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Litter size and relative clutch mass of the earthsnakes *Conopsis biserialis* and *C. nasus* (Serpentes: Colubridae) from the central Mexican Transvolcanic Axis

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Being highly secretive, cryptic in coloration, and infrequently active, most small fossorial snakes are poorly studied (How & Shine 1999, Goodyear & Pianka 2008). The colubrid genus *Conopsis* Günther, 1858 comprises six species (*C. biserialis, C. nasus, C. acuta, C. amphisticha, C. megalodon,* and *C. lineata*) of fossorial snakes that are endemic to México with a distribution ranging from the states of Chihuahua in the north to Oaxaca in the south (Goyenechea & Flores-Villela 2006). All species are viviparous and relatively small (adults of all species range from 100 to 330 mm in snout–vent length). Populations of these species occur mainly in pine and pine/oak forests, although they have also been collected in fir forests, xerophilous underbrush, submontane underbrush and deciduous forest, between ~1,500 and 3,200 m (Goyenechea & Flores-Villela 2006). Information about the biology and natural history of these species is markedly limited.

Conopsis biserialis and *C. nasus* are endemic to northern and central Mexico and to central and southern Mexico, respectively. Both species inhabit xeric scrub, pine/oak forest, and pine forest (Goyenechea & Flores-Villela 2006). Although the IUCN (2011) places both *C. biserialis* and *C. nasus* in the category of "Least concern", Mexican conservation laws (Diario Oficial de la Federacion 2010) consider *C. biserialis* as "Threatened (Amenazada)" and *C. nasus* as "No status (No listada)". Due to their degree of endemism and narrow ecological distribution, Wilson et al. (2013) consider both species at the high end of the medium level of vulnerability (Environmental Vulnerability Score [EVS] = 13 for *C. biserialis* and 11 for *C. nasus*, range of EVS: 3–9 for low vulnerability species; 10–13 for medium vulnerability species, and 14–20 for high vulnerability species). EVS is a measure developed by Wilson & McCranie (2004) to assess the conservation status of herpetofauna. Information on geographic distribution, ecological distribution, and degree of human persecution is used to calculate the EVS of individual reptiles. *Conopsis biserialis* in particular might be in decline over an important extension of its original range, which is apparently related to the destruction and fragmentation of its forest habitat in Central Mexico (Flores-Villela & Gerez 1994). The impact of habitat fragmentation on species with highly limited dispersal abilities, such as small, fossorial snakes, may be one of the main threats to the survival of *Conopsis* species (Castañeda-González et al. 2011).

Like most snakes with a fossorial life style, *C. biserialis* and *C. nasus* are poorly studied (Castañeda-González et al. 2011). Most studies on these species cover taxonomic issues (Goyenechea & Flores-Villela 2006, Goyenechea 2009) and information about their biology and natural history is notoriously scarce (Ramírez & Arizmendi 2004). With regard to reproduction, it is known that both species are viviparous, that mating takes place in burrows under rocks (Greene 1997), and that it occurs in the summer for *C. biserialis* (Fitch 1970) and in October and November for *C. nasus* (Greer 1966). Further information on the reproduction of *C. biserialis* includes reports on litter size (LS) and relative clutch mass (RCM) by Estrada-Virgen & Alvarado-Díaz (2003) (LS = 4, RCM = 0.21, N = 1) and Castañeda-González et al. (2011) (LS = 4, RCM = 0.35, N = 1), and on litter size by Ramírez-Bautista et al. (1995) (average LS = 4.5, range = 2–8, N = 4) (Table 1). Further information on the reproduction of C. *nasus* includes reports on litter size by Greer (1966) (average LS = 3.6, range = 1–6, N = 20), and Juárez-Escamilla & Ramírez-Bautista (2013) (LS = 11, RCM =

Table 1. Litter size, neonate size and mass, and relative clutch mass (RCM) of *Conopsis biserialis* and *C. nasus*. Average values are followed by range in parenthesis.

Species	No. females	No. neonates	Mean SVL neonates (mm)	Mean body mass neonates (gr)	RCM	Source
C. biserialis	1	4	93 (82–101)	1.3 (1.3–1.3)	0.21	Estrada-Virgen (2003)
C. biserialis	1	4	71 (68–75)	0.87 (0.8–0.9)	0.35	Castañeda-González et al. (2011)
C. biserialis	4	4.5 (2–8)	–	–	–	Ramírez Bautista et al. (1995)
C. biserialis	1	8	83.6 (79–85)	1.2 (1.2–1.5)	0.39	This study
C. nasus	20	3.6 (1–6)	–	–	–	Greer (1966)
C. nasus	1	11	84.2 (77.3–90.8)	0.78 (0.60–0.97)	0.42	Juárez & Ramírez-Bautista (2013)
C. nasus	1	4	90 (85–100)	1.2 (1.2–1.2)	0.28	This study

Figure 1. Adult female *Conopsis biserialis* and neonates. Photo by Ernesto Raya-García.

Figure 2. Adult female *Conopsis nasus* and neonates. Photo by Ernesto Raya-García.

0.42) (Table 1). The objective of the present study is to provide information on reproductive characteristics of *C. biserialis* and *C. nasus*. Specifically, our goal is to update the information on litter size and relative clutch mass.

