

Snake interspecific aggregation: *Crotalus polystictus* (Cope, 1865), *Thamnophis eques* (Reuss, 1834) and *T. scaliger* (Jan, 1863)

Octavio I. Martínez Vaca-León^{1*}, Sheridan J. Maya-García, Javier Manjarrez¹, and Luis E. Estrada-García¹

In animals, both intra and interspecific interactions are determinants for success in individual fitness. Interspecific interactions among species can potentially benefit the individual by reducing the probability of predation, increasing reproductive success, and facilitating thermo- and hydro-regulation (Krause and Ruxton, 2002).

Although reptiles have been stereotyped as solitary and, in some cases, territorial animals, there are many studies that report on gatherings (Graves and Duvall; 1995; Giles et al., 2009; Davis et al., 2011; Clark et al., 2012). In the case of snakes, intra and interspecific aggregations have been mostly associated with reproductive and thermoregulatory events (Huey et al., 1989; Gregory, 2004; Amarello, 2012; Amarello and Smith, 2012; Clark et al., 2012, Meek, 2014).

On October 14, 2017, at 0910 h, we recorded an aggregation of 16 adult *Thamnophis scaliger* Jan, 1863; one adult *T. eques* Reuss, 1834 (Colubridae), and one adult *Crotalus polystictus* Cope, 1865 (Viperidae), all under the same shelter. They were in an abandoned construction field near an agricultural area in Atlacomulco, State of Mexico (19° 46'05 "N, 99° 51'10" W, elevation 2524 m) and were grouped under a 46 x 47 cm concrete block (Fig. 1).

We recorded temperature and humidity immediately after capturing the snakes. At two cm above the ground near the concrete block, ambient air temperature was

14.7 °C and humidity was 82.6%. At ground level (two cm above ground) where the snakes had been aggregated, the temperature was 15.7 °C and humidity was 88%. We recorded morphometric data for all 18 individuals aggregated under the concrete block (Table 1).

On the same day and in the same area, we captured and measured another 26 *T. scaliger* snakes that were by themselves under other shelters. We founded that sizes of aggregated snakes were larger than snakes found individually (Fig. 2, *t-Student* $t_{39} = 2.73$, $p = 0.009$).

Aggregations of snakes under the same shelter do not correspond to a random event, and can be explained by physiological demands, such as gravity or digestion (Burghardt, 1983; Ford and Holland, 1990; Gregory, 2004), or those involved in intra- and interspecific chemical communication such as mate searching or in predator-prey interactions as an anti-predatory shelter



Figure 1. Interspecific aggregation of snakes (*Thamnophis scaliger*, *Thamnophis eques*, and *Crotalus polystictus*) in Atlacomulco, State of México. (Photo by O. Martínez Vaca-León).

¹ Laboratorio de Biología Evolutiva, Centro de investigación en Recursos Bióticos. Facultad de Ciencias, Universidad Autónoma del Estado de México, Km 14.5 carretera Toluca – Ixtlahuaca, San Cayetano, Toluca, Estado de México 50200, México.

* Corresponding author. E-mail: imvleon83@gmail.com

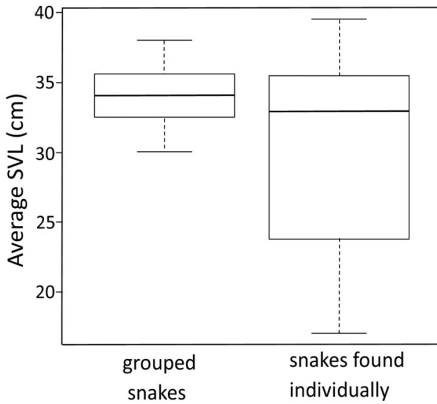


Figure 2. Boxplots showing differences between Snout-vent length of *T. scaliger* individuals grouped under the refuge ($n = 16$) versus *T. scaliger* found individually ($n = 26$) outside the shelter. Bars represent averages, boxes represent 50th percentiles, and whiskers represent ranges.

or group vigilance against predators (Gregory, 2004). They may also be associated with the thermal selection of the environment (Gibson and Falls, 1979). During our observation, the aggregation of 16 *T. scaliger* could also indicate a different physio-ecological condition. It is possible that the observed aggregation of *T. scaliger* is associated with reproduction (Feriche *et al.* 2011, 2016), since all the snakes under the refuge were adults (>340 and 350 mm SVL for males and females, respectively) with a male sexual bias (7:1). This pattern is supported with that reported for *T. sirtalis*, which present aggregations of dozens of males around a single female during the reproductive period (Rossman

et al., 1996). In addition, a birth season from June to August has been recorded for *T. scaliger* (Feriche *et al.*, 2016), with a possible breeding season before winter, for example in October when our observation occurred, which is a common pattern in high mountain species with non-annual reproductive cycles. In this way, adult sex bias of *T. scaliger* suggest a possible link between their aggregation under the shelter and reproduction.

