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Short Communication

Observations on sexual dimorphism, sex ratio, and reproduction of *Anolis nebulosus* (Squamata: Dactyloidae) from Nayarit, Mexico

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Anolis nebulosus (Wiegmann, 1834) is one of the most widely distributed and common *Anolis* in Mexico, occurring from Chihuahua and Sonora in the north to Guerrero, Morelos, and Puebla to the south (Lemos-Espinal *et al*. 2013, Köhler *et al*. 2014). *Anolis nebulosus* occurs mainly on the ground (Wilson and McCranie 1979) but seasonal, sex, and size variation in habitat use have been observed (Jenssen 1970a, Lister and Aguayo 1992, Ramírez-Bautista and Benabib 2001). *Anolis nebulosus* feeds primarily on insects, especially termites and orthopterans (Boyd *et al*. 2007), and in turn may be eaten by other lizards, including *Sceloporus melanorhinus* (Siliceo-Cantero and García 2013). The growth, body size, and morphology from island and mainland populations in Jalisco, Mexico have been compared (Senczuk *et al.* 2014, Siliceo-Cantero and García 2014, Hernández-Salinas and Ramírez-Bautista in press). Some previous work found no evidence of sexual size dimorphism in *A. nebulosus* (Fitch 1976), whereas others found that males are larger than females (Jenssen 1970a, Senczuk *et al*. 2014). Ramírez-Bautista and Vitt (1997) and Hernández-Salinas and Ramírez-Bautista (in press) have described the reproduction of this species from Jalisco. In addition, observations on aspects of their natural history, such as body temperature and displays, have been reported (e.g., Jensen 1970b, 1971, Ramírez-Bautista and Benabib 2001).

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Here, we report observations on sexual dimorphism, sex ratio, and reproduction for a population of *Anolis nebulosus* from Nayarit, Mexico, in an effort to increase our understanding of the ecology and natural history of this widespread, but understudied anole. In particular, we are able to compare the results for our population with other populations to determine if there is geographical variation in sexual dimorphism, sex ratios, and reproduction among populations of this widespread species.

The study area was located in the Xalisco municipality, Nayarit (21°25'32" N, 104°53'31" W, 980 m), which has an average temperature and rainfall of 23.9°C and 1452 mm respectively (García 1988). Average temperature during the dry season (winter) is approximately 22.3°C and in the wet season (summer) is approximately 25.4°C. Rainfall in the dry season averages approximately 620 mm and in the wet season 2270 mm. The study was conducted in an area of 5625 m^2 within a patch of deciduous forest. Vegetation was a mixture of *Acacia hindsii* Benth., *Bursera arborea* (Rose) L. Riley, *Bursera pinnata* (DC.) Engl., *Bursera simaruba* (L.), *Ceiba pentandra* (L.) Gaerth., *Cedrela odorata* L., *Ficus glabrata* Kunth, and *Mimosa albida* Humb. & Bonpl., among others.

We collected lizards by hand or noose during July 2010 (summer; $N = 58$ adults) and January 2011 (winter; $N = 18$ adults) from 08:00 to 17:00 h. We measured snout-vent length (SVL; to nearest mm with plastic ruler) for each captured lizard. We also measured head width (HW) at the widest point, head length (HL) from anterior edge of ear to tip of snout, and femur length (FL) from knee to middle of pelvic region to the nearest 0.01 mm using calipers. We report mean ± 1 SE for each measurement in Table 1. We evaluated sexual dimorphism in SVL using analysis of variance (ANOVA) and in HW, HL, and FL using analyses of covariance (ANCOVA). We used SVL as the covariate and log transformed both the dependent variables and the covariate. All three dependent variables were significantly influenced by SVL. In all cases, slopes in the ANCOVAs were homogeneous, so we removed the interaction terms from the final model. We used a chi-square test to compare the observed sex ratio to a 1:1 ratio for the overall sample, and for each season's sample.

Male and female *Anolis nebulosus* were not sexually dimorphic with regard to SVL ($F_{1,74} = 0.12$, $p = 0.73$), HL ($F_{1,73} = 0.95$, P = 0.33), and HW ($F_{1,73} = 1.72$, $p = 0.19$). Head length increased with SVL ($F_{1,73} = 27.31$, $p < 0.0001$), as did HW ($F_{1,73} = 11.7$, $p = 0.001$). Males had significantly longer femurs than females ($F_{1,73} = 8.82$, $p = 0.004$). Femur length was positively related to SVL ($F_{1,73} = 66.6$, $p < 0.0001$).

We found little evidence of sexual size dimorphism in *Anolis nebulosus*, with SVL and head size not differing between males and females. However, we found that males had relatively longer femurs than females. Fitch (1976) found no significant sexual size dimorphism in *A. nebulosus* pooled across several populations in Mexico, and concluded

Table 1. Mean ± SE (in mm) for snout-vent length (SVL), head width, head length, and femur length of male and female *Anolis nebulosus* from Nayarit, Mexico. * indicates means significantly different between males and females.

