DISTRIBUTION AND STATUS OF THE ARIZONA STRIPED WHIPTAIL
Aspidoscelis (=Cnemidophorus) arizonae

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ABSTRACT: I surveyed historic and nearby collecting localities for *Aspidoscelis* (= *Cnemidophorus*) *arizonae* in Cochise and Graham counties, Arizona, during spring and summer, 2000-2004. *Aspidoscelis arizonae* was present at or nearby all but one of the historic sites (seven of eight) that I surveyed located near Willcox (within 15 km), and the Whitlock Valley 65 km to the northeast in Graham County, but not the type locality 65 km to the west at Fairbank, Cochise County. The Whitlock Valley was the only site occupied by both *A. arizonae* and *A. tigris*. The Desert Grassland Whiptail, *A. uniparens*, was present at most sites unoccupied by *A. arizonae*, including the type locality; three sites were occupied by both taxa. Cattle grazing was apparent at virtually all sites occupied by either species; *A. arizonae* was associated with relatively open grasslands whereas *A. uniparens* was often found in habitats with numerous invader shrubs (e.g., mesquite), regardless of grazing activity.

This report summarizes work conducted as part of Heritage Grant I03002, undertaken to ascertain the status of the Arizona Striped Whiptail, *Aspidoscelis (=Cnemidophorus) arizonae*. The goals as stated in the original proposal were to: 1) survey all known historic and nearby (within 40 km) collecting sites for *A. arizonae* in Cochise County, Arizona; 2) characterize known and any newly discovered sites with respect to cattle grazing impacts; 3) evaluate the potential for negative interactions between Arizona Striped and Desert Grassland whiptails (*A. uniparens*); and 4) assess the taxonomic relationship of *A. arizonae* to other whiptails. Herein I describe results obtained from preliminary surveys in 2000, and more intense work in 2002, 2003 and 2004.

Is *Aspidoscelis arizonae* a "full" species?

The Arizona Striped Whiptail, *A. arizonae* has enjoyed a complex taxonomic history. Originally described by Van Denburgh (1896) based on a single specimen labeled "Fairbank, Cochise County, Arizona," it was relegated to synonymy with *A. perplexa* (= *inornata*) by Van Denburgh (1922) and noted as extirpated from the type locality some twenty years after its initial collection (Van Denburgh and Slevin, 1913). Wright and Lowe (1965) rediscovered *A. arizonae* at Willcox Playa in 1962 and since that time it has been known from only a handful of localities near Willcox, and in the Whitlock Valley, Graham County, Arizona (Mitchell, 1979; Wright and Lowe, 1993; Rosen et al., 1996). Wright and Lowe (1965) recognized *A. arizonae* as a subspecies of the widely distributed Little Striped Whiptail, *A. inornata*.

Although Wright (1993) and Stebbins (2003) viewed *A. arizonae* as a subspecies of the Little

Striped Whiptail (*A. inornata*), Crother et al. (2000) recognized it as a species. This recommendation, followed here, was based on 1) allopatry of extant populations, and 2) morphological diagnosability relative to other subspecies of *A. inornata*. The genetic analysis reported here supports recognition of *A. arizonae* as the sister taxon to *A. pai* (*A. i. pai*).

Is *Aspidoscelis uniparens* replacing *A. arizonae*?

Wright and Lowe (1965) and Rosen et al. (1996) suggested that *A. arizonae* was a desert grassland form distributed widely in southeastern Arizona historically that declined following alteration and reduction of habitat due to overgrazing and drought that began in the late 1800s. They also indicated the *A. arizonae* may have been replaced in these altered habitats by the unisexual form, *A. uniparens*. Unfortunately, few historic records exist to allow assessment of the hypothesis that *A. arizonae* are no longer present at sites currently occupied by *A. uniparens*.

The observation that the (single) type specimen of *A. arizonae* was collected at Fairbank (approximately 65 km southwest of Willcox), a site where it does not occur today, is central to the hypothesis that *A. arizonae* was historically more widespread in southeastern Arizona (Wright and Lowe, 1965). However, there is reason to suspect that the collecting locality for the type specimen was assigned in error. The W. W. Price expedition used Fairbank as a base in southeastern Arizona in 1894; many other herpetological specimens (e.g., exclusively high elevation, montane forms) likely collected elsewhere were labeled "Fairbank" (P.C. Rosen, pers. comm.). Additionally, the creosote/acacia dominated community near Fairbank, although presumably altered relative to its historic state, is not a habitat typically occupied by *A. arizonae*

(but see below). I am aware of no other historic collecting localities in which *A. uniparens* has replaced *A. arizonae*.

Rosen et al. (1996) suggested that *A. uniparens* might be competitively superior to *A. arizonae*. Mitchell's (1976, 1979) analysis indicated that these two taxa are nearly identical with respect to diet, and thus if resources are limiting, and the unisexual *A. uniparens* has a reproductive advantage (Hulse, 1981), then it might replace the bisexual *A. arizonae* over time in zones of overlap. Rosen et al. (1996) observed sympatric populations of *A. arizonae* and *A. uniparens* west of Willcox in 1993, but no specimen series were retained, nor were observations on interactions noted. The evidence reviewed here, including consistent distributions among these taxa, indicates that if wide-spread decline of *A. arizonae* with replacement by *A. uniparens* occurred, it was prior to 1900, and that their current distributions in Cochise County appear relatively stable over the past fifty years.

