Effects Of Saltcedar

On Population Structure and Habitat Utilization of the

Common Side-Blotched Lizard

by

Danny Nielsen

A Thesis Presented in Partial Fullfilment
of the Requirements for the Degree
Master of Science

Approved April 2011 by the
Graduate Supervisory Committee:

Heather L. Bateman, Chair
William H. Miller
Brian K. Sullivan

ARIZONA STATE UNIVERSITY

May 2011

ABSTRACT

Non-native saltcedar (*Tamarix* spp.) has invaded many riparian communities and is the third most abundant tree in Southwestern riparian areas. I evaluated lizard populations and microhabitat selection during 2009 and 2010 along the Virgin River in Nevada and Arizona to determine the impact of saltcedar. Along the riparian corridor, I observed common side-blotched lizards (*Uta stansburiana*) within two vegetation types: monotypic non-native saltcedar stands or mixed stands of cottonwood (*Populus fremontii*), willow (*Salix* spp.), mesquite (*Prosopis* spp.) and saltcedar. I predicted that population parameters such as body condition, adult to hatchling ratio, abundance, and persistence would vary among vegetation types. Also, I predicted the presence of saltcedar influences how lizards utilize available habitat. Lizard population parameters were obtained from a mark-recapture study in which I captured 233 individual lizards. I examined habitat selection and habitat availability using visual encounter surveys (VES) for lizards and recorded 11 microhabitat variables where 16 lizards were found. I found no significant difference in population parameters between mixed and non-native saltcedar communities. However, population parameters were negatively correlated with canopy cover. I found that lizards selected habitat with low understory and canopy cover regardless of vegetation type. My results indicate that lizards utilize similar structural characteristics in both mixed and non-native vegetation. Understanding impacts of saltcedar on native fauna is important for managers who are tasked with control and management of this non-native species.

For my loving parents, Brent and Marty.

For putting up with my antics

and still supporting me in all of my endeavors.

Without their support and motivation,

I would not be where I am today.

ACKNOWELDGMENTS

I would like to especially thank Heather Bateman, the chair of my committee. She has given me a wonderful opportunity to study a subject which I greatly enjoy. She was always eager to help me with problems and was a constant guide for me during my time at Arizona State University. Also, I would like to thank my other committee members, Dr. William Miller and Dr. Brian Sullivan. Their knowledge of statistical analysis, field methods, and experimental design helped me greatly throughout my research. I would also like to thank everyone who helped with field work, especially Bill Bubnis. His construction background was of tremendous help in the field and his prowess at the grill was much needed at the end of a long work week. I would also like to acknowledge my funding sources. Funding for this work was provided by Arizona State University Polytechnic, Department of Applied Sciences and Mathematics, and the U.S. Geological Survey National Invasive Species Program.

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INTRODUCTION

Riparian communities are among the most biologically diverse habitats on earth (Naiman et al., 1993). Riparian habitats are important for a variety of wildlife, including butterflies (Nelson and Wydoski, 2008), small mammals (Ellison and van Riper, 1998; Ellis et al., 1997), birds (Szaro and Jakle, 1985), and reptiles and amphibians (Bateman et al., 2008a,b; Szaro and Belfit, 1985). Within riparian communities, physical processes, such as flooding, erosion, and groundwater levels interact with vegetation in a complex manner in which each influence the other (Everitt, 1980).

Conservation biologists are increasingly concerned as stream regulation and non-native species have altered historical structure and flow regimes in riparian habitats. River regulation impacts relationships between vegetation and physical process by altering hydrologic patterns leading to loss of native riparian vegetation and proliferation of non-native vegetation (Merritt and Cooper, 2000). In the United States, non-native invasive species cause approximately 120 billion dollars per year in damages (Pimentel et al., 2005) and in the western United States, management and control of non-native saltcedar (*Tamarix* spp.) costs millions of dollars each year (Shafroth et al., 2005). Saltcedar, which was introduced in the 1800s for use as an ornamental and for erosion control, is currently the third most abundant riparian tree in the western United States (Deloach et al., 1999; Friedman et al., 2005). Consequently, invasive species, such as saltcedar, are of concern as they impact riparian habitats and the native biota which utilize them.

Saltcedar has invaded many riparian habitats in the southwestern United States frequently establishing monotypic stands and may alter habitat structure to the detriment of native biota (Deloach et al., 1999). Smith et al. (1998) reported that saltcedar can invade habitat formerly inhabited by native riparian vegetation due to its high tolerance to drought stress. Many taxonomic groups respond negatively to saltcedar; Nelson and Wydoski (2008) found riparian butterfly diversity was greater in native vegetation in Colorado. On the Colorado River, species richness of birds was lower in saltcedar compared to native vegetation (Anderson et al., 1977).

Although many studies indicate saltcedar may negatively impact native riparian wildlife, there is debate over the impacts of this invasive species. For example, in central Arizona the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) breeds in saltcedar with no apparent negative effects (Sogge et al., 2005). Along the middle Rio Grande in New Mexico, arthropod and small mammal abundance and richness were greater in saltcedar compared to native cottonwood and willow vegetation (Ellis et al., 2000; Ellis et al., 1997). Zavaleta et al. (2001) proposed that control of invasive species can adversely affect native habitat if not planned appropriately. Therefore, understanding how saltcedar affects a variety of native plant and animal populations in different locations is important for management of this non-native species.

Herpetofauna, which utilize riparian habitat, may provide insight into how structural shifts in riparian habitat caused by non-native invasive vegetation affect native biota. Lizard populations respond to structural changes in habitat (Pianka,

1967) and have responded positively to saltcedar removal along the middle Rio Grande in New Mexico (Bateman et al., 2008a). Reptiles and amphibians are good indicators of environmental conditions and changes (Bateman and Paxton, 2010). Therefore, lizards may be used as a model to better understand the impacts of saltcedar.

