recreational use of off-road vehicles (ORVs), popular since the late 1960s in the southwestern deserts of the United States, poses significant threats to desert tortoises in some parts of their geographic range (U. S. Fish and Wildlife Service [USFWS], 1994). The threats are both direct and indirect: direct encounters, damage to and loss of habitat, damage to or loss of burrows, and loss or changes in both the composition of the forage and the quality of shrub cover. In this paper, I report findings from research conducted in the western Mojave Desert in and adjacent to the Desert Tortoise Research Natural Area (Jennings, 1993), specifically, desert tortoise use of different habitat types, their preferred forage plants, and the possible impacts of ORVs on these two critical aspects of desert tortoise ecology.

METHODS

The study area was typical of the western Mojave Desert, a topographic and vegetational mosaic of subhabitats or strata that includes washes, sandy flats, low hills, and rocky slopes where the most common vegetation types are saltbush (*Atriplex* spp.) scrub and creosote bush (*Larrea tridentata*) (U. S. Bureau of Land Management and California Dept. of Fish and Game, 1988; USFWS, 1994). Specifically, the 2.6 km² study area was composed of four strata or subhabitats, each with its unique composition of perennial and ephemeral plants (Jennings, 1993). The four strata were flats (comprising 47.4% of the study area), hills (42.3%), washes

(7.9%), and washlets (2.4%). Wash and washlet strata were lumped for a portion of the analyses. In the flats, the dominant species were three shrubs: goldenhead (*Acamptopappus sphaerocephalus*), burro bush (*Ambrosia dumosa*), and creosote bush. In the hills the most diverse of the strata with 11 species, five species of shrubs were dominant: burro-bush, California buckwheat (*Eriogonum fasciculatum*), goldenhead, Mojave aster (*Xylorhiza tortifolia*), and creosote bush. Shrubs in wash and washlet strata were burro-bush, cheesebush (*Hymenoclea salsola*), goldenhead, bladdersage (*Salazaria mexicana*), creosote bush, and Anderson thornbush (*Lycium andersonii*). Data on absolute and relative densities of plant species were collected once for the perennial shrubs using linear transects and 2 × 5 m quadrats. Similar data were collected using the same method for herbaceous perennial and ephemeral plant species on 17–20 April, 12–15 May, and 12–13 June. Details of methodology are in Jennings (1993). Scientific names of plants are taken from Hickman (1993).

To determine how the tortoises used the four habitat strata, I observed 18 large immature and adult tortoises (8 females and 10 males), which ranged from 179 to approximately 380 mm in carapace length at the midline (Jennings, 1993). Most tortoises had been fitted with radio transmitters as part of other research programs. The tortoises were tracked from the time they emerged from hibernation through the spring (1 March–30 June), and their activities, use of habitat, and forage items were recorded. Because the

ephemeral and herbaceous perennial plants on which tortoises feed have different growth, flowering, and fruiting periods during the year, I grouped the species into three phenological periods for analysis: 1 March to 30 April, 1 to 31 May, and 1 to 30 June. The use of phenological periods for data analysis also provided a better understanding of when and where tortoises were foraging, how they were using the habitats, and when the different forage plants were consumed.

RESULTS

The tortoises made differential use of the four habitat strata (Jennings, 1993). Between 1 March and 30 April, they spent a disproportionately longer time within the hill and washlet strata (84%; $\chi^2 = 1353.01$, d.f. = 2, $P = 0.0001$) and foraged on preferred food plants located exclusively in hill areas (*Mirabilis bigelovii*, *Astragalus didymocarpus*) and washlet margins (*A. layneae*, *Camissonia boothii*). During the second phenological period, the use of hill, wash, and washlet areas continued to be important (100%; $\chi^2 = 1405.8$, d.f. = 2, $P = 0.0001$). Tortoises foraged on *A. layneae* and *C. boothii* and then moved into the hills to eat the preferred *Lotus humistratus* and *Prenanthes exigua*. (Both *Lotus* and *Prenanthes* were restricted to the hills.) During the third phenological period, tortoise activity declined markedly because of heat and dry weather, and the few tortoises that remained above ground used primarily washes and washlets (68%; $\chi^2 = 753.83$, d.f. = 2, $P = 0.0001$), drawing on plants confined to those areas (*Euphorbia albomarginata* and *C. boothii*). Overall, tortoises made little use of the more common flat stratum.

The tortoises' diet and preferred foods were determined from observations of a total of 34,657 bites taken from 2,423 individual plants between 24 March and 21 June of 1992 (Jennings, 1993). Tortoises foraged from at least 43 species of plants (37 species of winter-spring annuals and 6 perennial species) as well as a dead leopard lizard (*Gambelia wislizenii*) and tortoise scat. Some important patterns emerged. These tortoises were highly selective foragers and preferred to consume native plants (33,712 bites or 95.3%) over non-native species (1,644 bites, 4.1%). The non-native species were filaree (*Erodium cicutarium*), Mediterranean grass (*Schismus arabicus*, *S. barbatus*), and foxtail chess (*Bromus madritensis* ssp. *rubens*), and were readily available. The tortoises also took more bites from annuals (69.2%) than from perennial plants (30.8%); with the exception of four bites from cheesebush, all bites of perennial plants were from herbaceous or suffrutescent perennial plant species. Tortoises took more bites from legumes (44%) than from any other plant family.