Recent survey efforts

During spring and summer, 2000, Sullivan et al. (2001) surveyed the vicinity of the Willcox Playa for whiptails, both *A. arizonae* and *A. uniparens*. *Aspidoscelis arizonae* was present at or nearby four of four historic sites surveyed excepting the type locality (Fairbank), and *A. uniparens* was present at most sites unoccupied by *A. arizonae*. The continued presence of *A. arizonae* at a "pure" site surveyed by Mitchell (1976) adjacent to an area occupied by *A. uniparens*, in spite of heavy grazing throughout the region, indicates a lack of competitive exclusion of *A. arizonae* by *A. uniparens* in the one grazed habitat with voucher specimens over

a twenty-five year period (Sullivan et al., 2001). Hence, the hypothesis that *A. uniparens* is competitively or behaviorally superior to and possibly replacing the Arizona whiptail requires additional study.

Herein I report on surveys for whiptails in Cochise and Graham counties during 2000, and 2002-2004. Presence of *A. arizonae*, *A. uniparens*, and other whiptails, as well as habitat characteristics in relation to grazing impacts were assessed for all historic collecting localities and nearby sites.

MATERIALS AND METHODS

Current distribution of *Aspidoscelis arizonae*

I obtained information about historic collecting sites for *A. arizonae* from publications and museum records (Arizona State University Vertebrate Collection; California Academy of Sciences; Los Angeles County Museum; Museum of Vertebrate Zoology; San Diego Natural History Museum; University of Arizona). Fieldwork was conducted during April through September 2000, and again during those months in 2002-2004. Sites near Willcox were visited and the following information recorded (for most sites): 1) precise location (UTMs; Garmin GPS 12 XL unit); 2) temperature (air temperature approximately 1.5 m above ground in shade); 3) time and duration of survey; 4) cloud cover; 5) general habitat characteristics (soil color and texture; numerically dominant perennial plants; apparent condition vis a vis grazing by cattle and sheep); and 6) all reptiles observed during survey efforts (typically 30 minutes per site).

Sites were visited repeatedly within and across years to document consistency in presence/absence of *A. arizonae* and *A. uniparens*.

Because *A. arizonae* can be confused with *A. uniparens*, during surveys all individual lizards were followed closely until the observer obtained a clear visual image for identification. In the Willcox area, *A. arizonae* can be distinguished from *A. uniparens* by the presence of a well-developed dorsal stripe, relatively larger paravertebral stripe area (i.e., wider space between paravertebral stripes), and sky-blue wash on tail and lateral surfaces (green-blue when present in *A. uniparens*; Fig. 1). I found that these features were discernable, even in juveniles, if the subject was motionless for approximately 5 seconds in good light and viewed from an unobstructed position within one meter. In hand, in the Willcox area these taxa differ in scale counts (e.g., number of scales between paravertebral stripes), scale shape and size (e.g., postantebrachials), and femoral pores (e.g., number) as noted by Wright and Lowe (1993).

The need for identification of individuals restricted my ability to implement a consistent, easily repeatable sampling regime for each locality. Rather, I typically arrived at a site, began walking through the habitat in one compass direction, and then pursued each individual lizard seen until it was positively identified or escaped (e.g., entered a burrow). I then resumed searching along the original path taking care not to duplicate any effort in areas previously sampled. Hence, I am confident that I generally did not double count individuals at a site.

Whenever possible I captured up to five voucher specimens at each site in order to confirm

visual taxonomic assignments and obtain tissues for future genetic analysis. At sites with apparently "thriving" (more than five individuals observed within five minutes of survey effort) populations of *A. arizonae*, I collected (using nooses or a .22 caliber pistol with dust shot) up to five individuals to absolutely verify the absence of *A. uniparens*.

Habitat characteristics

At 25 survey sites in Cochise and Graham counties, Arizona, grazing impacts were assessed by surveying plants and cattle sign (dung) using modified belt transects (50 m by 2m width) in which substantive plants (greater than 5 cm stem/soil base area) were recorded using the criteria listed in Appendix A. Although a more detailed analysis of plant diversity and abundance might be considered ideal, in the present case the effort required for such work was unwarranted given the fact that degradation of grassland habitats due to overgrazing in the Southwest is generally associated with reduction in grass cover and an increase in shrub densities, especially mesquite.

Grazing activity was assessed directly using dung pile counts along the plant survey transects. Specifically, all dung piles were scored along each plant transect (regardless of size or shape). All transects were completed between 18 April and 10 July 2003.

Because virtually all survey sites were located near dirt roadways, transects could not be placed randomly. Rather, they were placed perpendicular to the main road or trail in the vicinity, with the starting point placed at least 10 m from the roadway. The first habitat survey transect was

initiated at the first capture site of a whiptail, and the others were placed 50 m to either side, again perpendicular to the nearest roadway. A minimum of two, and if time permitted up to four, transects were surveyed at each site.

Interactions between *Aspidoscelis arizonae* and *A. uniparens*

Behavioral interactions between Arizona and desert grassland whiptails were assessed by staging paired (dyad) interactions in which one individual of each species was simultaneously introduced into a portable arena (1 m diameter) and the outcome with respect to all behavioral interactions was noted (e.g., dominant individuals chase the other subject). This method has been widely used to assess dominance among squamates (e.g., Kwiatkowski, 2001), and was adopted to assess the hypothesis that Desert Grassland Whiptails are dominant to Arizona Whiptails in direct interactions for resources, as proposed by Rosen et al. (1996). Using the individuals collected from thriving populations for voucher specimens, eight pairs (one Arizona and one Desert Grassland whiptail) were tested for dominance.