The ecology and life history of the common side-blotched lizard (*Uta stansburiana*) have been well documented (Ferguson and Fox, 1984; Fox, 1978; Parker and Pianka, 1975; Tinkle, 1967; Wilson, 1992). This species' abundance is positively correlated with precipitation (Parker and Pianka, 1975). This small lizard reaches a maximum adult size of 64 mm in males and 58 mm in females (Brennan, 2009). It reaches sexual maturity after its first winter and is annual in its life history; approximately 90 percent of individuals only live a single year (Tinkle, 1967).

Common side-blotched lizards occur across the western United States from Washington to Mexico and utilize a wide variety of habitats, from rocky hillsides to desert washes and desert flatlands (Tinkle, 1967). Therefore, Tinkle (1967) reports that it is difficult to identify preferred habitat for this species, but that refugia such as rocks, shrubs, and mammal burrows are common in their microhabitat. Waldshmidt (1980) described thermoregulatory behavior in the common side-blotched lizard and found that presence of both sun and shade within habitat was important for maintaining optimal body temperature. Adolph (1990) addressed the importance of habitat structure on thermal suitability and use of microhabitat for two species of *Sceloporus* lizards and suggested that an otherwise suitable habitat may be inadequate if the thermal environment cannot support thermoregulation. Therefore, structural changes associated with establishment of non-native vegetation are important to consider when investigating microhabitat utilization of native lizard species.

Abundance, body condition, recapture rate (percentage of individuals captured more than once at each site), persistence, adult to hatchling ratio, and population structure are important characteristics for monitoring lizard populations. Body condition (body mass/body length) may be used as a measure of physical condition of lizards within a population. Meylan et al. (2002) found in the common lizard (*Lacerta vivipara*) that increases in maternal body condition and in offspring body condition led to greater dispersal among hatchlings. Persistence, a measure of the average length of time that individual lizards are present at a given site, may be used as proxy to factors such as mortality and emigration of individuals. Kreuzer and Huntly (2003) used a similar measurement (rate of disappearance) to signify maximum mortality in a mark-recapture study of population dynamics of the American pika (*Ochotona princeps*).

Its abundance within many habitats, well documented ecology, and rapid generation time make the common side-blotched lizard a suitable focal species for studying how structural changes in habitat caused by the presence of non-native vegetation may impact population structure and habitat utilization of native biota. My objectives were to determine how this species utilizes non-native habitat and if habitat quality for side-blotched lizards differs between two habitat types:

monotypic saltcedar stands and mixed stands of cottonwood (*Populus fremontii*), willow (*Salix* spp.), mesquite (*Prosopis* spp.), and saltcedar. I addressed (1) habitat selection and use within mixed and non-native riparian vegetation, and (2) abundance and population structure of side-blotched lizards in sites composed of mixed and non-native vegetation. I used visual encounter surveys and recorded microhabitat measurements to assess habitat usage, and mark-recapture techniques to determine abundance, body condition, recapture rate, persistence, and adult to hatchling ratio. I hypothesized that if non-native vegetation provides poorer quality habitat to lizards, then habitat utilization and population parameters will show a negative response to non-native vegetation.

STUDY SITE

I conducted this study along 40 km of the Virgin River riparian corridor (Figure 1). This area is located within Clarke County, Nevada and Mohave County, Arizona. Along the river, in Bunkerville, Nevada, the average annual rainfall is 15.5 cm and average annual temperatures reach a maximum of 28.1 C during the summer and a minimum of 8.5 C during the winter (Desert Research Institute, 2010).

The Virgin River riparian corridor consists of a mixture of vegetation communities composed of native and non-native species and varied structural characteristics. The presence of non-native saltcedar within much of the riparian corridor has resulted in many habitat patches characterized by dense canopy and thick understory. Study sites were established in mixed native vegetation and non-native saltcedar vegetation. Mixed sites were characterized by mixed stands of cottonwood, willow, mesquite, and saltcedar. Non-native saltcedar sites were characterized by monotypic saltcedar stands. Other common shrubby species present in the riparian community were: arrow weed (*Pluchea sericea),* baccharis (*Baccharis emoryii*), catclaw (*Acacia gregii*), thornbush (*Lycium cooperi*), and Brewer's saltbush (*Atriplex lentiformis*).

