

TIPTON KANGAROO RATS (*DIPDOMYS NITRATOIDES NITRATOIDES*), SHRUBS, AND INTRAGUILD COMPETITION

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Abstract.—The Tipton Kangaroo Rat (*Dipodomys nitratoides nitratoides*: TKR) is an imperiled species in the San Joaquin Valley of California. Habitat relationships and competition with other kangaroo rat species are still being defined. We examined the relationship between shrubs and TKR as well as the more common Heermann's Kangaroo Rats (*D. heermanni*: HKR) on two live-trapping plots at a study site on the Kern National Wildlife Refuge. The mean distance from capture locations to the nearest shrub was similar for both kangaroo rat species although HKR clearly traveled farther from shrubs (maximum distance > 50 m for HKR versus 14.5 m for TKR). The proportion of stations where only TKR were captured (28.8%) was higher than the proportion where both TKR and HKR were captured (11.0%) suggesting avoidance of the larger HKR by TKR. The proportion of stations with captures of TKR, HKR, or both species did not differ based on the particular species of nearest shrub. Thus, neither kangaroo rat species exhibited an association with a particular shrub species, although TKR were more abundant on the plot where Seepweed (*Suaeda nigra*) was more abundant. Seepweed does not appear to influence microhabitat use by TKR, but Seepweed may be an indicator of habitat suitability for TKR. Shrubs may facilitate the occurrence of TKR in areas where HKR, a larger intraguild competitor, also occurs, and this possibility warrants further investigation..

Key Words.—California; facilitated coexistence; kangaroo rats; Kern National Wildlife Refuge

INTRODUCTION

Tipton Kangaroo Rats (*Dipodomys nitratoides nitratoides*: TKR) are endemic to the southern San Joaquin Valley in central California (U.S. Fish and Wildlife Service [USFWS] 1998). TKR once were widely distributed on the Valley floor from about the Kings River in Kings County in the north down to the southern end of the Valley in Kern County. They occur in arid scrub habitats, but much of this habitat has been converted to agricultural, urban, and industrial uses (USFWS 1998). By 1985, only an estimated 3.7% of historical habitat remained, and many of these lands consisted of small, isolated fragments of varying quality (Williams and Germano 1992). Due to this profound habitat loss, fragmentation, and degradation, TKR were Federally listed as Endangered in 1988 and by California as Endangered in 1989 (USFWS 1998).

According to the species account in the recovery plan for San Joaquin Valley upland species (USFWS 1998), TKR occur in arid-land communities with generally level terrain and soils with higher salinity. Shrubs typically present include Spiny Saltbush (*Atriplex spinifera*), Desert Saltbush (*Atriplex polycarpa*), Arrowscale (*Stutzia covillei* [= *Atriplex phyllostegia*]), Quailbush (*Atriplex lentiformis*), Iodine Bush (*Allenrolfea occidentalis*), Pale-leaf Goldenbush (*Isocoma acradenia*), and Honey Mesquite (*Prosopis glandulosa*). Seepweed (*Suaeda nigra* [= *S. moquinii* and *S. fruticosa*]) is described as

a conspicuous semiwoody species in areas with TKR. Shrub cover typically is sparse to moderate in areas with high TKR density. Cypher et al. (2017. Conservation of endangered Tipton kangaroo rats (*Dipodomys nitratoides nitratoides*): status surveys, habitat suitability, and conservation strategies. Endangered Species Recovery Program. Available from http://esrp.csustan.edu/publications/pdf/Cypher_et_al_2017_TKR_Conservation.pdf [Accessed 8 April 2020]) found that TKR were particularly associated with alkali sink communities where Iodine Bush and Seepweed were the dominant shrubs. Iodine Bush was present on 40.0% of the sites where TKR were captured while Seepweed was present on 73.3%.