It has been proposed that thermoregulatory requirements in snakes are related to body size. Larger individuals are more efficient in controlling their body temperature than smaller ones, which may favour a differential use of the thermal environment (Stevenson, 1985; Peterson *et al.*, 1993). All *T. scaliger* in the aggregated group were similar in body size (Table 1, Fig. 2). This finding suggests that the temporary shelter was thermally appropriate for the physiological demand of similarly size snakes, since the measures of air temperature and humidity inside the shelter were greater than outside (1° C and 5.4%, respectively).

The aggregation of the three species of snake under the same refuge, may be an interspecific trophic response or due to the appropriate thermal condition of the shelter. Although *Thamnophis scaliger*, *T. eques*, and *C. polystictus* have all been reported as potential predators to each species (Venegas-Barrera and Manjarrez, 2001; Manjarrez *et al.*, 2007, Mociño-Deloya, 2015), predation among these species occurs when one individual is larger than the other, in this case all individuals were adults. The similarity in body size under the refuge, can be interpreted as a reciprocal anti-predator strategy, which functions to help predators to avoid predation for larger individuals. On the other hand, the aggregation is more common in Nearctic species compared with Neotropical

Table 1. Averages (± 1 SD with ranges and sample sizes in parentheses) of five morphometric measurements taken from the 18 snakes sheltered under the concrete block.

Species	Total Length (mm)	SVL (mm)	Head wide (mm)	Head length (mm)	Body weight (g)
<i>Crotalus polystictus</i> male ($n = 1$)	472	425	15.2	27.8	53
<i>Thamnophis eques</i> female ($n = 1$)	305	245	9.02	10.93	8.9
<i>Thamnophis scaliger</i>					
females ($n = 2$)	419 \pm 15.55 (408-430)	350 \pm 14.14 (340-360)	9.74 \pm 0.65 (9.2-10.2)	12.82 \pm 0.007 (12.82-12.83)	25.65 \pm 4.31 (22.6-28.7)
males ($n = 14$)	416.8 \pm 29.74 (365-460)	340.1 \pm 24.32 (305-380)	9.6 \pm 0.87 (8.0-11.2)	12.3 \pm 0.73 (11.0-13.9)	19.9 \pm 3.68 (14.9-27.4)

SVL, snout-vent length

species (Gillingham, 1987). At Atlacomulco, this could be a consequence of more favourable climatic conditions for these species. This is not likely to a consequence of reproduction, due to the month of collection, but more for its survival given the low temperatures of the area.

The information presented here can help explain the mechanisms of coexistence between these three sympatric snake species. Although there is data on snake interactions between the same genus, little is known about interactions between the *Thamnophis* and *Crotalus* genera, and even less regarding the interaction between both genera in sympatry. Our record provides an example of both an interspecific and an intergeneric aggregation of snakes.

Acknowledgments. The authors thank the National Council of Science and Technology (CONACYT) for scholarships No. 291142 and 485769, which were granted to the first and second authors, respectively. We also thank Ruthe J. Smith, Crystian S. Venegas Barrera and the reviewer anonymous for his comments and corrections of the typescript. To Carlos A. Suárez Barrales for his support in the field.

