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COMMON CHUCKWALLA (*SAUROMALUS ATER*) IN AN URBAN PRESERVE: PERSISTENCE OF A SMALL POPULATION AND ESTIMATION OF LONGEVITY

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***Abstract.*—Field studies of amphibians and reptiles rarely span more than two or three years necessitating that inferences concerning population biology of many forms are derived from brief snap-shots of their life history. In 2011 we re-surveyed one small population of the Common Chuckwalla (*Sauromalus ater*) in the Lookout Mountain Preserve in the Phoenix Metropolitan region studied intensively during the 1990s. Extending prior work with this low density population, we assessed current population size by direct count and in relation to variation in abundance in previous years. Recaptures separated by 12–16 years confirmed prior short-term studies indicating that *S. ater* exhibit growth rates of 1–2 mm per year as adults. Moreover, two females, initially captured in 1995, still resided within 20 m of their original capture sites in 2011. Overall, this urbanized population of *Sauromalus ater* persists in spite of its small size, increases in recreational activity, trail establishment, and heat island effects associated with the Phoenix Metropolitan region.**

Key Words.—growth; longevity; preserves; reptile conservation; stability; urbanization

INTRODUCTION

Long-term studies of reptile populations in relation to environmental variation and anthropogenic impacts, especially in natural areas isolated within urban landscapes, are increasingly important to their conservation. Growth and survivorship have been surveyed in a variety of reptiles, including squamates (e.g., Abts 1987; Bull and Freake 1999; Pike et al. 2008), but few studies except those concerning chelonians (e.g., Lovich et al. 2012) span a decade or more. Increases in temperature in urban landscapes of southwestern North America, due to heat island effects (Brazel et al. 2000, 2007) and other factors may profoundly impact squamates in the next decade (Pianka and Vitt 2003; Huey et al. 2010; Barrows 2011). Another aspect of anthropogenic effects on reptiles in urban landscapes is habitat destruction during collection of reptiles for the pet trade (Goode et al. 2005), or recreational activity (e.g., rock climbing). Documentation of population persistence in such settings will be vital to baseline assessments and future monitoring.

The Common Chuckwalla (*Sauromalus ater*) is a large, herbivorous lizard of the Sonoran Desert of Arizona and California, as well as the Mojave Desert of California, Nevada, and Utah (Fig. 1). They occur in densities of as few as two per ha to as many as 65 per ha (Kwiatkowski and Sullivan 2002a, b), and are thought to live to at least 10 or more years, based on life-table analyses (Abts 1987). Field (Abts 1987) and lab (Tracy 1999) studies established that *S. ater* grows rapidly when small (hatchlings ca. 45 mm SVL), reaching sexual maturity within 2–3 years (ca. 125 mm SVL). A previous study of two Sonoran Desert populations of *S. ater* (Sullivan et al. 2004), including the population reported on herein, documented growth rates of 1–2 mm yr^{-1} for adult females and 1–4 mm yr^{-1} for adult males, but used data for a small number of subjects over only 2–4 years.

Sullivan and Flowers (1998) documented that *S. ater* are present in all preserves of the Phoenix Mountains with rocky outcrops in spite of the fact that other large squamates (e.g., *Dipsosaurs dorsalis, Gambelia wislizenii*) are absent or declining. Although *S. ater* have a high body temperature when active (reviewed in Barrows 2011), any additional increase in ambient temperature may compromise activity periods or negatively impact nest site selection. The Phoenix Metropolitan area has already experienced significant heat island effects (2–4° C; Brazel et al. 2007), and Barrows (2011) argued that *S. ater* may lose over 90% of its Sonoran Desert habitat due to global warming over the next 50 years.

During 2008 and 2009 we re-surveyed eight sites previously scored for fecal counts (indirect indicators of occupancy) for *Sauromalus ater* in 1995 (Sullivan and Williams 2010). Fecal counts were consistent across 1995–2008, and overall plant diversity at each preserve site was the best predictor of relative population size in *S. ater*. In 2011 we returned to Lookout Mountain Preserve, one of the eight sites investigated in these earlier studies, and over the entire activity season, captured all lizards present on the rocky ridge that had served as a primary study area during a radio telemetry