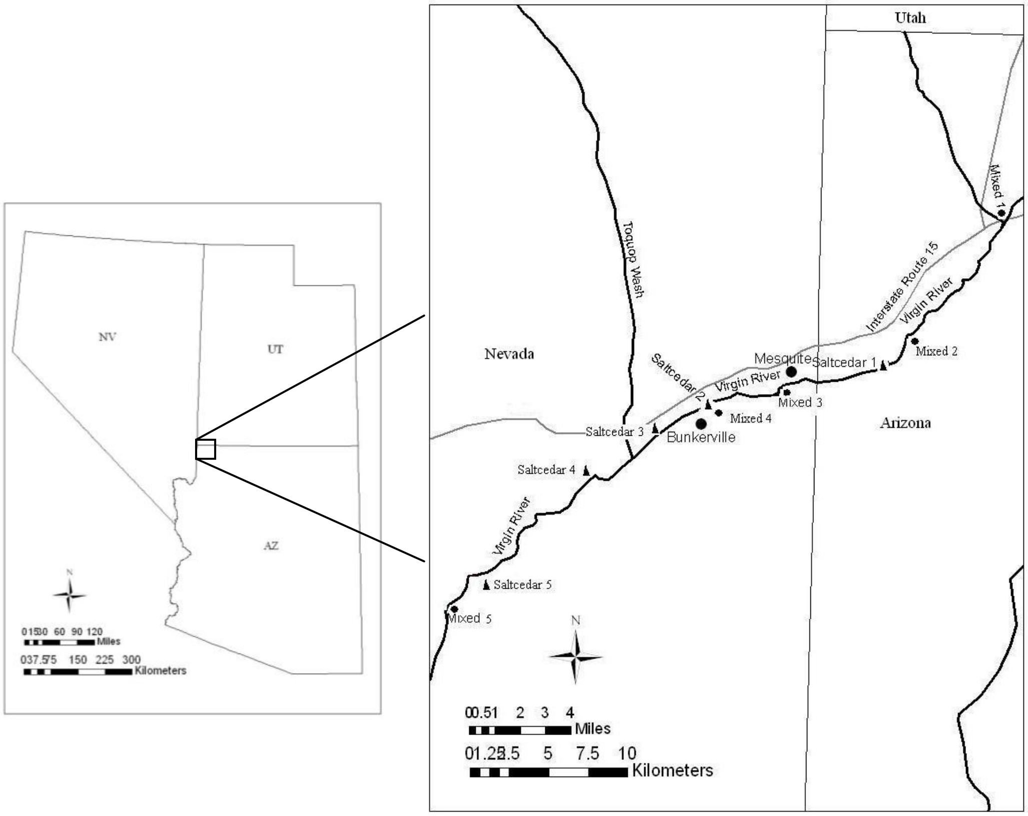

Figure 1. Study Area
The study site is located in southern Nevada/northern Arizona. Triangles represent non-native vegetation, circles represent mixed vegetation.

METHODS

Microhabitat

To investigate microhabitat use by the common side-blotch lizard, I conducted visual encounter surveys (VES) at 8 sites, with up to 6 visits per site. Surveys were conducted from May to August 2010 between the hours of 0900 and 1300. I recorded the start and stop time of each survey as well as air temperature and other environmental conditions such as wind speed, and cloud cover. To avoid temporal bias in weather, I assured temperature, wind speed, and cloud cover were similar before each survey. ArcGIS software was used to generate sample points within each site. The point density was set to one point per 1.5 hectare. Also, generated survey points were selected to assure there was at least 50 meters of separation between each point. During each survey, I navigated to points by walking upstream to downstream, using a handheld GPS unit. I made observations of lizards while walking in the direction of the next generated point.

To examine whether lizards utilize all available microhabitat within the Virgin River riparian corridor, I collected microhabitat data for each lizard sighting and for each generated point in 8 study sites. This allowed for the characterization of habitat at all study sites, even where there were no sightings of lizards. Due to the small home range size of the common side-blotched lizard (approximately 0.06 hectares; Tinkle 1967) and the large size of each study area, each lizard sighting was considered an independent observation. For each encounter with a lizard I took note of the age class (hatchling or adult) and the exact location and activities when first sighted. I recorded the lizard’s activity (i.e., stationary in shade, stationary in sun, running, or on perch) and the substrate type used by the lizard (i.e., woody debris, soil, rock, or litter). The exact point where I first observed the lizard was called the “lizard point”; points generated for navigation were termed “generated points”. Methods used to measure microhabitat characteristics were modifications of those described by Paulissen (1988) and Martin and Lopez (1998).

To characterize microhabitat utilization of lizards I measured 11 microhabitat variables (Table 1) at each lizard point and generated point within a study area. At the lizard or generated point I recorded substrate type and elevation from ground. Also, at each point, I measured canopy cover by averaging two readings using a concave densiometer. To account for my inability to locate the precise location of generated points, once I reached the point I tossed a flag over my shoulder and used the landing point to record microhabitat variables. I recorded ground temperature with a Spot IR digital thermometer and air temperature at 15 cm above the point using a Kestrel 4500 weather tracker. I excluded temperature data from analysis. I measured distance to first contact of woody material at the base of the nearest 3 shrubs/trees greater than 20 cm tall and recorded the plant species of each. I measured distance to the nearest open patch of sunlight at least 15 x 21 cm large. If the point was already in an open patch, distance was recorded as zero. I measured distance to nearest refuge and recorded type (e.g., burrow hole, log, rock crevice, or other hiding structure). To account for microhabitat and not broader characteristics, I limited my search radius for shrubs, open patches, and refugia to 5 meters from the point (any further was considered infinity or absent). Last, I visually estimated percent vegetation cover up to 1 meter above the ground in a 0.5 meters radius circle centered on the point. Modified Daubenmire classes were used for percent vegetation cover: 0%, 1-5%, 5-25%, 25-50%, 50-75%, >75% (Daubenmire, 1959).

Table 1. Microhabitat Variables
Microhabitat variables measured at each lizard and generated point in both mixed and non-native saltcedar vegetation during May-August 2010 along the Virgin River AZ, NV. Methods which were modified from other research are cited in the reference column.

Variable	Description	Method	References
Substrate used	Surface on which the point lies.	For each point, random or lizard, I recorded the substrate (e.g. soil, litter, woody debris, etc.)	
Canopy Cover	One (1) measurement taken per lizard/random point	Taken from a densiometer held at breadth height	
Shrub proximity	Distance (m) to the base of the nearest three (3) shrubs/trees.	Only shrubs/trees >20cm tall were be considered. I recorded species. Constrained to a 5 meter search radius.	Paulissen, 1988
Distance to open	Distance (m) from point to nearest open patch (sunlight). If point is already in open, then it will be 0.	Open patch was large enough to cover more than half the surface of my clipboard. Constrained to a 5 meter search radius.	Paulissen, 1988
Distance to refuge	Distance (m) from point to nearest refuge.	Refugia were vegetation, woody debris, or burrow. Constrained to a 5 meter search radius.	Paulissen, 1988; Martin and Salvador, 1992
Temperature	Ground and air 15 cm above ground.	Temperature was recorded using a Kestrel 4500 Weather Tracker and Spot IR thermometer.	
Percent vegetation cover	Percent vegetation of area centered on the point in a 1m diameter circle.	Visual estimation of total vegetation cover 1 meter above ground and centered on the point.	Paulissen, 1988

Population Structure

To test the influence of vegetation type, ten sites, 300-400 meters in diameter, were established within the two vegetation types, 5 in mixed sites and 5 in non-native saltcedar sites. Two herpetofauna trap arrays were randomly placed in each of the 10 study sites.