Taxonomic status of *Aspidoscelis arizonae*

Mitochondrial ATPase 8 and 6 genes were amplified in 54 individuals using primers specified in Douglas et al. (2002). These individuals comprised 29 *A. arizonae* (*A. sexlineata* Group), eight *A. inornata* (*A. sexlineata* Group), six *A. pai* (*A. sexlineata* Group), and eight *A. tigris* (*A. tigris* Group), with group membership according to Reeder et al. (2002). Outgroup was *Gekko gecko* (following Lee, 1998).Double-stranded sequencing reactions were conducted with fluorescently-labeled dideoxy terminators according to manufacturer recommendations [Applied Biosystems

Inc. (ABI), Forest City, CA]. Labeled extension products were gel-separated and analyzed with an automated DNA sequencer (ABI model 3100). Sequences were aligned automatically using Sequencher (Gene Codes, Ann Arbor MI), and the effectiveness of combining these sequences for analysis was tested with the partition homogeneity test (Farris et al. 1994) implemented in * (ver. 4.04b10, Swofford 2001). DNAsp was used to compute Tajima's (1989) D-statistic to determine if sequence evolution was consistent with neutral expectations.

Individuals served as unweighted input to the maximum parsimony (MP) algorithm of PAUP*. Shortest trees were sought by using heuristic searches that employed accelerated character transformation (ACCTRAN) optimization, tree bisection-reconnection (TBR) branch swapping, retention of minimal trees (MULPARS), and collapse of zero-length branches to yield polytomies. Support for individual nodes was evaluated by nonparametric bootstrapping, using 1,000 pseudoreplicates per analysis with 100 random addition sequences per pseudoreplicate. A node with a bootstrap value > 70% was considered strongly supported (Hillis and Bull, 1993).

For the *A. arizonae* samples, I calculated nucleotide diversity (average weighted sequence divergence among haplotypes, varying between 0% for no divergence to over 10% for deep divergence) using DNAsp (ver. 4, Rozas et al. 2003). Values provided an estimate of the probability that two randomly chosen homologous nucleotides are identical. I also calculated haplotype diversity (*h*: a measure of the frequencies and numbers of haplotypes among individuals) for *A. arizonae* individuals (again using DNAsp). Here, values range from zero to one and provided an estimate of the probability that two randomly chosen homologous nucleotides are identical. I also computed Tajiima's D statistic (Tajima 1989) to test the hypothesis that all mutations are selectively neutral. To accomplish this, the test examines if the

number of segregating sites in the sequences differ significantly from the average number of nucleotide differences they contain.

Sequence divergence values and standard errors were generated for each taxon from 1,000 bootstrapped sequences using MEGA2 (S. Kumar et al., unpubl.). Values were corrected for within-group variation and all deletions resulting from outgroup inclusion were removed. The sequence divergence represents the proportion of nucleotide sites at which the two sequences compared are different. It is obtained by dividing the number of nucleotide differences by the total number of nucleotides compared. Values were calculated and compared across the four available groups: *A. tigris*, *A. inornata*, *A. pai* and *A. arizonae*.

Two measures of homoplasy were derived for the parsimony tree: the consistency index (CI) and the retention index (RI), both commonly cited in most phylogenetic studies. CI (also called the homplasy index) represents the fit of an entire data set to a tree, and trends from one (if there is no convergence) towards zero as the amount of convergence on the tree increases. However, the minimum possible value of CI on minimum length trees is correlated both with numbers of taxa and characters. Hence CI is inappropriately scaled to permit meaningful comparisons among studies that employed different sets of characters or different taxa. On the other hand, RI measures the proportion of apparent homoplasy in the data that is retained in the phylogenetic tree.

Archie (1996:184--185) recommended two new statistics for interpretation of evolutionary change on a tree, and indicated both are more useful than CI as a direct measure of homoplasy. These are SC (average number of steps per character), and HC (average homoplasy per

character). SC (= 1/CI) contains information inherent in CI but in a form directly interpretable in terms of character change on a tree. It also lacks the pretense of being scaled between fixed limits. When data contain no homoplasy, SC = 1.0. As homoplasy increases, SC increases (essentially) without bounds. In an examination of 28 different data sets from the literature, Archie (1996) found SC ranged from 1.06--4.71. HC, the average homoplasy per character (where HC = SC - 1) has a minimum value of 0.0.

RESULTS

Historic distributions

Based on museum specimens, historically, *A. arizonae* has been collected primarily along the eastern and northern edges of the Willcox Playa. Only two historic sites were more than about 15 km from Willcox: the type locality at Fairbank (Van Denburgh, 1896) about 65 km to the southwest, and the Whitlock Valley (discussed by Wright and Lowe, 1993) about 65 km to the northeast. No other localities were revealed by examination of museum specimens.

Many specimens listed in various museum collections as *A. inornata* from Cochise County, are likely misidentified *A. uniparens* (J. W. Wright, pers. comm.). In confirmation of this hypothesis, I found that for *A. inornata* (= *arizonae*) from Cochise Co. held at the MVZ, UC Berkeley, only 7 of 29 are in fact *A. arizonae*. All of these were from within 5 km of Willcox; the remainder were *A. uniparens*. Interestingly, many of these *A. uniparens* were collected by J. E. Law in 1919 along rte 186 southeast of Willcox, revealing that this taxon has been present at

sites within 10 km of Willcox for at least 80 years rather than having recently colonized these areas following overgrazing and habitat disturbance. Verified, valid specimens of *A. arizonae* in other collections (e.g., UAZ, ASU, etc.) were all from sites within 15 km of Willcox, Cochise County, Arizona.