References

- Amarello, M. (2012): Social Snakes? Non-random association patterns detected in a population of Arizona blackrattlesnakes (*Crotalus cerberus*). Unpublished MS thesis, Arizona State University, Tempe, USA.
- Amarello, M., Smith, J.J. (2012): Social snakes? The role of kin selection in rattlesnake aggregations. *Sonoran Herpetologist* **25**: 129-130.
- Burghardt, G.M. (1983): Aggregation and species discrimination in newborn snakes. *Ethology* **61**: 89-101.
- Clark, R.W., Brown, W.S., Stechert, R., Greene, H.W. (2012): Cryptic sociality in rattlesnakes (*Crotalus horridus*) detected by kinship analysis. *Biology Letters* **8**: 523-525.
- Davis, A.R., Corl, A., Surget-Groba, Y., Sinervo, B. (2011): Convergent evolution of kin-based sociality in a lizard. *Proceedings of the Royal Society of London B* **278**: 1507-1514.
- Feriche, M., Reguera, S., Santos, X., Mociño-Deloya, E., Setser, K., Pleguezuelos, J.M. (2011): Biometry and pholidosis of *Thamnophis scaliger*: an atypical example of sexual dimorphism in a natricine snake. *Basic and Applied Herpetology* **25**: 105-113.
- Feriche, M., Reguera, S., Santos, X., Mociño-Deloya, E., Setser, K., Pleguezuelos, J.M. (2016): Female Reproduction in *Thamnophis scaliger*: The Significance of Parturition Timing. *Journal of Herpetology* **50**: 209-215.
- Gibson, A.R., Falls, J.B. (1979): Thermal biology of the common garter snake *Thamnophis sirtalis*, I. Temporal variation, environmental effects and sex differences. *Oecologia* **43**: 79-97.
- Giles, J.C., Davis, J.A., McCauley, R.D., Kuchling, G. (2009): Voice of the turtle: the underwater acoustic repertoire of the long-necked fresh water turtle, *Chelodina oblonga*. *Journal of the Acoustical Society of America* **126**: 434-443.
- Ford, N.B., Burghardt, G.M. (1993). Perceptual mechanisms and the behavioral ecology of snakes.
- Gillingham, J.C. (1987). Social behavior. In: *Snakes. Ecology and Evolutionary Biology*, p. 184-209. Seigel, R.A., Collins, J.T., Novak, S.S. Ed., Caldwell, USA, Blackburn Press.
- Graves, B.M., Duvall, D. (1995): Aggregation of squamate reptiles associated with gestation, oviposition, and parturition. *Herpetological Monographs* **9**: 102-119
- Gregory, P.T. (2004): Analysis of patterns of aggregation under cover objects in an assemblage of six species of snakes. *Herpetologica* **60**: 178-186.
- Gregory, P.T., Holland, D. (1990): The role of pheromones in the spacing behaviour of snakes. In: *Chemical Signals in Vertebrates*, p. 466-472. Duvall, D., Muller-Schwarze, D., Natynczuk, S.E. Ed., Oxford, UK, Oxford University Press.
- Huey, R.B., Peterson, C.R. Arnold, S.J., Porter, W.T. (1989): Hot rocks and not-so-hot rocks: retreat-site selection by garter snakes and its thermal consequences. *Ecology* **70**: 931-944.
- Krause, J., Ruxton, G.D. (2002): *Living in groups*, 1st Edition. New York, USA, Oxford University Press.
- Manjarrez, J., Venegas-Barrera, C.S., García-Guadarrama, T. (2007): Ecology of the Mexican Alpine blotched garter snake. *The Southwestern Naturalist* **52**: 258-262.
- Meek, R. (2014): Reptile dispersal from a hibernaculum in agricultural landscape in western France. *Herpetological Bulletin* **127**: 17-21.
- Mociño-Deloya, E. (2015): Ecología trófica de tres especies de serpientes de cascabel en México: *Crotalus aquilus*, *Crotalus polystictus* y *Crotalus willardi*. Unpublished PhD thesis, University of Granada, Granada, Spain.
- Peterson, C.R., Gibson, A.R., Dorcas, M.E. (1993): Snakes thermal ecology: The causes and consequences of body temperature variation. In: *Snakes. Ecology and behavior*, p. 241-314. Seigel, R.A., Collins, J.T., Ed., New York, USA, McGraw-Hill, Inc.
- Rossman, D.A., Ford, N.B., Seigel, R. (1996): *The Garter snakes. Evolution and Ecology*, 1st Edition. Norman, USA. University of Oklahoma Press.
- Stevenson, R.D. (1985): Body size and limits to the daily range of body temperatures in terrestrial ectotherms. *American Naturalist* **125**: 102-117.
- Venegas-Barrera, C.S., Manjarrez, J. (2001): *Thamnophis eques* (Mexican Garter Snake) and *Thamnophis scalaris* (Mexican Alpine Blotched Garter Snake). *Predator/Prey. Herpetological Review* **32**: 187.