I captured, marked, measured, and released common side-blotched lizards from June to August in 2009 and 2010 using arrays consisting of funnel and pitfall traps (Jones, 1981; Figure 2). Individuals were given a unique toe-clip for later identification using the Waichman method (Waichman, 1992). Snout-vent length (SVL), vent-tail length (VTL) and mass (grams) were measured for each individual. Also, I identified the sex and age class (hatchling or adult) of each individual. I considered adults any individual at least 40 mm SVL and hatchlings any individual under 40 mm SVL. I standardized abundance of lizards to captures per 100 trap days and compared lizard abundance between mixed and non-native vegetation. I quantified population parameters such as abundance (number of individuals/100 trap days), adult to hatchling ratio, body condition (body mass/body length), persistence

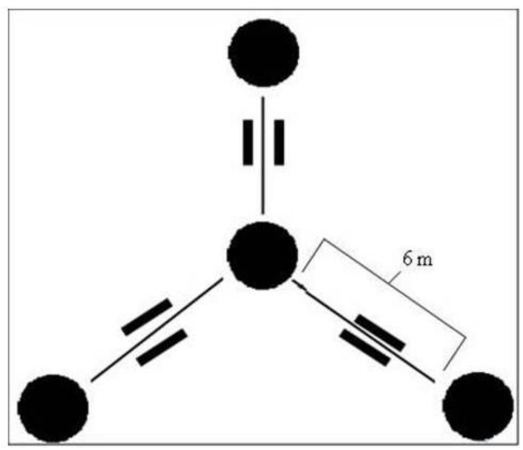

Figure 2. Trap Array.
Each trap array consisted of 4 pitfall traps (circles) and 6 funnel (rectangles). Three 6 meter long fences (lines) were oriented at 0, 120, and 360 degrees from the center point. Not drawn to scale.

(mean length of time individuals persist at a site), and recapture rate (percent of individuals captured more than once at each site. To relate population structure to vegetation structure, I measured canopy cover at each site by averaging densitometer readings taken from four 2 meter by 2 meter grids at each trapping location.

Statistical Analysis

Because of small sample sizes, all statistical analyses were reported with a significance level of $p < 0.10$. Lizards were captured with herpetofauna trap arrays over two summers; therefore, my study design was a random two factor factorial with repeated measure (replication of years). I used a two factor factorial with repeated measures ANOVA to test for differences in abundance of side-blotched lizards (standardized to captures/100 trap days) between native and non-native vegetation and to determine if there was a significant affect of year and vegetation type on lizard abundance. I used chi-square analysis to determine which microhabitat variables showed significant differences between lizard use and available habitat. I used a test of proportions (Z) for all significant microhabitat variables to determine which categories of microhabitat lizards selected for or avoided. I used linear regression analysis to relate hatchling population parameters such as body condition, persistence, recapture rate, and adult to hatchling ratio to canopy cover percent at each site. Also, I used regression analysis to relate the abundance of adult side-blotched lizards to canopy cover.

RESULTS

A total of 233 individual lizards, 202 hatchlings and 31 adults, were captured in 2009 and 2010. One of the sites yielded no captures of side-blotched lizards during either year, and one site yielded captures at only one of two arrays. Abundance of lizards was similar in both native and non-native vegetation and there was no significant affect of years (Vegetation type, F = 0.09, p = 0.77, df = 1; Year, F = 1.39, p = 0.29, df = 1; Vegetation by Year interaction, F = 0.28, p = 0.62, df = 1; Table 2).

Table 2. Side-blotched lizard abundance
Mean abundance (± SE) of side-blotched lizards in native mixed sites and non-native saltcedar vegetation during May-August of 2009 and 2010.

Vegetation Type	2009	2010
Native mixed	18.1 (6.4)	30.8 (9.9)
Non-native saltcedar	20.8 (7.4)	23.1 (5.7)

I observed 16 individual side-blotched lizards during visual encounter surveys and generated 52 survey points. Of the 9 microhabitat variables analyzed, five had significant chi-square results, and only percent canopy cover, distance to nearest shrub, and height above ground showed significant selection (Appendix A). Side-blotched lizards showed a preference for moderate levels of canopy cover and vegetation cover and preferred to be elevated from the ground.

Abundance of adult lizards was not significantly correlated with percent canopy cover (Figure 3). Hatchling body condition was significantly negatively correlated with percent canopy cover (Figure 4).

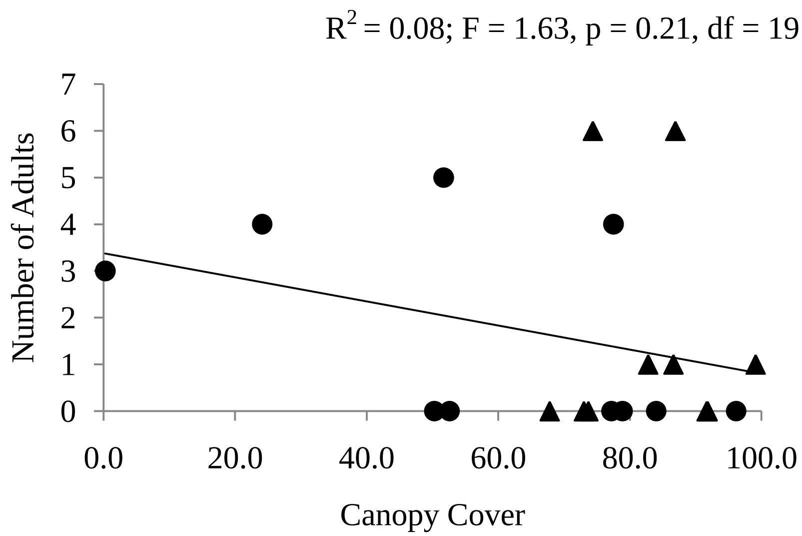

Figure 3. Adult Abundance
Abundance of adult side-blotched lizards at sites from May-August of 2009 and 2010 related to canopy cover. Triangles represent non-native saltcedar vegetation and circles represent native vegetation.