Current distributions

A total of 111 person hours was spent surveying on a total of 25 days from 20 April through 5 September 2000; similarly, surveys comprised 41 person hours on eight days from 24 June through 1 September 2002, and 53 person hours on 12 days from 18 April through 30 August 2003. In 2004, most fieldwork was focused on collection of Little Striped Whiptails from central and northern Arizona, and southern New Mexico, but the Whitlock Valley was visited once in May and once in June (4 person hours total).

A total of 81 independent sites were surveyed in Cochise and Graham counties; Appendix I, Parts 1 and 2, provides a listing (referenced to BKS field tags) of voucher specimens and UTM coordinates for all sites where whiptails were collected in 2002-2004, including all sites occupied by *A. arizonae*. The majority of sites were heavily grazed, with ample sign (e.g., droppings, active trails, grazed shrubs and grasses) of persistent, recent grazing by cattle. Overall, *A. arizonae* were present at 12 sites, *A. uniparens* were present at 45 sites, *A. tigris* were present at 15 sites, and no whiptails were observed at the remaining 15 sites. Three sites were occupied by both *A. arizonae* and *A. uniparens* (Willcox Airport; northeast of Willcox at exit 340 on Interstate 10; and Ash Creek Road, 8 km southwest of Bonita; see Appendix I for precise

coordinates) and a single site was occupied by *A. arizonae* and *A. tigris* (northern Whitlock Valley at State Route 70).

Multiple visits to most sites in the vicinity of Willcox over the course of the activity season confirmed that activity of *A. arizonae* and *A. uniparens* was primarily restricted to May-August. For example, no adult *A. arizonae* were seen active prior to 14 May, and only one adult was observed active after 31 August.

With regard to specific observations of Arizona Striped Whiptails, I observed *A. arizonae* at 12 sites (Appendix I, Part 3: Table 1), including all but one of the eight Willcox area historic localities, and at two sites roughly 35 km to the north, near Bonita, Graham County (Fig. 2; Appenidx I). One historic collecting locality, roughly 13 km north of Willcox, is now occupied by a housing development, and no whiptails were observed. Relatively large numbers of *A. arizonae* were observed at three sites: 1) Twin Lakes Golf Course three km southwest of Willcox; 2) along state route 186, seven km southeast of Willcox; and 3) two sites roughly eight km south of Bonita, Graham County. At each of these sites more than 10 *A. arizonae* were visually confirmed within 30 minutes of field survey activity on several occasions. Like other collectors (e.g., Van Denburgh and Slevin 1913; Wright and Lowe 1965), I documented only *A. tigris* and *A. uniparens* at Fairbank, the type locality (listed only as "Fairbank" in Fig. 2).

The northern Whitlock Valley, an area of rocky, relative well drained and extensive creosote flats, was occupied exclusively by *A. tigris* when surveyed in 2000, 2002 and 2003; it may be

that other areas in this valley that were not accessible (private holdings) contain suitable habitat (e.g., grassland) that I could not access. In 2004, I surveyed the precise locality near the Hackberry Ranch in the central Whitlock Valley (a degraded grassland with much creosote and mesquite) where a single *A. arizonae* was recorded in 1983 (in the UA collection), and found 12 *A. tigris*. However, on this same day, a single *A. arizonae* was collected at the north end of the Whitlock Valley, in the previously described upland creosote flats, near state route 70 (not specifically indicated in Fig. 2). Numerous *A. tigris* were also observed at the site, as recorded in 2000-2003.

At one site (7 km southeast of Willcox along State Route 186), recognized as "area I" by Mitchell (1979), I found only *A. arizonae* (12 of 12 individuals captured) and no *A. uniparens*, just as Mitchell documented in 1975. I observed *A. uniparens* at a number of sites to the west, south and north of Willcox Playa, and at many localities in eastern Cochise County. However, I found no evidence that *A. uniparens* was present at sites historically occupied by *A. arizonae* (except for the type locality, Fairbank; see above). *Aspidoscelis tigris* was found at rocky sites with creosote and other shrubs, rarely with *A. uniparens* and only once (Whitlock Valley) with *A. arizonae*.

Habitat characteristics

Habitat surveys were conducted at nine sites occupied by *A. arizonae* (one of the nine sites also had *A. uniparens*) and at one additional site occupied by *A. uniparens* and hybrids between *A. arizonae* and *A. uniparens* (Appendix I, Part 4: Table 2). Fifteen nearby additional sites (most

were within 10 km of a site occupied by *A. arizonae*) with only *A. uniparens* were surveyed for comparative habitat characteristics (Appendix I, Part 5: Table 3). Sites occupied by *A. arizonae* were significantly higher (Table 1) in grass cover indices (MW U = 116.5, P = 0.019), and lower in both mesquite (MW U = 45.0, P = 0.09) and invader shrub counts (MW U = 35.0, P = 0.026) than sites occupied by *A. uniparens*. However, the sites did not differ in current grazing index scores (i.e., dung counts; MW U = 72.5, P = 0.888; Table 1).

Interactions between *Aspidoscelis arizonae* and *A. uniparens*

Lizards of both taxa were collected by hand and noose during mid-May from near Willcox, Arizona (eight male *A. arizonae* and four *A. uniparens*). Trials were executed at the Southwestern Research Station of the American Museum of Natural History, near Portal, Arizona. In each trial (eight total) each lizard avoided the other for the duration of the trial (20 minutes). When an individual moved toward the other subject, the approached subject retreated, regardless of species. The only contact occurred when a male *A. arizonae* approached and bit a female *A. uniparens*. The male immediately released the female and rubbed its mouth in the soil vigorously. It appeared that lizards were not amenable to a simple dyad protocol for assessing interactions, perhaps due to their response to capture or the artificial setting of arena trials.

