Natural history of *Xenosaurus phalaroanthereon* (Squamata, Xenosauridae), a Knob-scaled Lizard from Oaxaca, Mexico

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Abstract

Natural history of *Xenosaurus phalaroanthereon* (Squamata, Xenosauridae), a Knob-scaled Lizard from Oaxaca, Mexico. We made observations on the natural history of a population of the lizard *Xenosaurus phalaroanthereon* from Oaxaca, Mexico. Females were larger than males (SVL). Most lizards were found completely inside rock crevices. Mean body temperature was 20.3°C. Body temperature was related primarily to substrate temperature. Body temperature was not influenced by any crevice characteristic. Based on abdominal palpation, the size at maturity for females appears to be 117-119 mm SVL. Sex ratio did not differ from 1:1. We compare the ecology of this population to that of other *Xenosaurus*.

Keywords: Squamata, Xenosauridae, *Xenosaurus phalaroanthereon*, body temperature, sex ratio, sexual dimorphism, size at maturity, Mexico.

Introduction

Lizards in the genus *Xenosaurus* (Xenosauridae) share a flattened morphology, which is presumably an adaptation for a crevice-dwelling habit (Ballinger *et al.* 2000a). Populations of *Xenosaurus* are often geographically isolated (e.g., Pérez Ramos *et al.* 2000, Nieto Montes de Oca *et al.* 2001), and movement appears to be minimal (Lemos-Espinal *et al.* 2003b), and thus each population may be relatively isolated genetically and subject to differentiation among populations and species. While there are many similarities among *Xenosaurus*, there is also a

great deal of variation in their ecology (see Lemos-Espinal *et al.* 2004 for a review). Even populations of nominally the same species (e.g., *X. grandis grandis* and *X. g. agrenon*) show variation, sometimes as much as between different species (Ballinger *et al.* 1995, Smith *et al.* 1997, Lemos-Espinal *et al.* 2003a). Unfortunately, very few populations of *Xenosaurus* have been studied. In order to further our understanding of interspecific variation within this genus, we report on the sexual dimorphism, crevice use, temperature relationships, and reproduction of a population of *X. phalaroanthereon* from Oaxaca, Mexico. *Xenosaurus phalaroanthereon* has only recently been described as a new species (Nieto Montes de Oca *et al.* 2001), and the data we report represent the only information on this species

available beyond the original species description.

Materials and Methods

The study population was located 8 km southwest of the town of Santa María Ecatepec, Oaxaca (16°14'43.6" N, 95°57'38.6" W, 2185 m elevation). The vegetation at this site is low density oak forest (*Quercus* spp.) with maximum height of the trees of 2 m, interspersed with corn fields. Lizards were found on steep hills on which granite boulders are abundant. Although most of the area is covered by the low density oak forest, a large number of lizards were located on the SW face of the hill on which there is a corn field (≈ 1 ha).

Lizards were collected by hand on 22-23 February, 27-28 March, and 23 May 2003. We made several measurements and observations on each captured lizard. While in the field we measured snout-vent length (SVL; to nearest mm), and body mass (BM). In addition, body temperature (T_b; nearest 0.1°C) was taken with a quick-reading cloacal thermometer immediately upon capture. The reproductive status of females could be determined by palpation of the abdomen.

We also measured air temperature (T_a; shaded thermometer 1 cm above substrate where individual first observed), and substrate temperature (T_s; shaded thermometer touching substrate where individual first observed). Preliminary analyses found that T_b did not differ among months after taking variation in T_a into account (P > 0.05), so we pooled the temperature data for analysis. We recorded the body position of each lizard (i.e., entirely inside the crevice, just head and front legs out of crevice).

We recorded several characteristics of the crevice in which lizards were found, including the thickness of the crack (the vertical width of the crevice opening; with plastic ruler), the depth of the crevice (with plastic ruler or meter tape), and the height of the crevice from the ground (with plastic ruler or meter tape). We measured the diameter of the rock in which the crevice was found (with plastic ruler or meter tape). We noted whether the occupied crevice was found in the open sun, the shade, or in a sun/shade mosaic.

We used analysis of variance to compare SVL between the sexes (after examining the data for conformity with the assumptions of the analysis), and multiple linear regression to determine how T_a and T_s affected T_b, and simple linear regression to determine how body size (SVL) affected the choice of the characteristics of the crevice in which the individual was found. We used Chi-square tests to examine sex ratios overall and in each month.