Adult to hatchling ratio was negatively correlated with canopy cover (Figure 5). Hatchling abundance was not correlated with canopy cover (Figure 6). However, hatchling recapture rate was negatively correlated with canopy cover (Figure 7). Hatchling persistence was also negatively correlated with canopy cover (Figure 8).

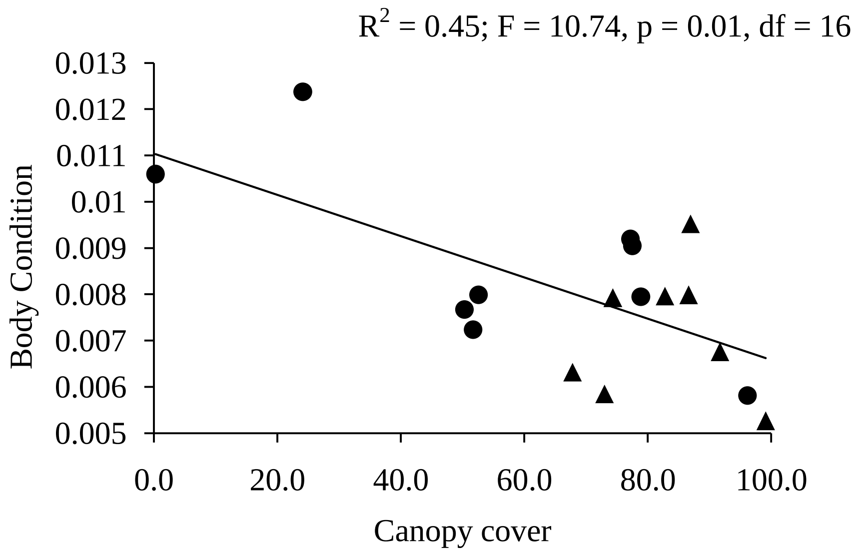

Figure 4. Hatchling Body Condition.
Body condition (body mass/body length) of hatchling common side-blotched lizards captured during May-August of 2009 and 2010 related to percent canopy cover. Triangles represent non-native saltcedar vegetation and circles represent mixed

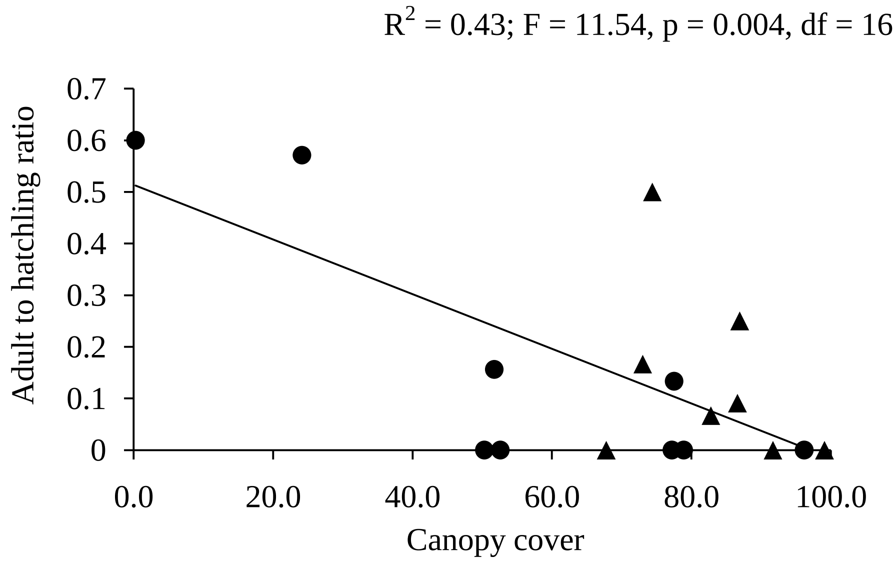

Figure 5. Adult to Hatchling Ratio
Adult to hatchling ratio of captured common side-blotched lizards at sites during May-August of 2009 and 2010 related to canopy cover. Triangles represent non-native saltcedar vegetation and circles represent mixed vegetation.