Some of the ten most-preferred food plants consumed during 1992 were uncommon to rare in the environment

(Jennings, 1993). For example, during the first phenological period, plants of the suffrutescent perennial *M. bigelovii* constituted 29.7% of the bites taken by tortoises, yet *M. bigelovii* constituted <1% of the perennial plants in the environment and far less of the total biomass of both ephemeral and perennial plants. *A. layneae* was also an important forage plant (3.9% of bites) but was not found on plant transects. During the second phenological period the annual *L. humistratus* constituted 63.9% of bites taken, yet was not found in annual plant samples. During the third phenological period, the herbaceous perennial *Euphorbia albomarginata* constituted 57.4% of bites but did not appear on any plant transects. Overall, >25% of all the plants on which tortoises fed were in the washes and washlets, about twice the number as might be expected considering that washes and washlets comprised only 10.3% of the study area habitats. Three of the ten most-preferred plants, *E. albomarginata*, *A. layneae*, and *C. boothii*, were largely confined to washes.

DISCUSSION

Desert vertebrates and their habitats are vulnerable to and negatively affected by ORVs (Busack and Bury, 1974; Bury et al. 1977; Luckenbach, 1982; Webb and Wilshire 1983). The desert tortoise is not exempt from these effects (Berry et al., 1986). In the western Mojave Desert where the use of ORVs is prevalent, tortoise populations have undergone steep declines, compared to relatively undisturbed desert tortoise populations and in habitat in the eastern parts of their geographic range (USFWS, 1994).

Hills and washes are favored in the western Mojave Desert for use by ORV recreationists (U.S. Bureau of Land Management, 1980). Four major ORV recreation areas with hills, washes, and canyons are adjacent to the Desert Tortoise Research Natural Area (Rand Mountains) or are within 50 km (Jawbone Canyon, Dove Springs, and Spangler Hills). The users of motorcycles, trail bikes, all-terrain vehicles, and other four-wheel vehicles prefer the washes, washlets, canyon bottoms, and hilly country for riding (see Goodlett and Goodlett, 1993 for an example of trail densities in flats, hills, and wash habitats). They gradually widen trails and create more individual tracks and trails, which damages or destroys increasing amounts of habitat. The flats are used primarily for camping, as staging areas for competitive events, and as play areas.

Desert tortoises are vulnerable to negative effects from ORVs because of their habitat preferences. The tortoises in this study spent significantly more time traveling and foraging in hills, washes, and washlets than on the flats, the same areas preferred by ORV users. In other parts of the species' geographic range (the southern, eastern, and northeastern Mojave and the Sonoran deserts), washes are also important

in the ecology and behavior (Woodbury and Hardy, 1948; Burge, 1978; Baxter, 1988). The tortoises use the washes for travel, excavation of burrows or dens, and for feeding. Because tortoises spend so much more time in washes and hills, they are also more likely to suffer direct mortality from vehicles than if they used the habitat randomly.

The food preferences and forage locations of the tortoises provide additional insights. A substantial portion of the food bites taken by tortoises were from plants that were infrequent to rare in the environment and occurred in the hill, wash, and washlet strata. Four of the ten most-preferred food plants were found exclusively in the hills, and an additional three were confined largely to washes. At least 25% of the forage plants were in or on the margins of washes or washlets. Vehicles disturb the soil and terrain in washes and other areas, which results in deterioration or denudation of vegetation (Burge, 1983; Woodman, 1983; Goodlett and Goodlett, 1993). They destroy the natural margins of washes and small washlets as the trails are widened over time (Berry et al., 1986). If the preferred forage plants are damaged or destroyed, tortoises will be forced to select other less-preferred and possibly less-nutritious species.

The 18 desert tortoises preferred native to non-native or alien plant species. The Desert Tortoise Reserve Natural Area has been protected from disturbance for almost two decades, and it has a relatively lower biomass of the alien plants than do the adjacent areas outside its protective fence (Brooks, 1995), where sheep grazing and uncontrolled ORV use occur. Most native desert plant species thrive in undisturbed habitats, in contrast to the alien species, which are common in disturbed lands. Some alien species, particularly the grasses, have invaded arid habitats, are fire prone, and have increased fire regimes globally (D'Antonio and Vitousek, 1992). The alien plant/fire cycle is prevalent throughout parts of the Mojave and Great Basin deserts, and wildfires burn thousands of hectares of desert annually (D'Antonio and Vitousek, 1992; USFWS, 1994). In areas disturbed by ORVs, these alien species are likely to constitute increasingly greater portions of the floral biomass, thus increasing the threat of fires.

Recommendations to Protect Desert Tortoises and Their Habitats

1. Reduce or prohibit vehicle travel off existing roads. Disturbance to desert soils increases the potential for alien plants to invade and become established, causing significant and deleterious alterations to the flora. And, although washes and washlets constitute only a small portion of desert habitats, they have a disproportionate share of the forage plants favored by tortoises and are frequented by tortoises a significantly greater amount of the time. Therefore, vehicle travel off existing highways and established roads—par-

ticularly in desert washes and washlets—in desert tortoise Critical Habitat should be minimized and, where possible, prohibited (see USFWS, 1994).

2. Investigate food habits of neonates and juveniles. The tortoises observed in this study were large immature and adult animals. Neonates and juveniles are likely to have different forage requirements and patterns of use because of their small body sizes, limited activity areas, and inability to travel great distances. The food habits of neonate and juvenile tortoises should therefore be determined also by desert region and habitat strata.

ACKNOWLEDGMENTS

Thanks are due to Dr. Michael Klemens and Dr. Kristin Berry for inviting me to participate in this conference and to Dr. Berry and Jim Van Abbema for valuable assistance on the manuscript. The U. S. Bureau of Land Management supported research on the foraging ecology and habitat utilization of the desert tortoise under Contract No. B950-C2-0014.

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