Heermann's Kangaroo Rats (*D. heermanni*: HKR), a non-protected species, are sympatric with TKR. HKR are larger than TKR (56–74 g versus 35–38 g; Jameson and Peeters 1988; USFWS 1998) and potentially competitively exclude TKR (Williams and Germano 1992; USFWS 1998; Tennant and Germano 2013). Also, Nelson et al. (2007) found that HKR were significantly more abundant on traplines in areas with shrubs compared to traplines without shrubs. Conversely, Short-nosed Kangaroo Rats (*D. n. brevinasus*), which are conspecific with and ecologically similar to TKR, were more abundant in areas without shrubs. Thus, HKR may be more closely associated with shrubs than smaller kangaroo rats like TKR. We assessed the association between shrubs and both HKR and TKR

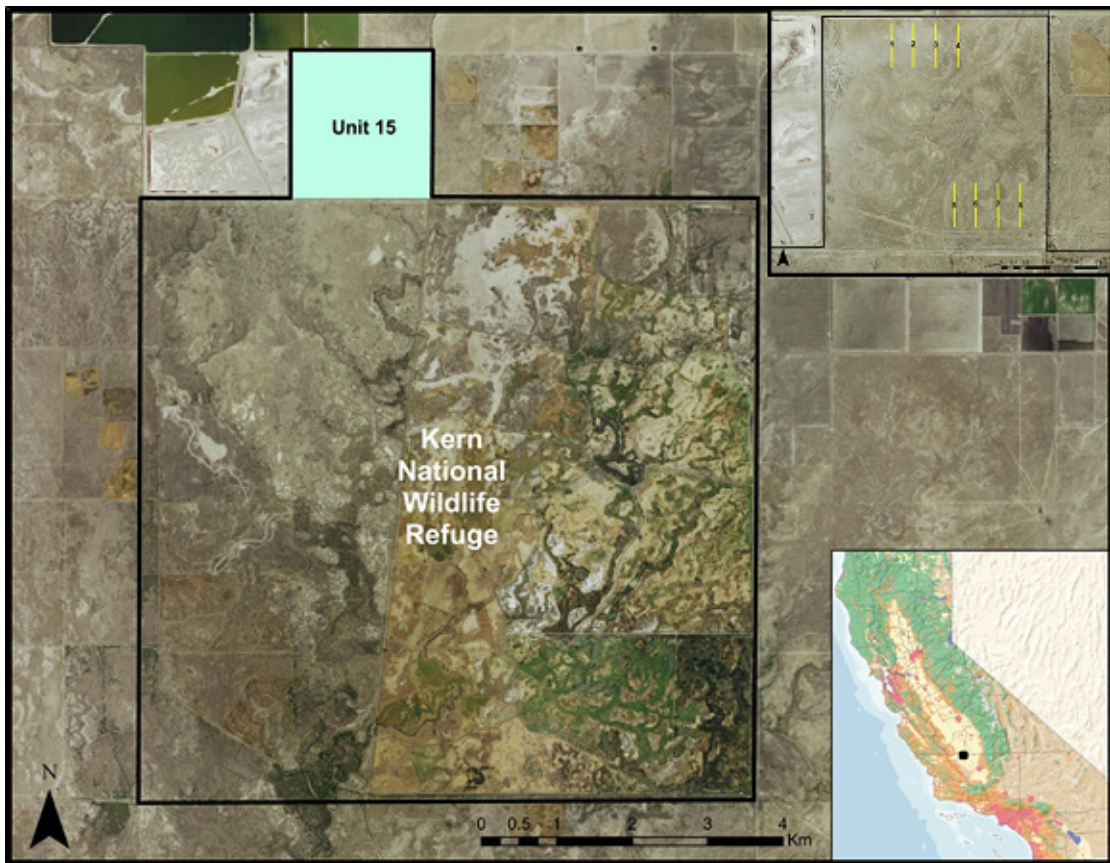


FIGURE 1. Unit 15 study area at the Kern National Wildlife Refuge in Kern County, California. The top inset shows the location of the two study plots on Unit 15, each consisting of four traplines.

at the scale of specific trap locations on a study site in alkali sink habitat at the Kern National Wildlife Refuge (KNWR). We hypothesize that TKR are not as closely associated with shrubs for cover as are HKR. We predict that the distance between trap locations and shrubs will be greater for TKR than for HKR. We also hypothesize that TKR are associated with alkali sink communities characterized by Iodine Bush and Seepweed shrubs. We predict that TKR will be more frequently captured where Seepweed is abundant.

METHODS

Study area.—Our study was conducted on Management Unit 15 at the KNWR, in northern Kern County, California (Fig. 1). KNWR is located approximately 32 km west of the town of Delano. Unit 15 is a parcel approximately 255 ha in size on the north side of the KNWR. KNWR is on the floor of the San Joaquin Valley and the terrain is flat. Mean elevation averages 67 m. The soils in Unit 15 are primarily Twisselman clay and Nahrub clay-lentent silt loam complex (USFWS 1985, 2005). The regional climate is Mediterranean with hot, dry summers and cool, wet winters. At the town of Wasco, 25 km to the southeast, the average high temperature in August was 37.8° C and the average low was 18.2° C, and the average high

temperature in January was 13.8° C and the average low was 1.6° C. Average yearly rainfall was 183.1 mm with most falling from November through April (<https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9452>).