	N	SVL	Head Width	Head Length	Femur Length*
Males	38	35.2 ± 0.6	5.94 ± 0.10	5.76 ± 0.06	7.74 ± 0.12
Females	38	35.4 ± 0.4	5.79 ± 0.08	5.72 ± 0.05	7.44 ± 0.08

that the species was the only mainland anole not to show significant sexual size dimorphism. However, Fitch and Hillis (1984) documented other mainland anoles that also lack sexual size dimorphism. Our finding of no sexual dimorphism in SVL is also consistent with a previous study that found that male and female *A. nebulosus* did not have significantly different growth rates in populations from Jalisco, Mexico (Siliceo-Cantero and García 2014). These results contrast with those of Senczuk *et al*. (2014) who found that males in populations of *A. nebulosus* in Jalisco, Mexico were larger than females in SVL (especially in an island population), females had greater relative trunk length, and males had longer and wider heads, and there was no difference in femur length or tibia length. Jenssen (1970a) also found that male *A. nebulosus* were larger than females in a population from Nayarit, at least in the spring. The evolution of sexual size dimorphism in *Anolis* probably is not limited to a single explanation (e.g., Steffen 2009). Therefore, it may be that different populations of *A. nebulosus* have experienced different ecological pressures, perhaps leading to local differences in sexual dimorphism. Additional research is needed to examine whether these populations are experiencing different ecological or evolutionary pressures on sexual size dimorphism. For example, Fitch and Hillis (1984) found that anoles showed male-biased sexual size dimorphism in populations from seasonal environments and no sexual size dimorphism in anoles from aseasonal environments. In addition, *A. nebulosus* may actually be a species complex (see Nieto Montes de Oca *et al*. 2013, Köhler *et al*. 2014), and so some of the variation in sexual size dimorphism among populations may reflect species-level differentiation.

The overall sex ratio of *Anolis nebulosus* that we observed was 38 males: 38 females, a 1:1 sex ratio ($\chi_1^2 = 0$, $p = 1$). Sex ratio in the summer (26 males: 32 females; $\chi_1^2 = 0.62$, $p = 0.43$) and the winter (12 males: 6 females; $\chi_1^2 = 2$, $p = 0.16$) also did not differ from a 1:1 ratio. The sex ratios of the two seasons did not differ ($\chi_1^2 = 2.62$, $p = 0.10$). A previous report of the sex ratio of a population of *A. nebulosus* from Nayarit also found a 1:1 sex ratio in late March/early April (Jenssen 1970a).

Twenty-three of the 32 females we observed in the summer were gravid (71.9%), whereas we observed no gravid females (0 of 6) in the winter. This observation is consistent with previous observations of a general lack of reproductive behavior (Lister and Aguayo 1992) and reproduction (Ramírez-Bautista and Vitt 1997, Hernández-Salinas and Ramírez-Bautista in press) in *A. nebulosus* during the winter.

The smallest gravid female was 34 mm SVL, which was also the smallest female we collected overall. Our estimate of size at maturity for females is similar to that reported in a population of *Anolis nebulosus* from Jalisco (35 mm SVL; Ramírez-Bautista and Vitt 1997, see also Hernández-Salinas and Ramírez-Bautista in press). The smallest reproductive female on San Pancho Island, W of Jalisco's coast was 40 mm SVL (Hernández-Salinas and Ramírez-Bautista 2014). Ramírez-Bautista and Vitt (1997) estimated that this size at maturity ($\approx$ 35 mm SVL) in female *A. nebulosus* was reached in ca. 9 months. Assuming similar growth rates, we think it is likely that *A. nebulosus* in our study population probably reach size at maturity at about the same time (9 months), although this is still to be confirmed.

In conclusion, our results, while consistent with previous findings on sexual dimorphism and reproduction in *Anolis nebulosus*, show that there is geographic variation in these traits among populations. In particular, it appears that the island populations (see Senczuk *et al.* 2014, Siliceo-Cantero and García 2014, Hernández-Salinas and Ramírez-Bautista in press) differ from the mainland populations. Additional studies on both on island and mainland populations of *A. nebulosus* throughout its range are needed to determine the extent of variation in ecological and reproductive traits in the species, as well as to examine the underlying ecological and evolutionary causes of such variation. *Anolis*

nebulosus has the potential to be a useful model system for exploring such questions. Indeed, comparisons of island and mainland populations of other lizards have helped our understanding of the ecological and evolutionary factors driving ecological divergence among populations (e.g., Meiri 2007, Sogonas *et al*. 2014, Sacchi *et al*. 2015). The information reported here represents a key first step to answering such important questions.

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