Taxonomic status of *A. arizonae*

PCR amplifications and automated sequencing of ATPase 8/6 resulted in 848 base pairs (bp) of unambiguous sequence. An additional nine deletions resulted from the accommodation of the

outgroup. Combining the two ATP genes was supported by a non-significant partition homogeneity test (PAUP*: P > 0.45). Across all 29 *A. arizonae* individuals, the sequence data were 95.8% monomorphic and 4.2% polymorphic, with 61% of the latter parsimony informative (i.e., 2.6% of total). There were 18 total haplotypes within *A. arizonae*, and haploype diversity was high (0.919 ± 0.041) while nucleotide diversity was low (0.0059 ± 0.0013). Tajima's D statistic = -1.668 (0.10 > P > 0.05) indicated that mutations in our sequence data are selectively neutral. There were a total 56 most parsimonious trees generated, each with length = 562. The bootstrapped consensus tree had a consistency index (CI) of 0.836 and a retention index (RI) of 0.937. The average number of steps per character (SC) was 1.16, while the average homoplasy per character (HC) = 0.16. Thus, all statistics indicate that the data contain little homoplasy.

Average sequence divergence (%) for the four groups (*A. tigris*, *A. inornata*, *A. pai* and *A. arizonae*) ranged between a high of 14.8 % (± 0.011 SE) for *A. tigris* and *A. arizonae*, to a low of 2.4 % (± 0.005) for *A. arizonae* and *A. pai*. Sequence divergence between *A. arizonae* and *A. inornata* (3.9 ± 0.006%) was higher than the value between *A. inornata* and *A. pai* (3.2 ± 0.006%).

Aspidoscelis arizonae was relatively uniform genetically (Fig. 3). The top-most two clusters showed a small amount of variability, but each contained individuals from Cochise and Graham counties, suggesting that while variability was indeed apparent, it was not structured geographically in that individuals from different counties clustered together. Sister to the larger *arizonae* clade was a smaller one containing two individuals (BKS 1176 and 1265) from Cochise County that differed somewhat from those haplotypes in the main *arizonae* cluster.

The next cluster contained *A. pai* (all from Coconino County); no other *A. pai* were collected from different geographic regions. The next most basal cluster contained two samples of *A. inornata* from Socorro Co. NM. The fourth cluster contained only *A. tigris* and revealed reasonable geographic variation, with discrete clusters containing individuals from Coconino Co. (Grand Canyon), Cochise and Yavapai cos.

The outgroup (*Gekko gecko*) was basal in the tree. A list of individuals by BKS number (if available; not available for NM specimens or those that were released) is provided in Appendix B.

DISCUSSION

Historic and current distributions

Although I focused primarily on simple assessments of presence and absence, I found no evidence that *A. arizonae* has declined and been replaced by *A. uniparens*; it appears that *A. arizonae* is persisting in most historic localities identified in the 1960s (e.g., sites 3-7 km west, southwest and southeast of Willcox). Independent of high levels of grazing apparently maintained throughout the region, surveys suggest that *A. arizonae* is at least as abundant at the 12 sites observed in 2000-2004 as *A. uniparens* is at the nearby sites it occupies, although this is distinctly not the case for the northern Whitlock Valley site surveyed in 2004 (i.e., a single *A. arizonae* and numerous *A. tigris*).

Perhaps most significantly, the continued presence of *A. arizonae* at a "pure" site surveyed by Mitchell (1976) adjacent to an area occupied by *A. uniparens*, in spite of heavy grazing throughout the region, indicates a lack of competitive exclusion of *A. arizonae* by *A. uniparens* in some grazed habitats. Interestingly, the collections of J. E. Law held at the MVZ, obtained in 1919, reveal the long-standing presence of *A. uniparens* in this area 7-25 km southeast of Willcox, certainly ample time for this taxon to have expanded and replaced *A. arizonae*. Further, I found no evidence that *A. uniparens* has increased in abundance at a site close to an area of sympatry studied by Mitchell in the 1970s (Mitchell, 1976, 1979).

I documented the presence of *A. arizonae* at seven of eight historic sites within 10 km of Willcox, at the Whitlock Valley in Graham County, and discovered two disjunct populations roughly 37 km north of Willcox, near Bonita, Graham County. With the exception of the type locality at Fairbank, and a single site north of Willcox, I documented the presence of *A. arizonae* at (or nearby) all historic localities near Willcox. I was able to confirm the presence of *A. arizonae* at the disjunct site in the Whitlock Valley 65 km to the northeast (discussed in Wright and Lowe, 1993), in addition to the two separate populations roughly 37 km north of Willcox near Bonita, Graham County, Arizona.

My observation of a single *A. arizonae* in the northern Whitlock Valley, in a creosote flat, is of interest for at least two reasons. First, it indicates that the Arizona Striped Whiptail persists in this region, in spite of large numbers of *A. tigris*. Second, it casts doubt on the hypothesis that this whiptail is restricted to grassland and degraded grassland habitats. Alternatively, the single

specimen (of literally dozens of whiptails observed and collected), might be appropriately viewed as the "exception that proves the rule" (i.e., that it generally is not found in such habitats). This observation does suggest that future surveys should proceed under the assumption that habitat specificity in the Arizona Striped Whiptail may be more plastic than previously thought.

The evidence reviewed here, including consistent distributions among these taxa, indicates that if wide-spread decline of *A. arizonae* with replacement by *A. uniparens* occurred, it was prior to 1900, and that their current distributions in Cochise County appear relatively stable at least over the past fifty years.