Vegetation communities in Unit 15 were broadly classified as Valley Sink Scrub (USFWS 2005). The Valley Sink Scrub community was further classified as Valley Iodine Bush Scrub (USFWS 1985). This community consisted primarily of widely spaced shrubs including Iodine Bush, Seepweed, and Alkali Heath (*Frankenia salina*). The California Native Plant Society classifications for this community are the Bush Seepweed Scrub Alliance and the Iodine Bush Scrub Alliance (Sawyer et al. 2009). Common herbaceous plants included brome grasses (*Bromus* spp.), barley (*Hordeum* spp.), annual fescues (*Festuca* spp.), Bird's-eye Gilia (*Gilia tricolor*), Spikeweed (*Centromadia* [= *Hemizonia*] *pungens*), and goldfields (*Lasthenia* spp.). On Unit 15, ground cover typically is sparse (Fig. 2).

Rodents and shrubs.—We live trapped rodents on two plots in Unit 15 (Fig. 1); one plot was in the northern half of the unit and one was in the southern half. On each plot, we established four traplines spaced 150 m apart. Each line was oriented north-south and consisted of 20 medium Sherman box traps (30.5 × 9.5 × 7.6 cm; XLK Extra-Large Kangaroo Rat Trap, H.B. Sherman



FIGURE 2. Typical shrub density and fall ground cover conditions on the Unit 15 study area, Kern National Wildlife Refuge, California. The shrubs visible in the image are all Iodine Bush (*Allenrolfea occidentalis*). The south plot is shown but conditions on the north plot were similar. (Photographed by Brian Cypher).

Traps Inc., Tallahassee, Florida) spaced 15 m apart. We opened the traps within 2 h of sunset and we provisioned each trap with a handful of millet seed and two sheets of crumpled unbleached paper towel for insulation and preoccupation. We checked and closed the traps the following morning within 2 h of sunrise. For the first capture of each animal, we recorded species, sex, age, and reproductive condition, and we marked each animal ventrally with a non-toxic felt-tipped pen. At first capture, we weighed kangaroo rats and released them at the capture site. We trapped for rodents 30–31 October 2018 for a total of 160 trap-nights on each plot.

We measured the distance (to 0.01-m accuracy) from each trap location to the nearest shrub (> 0.5 m tall) using a 50-m open-reel measuring tape. We also recorded the species of the nearest shrub. We then determined whether at each trap station, no kangaroo rats, only TKR, only HKR, or both species were captured.

We used Contingency Table Analysis and a Chi-square Test to compare the proportion of stations with Seepweed or Iodine Bush as the nearest shrub between plots, the proportion of stations with TKR and HKR captures between plots, the proportions of stations with captures of TKR and of both species, and the proportion of stations with captures of TKR, HKR, or both species relative to the species of shrub nearest the station. For the last two analyses, data from the two plots were combined as there were insufficient data to conduct the analyses for each plot. We used a Yates correction for 2×2 Contingency Tables (Zar 1984). We used a Mann-Whitney U test to compare the mean distance from stations to the nearest shrub between plots and to compare the mean distance to the nearest shrub between stations with TKR and HKR captures. We also used a Levene statistic to compare variances in distance to the nearest shrub between stations with TKR and HKR captures. For all statistical

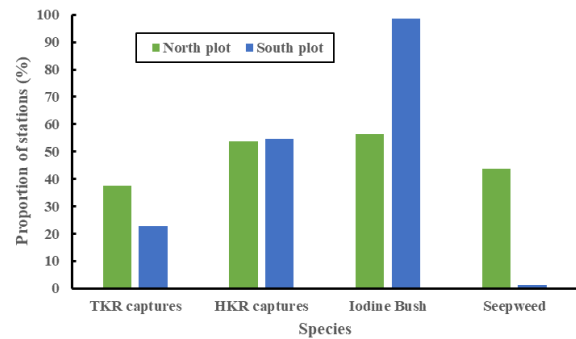


FIGURE 3. Proportions of stations with captures of Tipton Kangaroo Rats (*Dipodomys n. nitratoides*) and Heermann's Kangaroo Rats (*D. heermanni*) and the proportions at which either Iodine Bush or Seepweed were the nearest shrub on two plots on the Unit 15 study area, Kern National Wildlife Refuge, California, October 2018.

analyses, we set α at 0.10. We chose a more relaxed alpha value in an effort to reveal potential ecological relationships that could be more fully explored through further investigation (Taylor and Gerrodette 1993; di Stefano 2003; Scherer and Tracey 2011). We analyzed data using the SPSS statistical software package (ver. 26, International Business Machines Corporation, Armonk, New York).