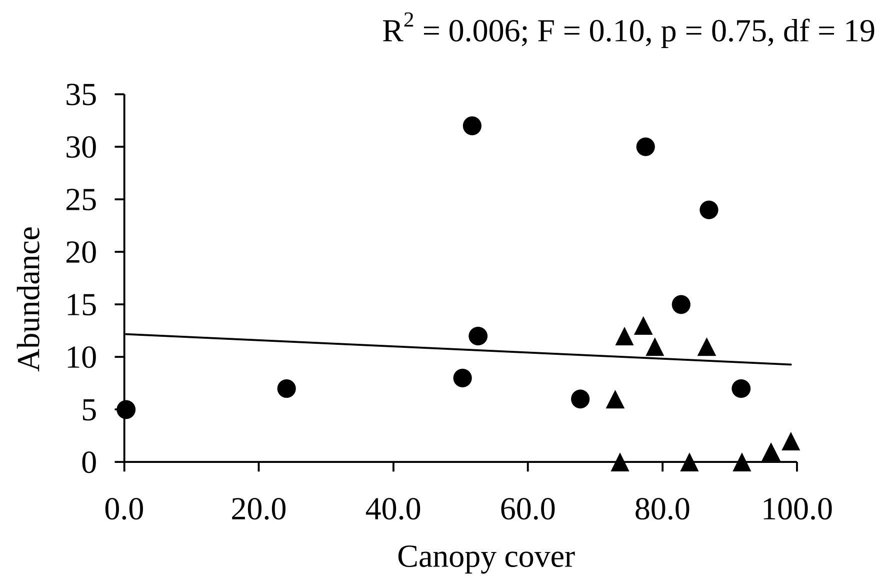

Figure 6. Abundance of Hatchlings.
Abundance of captured hatchling common-side-blotched lizards at sites from May-August of 2009 and 2010 related to canopy cover. Triangles represent non-native saltcedar vegetation and circles represent mixed vegetation.

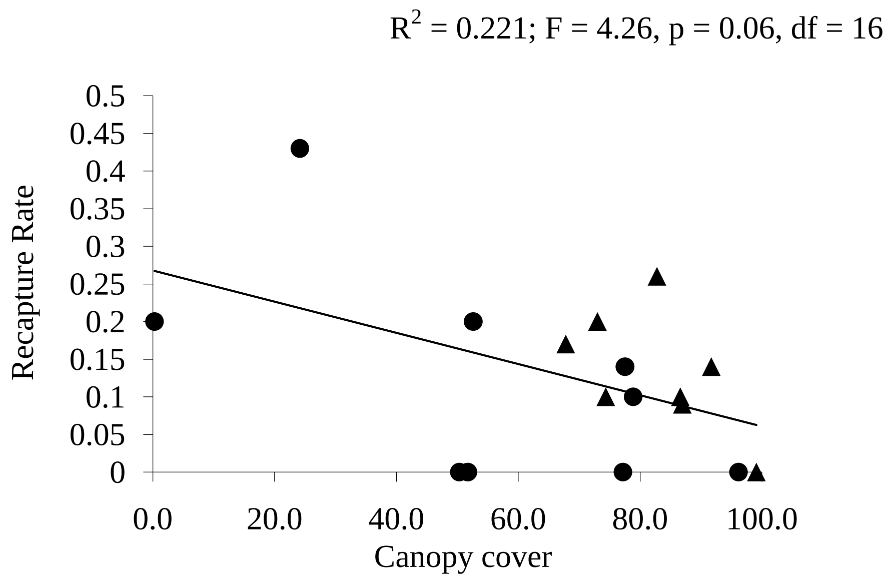

Figure 7. Recapture rate of Hatchlings.
Recapture rate of captured hatchling common side-blotched lizards at sites from May-August of 2009 and 2010 related to canopy cover. Triangles represent non-native saltcedar vegetation and circles represent mixed vegetation.

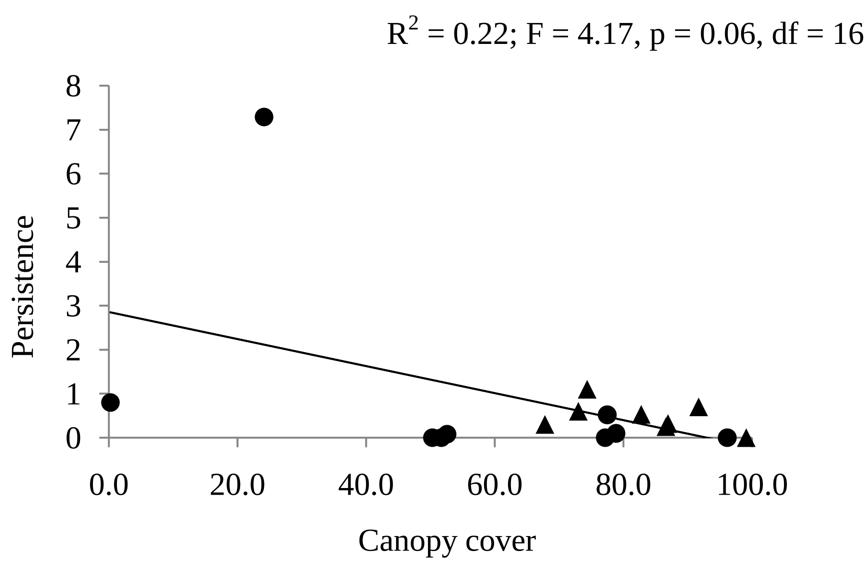

Figure 8. Persistence of Hatchlings.
Persistence of captured hatchling common side-blotched lizards at sites during May-August of 2009 and 2010 related to canopy cover. Triangles represent non-native saltcedar vegetation and circles represent mixed vegetation.

DISCUSSION

My study demonstrates that lizard abundance and microhabitat utilization are similar between mixed and non-native vegetation along the Virgin River, and that lizards may utilize sites with moderate levels of both vegetation cover and canopy cover. Common side-blotched lizards selected microhabitat with 50-75 percent canopy cover and avoided microhabitat with greater than 75 percent canopy cover. Other microhabitat variables, such as understory and distance to nearest shrub, also indicated that lizards selected for moderate levels of cover and open structure. Population parameters such as hatchling body condition, recapture rate, and persistence were found to be lower in sites with high percent canopy cover. Similar patterns of selection for moderate levels of cover have been found for the common side-blotched lizard in other studies. Baltosser and Best (1990) found that side-blotched lizards utilized microhabitat within desert scrub habitat that had approximately 60 percent vegetation cover and 40 percent bare ground.