Results

Body Size and Sexual Dimorphism

Mean SVL was 110.7 + 1.8 mm (n = 87; range 65 to 130 mm). The average BM of individuals was 26.2 + 1.3 g (n = 87; range 4 to 48 g). Body mass increased with SVL (n = 87, r^2 = 0.98, P < 0.0001; logBM = -6.65 + 3.92logSVL).

For all individuals, males and females did not differ in SVL (males: 111.1 + 2.3 mm, n = 39; females: 110.3 + 2.6 mm, n = 48; $F_{1,85}$ = 0.046, P = 0.83). However, using only the largest 20 individuals of each sex, we found that females were larger than males (males: 121.6 + 0.8 mm; females: 125.0 + 0.4 mm; $F_{1,30}$ = 13.2, P = 0.0008).

Crevice Use

Most *X. phalaroanthereon* were completely within their crevice (85 of 87, 97.7%). Two lizards (2.3%) were found with their heads and front legs outside the crevice. None were found completely out of a crevice.

We found lizards in crevices in the shade 3.4% of the time (3 of 87), crevices in the open 65.5% of the time (57 of 87), and in a shade-open mosaic 31.0% of the time (27 of 87).

The thickness of the crevice used or the diameter of the hole used by *X. phalaroanthereon* averaged 2.4 + 0.1 cm (n = 87, range 0.5 to 6.5 cm). The depth of the crevices or holes was 24.7 + 0.9 cm on average (n = 87, range 7.8 to 50.0 cm). *Xenosaurus phalaroanthereon* individuals used crevices that had a mean height above ground level of 23.1 + 2.9 cm (n = 87, range 0 to 150 cm). The rocks in which the crevices used by *X. phalaroanthereon* were found were 1.19 + 0.07 m in diameter (n = 87, range 0.30 – 3.00 m).

The larger an individual (SVL), the larger the opening of the crevice in which it was found, however, body size explained little of the variation in crevice or hole opening size (n = 87, r^2 = 0.116, P = 0.0013; thickness = -0.11 + 0.022SVL). Larger *X. phalaroanthereon* were also found in deeper crevices (n = 87, r^2 = 0.183, P < 0.0001). The height of a crevice was not related to the size of the individual living in it (n = 87, r^2 = 0.040, P = 0.06), although only the largest individuals (n = 3) were found in crevices > 1 m above the ground. The size of the rock containing the occupied crevice was not related to the size of the lizard (n = 87, r^2 = 0.0009, P = 0.38).

Most individuals were found alone in their crevice. However, one group of three individuals was observed, but only one was caught so the make-up of this group is unknown. In addition, we observed one pair consisting of an adult female and a juvenile.

Temperature Relationships

Mean T_b was 20.3 + 0.4 C (n = 87; range 14.6 to 32.8 C). Mean T_a was 15.4 + 0.3 C (n = 87; range 8.6 to 22.6 C), and mean T_s was 15.7 + 0.3 C (n = 87; range = 9.0 to 26.2 C). Air temperature and T_s were positively related (n = 87, r^2 = 0.82, P < 0.0001; T_S = 1.34 + 0.93T_a). The multiple linear regression revealed that T_s significantly affected T_b, but that T_a did not (Overall regression: n = 87, r^2 = 0.54, P < 0.0001; P_{Ts} = 0.0002; P_{Ta} = 0.78; T_b = 4.706 + 0.924T_s + 0.067T_a).

Reproduction

The two smallest pregnant females (as determined by palpation) were 117 mm and 119 mm SVL. Pregnant females were observed in all three months we sampled the population (February, March, and May); however, 9 of the 11 pregnant females were observed in May. In May, 90% (9 of 10) of females > 117 mm SVL were pregnant.

Sex Ratio

The overall sex ratio was 48 females: 39 males, which is not different from 1:1 (χ_1^2 = 0.93, P = 0.33). The sex ratio in February was 19 females: 14 males (χ_1^2 = 0.76, P = 0.33), in March it was 14 females: 16 males (χ_1^2 = 0.13, P = 0.72), and in May it was 15 females: 9 males (χ_1^2 = 1.50, P = 0.22).

Discussion

When considering only the 20 largest individuals of each sex we captured, female *X. phalaroanthereon* were larger than males. Other species of *Xenosaurus* also have larger females (*X. newmanorum*, Smith *et al.* 1997; *X. platyceps*, Lemos-Espinal *et al.* 1997b, 2004), but others show no dimorphism in body size (*X. grandis*, Smith *et al.* 1997, Lemos-Espinal *et al.* 2003a; *X. rectocollaris*, Lemos-Espinal *et al.* 1996). To date, no species or population of *Xenosaurus* has had larger males than females. The 1:1 sex ratio in *X. phalaroanthereon* suggests that differential mortality of males and females does not explain the observed sexual dimorphism.

