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Spatial Distribution and Habitat Utilization of the Zebra-tailed Lizard (*Callisaurus draconoides*)

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ABSTRACT.—**Spatial distribution patterns of animals are shaped by their ecology and can give insights into their habitat use and behavioral interactions. Most methods used to study spatial distribution, including quadrat sampling, and nearest-neighbor distance analyses have been used primarily with sessile organisms. We used nearest-neighbor distances to look at the spatial distribution of the Zebra-tailed lizard (*Callisaurus draconoides*) in the Rillito Wash in Tucson, Arizona, and to determine whether these distances gave meaningful results when used with a mobile lizard. We hypothesized that spatial distributions would be random for both sexes but would differ between juveniles and adults because of differences in dominance between these groups. We recorded individuals' locations using a GPS and collected data on sex, age group, substrate, distance to nearest vegetation, and percent vegetation cover at each individual's location. Males and females were distributed randomly, whereas juveniles were distributed regularly. Juveniles were closer to one another than to adults, and females were closer to one another than they were to males, or than males were to one another. Juveniles inhabited areas with less vegetation cover than adults, which may represent marginal habitats. All individuals were distributed in a clustered manner. A lack of difference in spatial distribution between males and females may be a result of abundant resources and subordinate, nonreproducing males. The study occurred at the end of the breeding season, which may also have contributed to the lack of difference. We show that nearest-neighbor distance methods can give meaningful results when used with mobile organisms and can complement ecological studies, including more focused mark–recapture approaches.**

The spatial distributions of animals are shaped by their ecology, and especially by their social interactions, territoriality, habitat preferences, foraging mode, and diet (Brown and Gordon, 1970; Stamps, 1990; Perry and Garland, 2002). However, the spatial distribution of animals, in general, and of lizards in particular, is difficult to study because they are mobile. The spatial distributions of sessile organisms like plants are frequently characterized (Forman and Hahn, 1980; Stoyan and Penttinen, 2000; Andrew and Derek, 2008). The main goal of our study is to evaluate the utility of nearest-neighbor distance methods for studying the spatial distribution of a mobile lizard that inhabits a home range.

Typically, studies of home-range sizes of mobile organisms, including lizards, have been estimated using mark–recapture techniques and visual observation. The strength of such an approach is that it provides a detailed understanding of the size, shape, and overlap of the home range (Johnson, 2005). However, mark–recapture studies have the drawback of being time consuming, often resulting in low sample sizes and, therefore, providing only a local view of the spatial distribution of the target organism (Stamps, 1977b). There are two approaches that have been used to study the spatial distributions of stationary organisms: quadrat sampling and nearest-neighbor distance methods (Cressie, 1993). Under quadrat sampling, small plots are selected randomly from an area and surveyed for the number of individuals of interest in each quadrat (Gleason, 1920; Cressie, 1993). Counts of individuals are then compared to a Poisson distribution, which represents the null hypothesis of complete spatial randomness (CSR). The results obtained from the quadrat approach are dependent on the size of the quadrats (Cressie, 1993), and this method is particularly unsuitable for mobile organisms that can move between quadrats, causing erroneous counts. Nearest-neighbor distance methods record locations of individuals and measure the distance from each to its nearest neighbor (Cressie, 1993). The average nearest-neighbor distance for a sample is then compared to the null expectation under CSR (Cressie, 1993). Today, nearest-neighbor methods are implemented easily using a GPS and allow for larger sample sizes to be obtained over a relatively short period of time compared to mark–recapture studies. However, depending on the density of subjects and size of the sampling area, this approach can be limited by the accuracy of the GPS. This approach also makes the important assumption that the spatial distribution of individuals is constant over time and that individuals will remain similarly distributed even as they move. This is often a reasonable assumption because many mobile animals defend territories and have high site fidelity. Nearest-neighbor methods have only infrequently been used with mobile animals, but some examples include rodents, frogs, and cranes (Miller and Stephen, 1966; Cooper and Randall, 2009; Gorman et al., 2009).