I hypothesized that capture abundance and habitat selection of side-blotched lizards would be impacted by the presence of non-native saltcedar in the riparian community. Abundance of lizards was not significantly different between mixed and non-native vegetation. Also, average canopy cover at sites where adult lizards were captured was not significantly lower than sites where adult lizards were not captured; however, two conditions may have influenced this result. First, the number of adult individuals captured was low and were recorded in less than half of the sampling areas. This lack of sample size may have inhibited my ability to detect significant differences. Second, several sites yielded only a single individual adult record suggesting a deficient adult population. Where hatchling side-blotched lizards were captured, patterns were evident that suggested higher quality habitat within vegetation with more open structure.

During visual encounter surveys, I documented microhabitat selection from 16 observed lizards; this low sample size constrains my analysis. However I am confident in my ability to detect lizards because sites in which no lizards were sighted also had few or no captures of lizards in the trap arrays. In Arizona, Szaro and Belfit (1986) captured 6 times as many common side-blotched lizards in desert washes and uplands as compared to adjacent riparian habitat. Therefore, low numbers of side-blotched lizards within riparian habitat may be expected. Lizards were monitored for only two seasons. However, this species is annual and reaches sexual maturity within one year of hatching (Tinkle, 1967). Therefore, observations on a single generation may be obtained by trap and survey methods.

I propose lizard abundances were similar between mixed and non-native saltcedar vegetation because the structural requirements which provide sunlight and shade needed for small ectothermic organisms to thermoregulate were met (Adolph, 1990; Waldschmidt, 1980). The thermoregulatory requirements of side-blotched lizards may be met in habitat with a proper amount of sunlight and shade; therefore, habitat physiognomy may be more important than species composition. On the San Pedro River in Arizona, Stromberg (1998) found vegetative characteristics important to wildlife, such as light availability and stand density, were equivalent between saltcedar and native vegetation. At moderate levels, saltcedar may provide adequate structure to support habitat requirements at a similar level as mixed vegetation. I observed side-blotched lizards in 7 of the 8 sites that I conducted visual encounter surveys. Similarly, side-blotched lizards were captured in 9 of 10 sites. The only site which produced no side-blotched lizard captures or encounters during surveys was a monotypic saltcedar site with greater than 80 percent canopy cover. On the lower Colorado River, a threshold response was observed in which bird abundances were greatest in habitats characterized by moderate levels of saltcedar and few birds were present in dense saltcedar stands (Van Riper et al., 2008). Similarly, under moderate levels, saltcedar vegetation may resemble native riparian vegetation and support populations of side-blotched lizards along the Virgin River. However, when saltcedar levels become exceedingly high within riparian vegetation, the habitat may no longer support populations of side-blotched lizards.

Common side-blotched lizards appear to select for particular structural components within the habitat and, if available, these lizards are likely to be present. This suggests that saltcedar may indeed provide adequate habitat for side-blotched lizards. However, where side-blotched lizards were present within the riparian corridor, there exists a gradient of vegetative characteristics. I found that 4 of 5 population parameters of side-blotched lizards were negatively correlated with percent canopy cover. Adult to hatchling ratio, which indicates the age structure of a population, was negatively correlated with canopy cover. Hatchling body condition was also negatively correlated with canopy cover. Hatchling abundance, however, was not correlated with percent canopy cover.

However, the 5 sites with the lowest abundance were all in non-native saltcedar vegetation with high levels of canopy cover. Recapture rate and persistence were both negatively correlated with canopy cover. This finding may be attributed to dispersal of neonate lizards. Common side-blotched lizards actively compete and defend territories (Tinkle, 1967). Therefore, it is presumable that hatchling side-blotched lizards may disperse from hatching site to seek territories. Doughty and Sinervo (1994) found median dispersal distances of hatchling side-blotched lizards to be between 20 and 40 meters and that the majority of dispersal took place within a month of hatching. Dispersal could explain why hatchling abundance was not correlated with canopy cover, whereas recapture rate and persistence were. Soon after hatching, individuals may be abundant across a broad range of microhabitats searching for territories. However, recapture rate and persistence indicate that hatchling side-blotched lizards persist longer within microhabitat with moderate levels of canopy cover. This provides further evidence that side-blotched lizards select habitats with moderate levels of canopy cover regardless of plant species composition.

CONCLUSION

My findings are specific to a single species of lizard within one river system and are not intended to be representative of other species of wildlife which utilize riparian habitat or of other riparian systems within the western United States. However, there have been other scientific investigations conducted within riparian systems of the southwestern United States that have found abundances and utilization of native biota to be similar in non-native saltcedar vegetation compared to native riparian vegetation.

Saltcedar has become a concern for both private land owners and land managers and much money has been allocated for the study and management of this non-native species. Furthermore, much literature has shown the negative impact this species has on native biota and natural ecosystem processes. However, debate has developed over the impacts of saltcedar. In some Southwestern riparian systems, abundances of birds, arthropods, and small mammals have been found to be greater in saltcedar than in native vegetation. Furthermore, the endangered southwestern willow flycatcher has been found to breed in non-native saltcedar. Trends in habitat use and abundance of native wildlife within non-native saltcedar vegetation should not be overextended across the entire landscape, as they are specific to the system in which they were studied. However, these trends offer evidence that saltcedar can provide habitat where it resembles the structural characteristics necessary for native wildlife.

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APPENDIX A

CHI-SQUARE ANALYSIS

Table A. Chi Square Analysis

Chi-square analysis and test of proportions of microhabitat variables measured at lizard and generated points within both mixed and non-native vegetation along the Virgin River during May-August of 2010.

