THERYA NOTES 2023, Vol. 4 : 79-83 DOI: 10.12933/therya_notes-23-110 ISSN 2954-3614

Mother's defense of a juvenile rock squirrel (*Otospermophilus variegatus*) against a rattlesnake (*Crotalus molossus*)

La defensa de una madre de un ardillón de roca juvenil (*Otospermophilus variegatus*) contra una serpiente de cascabel (*Crotalus molossus*)

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Predation of rock squirrels (*Otospermophilus variegatus*) by rattlesnakes (*Crotalus* sp.) has led to a coevolutionary process during which rock squirrels have developed resistance to the rattlesnake venom and a series of behaviors that allow squirrels to protect themselves against predation. In this note, we describe an observation of such behavior; how a squirrel mother protects a juvenile against a rattlesnake attack. We witnessed a confrontation between a mother squirrel and a rattlesnake over a juvenile that was attacked by the snake and the squirrel's strategy used to guide her offspring away from danger. The mother squirrel threatened the rattlesnake by moving its tail and retreated laterally to a nearby tree. The juvenile followed the mother, guided by its smell. When they reached a safe distance, they jumped from the tree and went away, keeping their distance. Before withdrawing, the mother attempted to interact with the observers; local workers confirm that rock squirrels warn them about rattlesnake presence. The defensive behavior we observed was complex and effective. The mother squirrel was able to guide the juvenile out of danger, and the strategy was well planned since they retired to a nearby tree where the rattlesnake would be at a disadvantage. Therefore, rock squirrels have a well-developed behavior to protect their offspring against snake attacks.

Key words: Attack; behavior; mammals; predation; reptile; warning.

La depredación de ardillones de roca (*Otospermophilus variegatus*) por serpientes de cascabel (*Crotalus* sp.) ha llevado a un proceso coevolutivo durante el cual los ardillones han desarrollado resistencia al veneno de serpiente de cascabel y una serie de comportamientos complejos que les permiten protegerse contra la depredación. En esta nota describimos una observación de tal comportamiento; cómo una madre ardillón protege a un joven contra el ataque de una serpiente de cascabel. Fuimos testigos de un enfrentamiento entre una madre ardillón y una serpiente de cascabel por un juvenil que fue atacado por la serpiente, y la estrategia utilizada para guiar a su cría lejos del peligro. La madre ardillón amenazó a la serpiente de cascabel moviendo su cola y se retiró lateralmente a un árbol cercano. El juvenil siguió a la madre guiado por su olor. Cuando llegaron a una distancia segura, saltaron del árbol y se alejaron manteniendo la distancia. Antes de retirarse, la madre intentó interactuar con los observadores. Trabajadores locales confirman que las ardillas les advierten sobre la presencia de serpientes de cascabel. El comportamiento defensivo que observamos fue complejo y efectivo. La madre pudo guiar al joven ardillón fuera del peligro, y la estrategia estuvo bien planeada, ya que se retiraron a un árbol cercano donde la serpiente de cascabel estaría en desventaja. Se concluye que los ardillones de roca tienen un comportamiento bien desarrollado para proteger a sus crías contra los ataques de serpientes.

Palabras clave: Advertencia; ataque; comportamiento; depredación; mamíferos; reptil.

Prey-predator interaction between *Otospermophilus* (for this study, we refer to the genus as ground squirrels and rock squirrels to the species *O. variegatus*) and *Crotalus* sp. (rattlesnakes) has shaped the biochemical evolution and behavior of ground squirrels. Previous studies show that ground squirrels are a preferred alimentary item for rattlesnakes and can account for up to 80 % of the total biomass consumed (Diller and Wallace 1996). However, this predation contributed to exerting a selective pressure that led to the development by the ground squirrels of resistance to rattlesnake venom (Martinez *et al.* 1999; Biardi *et al.* 2006; Biardi and Coss 2011) and elaborated behaviors to avoid and confront this threat (Owings *et al.* 2001).

During encounters, ground squirrels attempt to intimidate the snakes by raising their tail, moving it from side to side, and harassing them by throwing substrate or even direct attacks (Owings *et al.* 2001). At the same time, ground squirrels use snake scent to protect against pre-

dation by applying on themselves substrate on which the snake rested (Owings *et al.* 2001) or by chewing rattlesnake skins and licking their fur (Clucas *et al.* 2008). All this reveals a strong interaction between those 2 genera that shaped recent evolution and ecological patterns of ground squirrels. However, previous studies suggest that adult ground squirrels are well prepared to confront rattlesnakes but are vulnerable during the first stages of their lives as kittens and juveniles (Swaisgood *et al.* 1999; Owings *et al.* 2002; Clucas *et al.* 2008), despite that there is very limited information on how these vulnerable groups respond to a rattlesnake threat and even less on how ground squirrel mothers defend their offspring (see Swaisgood *et al.* 1999; Clucas *et al.* 2008). In this work we report an observation of an attack by a *Crotalus molossus* rattlesnake on a *Otospermophilus variegatus* juvenile and the response by its mother.

The observation was made inside Pedregal de San Ángel (PSA) Ecological Reserve, a lava field supporting a temperate xeric scrub ecosystem in México City, Mexico. Both rock squirrels and rattlesnakes are common to this reserve, and predation of rock squirrels was reported (Balderas-Valdivia *et al.* 2009; Hortelano-Moncada *et al.* 2009). The encounter took place inside the west core zone of the reserve (an area of 95 ha of natural vegetation and 17 ha of managed vegetation; Figure 1) on edge between natural vegetation (xerophytic shrubs) and managed vegetation (grass plantation) at 17:08 hr on November 14, 2022, and was observed by S. I. González-Jaramillo and I. Lozano-Amaro.