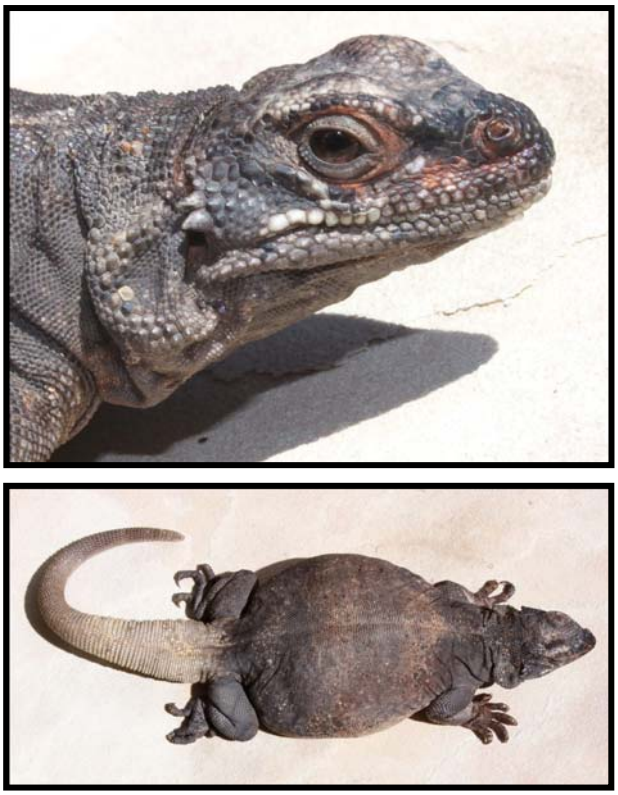

FIGURE 1. One of the largest female *Sauromalus ater* observed at Lookout Mountain, first captured in 1995 and again in 2011, estimated (minimally) to be 30 years of age (170 mm SVL). (Photographed by Brian K. Sullivan).

FIGURE 2. Lookout Mountain Preserve, Phoenix Mountains, Maricopa County, Arizona, USA. Upper panel is view of the entire preserve from the southwest; West Ridge, the primary study area, is on the left side; lower panel is view of West Ridge from the north side. (Photographed by Brian K. Sullivan).

study of territoriality in *S. ater* (Kwiatkowski and Sullivan 2002a, b). Data gathered in 2011 allowed us to evaluate growth of individuals over 12–16 years, and confirm the stability of this population by direct count in a 5 ha plot.

MATERIALS AND METHODS

Study population.—Lookout Mountain Preserve, located on the northern edge of the Phoenix Mountains in the Phoenix Metropolitan area, Arizona, USA, is 84 ha in total area, although the primary study site we used from 1995 to 1999 was a single ridge line ("West Ridge") running east to west on the southwestern edge of the preserve, with a survey area of 5.0 ha. We estimated precise areas from a high resolution aerial photograph (2 × 2 m) of the site taken in 1998, and confirmed in the field using a Garmin 12XL GPS unit (Garmin International, Olathe, Kansas, USA; UTM, datum = NAD 1927) in both 1998 and 2011 (e.g., capture sites of each lizard). Lookout Mountain (Figs. 2 and 3) is the site with the lowest recorded density of *S. ater* (2.4 individuals per ha; Sullivan and Flowers 1998). Geologically, this site is a Cherioni-rock outcrop complex, with a large basaltic core, limited boulder fields, cemented colluvium below ca. 200 mm soil depth (Soil Survey Staff, Natural Resources Conservation Service, USDA: Available from http://websoilsurvey.nrcs.usda.gov/app/ [Accessed 20 May 2012]), and as a result, very few crevices relative to other preserve sites with *S. ater* (Sullivan and Williams 2010). Elevations range from 300 to 500 m. Botanically, it is within the Sonoran Desert Upland Community (Brown 1982), dominated by (in rough order of numerical abundance): Brittlebush (*Encelia farinosa*), Bursage (*Ambrosia deltoidea*), Creosote (*Larrea tridentata*), Foothill Palo Verde (*Parkinsonia microphyllum*), Ocotillo (*Fouquieria splendens*), and Saguaro Cactus (*Carnegiea gigantea*; see Sullivan and Williams 2010 for plant diversity information).