There are three statistically recognizable spatial distribution patterns: CSR, regular distributions, and clustered distributions (Skellam, 1952; Clark and Evans, 1954; Cressie, 1993). Each of these patterns can have various underlying biological explanations. For example, a regular distribution may result from a high degree of territoriality because such a distribution will minimize home-range overlap (Pielou, 1960). A clustered distribution is typical of individ uals tracking patchily distributed resources (Stamps, 1977b; Kraus et al., 2003). Resources can include food and refuges (Stamps, 1977a), or females, as seen in some *Anolis* lizards (Arnold and Duvall, 1994; Johnson et al., 2006; Johnson et al., 2010) and the orange morph of *Uta stansburiana* (Sinervo and Lively, 1996; Sinervo, 2001). Finally, distributions following CSR are expected to occur when there is no territoriality or when resources are abundant and widespread (Brown and Gordon, 1970).

The phrynosomatine lizard *Callisaurus draconoides* is an ideal species for testing nearest-neighbor distance methods on mobile animals because it is well studied, with much known about its natural history, and it is abundant; therefore, large sample sizes are easily obtainable (Kay et al., 1970; Pianka and Parker, 1972; Vitt and Ohmart, 1977). *Callisaurus draconoides* is a sit-and-wait forager, (Tanner and Krogh, 1975) that runs quickly (Belkin,

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1961; Irschick and Jayne, 1998; Bonine and Garland, 1999). It typically has small home ranges of ~4.6 m^2 (Clarke, 1965; Tanner and Krogh, 1975), leading to the expectation that individuals do not move widely across the landscape. Male *C. draconoides* are territorial during breeding season, defending territories from other males but not females, which are not territorial (Clarke, 1965). Females and subordinate, non-breeding males can both have home ranges that overlap those of adult males (Clarke, 1965). Less is known about the spatial habits of juveniles, but because they run slower than adults (Belkin, 1961), they may be more susceptible to predation and, therefore, may stay closer to refuges, as seen in cordylids, where slower species tend to remain closer to refuges (Losos et al., 2002).

Here we study the spatial distribution of adult male, adult female, and juvenile *C. draconoides* using nearest-neighbor methods to gain a clearer understanding of the spatial ecology of this species and to compare our quantitative observations to expectations based on the literature. We expect that both males and females will follow a random distribution because males are not territorial after the breeding season, when our study was conducted (Kay et al., 1970; Pianka and Parker, 1972; Vitt and Ohmart, 1977), and there have been few studies on the potential of female territoriality (Pianka and Parker, 1972). Finally, juveniles may have a clustered distribution if they stay close to refuges or avoid adult individuals.

MATERIALS AND METHODS

Field Methods.—We collected data for this study in a single large, 33.33-ha plot situated in the Rillito River Wash in Tucson, Arizona. *Callisaurus draconoides* is abundant in this area, making it ideal for studying the spatial distribution of this species. The plot extended from 0.69 km west to 1.74 km east of the Craycroft Road Bridge. The north and south sides of the plot were bounded by steep, 1–2 m high banks of the Rillito River Wash. We sampled the plot exhaustively during September 2009 by walking transects separated by 30 m transversely between the banks. The distance between transects is similar to previous studies, in which transects were separated by 6 m and 12 m (Pianka and Parker, 1972; Tanner and Krogh, 1975), but this in itself does not prevent pseudoreplication because lizards commonly move in excess of 30 m (Vitt and Ohmart, 1977). To minimize pseudoreplication, we divided the plot into 10 subplots, each of which we could sample in a single day and whose boundaries coincided either with large open areas or obstacles like concrete embankments that the lizards were less likely to cross. Because we did not capture and mark individuals, pseudoreplication is a potential problem, but our approach of exhaustive sampling of specific areas only once minimized this to the extent possible. A total of approximately 78 transects were walked in all of the subplots. We conducted surveys between 0800 h and 1300 h, when the ambient temperature rose above 32°C, the temperature at which *C. draconoides* is most active (Pianka and Parker, 1972; Tanner and Krogh, 1975). We did not sample after 1300 h or when temperatures were greater than 41°C because the lizards become inactive and hide at extremely high temperatures.

