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Survivorship of *Xenosaurus newmanorum* (Sauria: Xenosauridae) from a Seasonal Tropical Environment in México

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Annual life history variation in lizards is commonly observed. For example, several studies have demonstrated that life history traits can often vary among years. and that such variation can often be linked to climatic variation among years (e.g., variability in precipitation: Tinkle *et al.* 1993, Anderson 1994, Smith and Ballinger 1994, Smith *et al.*, 1995; Smith, 1996, Dickman *et al.* 1999). Many of these studies have been conducted on temperate, desert, or temperate montane species. Fewer long-term mark-recapture studies are available that examine annual variation in survivorship in tropical species (but see Andrews and Nichols, 1990). Thus in order to understand the potential role of proximate variation in environmental conditions on lizards in general, we need additional studies on annual variation in life history traits, and survivorship in particular.

In this study, we examine annual variation in survivorship of a population of *Xenosaurus newmanorum*, a species of lizard that lives in rock crevices in the tropical cloud forests of México (see Lemos-Espinal *et al.* 2000 for a review of the species). We predicted that there would be variation in annual survivorship, because we have observed annual variation in other life history traits in this population (e.g., growth rate, proportion of females reproductive; Lemos-Espinal et al., 2003b).

Methods.

Xenosaurus newmanorum is a viviparous species, with a gestation period of approximately 11-12 months, an apparent biennial reproductive cycle, and a typical litter size of 1 or 2 (Ballinger *et al.* 2000). Members of this species live in cracks in rock walls (Lemos-Espinal *et al.* 1998), and exhibit marked sexual dimorphism in head size and body size (Smith *et al.* 1997). They also have adult female-neonate associations that may be related to parental care (Lemos-Espinal *et al.* 1997). Under the canopy of a rather dense second growth forest and citrus/coffee plantation, our population of *X. newmanorum* has a relatively low body temperature that is tied to environmental temperatures (Lemos-Espinal *et al.* 1998). *Xenosaurus newmanorum* eats primarily arthropods, but appears to be an opportunistic forager, eating anything that enters its crevice, including plants and small mammals (Lemos-Espinal *et al.*, 2003a).

We studied a marked population of *X. newmanorum* in a 50 m x 50 m area of mountains near Xilitla, San Luis Potosí, México. The study site consisted of coffee, orange, and lime plantations and forest edge interspersed with relatively dense second-growth forest, and falls into the perennial tropical forest zone of Rzedowski (1988). Unfortunately, climate data from the Instituto Meteorológico Nacional were not available for all years of this study at the time this paper was written, but for the years when data were available (1993-1997), all years had a month of greater than 600 mm rainfall, except for 1996 and 1997. Total annual precipitation was lowest in 1996 (1912 mm) and 1997 (1995 mm), and highest in 1994 (2535 mm) and 1995 (2617 mm) (see Lemos-Espinal et al., 2003b). There was very little among-year variation in maximum, minimum, and mean temperatures (see Lemos-Espinal et al., 2003b).

We surveyed the population approximately monthly from February 1994 to March 2000, although some years (e.g., 1998, 2000) had lower effort than others. We located lizards under rocks or in rock crevices, and whenever possible removed them from their crevices. Upon capture, we measured snout-vent length (SVL), and body mass (BM). Individuals were marked with unique toe clips and released at the site of capture.

Based on these mark-recapture records, we estimated survivorship for all lizards and for each sex using the mark-recapture model (basically the Cormack-Jolly-Seber model) of the program MARK (White and Burnham, 1999). The fully parameterized model provided the best goodness-of-fit for all lizards, males, and females ($P \leq 0.05$ in all three cases). We also used the statistical tests available in the program MARK to test for differences in survivorship between males and females, and for annual variation in survivorship.

Means are given $\pm$ 1 SE throughout.

Results.