Survey methods.—During the activity season of 2011 (April through September), one of us (KOS) surveyed West Ridge and adjacent areas (any portion of the preserve within 250 m of the study plot) twice each week. Given the time consuming nature of capture (see below), and the wariness of the subjects, a labor-intensive approach was required to insure we captured all individuals on the plot as well as any that might have moved to other areas of the preserve and established a home range off the primary site since the late 1990s (especially because we marked a number of small subjects in the initial study period, 1995–1999). Lizards typically took refuge within crevices when approached; after we noted the crevice to which a lizard retreated, we approached it and we laid a dark cloth over a portion of the crevice. We used a series of small diameter wood and plastic dowels (10–25 mm diameter; 1 m in length) to

FIGURE 3. Aerial photo of West Ridge study area (north is to the upper-right; houses with pools [blue] on west side provide rough scale), Lookout Mountain, Phoenix Mountains, Maricopa County, Arizona. (Google Earth©; used with permission).

tap the lizard on the head to maneuver it to the darkened cloth so that we could extricate it from the crevice. Once caught, we checked it for markings (toe-clips), we measured it, recorded its body temperature, and then released it. We matched subjects to toe-clip patterns as well as photographs of all subjects from the 1990s. We used complete counts of all lizards encountered on West Ridge obtained in 1995–1999 to compare with those in 2011.

RESULTS

We surveyed West Ridge 24 times (63 person hours) between April and October, 2011. We caught 12 adults on the study site (5 ha) and 12 individuals off site (within 250 m of the 5 ha boundary of West Ridge). Of the 12 individuals we captured on West Ridge, five had been marked between 1995 and 1999. The remaining seven were unmarked and thus were new recruits to the populations since 1999. None of the 12 adult individuals captured off site were marked. We captured 10 juveniles on and off the site, but we do not consider these further in this paper.

Direct counts of *S. ater* on West Ridge from surveys in 1995 through 1999, in which West Ridge and all of Lookout Mountain were intensively monitored (Kwiatkowski and Sullivan 2002a, b), revealed that on average, 12 individuals occupied the 5 ha West Ridge in a given year (Table 1). The number varied from a low of 10 to a high of 14 (all adults, > 135 mm SVL, summed for each year). Thus, the number of individuals within this 5 ha plot in 2011 was virtually identical to the population of more than 15 years prior. Lookout Mountain Preserve is 84 ha in total, and even if uniformly populated with chuckwallas in rocky substrates (ca. 25% of total area; see Fig. 1–2), has an estimated population, in total, of only 50 individuals.

TABLE 1. Total number of *Sauromalus ater* individuals observed on West Ridge (5 ha), Lookout Mountain, Phoenix Mountains, Arizona by year of study.

♂♂	♀♀	Total	Year
7	7	14	1995
6	6	12	1996
6	6	12	1997
6	5	11	1998
6	6	12	1999
5	7	12	2011

Although sample size issues obviate statistical or life table analyses, it is noteworthy that after 12 years this small population on West Ridge sustained 42% of the individuals present in the late 1990s.

Remarkably, of the five marked individuals that we recaptured in 2011, both females were within 25 m of their original capture sites in 1995. Crevices they used as retreats during the 1990s were still in use during the resurvey season of 2011, an impressive level of site fidelity. Two of males that we recaptured were small adults when initially marked in 1999; they were both found within 100 m of their original capture site, but most likely they became territory holders after they were initially observed. The one large male (181 mm SVL in 1999) occupied a different but adjacent territory in 2011 relative to the one he occupied in 1999.

Females grew at roughly 1–2 mm yr^{-1}, while males, especially those that were relatively small when initially captured (close to the minimum size for sexual maturity) grew at a slightly higher rate, between 2 and 4 mm yr^{-1} (Table 2). One female, initially captured at 156 mm SVL, was recaptured in 2011 with a SVL of 170 mm. Given attainment of sexual maturity at ca. 125 mm SVL, following a minimum of three years of growth (Abts 1987 and Tracy 1999 reviewed the evidence for rapid growth to maturity in *Sauromalus*), it is conceivable that this female was 15 years of age when first captured in 1995. Since then, it has grown ca.1 mm yr^{-1}, and is potentially over 30 years of age. By similar reasoning, the largest male ever observed at Lookout Mountain, an unmarked 200 mm SVL individual captured near West Ridge in 2011, could easily be almost 40 years of age.

DISCUSSION

Forty-two percent of *S. ater* marked in the 1990s on West Ridge of Lookout Mountain Preserve were still present in 2011. In addition, growth, as predicted by Sullivan et al. (2004), was higher in males than females, and directly related to size at initial capture. Although Sullivan et al. (2004) predicted growth of ca. 1.5 mm yr^{-1}, it is important to note that two of three males were

TABLE 2. Year of first and last captures, initial (SVL_1) and last (SVL_2) snout-vent length (mm), amount of size increase (mm), and growth rate (mm yr^{-1}) of five *Sauromalus ater* at Lookout Mountain Preserve, Phoenix Mountains, Arizona, 1995–2011. The growth rates are as predicted by Sullivan et al. (2004).