We used the waypoint function of a Garmin Vista HC GPS (Olathe, KS) to mark the locations of individuals that we spotted. In North America, this unit has accuracy within 3 m, but this depends on the number of satellites in range and signal strength from the satellites, which is a function of the antenna of the GPS (Bolstad, 2005; Wing, 2008; Weih, 2009). The accuracy of our readings was within a 5-m radius, given that cloud cover and canopy were minimal during the study. For each individual we recorded sex of adults, age class (juvenile or adult), the distance from the nearest vegetation, and perch type. We determined sex visually when each individual was spotted because *C. draconoides* are extremely fast runners and difficult to capture at high temperatures. We identified males as having black, blue, and tan cross-bars located posterior to their front limbs (Brennan and Holycross, 2006). We defined females as those individuals with faint or no cross-bars and juveniles as both lacking sexual markings and being <70 mm snout–vent length, or about three-quarters of adult size (Pianka and Parker, 1972; Tanner and Krogh, 1975; Stebbins, 2003). At the time of this study, females were post-gravid and neonates were hatching (Pianka and Parker, 1972; Tanner and Krogh, 1975; Vitt and Ohmart, 1977).

We estimated the distance from each lizard to the nearest vegetation with an accuracy of 0.15 m from the place where each lizard was first spotted to the edge of the vegetation. We also collected data on the substrate on which the lizard was first spotted. We identified six perch types: loose sand, concrete, vegetation, gravel, hard pack, and rock. We defined hard pack as sand that was hardened. A concrete substrate was located on the banks of the wash in the form of retaining walls.

Finally, we returned to the location at which each individual was first spotted and estimated the proportion of vegetation cover within a 1-m radius circle. We made our estimates by comparing observed vegetation cover to a series of graded diagrams that were visual representations of different amounts of cover (Anderson, 1986). Using this comparison, we were able to estimate vegetation cover to the nearest 10%.

Data Analysis.—We calculated pairwise two-dimensional Euclidean distances among all individuals from the UTM coordinates obtained from the GPS in meters, using R v.2.10 (R Development Core Team, 2009). We also compiled four subset matrices that included pairwise distances among males only, females only, all adults, and juveniles only. The adult category included males, females, and adults of undetermined sex. We then extracted nearest-neighbor distances for each demographic group and for all individuals from the matrices. Specifically, we extracted distances for the 20 nearest-neighbor distances for each individual.

We then used these nearest-neighbor distances to calculate in Microsoft Excel 2007 the statistics that allowed us to evaluate the spatial distribution for each demographic group and for all individuals. First, we calculated the R_k-statistic (Cressie, 1993), which is a generalization of the statistic, R_1, proposed by Clark and Evans (1954) as:

$$R_k = \left(\sum_{i=1}^{n} \frac{W_{ki}}{n} \right) \frac{(2^k k!)\lambda^{0.5}}{k(2k)!},$$

where W is the distance between the individual i and its k^{th} nearest neighbor, λ is the density of the individuals, and n is the number of individuals. We calculated the density as the quotient of the number of individuals and the total area that was surveyed, 33.33 ha (Cressie, 1993). We calculated R_k for $1 \leq k \leq 20$, or each of the first 20 nearest-neighbor distances. When $R_1 = 1$, the distribution of individuals approximates CSR. When $R_1 < 1$ individuals are in a clustered distribution, and when $R_1 > 1$, individuals follow a regular distribution. For $k > 1$, the interpretation is not as precise, but as R_k increases, individuals transition from clustered to CSR to regular distributions.

Sudden shifts in R_k as k increases suggest the size of clusters (Cressie, 1993).

Although the R_1-statistic gives an easily interpretable measure of the spatial distribution of individuals, it was not intended to be used to test the null hypothesis of CSR (Cressie, 1993). Instead, we used the statistic of Skellam (Skellam, 1952; Cressie, 1993), calculated as (using the same notation as above):

$$S=2\pi\sum W_i^2,$$

for this purpose because it follows a χ^2 distribution with 2n degrees of freedom, allowing a formal test of CSR. We calculated this statistic for the first nearest neighbor for each of our five demographic groups and used it to test for CSR.

To test whether R_1 differed between adult and juvenile lizards, we calculated 1,000 replicate bootstrap datasets for nearest-neighbor distance and calculated the mean for each age category using SYSTAT v.11.0. We then estimated the standard error of the mean from the bootstrap replicates. Because the R_1-statistic is the mean nearest-neighbor distance, multiplied by a constant, the standard error for the statistic and for mean nearest-neighbor are the same. We used the R_1-statistic and its estimated standard error to do a two-sample t-test by hand, allowing us to compare spatial distributions of adults and juveniles statistically.