Survivorship estimates for all lizards varied from year to year (Fig. 1; $P = 0.0004$). Survivorship declined from a peak from 1994-1995, and leveled off after 1997. This was also true when males and females were considered separately, although females had high survivorship from 1998-1999 (Fig. 1; $P < 0.0001$ in both cases). Males and females had significantly different survivorship rates, but this may be due in large part to the very high survivorship of females from 1998-1999 (Fig. 1; $P < 0.0001$).
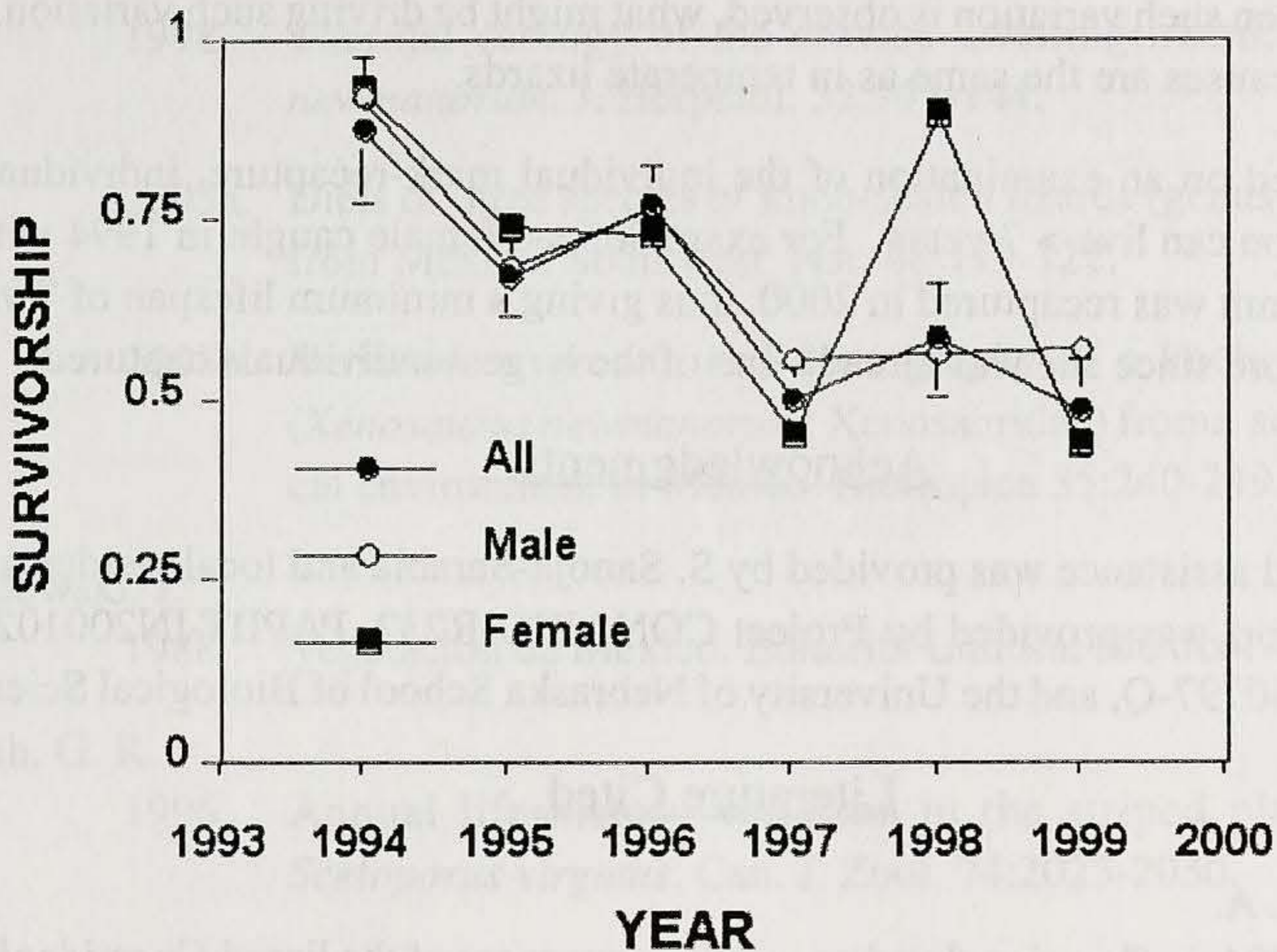
Figure 1.— Annual variation in survivorship estimates for a population of *Xenosaurus newmanorum* from Xilitla, San Luis Potosí, México. Estimates are given ± 1 SE. Standard error bars are not given for 1999 for males and all lizards since their size (41.6 and 70.7, respectively) would have reduced the ability of the figure to show the annual variation in survivorship estimates.

Discussion.

We found significant annual variation in survivorship in this population of *Xenosaurus newmanorum*. For the years we have climate data, the lowest survivorship estimate was found in the second year (1997) of two consecutive years of lower rainfall (1996 and 1997). Numerous studies on temperate and desert lizards have shown a relationship between precipitation levels and arthropod abundance, and variation in life history traits (e.g., Tinkle *et al.* 1993, Anderson 1994, Smith and Ballinger 1994, Smith *et al.*, 1995; Smith, 1996, Dickman *et al.* 1999). Thus it is possible that variation in survivorship in this population reflects variation in precipitation. However, annual variation in survivorship in our population may have another, undiscovered cause. For example, Andrews and Nichols (1990) documented significant variation in annual survivorship estimates in *Anolis limifrons* in Panama; however, they were unable to find a correlate of this temporal variation in survivorship. Additional study on annual variation in survivorship is clearly needed in tropical lizards to deter-

mine how often such variation is observed, what might be driving such variation, a nd whether the causes are the same as in temperate lizards.

Based on an examination of the individual mark-recapture, individuals in this population can live > 7 years. For example, one female caught in 1994 with an SVL of 116 mm was recaptured in 2000, thus giving a minimum lifespan of 7 years, and likely more since she was already one of the largest individuals captured.

Acknowledgments.

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