RESULTS

The species of shrub nearest to each trap station differed between plots ($\chi^2 = 36.723$, $df = 1$, $P < 0.001$; Fig. 3). The proportion of stations with Seepweed was higher on the north plot (43.7%) than on the south plot (1.3%). The proportion of stations with Iodine Bush was higher on the south plot (98.7%) than on the north plot (56.3%). The mean (\pm standard error) distance from stations to the nearest shrub was not significantly different ($U = 3013.0$, $P = 0.963$) between the north plot (4.88 ± 0.95 m) and the south plot (4.20 ± 0.78 m) indicating that shrub density was similar between the plots.

For TKR, we caught 26 individuals (16.3/100 trap-nights) on the north plot and 16 (10.0/100 trap-nights) on the south plot. For HKR, we captured 36 individuals (22.5/100 trap-nights) on the north plot and 41 (25.6/100 trap-nights) on the south plot. The proportion of stations with any TKR captures was significantly higher ($\chi^2 = 3.362$, $df = 1$, $P = 0.067$; Fig. 3) on the north plot (37.5%) than on the south plot (22.7%). The proportion of stations with HKR captures was not significantly different ($\chi^2 < 0.013$, $df = 1$, $P = 0.909$; Fig. 2) between the north plot (53.8%) and the south plot (54.7%).

The proportion of stations where we only caught TKR (28.8%) was significantly higher ($\chi^2 = 10.63$, $df = 1$, $P = 0.001$) than the proportion where we caught both TKR and HKR (11.0%). The proportion of stations with captures of only TKR, only HKR, or both species did not differ significantly ($\chi^2 = 0.887$, $df = 2$, $P = 0.642$) based on the species of the nearest shrub (Fig. 4). The

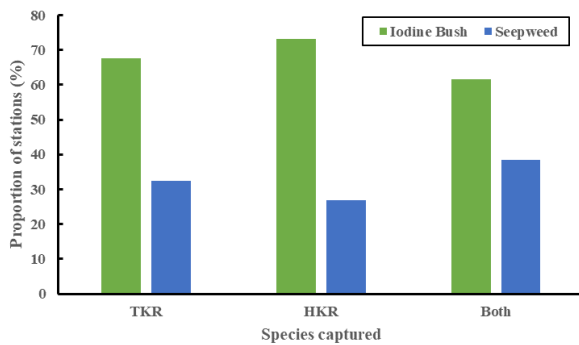


FIGURE 4. Proportions of stations with captures of Tipton Kangaroo Rats (*Dipodomys n. nitratoides*) and Heermann's Kangaroo Rats (*D. heermanni*), or both species relative to the nearest shrub species on the Unit 15 study area, Kern National Wildlife Refuge, California, October 2018.

mean distance between trap stations and the nearest shrub did not differ significantly ($U = 3182.5$, $P = 0.317$) between TKR (2.57 ± 0.44 m) and HKR (4.53 ± 0.85 m); however, the variance in distances was significantly greater (Levene statistic = 6.95; $df = 129$; $P = 0.009$) for HKR (60.84) than for TKR (8.96).

DISCUSSION

Based on our trapping results on Unit 15 at KNWR, we did not detect apparent avoidance of shrubs by TKR when compared to HKR. We predicted that TKR would be found farther from shrubs because HKR, a larger intraguild competitor, might be more prevalent near shrubs. TKR capture locations generally were closer to shrubs than those for HKR, although the difference was not statistically significant due to the high variability in HKR distances. No TKR capture location was > 14.5 m from a shrub whereas measured HKR capture locations were as far as 40.6 m from a shrub. Also, we captured HKR at two locations that were > 50 m from the nearest shrub (the exact distance was not measured). Thus, HKR clearly were traveling farther from shrubs than TKR.