Variable Classes ΣX^2 (df)	Lizard Use N = 16	Available Habitat N = 52	Significant	Z test
Canopy Cover				
0-50%	43.75%	50.00%		0.15
50-75%	43.75%	5.76%	$p < 0.10$	3.35*
>75%	12.50%	44.23%		2.00*
$\Sigma X^2 = 39.69$ (2)				
Understory				
0-50%	93.75%	71.15%	$p < 0.10$	1.52
>50%	6.25%	28.84%		1.52
$\Sigma X^2 = 4.66$ (1)				
Substrate				
Litter	37.50%	42.30%		
Soil	31.25%	46.15%	NS	
Woody Debris	31.25%	11.53%		
$\Sigma X^2 = 5.21$ (2)				
Refuge				
Vegetation	50.00%	57.69%		
Woody Debris	43.75%	30.76%	NS	
Burrow	6.25%	11.53%		
$\Sigma X^2 = 1.43$ (2)				
Distance to Refuge				
<1m	62.50%	67.30%		0.05
1-2m	12.50%	25.00%	$p < 0.10$	0.71
>2m	25.00%	7.69%		1.44
$\Sigma X^2 = 10.09$ (2)				
Distance to Open				
In open	43.75%	71.15%	NS	
Not in open	56.25%	28.84%		
$\Sigma X^2 = 1.01$ (1)				

Cont'd

Variable Classes ΣX^2 (df)	Lizard Use N = 16	Available Habitat N = 52	Significant	Z test
Nearest shrub				
0-1m	37.50%	69.23%	$p < 0.10$	1.98*
>1m	62.50%	23.07%		1.98*
$\Sigma X^2 = 7.27$ (1)				
Type of shrub				
Native	37.50%	48.08%	NS	
Non-native	62.50%	51.92%		
$\Sigma X^2 = 0.72$ (1)				
Height From Ground				
Not elevated	62.50%	92.30%	$p < 0.10$	2.54*
Elevated	37.50%	7.69%		2.54*
$\Sigma X^2 = 26.67$ (1)				

*Z test of proportions significant at the $p < 0.10$ level.

APPENDIX B

LOCATIONS OF SITES

Table B: The name, vegetation type, and geographic location of each site where lizards were captured from May-August of 2009 and 2010.

Site	Array	Habitat	UTM E	UTM N	Coordinate System/zone
Littlefield, AZ	1	Mixed	239617	4087585	WGS 84 12S
Littlefield, AZ	2	Mixed	239527	4087439	WGS 84 12S
Big Bend, AZ*	1	Mixed	233971	4081452	WGS 84 12S
Big Bend, AZ*	2	Mixed	233801	4081292	WGS 84 12S
Mesquite, NV	1	Non-native	764162	4077107	NAD 83 11S
Mesquite, NV	2	Non-native	763642	4077072	NAD 83 11S
Mesquite, NV	1	Mixed	760694	4075899	NAD 83 11S
Mesquite, NV	2	Mixed	760420	4075755	NAD 83 11S
Bunkerville, NV	1	Non-native	756519	4075058	NAD 83 11S
Bunkerville, NV	2	Non-native	756138	4074890	NAD 83 11S
Bunkerville, NV	1	Mixed	756374	4074574	NAD 83 11S
Bunkerville, NV	2	Mixed	756178	4074562	NAD 83 11S
Freeway, NV*	1	Non-native	753592	4072750	NAD 83 11S
Freeway, NV*	2	Non-native	753521	4072612	NAD 83 11S
Toquap, NV*	1	Non-native	748917	4069716	NAD 83 11S
Toquap, NV*	2	Non-native	748797	4069854	NAD 83 11S
Gold Butte, NV	1	Non-native	742331	4062936	NAD 83 11S
Gold Butte, NV	2	Non-native	742103	4062743	NAD 83 11S
Gold Butte, NV	1	Mixed	740744	4061172	NAD 83 11S
Gold Butte, NV	2	Mixed	740638	4060710	NAD 83 11S

*These sites were established in 2010.

APPENDIX C

LOCATIONS OF LIZARD OBSERVATIONS

Table C: Geographic location where 16 individual common side-blotched lizards were observed during visual surveys from May-August of 2010. The type of vegetation and site where the lizard was observed are also designated. Sites are in order most upstream to most downstream.

Site	Habitat	UTM E	UTM N	Coordinate System/zone
Littlefield, AZ	Mixed	239724	4087545	WGS 84 12S
Littlefield, AZ	Mixed	239587	4087438	WGS 84 12S
Mesquite, NV	Non-native	764492	4077200	NAD 83 11S
Mesquite, NV	Non-native	764133	4077190	NAD 83 11S
Mesquite, NV	Non-native	764133	4077190	NAD 83 11S
Mesquite, NV	Non-native	764112	4077176	NAD 83 11S
Mesquite, NV	Non-native	764210	4077161	NAD 83 11S
Mesquite, NV	Mixed	760830	4075977	NAD 83 11S
Bunkerville, NV	Non-native	756512	4075044	NAD 83 11S
Bunkerville, NV	Non-native	756217	4074971	NAD 83 11S
Bunkerville, NV	Mixed	756323	4074621	NAD 83 11S
Bunkerville, NV	Mixed	756301	4074615	NAD 83 11S
Bunkerville, NV	Mixed	756221	4074559	NAD 83 11S
Toquap, NV	Non-native	748926	4069704	NAD 83 11S
Gold Butte, NV	Mixed	740770	4061246	NAD 83 11S
Gold Butte, NV	Mixed	740711	4060883	NAD 83 11S

APPENDIX D

PHOTOGRAPHS OF COMMON SIDE-BLOTCHED LIZARDS

Figure D1. Picture of hatchling *Uta stansburiana.*

Figure D2. Picture of adult female *Uta stansburiana.*

Figure D3. Picture of adult male *Uta stansburiana*.

APPENDIX E

PERMITS

Arizona Game and Fish Department. Permit number 195230

Nevada Department of Wildlife. Permit number S32027

Institutional Animal Care and Use Committee. Permit number 09-1051R