The vast majority of *X. phalaroanthereon* was first observed entirely in their crevice. This observation is similar to previous studies (Ballinger *et al.* 1995, Lemos-Espinal *et al.* 1996, 1997b, 1998, 2003a). Indeed, only *X. platyceps* in a population in Querétero have been found entirely outside their crevice (Lemos-Espinal *et al.* 2004). Movement among

crevices in *Xenosaurus* does occur (Lemos-Espinal *et al.* 2003b for *X. newmanorum*). The failure to observe more *Xenosaurus* outside of their crevices despite thorough searching during the day suggests that movements are either very rare, or occur at night (or dawn or dusk). Further study on the activity patterns of *Xenosaurus*, perhaps via remote telemetry (e.g., Boarman *et al.* 1998, Gruber 2004), could be of interest, and may provide further insight into the biology of these lizards.

The majority of *X. phalaroanthereon* occurred alone, but a single pair (female and juvenile) and a single trio were observed. No trios have previously been observed in other species of *Xenosaurus*. Other species show some degree of gregariousness (*X. grandis agrenon*, Lemos-Espinal *et al.* 2003a; *X. platyceps* in Tamaulipas, Lemos-Espinal *et al.* 1997b; *X. newmanorum*, Lemos-Espinal *et al.* 1997a). A single female-neonate pair was found in *X. platyceps* in Querétaro (Lemos-Espinal *et al.* 2004). *Xenosaurus grandis grandis* and *X. rectocollaris* appear to be primarily solitary (Ballinger *et al.* 1995, Lemos-Espinal *et al.* 1996). It is not clear why there is such a range of aggregation behavior among species and even among populations of the same species.

The mean T_b of *X. phalaroanthereon* we observed is the second lowest in the genus. The only population with a lower mean T_b is *X. platyceps* from Tamaulipas (19.1 °C; Lemos-Espinal *et al.* 1997b). The T_b of *X. platyceps* from Querétaro (20.6°C) is similar to the T_b we found for *X. phalaroanthereon* (Lemos-Espinal *et al.* 2004). The other species have mean T_bs ranging from 22.7 to 25.6°C (Ballinger *et al.* 1995, Lemos-Espinal *et al.* 1996, 1998, 2003a).

Body temperatures in this population of *X. phalaroanthereon* were higher ($\approx 5°C$) than corresponding T_a or T_s, suggesting these lizards were able to elevate their T_b above the ambient temperature, perhaps through active thermoregulation. In particular, it appears T_s is more important than T_a in determining T_b. *Xenosaurus phalaroanthereon* is similar to *X. platyceps*

(Lemos-Espinal *et al.* 1997b, 2004) and *X. rectocollaris* (Lemos-Espinal *et al.* 1996) in its relative independence of T_b from environmental temperatures, at least compared to *X. grandis agrenon, X. g. grandis,* and *X. newmanorum* (Ballinger *et al.* 1995, Lemos-Espinal *et al.* 1998, 2003a). Previously, we speculated that these differences may reflect the habitats in which these species live: *X. platyceps* and *X. rectocollaris* occurring in relatively open habitats of low shrubs (*X. rectocollaris*) or low density forest (*X. platyceps*) where solar radiation can reach the ground, and *X. newmanorum* and *X. grandis* in Veracruz and Oaxaca occurring in more dense tropical forest habitats, perhaps reflecting differences in the opportunity for thermoregulation in these habitats (see Lemos-Espinal *et al.* 2003a). Our results for *X. phalaroanthereon* are consistent with this speculation – the study area is more open, with solar radiation reaching the ground. Future studies using techniques that allow for a better evaluation of thermoregulation (e.g., Hertz *et al.* 1993) in these species would be very useful and enlightening.

Only females of *X. phalaroanthereon* larger than 115-117 mm SVL were observed to be pregnant. Previous studies have found the size at maturity to range from 92-95 mm SVL in *X. platyceps* from Querétaro (Lemos-Espinal *et al.* 2004) to 107 mm SVL in *X. newmanorum* from San Luis Potosí (Ballinger *et al.* 2000b). The range of sizes at maturity in *Xenosaurus* suggests that this trait is under local proximate control or under differential selective pressures. We currently do not have the information needed to assess the potential causes, but long-term demographic studies on more species of *Xenosaurus*, such as the one on *X. newmanorum* (Lemos-Espinal *et al.* 2003b, unpubl. data) are needed.

Acknowledgements

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