Habitat characteristics

Sites occupied by *A. arizonae* were in general more open, with fewer shrubs and more grass (Table 1), but grazing impacts were high across all habitats occupied by either *A. arizonae* or *A. uniparens*. If grazing leads to an increase in shrub cover and reduction in grasses, it may be that *A. arizonae* will decline.

Behavioral interactions

Unfortunately, staged encounters with whiptails to assess dominance were unsuccessful. Although some workers have had success with laboratory studies of reproductive behavior in whiptails, it may be that subtle interactions associated with dominance (or the lack thereof) are less amenable to this approach so widely used with other squamates.

Taxonomy

Aspidoscelis arizonae from southeastern Arizona was relatively uniform genetically (Fig. 3). There was a small amount of variability within the top-most two clusters of the bootstrap tree, but each contained individuals from Cochise and Graham counties, suggesting that the variability was not structured geographically (individuals from different counties clustered together). The smaller clade sister to these two clusters contained two individuals (BKS 1176 and 1265) from Cochise County that differed somewhat from those haplotypes in the main *arizonae* cluster.

Aspidoscelis pai (all from Coconino County) were also uniform genetically, although only two sites were sampled, and they were sister to *A. arizonae* from southeastern Arizona. This result is consistent with current taxonomy recognizing the two as independent taxa. Sequence divergence between *A. arizonae* and *A. pai* (2.4 %) was lower than the value between *A. inornata* and *A. pai* (3.2 %) and *A. inornata* and *A. arizonae* (3.9 %). Sequence divergence alone is a poor metric with which to judge species boundaries, but one could infer from these data that all three lineages are distinct, and on separate evolutionary trajectories. *Aspidoscelis pai* is typically a six striped whiptail, while *A. arizonae* generally possesses seven stripes (other characters discussed in Wright and Lowe, 1993). Two samples of *A. inornata* from Socorro Co., central New Mexico, were sister to *A. pai* and *A. arizonae*. Unfortunately, no samples of *A. inornata* were obtained from southwestern New Mexico, proximate to *A. arizonae*, but the present results indicate that the immediate affinities of *A. arizonae* are with *A. pai* rather than *A. inornata* of New Mexico.

The present results (sequence divergence and phylogenetic analysis) do fulfill the criteria outlined by Wiens and Penkrot (2002) for detection of lineages: in-group lineages were exclusive of outgroups, and lineages within purported species were geographically exclusive of one another. Daniels et al. (2004) reviewed sequence divergence values of some recently studied squamates and found that percent divergences among recognized species are typically in the range of 5-10%; thus the present values are low by comparison. However, given the strongly supported clades (of currently recognized species), and fulfillment of the criteria of Wiens and Penkrot (2002), the present results are consistent with recognition of *A. arizonae, A. inornata* and *A. pai*.

RECOMMENDATIONS

First, my observations indicate that at least one viable population of *A. arizonae* persists in appropriate habitat (desert grassland with predominately sandy soil) some distance (i.e., near Bonita) from the Willcox Playa in southeastern Arizona. Additionally, the presence of *A. arizonae* in the Whitlock Valley in a creosote flat also suggests additional sites in southeastern Arizona, even non-grassland sites, might harbor this lizard. Thus, an even more thorough survey of the entire Sulphur Springs Valley might reveal additional sites occupied by *A. arizonae* that I did not detect or sample (i.e., non-grassland sites).

Second, given the persistence of *A. arizonae* at most historic sites, and the universal presence of cattle grazing at these sites, more field work is required to adequately evaluate the hypothesis

that *A. arizonae* is declining due to habitat alteration and subject to replacement by *A. uniparens*. Although I found that habitats occupied by *A. arizonae* differ from those occupied by *A. uniparens*, it is not clear that these differences are associated with habitat changes due to overgrazing, and the reduction in range of *A. arizonae*, or predate widely acknowledged grazing impacts in Arizona and simply indicate long term historic differences in playa grassland habitats independent of grazing.

Last, results indicate that *A. arizonae* is genetically uniform and sister to *A. pai* of northern Arizona. Discovery and examination of additional populations in eastern Cochise County, especially those geographically proximal to populations of *A. inornata* in New Mexico, would be profitable; inclusion of taxa from Texas and Mexico would also be enlightening.

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Appendix A

Criteria for scoring habitat characteristics of sites (per 50 X 2 m transect).

1) Grass cover index: 1 = no bunch grasses present; 2 = 1-10 bunch grasses (primarily *Sporobolus* spp.) present; 3 = 11-49 bunch grasses present; 4 = 50-99 bunch grasses present; 5 = ≥

100 bunch grasses present. Each individual grass "clump" was counted, regardless of diameter, height or condition.

2) Mesquite counts: number of plants. Each plant with any above ground vegetative part within the two m belt was counted.

3) Creosote counts: number of plants. Each plant with any above ground vegetative part within the two m belt was counted.

4) Invader shrub (primarily *Gutierrezia* spp., *Hymenoclea* spp., and *Isocoma* spp.) counts: number of non-mesquite/creosote shrubs. Each plant with any above ground vegetative part within the two m belt was counted.

5) Current grazing index: number of dung piles. Each discrete pile (i.e., contiguous), regardless of size, was counted.

Appendix B

Listing of specimens by code used in phylogenetic analysis (Fig. 3) and BKS field tag number. Species designations assigned geographically based on distributions (Wright and Lowe, 1993) of currently recognized taxa.