To test whether juvenile lizards avoided proximity to adults, we calculated the distance from each juvenile to its nearest juvenile neighbor and to its nearest adult neighbor. Likewise, we calculated the distance from each adult to its nearest juvenile neighbor and its nearest adult neighbor. In each case, we compared these distances using two-sample t-tests. In the former case, we tested whether juveniles were an equal distance from adults as they were from each other. In the latter case, we tested whether adults were an equal distance from juveniles as they were from each other. Both approaches test how juveniles are spacing themselves relative to adults but in subtly different ways. We repeated this approach to test whether males and females were equally spaced from one another, using a paired t-test to test whether male–male distances were equal to male–female distances and a second to test whether female–female distances were equal to female–male distances.

Finally, we considered how the demographic groups of *C. draconoides* compared with respect to substrate on which they were spotted, the proportion of vegetation cover where they were spotted, and their distance to the nearest vegetation. We combined hard pack, concrete, and rock substrate into a "hard" substrate category, ignored the vegetation category because only two lizards were observed on vegetation, and constructed a two-way contingency table with demographic group (male, female, juvenile) and substrate (sand, gravel, hard) as the categories. We then used a G-test to analyze the contingency table (Sokal and Rohlf, 1995), calculating expected cell frequencies as the product of the row and column totals, divided by the grand total. To analyze the proportion cover and distance vegetation data, we used two-sample t-tests, comparing males to females and adults to juveniles using Minitab 15 statistical software.

RESULTS

Basic Statistics.—We observed a total of 229 individuals in our 33.33-ha plot, including 50 males, 76 females, 36 juveniles, and 67 adults whose sex we were unable to determine. *Callisaurus draconoides* in our plot occurred at a density of 6.87/ha. Males occurred at a density of 1.50/ha, females at 2.28/ha, juveniles at 1.08/ha, and all adults at 5.79/ha.

Spatial Distribution.—The spatial distribution of both males and females was not significantly different from CSR (Table 1, Fig. 1). However, these two groups suffered from incomplete sampling because some adult individuals could not be sexed (see above), which could bias these results. When all adult individuals were considered, they were distributed in a significantly clustered fashion (Table 1, Fig. 1). In contrast, juveniles distributed themselves in a significantly regular manner (Table 1, Fig. 2). Despite juveniles being distributed regularly, and adults being clustered, our bootstrap analysis showed that the pattern of distribution between these age groups was not significantly different when the first nearest neighbor was considered (df = 23.6, mean difference = −0.18, $t = -0.15$, $P = 0.883$). When all *C. draconoides* were considered, they also spaced themselves in a significantly clustered manner (Table 1, Fig. 2). When considering values of R_k for $1 \leq k \leq 20$, most demographic groups showed slight increases from R_1 to R_2 (Fig. 1, 2), followed by gradual increases as k increased. Two exceptions to this pattern were males and juveniles. For males, there was a large increase from R_{12} to R_{13} (Fig. 1), whereas for juveniles there was a large increase from R_3 to R_4 (Fig. 2). This suggests that males loosely form groups of around 12 individuals, whereas juveniles form clusters of about three.

We found significant differences in distances between adult and juvenile individuals. Specifically, we found that juveniles remained closer to one another than they did to adults (df = 35, mean diff. = 53.50 m, $t = 2.75$, $P = 0.009$) and that juveniles remained further from adults than adults did from each other (df = 188, mean diff. = 196.95 m, $t = 20.19$, $P < 0.001$). This seems to suggest that juveniles cluster together and away from adults.

We also found significant differences in distances between the sexes. Specifically, distances between females were shorter than distances between females and males (df = 75, mean diff. = 13.49 m, $t = 3.24$, $P = 0.002$). Distances between males, however, were not significantly different from distances between the sexes (df = 49, mean diff. = 5.53 m, $t = 0.97$, $P = 0.336$). These results suggest that males maintain greater distances from individuals of either sex than females maintain from other females.