On 23 March 2014, in the locality of Ichaqueo, municipality of Morelia, Michoacán, México (19°56'86" N, 101°13'10" W; 2,257 m elevation), a *C. biserialis* female was collected by O. Medina-Aguilar. This female had a snout–vent length (SVL) of 280 mm and a body mass of 24 g. She was found at 11:00 h, under a rock in a clearing of a pine/oak forest. Air temperature and humidity were 24.8°C and 32.8%, respectively. On 18 March 2014 in the locality of Chiquimitio, municipality of Morelia, Michoacán, México (19°47'15.13" N, 101°17'27.10" W, 2,045 m elevation), a *C. nasus* female was collected by M. Sosa-Reyes. The distance between these collecting localities is ~ 28 km in straight line. Both snakes were collected under SEMARNAT permit No. FAUT-0113. The *C. nasus* female had a SVL of 270 mm, and a body mass of 16.9 g. She was found at 10:30 h under a rock in tropical deciduous forest (matorral subtropical). Subsequently, both females were maintained in captivity in the laboratory of herpetology of the Instituto de Investigaciones sobre los Recursos Naturales, Universidad Michoacana de San Nicolás de Hidalgo, located at Morelia Michoacán, México, at an altitude of 2,000 m. They were housed in separate containers and exposed to a natural night-day cycle. The snakes had permanent access to a drinking bowl and were fed crickets (*Acheta domesticus*) ad libitum. After 40 days (02 May 2014) from the date of collection, the *C. biserialis* female gave birth to eight young (Fig. 1), and after 52 days (08 May 2014), the *C. nasus* female gave birth to four (Fig. 2). After recording the length and weight of each neonate, mothers and neonates were released at the site where the mothers were collected. The average SVL of *C. biserialis* neonates was 83.6 mm (range = 79–85 mm), tail length (TL) was 17.7 mm (range = 10–29 mm), and mean body mass was 1.2 g (range = 1.2–1.5 g) (Table 1). Litter mass was 10.1 g. The *C. biserialis* mother had a body mass of 25.4 g before parturition and 15.3 g after. The average SVL of *C. nasus* neonates was 90.0 mm (range = 85–100 mm), TL was 15.7 mm (range = 15–18 mm), and mean body mass was 1.2 g (range = 1.2–1.2 g) (Table 1). Litter mass was 4.8 g. The *C. nasus* mother had a body mass of 16.9 g before parturition and 12.1 g after.

The almost identical dates of birthing of the *C. biserialis* and *C. nasus* females reported in the present study suggests that, at least in the study area located in the central Mexican Transvolcanic Axis, mating time (assuming gestation periods of similar duration) coincides in both species. This result contrasts with reports by Fitch (1970) and Greer (1966) that indicate different mating times for these species. Markedly small sample sizes for these species might be the principal reason for these discrepancies and highlight the lack of information on reproduction and about the natural history of these snakes in general.

Following Seigel & Fitch (1984), relative clutch mass (RCM) was calculated as litter mass/female total mass before parturition. The RCM value for the *C. biserialis* mother was 0.39 (10.1/25.4 g), and 0.28 (4.8/16.9) for the *C. nasus* mother. Seigel & Fitch (1984) summarized the RCM data of 106 populations of 97 species and subspecies of snakes, with RCM values ranging from 0.10 to 0.61. Only 20 populations (18%) exhibited RCM values equal to, or higher than, 0.40. Therefore, the RCM recorded in our study for *C. biserialis* (0.39) can be considered high and medium for *C. nasus* (0.28). RCM has frequently been considered an indirect operational estimate of reproductive effort (i.e., Shine 1992, Gerald & Miskell 2007). However, according to other authors (Vitt & Congdon 1978, Vitt & Price 1982), a high RCM value is not necessarily associated with a high reproductive effort, but it might be associated in squamates with a cryptic behaviour and sit-and-wait foraging mode. Therefore, it is not unexpected for *Conopsis* species to present medium to high values of RCM, considering that existing information suggests that they remain sheltered under rocks or fallen trunks for long periods of time (Ramírez-Bautista & Arizmendi 2004), likely waiting at their refuges or roaming short distances for the right kind of prey to come within striking distance. Therefore, it is feasible that energy that potentially might be used for foraging and escape from predation is instead invested in reproduction (Cooper et al. 1990). This strategy may be advantageous when snakes live in an environment with a high availability of good-quality food resources. Ford & Seigel (1989) demonstrated the plasticity of snake litter size and mass in relation to the abundance and nutritional quality of prey. The fossorial and secretive lifestyles of *C. biserialis* and *C. nasus*, in addition to their sit-and-wait hunting strategy, presumably confer these snakes protection from potential predators. Therefore, the danger of predation associated with the effects of a heavy litter on a female's locomotion may be markedly reduced by the lifestyle of these snakes.

In conclusion, our literature search yielded only three studies that presented information about litter size and/or RCM for *C. biserialis* and two for *C. nasus*. Therefore, ours is only the fourth study for *C. biserialis* and the third for *C. nasus* reporting on these two important natural history traits. Pulling all studies published to date, including ours, there is data for only seven *C. biserialis* females, all with data on litter size, three with data on size and mass of neonates, and three with RCM information. For *C. nasus*, there is data for 22 females, all with data on litter size, and two with data on size and mass of neonates and on RCM. Table 1 summarizes the information on litter size, neonate size, and RCM from these studies. Considering that the information presented about reproduction in these species derives from small sample sizes, it must be considered preliminary and highlights the need for further studies on the reproduction and natural history of these poorly known endemic species.

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