Aspidoscelis arizonae: CnAZ-1 to Cn AZ-8 BKS released specimens from south Willcox; CnAZ-9 = BKS 1202; CnAZ-10 = BKS 1201; CnAZ-12 = BKS 1198; CnAZ-14 = BKS 1176; CnAZ-15 = BKS 1174;CnAZ-16 = BKS 1173; CnAZ-17 = BKS 1172; CnAZ-18 = BKS 1199; CnAZ-19 = BKS 1296; CnAZ-23 = BKS 1228; CnAZ-24 = BKS 1229; CnAZ-25 = BKS 1248; CnAZ-26 = BKS 1253; CnAZ-30 = BKS 1264; CnAZ-31 = BKS 1265; CnAZ-32 = BKS 1266; CnAZ-33 = BKS 1267; CnAZ-36 = BKS 1298; CnAZ-37 = BKS 1303; CnAZ-38 = BKS 1304; CnAZ-39 = BKS 1377.

A. inornata: CnI-7 to CnI-12 = D. Burkett specimens from New Mexico; CnI-15 to CnI-17 = R. Jennings specimens from New Mexico.

A. pai: CnI-13 = BKS 1323; CnI-14 = released specimen; CnP-1 = BKS 1386; CnP-2 = BKS 1387; CnP-3 = BKS 1389; CnP-4 = BKS 1412.

A. tigris: CnT-1 = BKS 1276; CnT-2 = BKS 1277; CnT-5 = BKS 1305; CnT-6 = BKS 1319; CnT-7 = BKS 1320; CnT-8 = BKS 1322; HAV1 to HAV 2 = M. Douglas specimens from Grand Canyon.

Figure legends

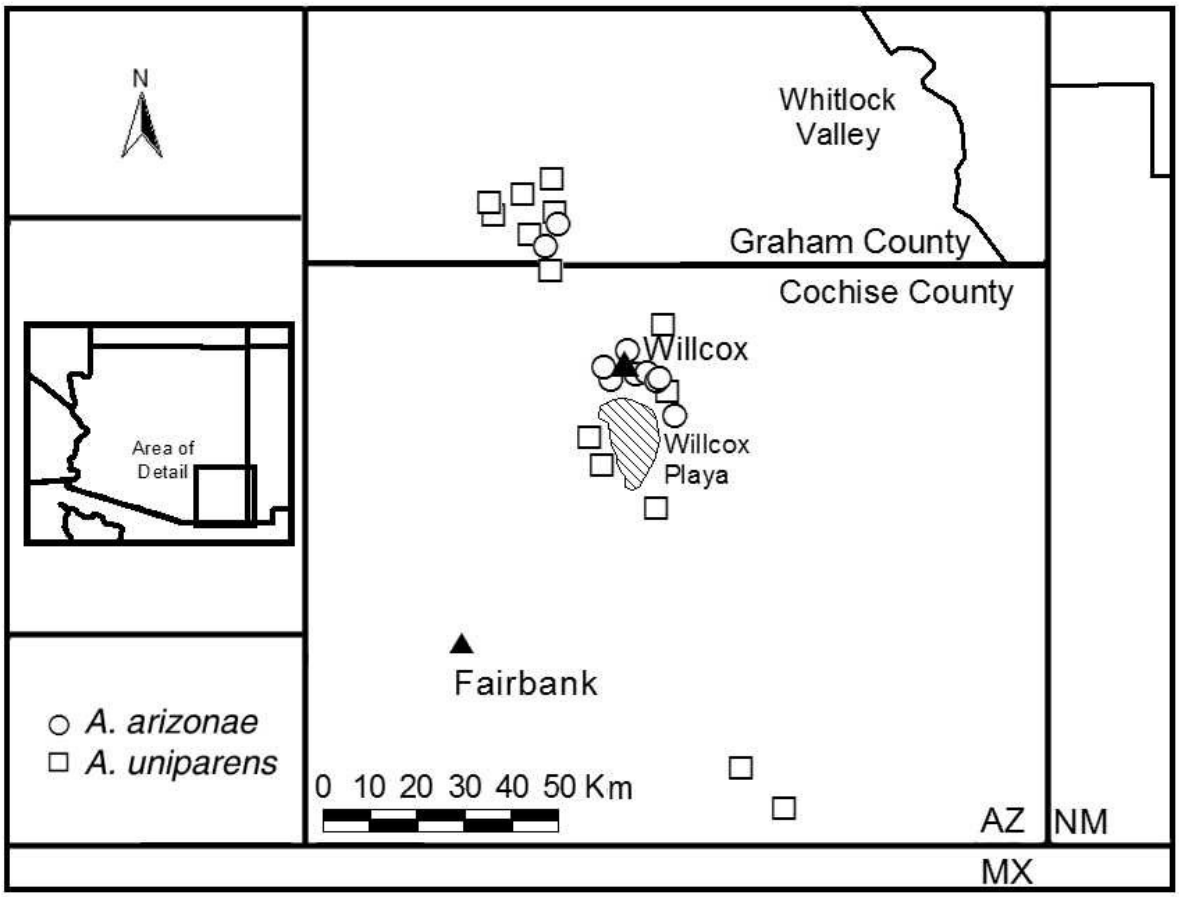
TABLE 1. Test statistics for comparisons of grazing impacts on sites occupied by *Aspidoscelis arizonae* (N = 10) and *A. uniparens* (N = 15). See Appendix I, Parts 4 & 5, Tables 2 & 3, for additional details of survey scores.