Relationship to Substrate and Vegetation.—We found a significant difference in the types of substrates used by males, females, and juveniles ($\chi^2 = 17.7$, df = 8, $P = 0.024$). The largest contribution to the χ^2-value was from the large number of female individuals spotted on gravel, because no males or juveniles were spotted on this substrate type (Table 2). *Callisaurus draconoides* in general preferred a sand substrate (Table 2). Males and females, however, did not differ

TABLE 1. Spatial statistics for each demographic category of *Callisaurus draconoides*. The R_1-statistic is presented for each group, as is the Skellam statistic (S), its degrees of freedom, and P-value, based on a χ^2 distribution.

	R_1	S	df	P
Males	0.93	106	100	0.322
Females	0.91	152	152	0.518
Juveniles	1.06	113	72	0.001
All individuals	0.85	830	458	<0.001
Adults	0.87	829	378	<0.001

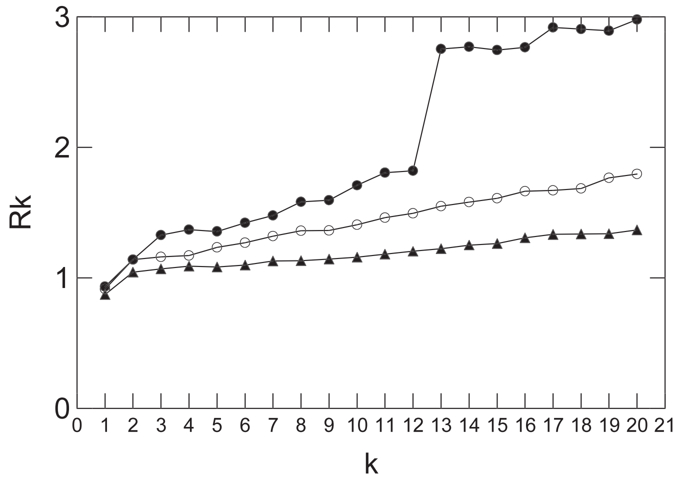

FIG. 1. A plot of R_k-values against the k^{th} nearest-neighbor for $1 \leq k \leq 20$ for adults (triangles), males (closed circles) and females (open circles).

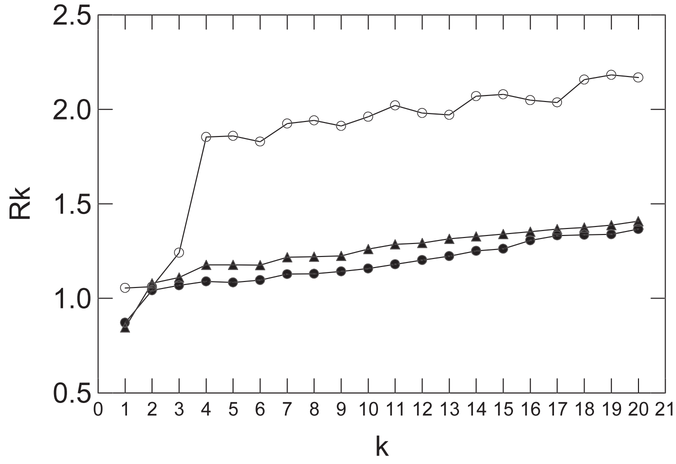

FIG. 2. A plot of R_k-values against the k^{th} nearest-neighbor for $1 \leq k \leq 20$ for all individuals (triangles), adults (closed circles) and juveniles (open circles). Juveniles are individuals less than or equal to 70 mm SVL.

significantly in the proportion of vegetation cover at sites where they were spotted (df = 109, mean diff. = 6.13%, t = 1.95, P = 0.054), although there was a tendency for females to inhabit areas with more cover than males. Adults inhabited sites with significantly more vegetation cover than did juveniles (df = 50, mean diff. = 5.91%, t = 2.19, P = 0.033). The distance to nearest vegetation did not differ significantly between sexes (df = 66, mean diff. = 0.084 m, t = 0.99, P = 0.328) or age groups (df = 25, mean diff. = 0.104 m, t = 1.51, P = 0.142).

TABLE 2. Contingency table showing frequency of individuals of different demographic groups spotted on different substrates. The "hard" category includes concrete, hard pack, and rocks (see text). The grand total is 156 individuals.