	Capture					
ID	First	Last	SVL_1	SVL_2	Growth (mm)	Growth rate
♂♂2.8	1999	2011	181	193	12	1.0 yr^{-1}
♂♂20	1999	2011	142	175	33	2.8 yr^{-1}
♂♂2.5.6	1999	2011	131	185	54	4.5 yr^{-1}
♀♀3.19	1995	2011	148	171	23	1.4 yr^{-1}
♀♀17	1995	2011	156	170	14	0.9 yr^{-1}

barely larger than the "sexual maturity cutoff" (inflection point; Tracy 1999) when marked in 1999, and thus exhibited higher growth initially. Unfortunately, this small population and its attendant sample size limitations precludes statistical analysis, but as is clear from Table 2, growth was directly related to initial SVL, and very low for larger individuals.

The female *S. ater* we captured in 1995 at 156 mm SVL grew to 170 mm SVL in 16 years: using growth rate data from Sullivan et al. (2004), it was likely ca. 30 years of age in 2011. Sullivan et al. (2004) found females exhibit growth rates of 3 mm yr^{-1} between 135 and 150 mm SVL, and 1 mm yr^{-1} for each year above 150 mm SVL. Assuming only three years to sexual maturity (ca. 135 mm SVL), it would require five years to reach 150 mm SVL and six more to reach 156 mm SVL, yielding an initial age of 3 years + 5 years + 6 years = 14 years (minimally) to reach 156 mm SVL. Abts (1987) used a life-table analysis to argue that female *S. ater* reach an average age of 15 years. Subsequent to his life-table calculations, Abts (pers. comm.) observed some marked individuals 18 years of age at one of his sites. In Sonoran Desert populations near Phoenix, *S. ater* females of ca. 170 mm SVL, and males of ca. 200 mm SVL, may represent individuals of 30 to 40 years of age. Stamps and Andrews (1992) argued that using the largest individual found in a given population is a reasonable predictor of asymptotic growth: the size at which growth equals zero. The largest sized individuals at Lookout Mountain were documented during our resurvey in 2011: a male of 200 mm SVL and a marked female of 171 mm SVL, both slightly in excess (ca. 1 mm or measurement error) of the precise predicted asymptote from the regression of growth against size provided in Sullivan et al. (2004).

Tracy (1999) found that growth and maximum size attained in *S. ater* are correlated with elevation, possibly due to the increased growing season of plants at higher elevation in the arid Southwest. Tracy also documented higher plant diversity at higher elevation sites occupied by *S. ater*, not unlike relationship between abundance of *S. ater* and plant diversity documented by Sullivan and Williams (2010) in Sonoran Desert preserves. Thus, productivity of the ecosystem may be a factor influencing both increased growth and higher population density in *S. ater*.

Bull and Freake (1999) documented that Sleepy Lizards (*Tiliqua ruguosa*) have stable home ranges over multiple years, and although based on only two individuals, the female *S. ater* we marked in 1995 were within the home ranges they occupied as adults 16 years previously. It may be that female *S. ater* maintain their home ranges in spite of changes in territory ownership by males. Bull (1995) and Iverson (2007) documented similarly high levels of survivorship of female Sleepy Lizards (*Tiliqua rugosa*) and Rock Iguanas (*Cyclura cyclura*), respectively. Although it remains for future study to determine the generality of our results as to the longevity of *S. ater*, it does appear that this population is remarkably stable over the past two decades.

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KEITH O. SULLIVAN conducted the research reported herein while attending Arizona State University, Tempe, Arizona. He has participated in a variety of wildlife studies on amphibian and reptile species throughout Arizona including work on the Desert Tortoise (*Gopherus agassizii*), Gila Monster (*Heloderma suspectum*), Arizona Striped Whiptail (*Aspidoscelis arizonae*), Pai Striped Whiptails (*A. pai*), Tiger Whiptails (*A. tigris*), and many others. He is currently working on Flat Tailed Horned Lizards (*Phrynosoma mcalli*) in the Yuma region of Arizona and California. (Photographed by Daniel Sullivan)