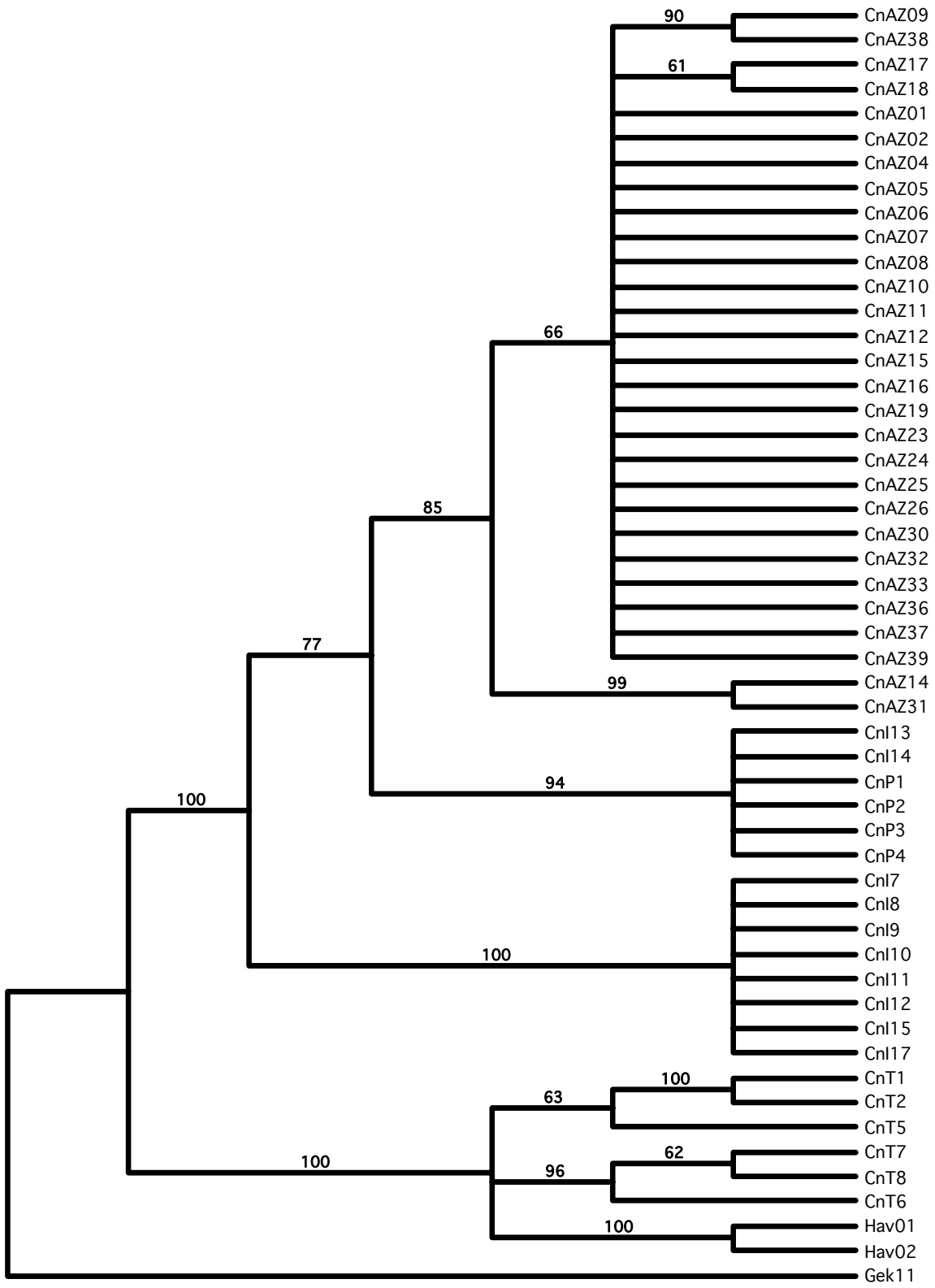
Variable	**MW U test statistic**	**P**
Grass index	116.5	0.019
Mesquite count	45.0	0.090
Shrub count	35.0	0.026
Dung count	72.5	0.888

Fig. 1. Arizona Striped Whiptail (*Aspidoscelis arizonae*; above) and Desert Grassland Whiptail (*A. uniparens*; below) from vicinity of Willcox, Cochise Co., Arizona.

Fig. 2. Habitat survey sites in south-eastern Arizona showing those with Arizona Striped Whiptails (*Aspidoscelis arizonae*; open circles) and Desert Grassland Whiptail (*A. uniparens*; squares). All sites where Arizona Striped Whiptails were observed from 2000-2003 are shown (sighting of Arizona Striped Whiptail in the Whitlock Valley occurred in 2004).

Fig. 3. Bootstrap results (1,000 pseudoreplicates per analysis with 100 random addition sequences per pseudoreplicate) of an unweighted maximum parsimony analysis employing all individuals sequenced (see Appendix B for listing).


N
Whitlock
Valley
Graham County
Cochise County
Willcox
Willcox
Playa
Area of
Detail
Fairbank
A. arizonae
A. uniparens
0 10 20 30 40 50 Km
AZ
NM
MX


90
61
66
85
77
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94
100
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100
63
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62
96
100
CnAZ09
CnAZ38
CnAZ17
CnAZ18
CnAZ01
CnAZ02
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CnAZ31
CnI13
CnI14
CnP1
CnP2
CnP3
CnP4
CnI7
CnI8
CnI9
CnI10
CnI11
CnI12
CnI15
CnI17
CnT1
CnT2
CnT5
CnT7
CnT8
CnT6
Hav01
Hav02
Gek11

Sensitive information removed from report.

Contact Sabra Schwartz in the Heritage Data Management Systems (HDMS) Department