	Sand	Gravel	Hard
Males	43	0	6
Females	53	11	10
Juveniles	28	0	5

DISCUSSION

We applied nearest-neighbor distance methods to study the spatial distribution of *C. draconoides*. Some of our predictions were realized, whereas others were not or were only partially supported. For example, we found that both females and males were distributed randomly, which was expected (Pianka and Parker, 1972; Tanner and Krogh, 1975; Vitt and Ohmart, 1977). A random distribution of female *C. draconoides* is not surprising, because there is no strong evidence to suggest that females are territorial (Eifler and Eifler, 2010), although their tolerance of males decreases when gravid (Stamps, 1977b). Our finding that females occurred closer together than they did to males (or than males did to males) further supports the nonterritoriality of females. This may not, however, be a general finding for phrynosomatines, because females of *Urosaurus ornatus* and *Uta stansburiana* do maintain territories, and these do not overlap those of other females (Sinervo, 2001). These latter species have considerably different ecologies from the strictly terrestrial specialist, *C. draconoides* (Brennan and Holycross, 2006).

A random spatial distribution for both sexes is also expected because these animals may distribute themselves based on food abundance (Simon, 1975). *Callisaurus draconoides* are insectivores, and insects were highly abundant during our survey in September. Under conditions of high abundance of food, smaller home ranges and more home-range overlap is expected (Brown and Gordon, 1970; Stamps and Tanaka, 1981; Hews, 1993; Perry and Garland, 2002). However, home-range size and overlap is better studied through mark–recapture studies, and we did not collect data on the distribution of insects in our study site.

Our hypothesis of a random spatial distribution for male *C. draconoides* was also supported, and this is likely because the breeding season had ended by the time of our survey. We would expect that males would be regularly distributed attributable to high degrees of territoriality during the breeding season (Vitt and Ohmart, 1977; Stamps, 1977b; Stamps, 1990). A high degree of territoriality is exemplified by frequent push-up, head bob, and tail display behaviors, as well as direct aggression, all used in territory defense during breeding season (Clarke, 1965; Stamps, 1977b; Eifler and Eifler, 2010). Even though our spatial distribution data clearly indicated a random distribution for males, our interindividual distance data did show evidence of some differences in how males and females space themselves from other conspecifics. Longer distances between males and between the sexes than observed between females suggest some sort of difference in either territoriality or home-range size between the sexes.

One factor that may influence male spatial distributions, particularly in the breeding season, but potentially throughout the year, is the occurrence of dominant and subordinate males. Subordinate males are often able to have overlapping home ranges with dominant males because they do not breed (Clarke, 1965; Stamps, 1977b; Alberts, 1994). The presence of subordinate males would decrease intermale distances, skewing the spatial distribution from regular to random. Identifying dominant and subordinate males would allow a test of this hypothesis but require more detailed study. The relative numbers of dominant and subordinate males would then determine the type of spatial distribution (Brown and Gordon, 1970). Even clustered distributions of males could be found when population densities are high and dominant–subordinate hierarchies are formed (Stamps, 1977b; Alberts, 1994; Kwiatkowski and Sullivan, 2002), illustrating that caution must be used when interpreting spatial distribution patterns. A similarly complex situation might be expected when studying *U. stansburiana*, where three male morphs have evolved with different reproductive and territoriality strategies (Sinervo and Lively, 1996). In fact, our R_1- to R_{20}-statistics for males (Fig. 1) lend some support to males having a clustered distribution. The large increase in magnitude from R_{12} to R_{13} suggests that males cluster in large groups of approximately 12 individuals (Cressie, 1993), and this may be a result of the high densities of *C. draconoides* in our study plot and the possible presence of subordinate males. These results also show that considering only the first nearest-neighbor distances gives a partial view of a population's spatial distribution.

The least is known about the ecology of juvenile *C. draconoides*, and our results give seemingly contradictory results about their spatial distribution. On the one hand, our R_k-statistics for juveniles are consistently high, with $R_1 > 1$ (Table 1, Fig. 2), indicating a regular distribution. This might be interpreted as evidence of territoriality (Brown and Gordon, 1970; Simon and Middendorf, 1980), and juvenile territoriality has been found in another phrynosomatine, *Sceloporus jarrovii*, where juveniles attempt to defend exclusive home ranges, with males only allowing female ranges to overlap after one year of age (Simon and Middendorf, 1980). Territorial behavior in juveniles would likely be predicated on food abundance and quality of habitat for avoiding predators (Stamps and Tanaka, 1981; Stamps, 1983).