The smaller proportion of stations with captures of both kangaroo rat species compared to the proportion with only TKR captures suggests some avoidance of HKR by TKR. Tennant and Germano (2013) documented a 500% increase in TKR on a plot from which HKR had been removed whereas no increase in TKR was observed on an associated control plot from which HKR were not removed. Cypher et al. (2017, *op. cit.*) reported that HKR were not detected on 46.7% of sites where TKR were captured, and capture rates for the two species were inversely related on sites where both species were present. So, HKR clearly can have an adverse competitive effect on TKR. Competitive suppression of smaller kangaroo rats by larger ones has been well documented (e.g., Blaustein and Risser 1976; Frye 1983; Brown and Munger 1985; Reichman and Price 1993; Perri and Randall 1999). Such suppression has been assumed to adversely impact TKR and other subspecies

of San Joaquin kangaroo rats as well (Williams and Germano 1992).

Shrubs potentially facilitate coexistence between the two kangaroo rat species by providing escape cover for TKR if they are harassed by HKR. The presence of shrubs increases habitat complexity and this can facilitate sympatric coexistence by two competing desert rodent species (*sensu* Rosenzweig and Winakur 1969). On the Carrizo Plain, the Giant Kangaroo Rat (*D. ingens*), a relatively large species (131–180 g; Jameson and Peeters 1988), is abundant and wide-spread. Consequently, the Short-nosed Kangaroo Rat (comparable in size to TKR) is competitively excluded from areas without shrubs but is found in some areas where shrubs are present (Williams 1992). Avoidance may be the behavioral mechanism that allows a smaller kangaroo rat species to coexist with a larger one (Perri and Randall 1999; Tennant and Germano 2013), and shrubs may facilitate avoidance of HKR by TKR.

In a previous study on Unit 15, in which TKR with transmitters were consumed by Pacific Rattlesnakes (*Crotalus oreganus*), I found that the snakes used shrubs for daytime cover (Brian Cypher, unpubl. data). Thus, I speculated that shrubs potentially constitute sites of elevated predation risk for TKR. Interestingly, Bouskila (1995) found that the Merriam's Kangaroo Rats (*D. merriami*), which are similar in size to TKR, exhibited preferential use of microhabitats with shrubs, despite greater snake predation risk, because these microhabitats were avoided by Desert Kangaroo Rats (*D. deserti*), a larger intraguild competitor. The lack of avoidance of shrubs by TKR on Unit 15 may indicate that a similar dynamic might be occurring where competition from HKR is much stronger than the risk of predation from snakes.

TKR capture locations on the Unit 15 plots appeared random with respect to the nearest shrub species. Thus, any shrub may serve as cover for TKR; however, TKR were more abundant on the north plot where Seepweed was more abundant. TKR have been consistently more abundant on this plot over the 4 y that population monitoring has been conducted (KNWR, unpubl. data). Cypher et al. (2017, *op. cit.*) found that Seepweed tended to be consistently present on sites where TKR were detected. Thus, an association between TKR and Seepweed may exist, but on a larger scale such as a study site or landscape and not on a microsite (e.g., capture location) scale. A potential explanation is that Seepweed is an indicator of site conditions (e.g., soil composition and texture, relative soil moisture and saturation, etc.) that are more suitable for TKR. HKR abundance was similar on the two plots despite the difference in shrub composition. The HKR is more of a generalist species (Kelt 1988) and is found in a wider range of environmental conditions compared to TKR.

In summary, this and previous studies suggest that shrubs may facilitate the occurrence of TKR in areas

where HKR, a larger intraguild competitor, also occurs. Shrub density did not appear to affect TKR abundance on our study site. Seepweed may positively influence the presence and abundance of TKR at a given site but does not appear to influence microhabitat use on the site as determined by trapping. Seepweed may be more of an indicator of site conditions associated with suitable habitat for TKR. Our results, however, were based on a relatively small data set collected on one site in one year but can serve as hypotheses for more extensive investigation, preferably employing more rigorous techniques such as radio telemetry.

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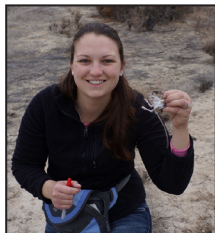
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TORY WESTALL has been working as a Research Ecologist with the Endangered Species Recovery Program of California State University, Stanislaus, since 2009. In that time, she has studied various sensitive species in the San Joaquin Desert and surrounding areas. She is interested in the ecology and conservation of endangered species and primarily studies the San Joaquin kit fox (*Vulpes macrotis mutica*). (Photographed by Christine Van Horn Job).