On the other hand, we found that juveniles maintain a shorter distance between one another than between themselves and adults and that they are also further from adults than adults are from one another. These findings suggest some degree of clustering among juveniles relative to adults and may be explained by juveniles inhabiting areas with less vegetation cover than do adults (see Results). In this light, it is possible that juveniles are being pushed into more marginal habitats where there is less cover from predators and less habitat for prey (Stamps and Krishnan, 1998). Juveniles may be especially susceptible to predation because they run slower and for shorter distances during escape from predators than do adults (Belkin, 1961; Martín and López, 1995). Slower sprint speeds combined with habitat containing less vegetation would result in decreased ability to avoid predators (Castilla and Labra, 1998; Pietrek et al., 2009). Juveniles may reside in these habitats until they are larger and mature enough to compete with adults. Finally, high intraspecific densities can lead to increased territoriality and aggression in adults directed at juveniles (Stamps, 1977b; Alberts, 1994; Kwiatkowski and Sullivan, 2002). Densities for our study site were much higher in comparison to previous studies (Pianka and Parker, 1972; Vitt and Ohmart, 1977), supporting the possibility of increased competition and aggression between individuals.

When considering all adults and all individuals, we found that both had a clustered spatial distribution (Table 1). If male home ranges overlap with those of multiple females to increase male mating success (Clarke, 1965; Pianka and Parker, 1972; Tanner and Krogh, 1975), then this may result in a clustered distribution. However, since mating season had ended at the time of our survey this is unlikely to be the case. Habitat may also play a role in the distribution of adults. Areas with high amounts of vegetation may be preferred for refuge from predators, for food, and for thermoregulatory opportunities (Bulova, 1994; Eifler and Eifler, 1998). If vegetation forms a clustered distribution, then *C. draconoides* may replicate that distribution to maximize habitat quality that they inhabit. However, the vegetation in our plot and most areas is not homogeneous, varying in growth form (grass, shrubs, or bushes) and the density of branches. These factors will influence the quality of a plant as a source of shade, a refugium from predators, and a habitat for prey, and all of these factors may be important to where a lizard spends its time. Subsets of the vegetation may well be important to *C. draconoides*, influencing their spatial distribution. Our study did not break down the available vegetation in this way, but other studies have not found a strong correlation between *C. draconoides* and vegetation (Baltosser and Best, 1990). However, this species does prefer open habitats with a sandy substrate (Pianka and Parker, 1972; Tanner and Krogh, 1975).

Using nearest-neighbor methods to study the distributions of mobile animals produces interpretable results based on large sample sizes of individuals. Interpretation of the distributions is based on known causes for distributions but is best supplemented with behavioral observations. In our study, we found that the spatial distribution of different demographic groups depends on many interactions and is sometimes difficult to interpret. However, distributions give valuable information that can lead to determination of habitat use, inter- and intraspecific interactions and even spatial dynamics over time (Brown and Gordon, 1970; Perry and Garland, 2002). Our study focused on the spatial distribution for a number of demographic groups of *C. draconoides*. However, less of our study focused on habitat and resource distribution. Previous studies on *C. draconoides* attempted to link ecological variables, precipitation, and percent cover to geographic distribution, but no correlation between these variables was found (Pianka and Parker, 1972). Future research should focus on the distribution of plants and other resources that *C. draconoides* may use and compare it to the distribution of *C. draconoides*. The distribution of plants and various types of plants is of particular interest because *C. draconoides* may use vegetation for shelter during extreme temperatures, refuge from predators, and for foraging opportunities when insects associate with the plants (Kay et al., 1970; Baltosser and Best, 1990). Therefore, the abundance and distribution of vegetation may influence the distribution of other resources, influencing home-range size and the degree of territoriality in a population (Simon and Middendorf, 1976). Future observations and analysis of plant and prey spatial distribution would further add to our understanding of the behavioral ecology of *C. draconoides* and the dynamics of spatial distributions within their populations.

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