During an unrelated work in the area, a strange behavior of a rock squirrel cached our attention. The squirrel had its tail upward and moved it vigorously; upon closer examination, we found that there were 2 squirrels, a bigger one (apparently the mother) and a smaller one (the offspring), and a large rattlesnake (*ca.* 135 cm in length). We consider that the squirrels were a mother-offspring pair due to their difference in sizes (that could only be attributed to age since sexual dimorphism in this species is small; Oaks *et al.* 1987) and previous studies show that *O. variegatus* females became territorial when taking care of youngs (Johnson 1981); therefore, it is unlikely that a young rock squirrel will

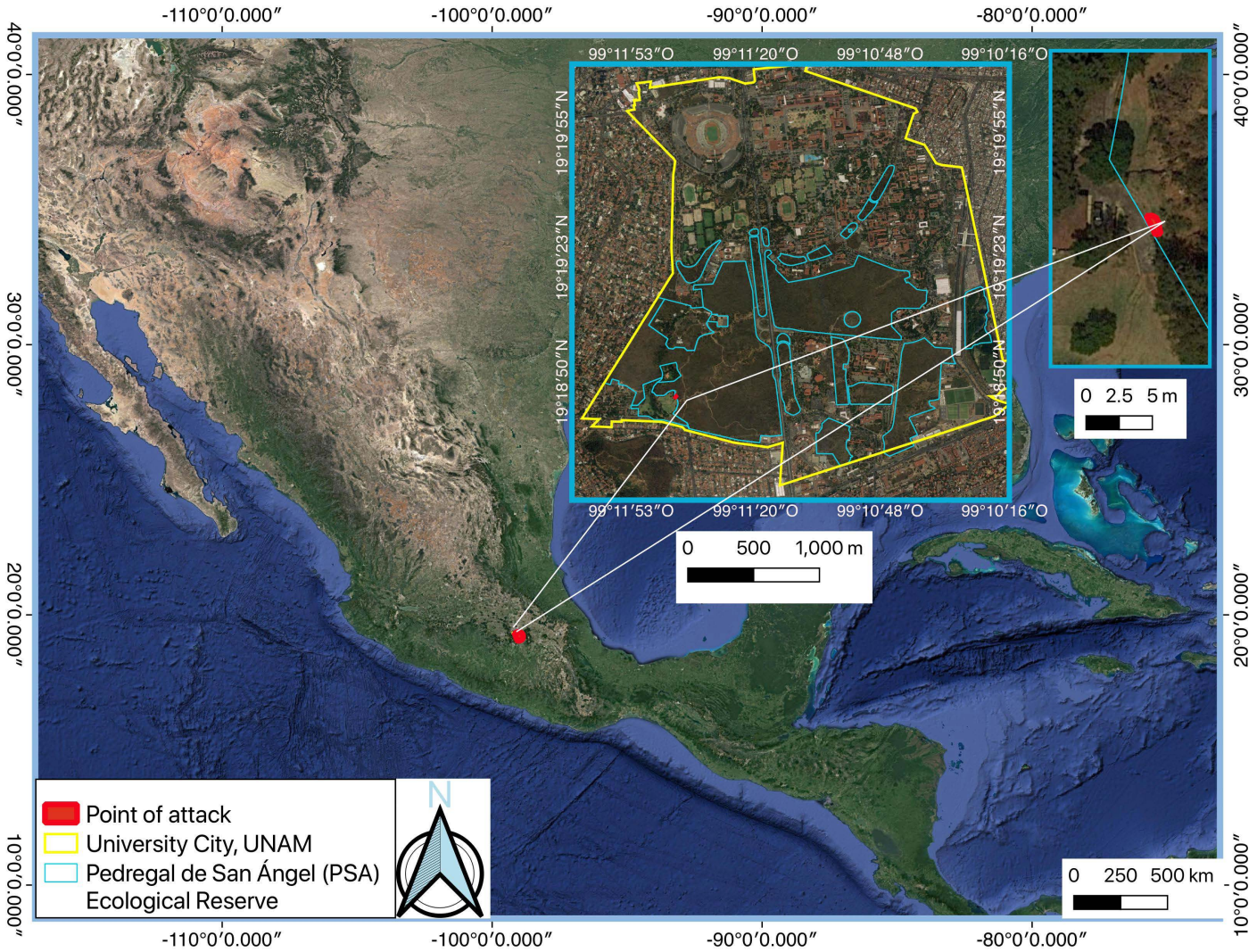

Figure 1. Location of the encounter between a rock squirrel (*Otospermophilus variegatus*) and a rattlesnake (*Crotalus molossus*) in Pedregal de San Ángel Ecological Reserve, located inside México City, México. Elaborated by: S. I. González-Jaramillo.

be in contact with an adult other than its mother. The small squirrel had clear marks of a recent snake bite, its face had blood and was swollen (a classical early sign of rattlesnake poisoning; Gil-Alarcón *et al.* 2011; Figure 2). The mother was moving laterally, climbing a fallen tree (Figure 2) with its tail up and moving it to the sides and up and down (Figure 3).

The small squirrel followed closely but made no attempts to intimidate the rattlesnake. After reaching a safe distance from the rattlesnake (~2 m) the mother jumped from the tree and guided the smaller squirrel around the rattlesnake, always maintaining a 2-2.5 m safe distance. Apparently, the smaller squirrel couldn't see clearly due to the attack; therefore, it was guided by its mother's smell; when climbing the tree, it had its head close to the mother's tail, and when the mother jumped off the tree the youngling couldn't follow so the mother returned and put its tail in front of the youngling's face after that it was able to follow the mother.

The rattlesnake was rattling its tail during the entire duration of the encounter (notice that this is a defensive behavior, not a hunting one; Owings *et al.* 2002) and appeared to move forward, but was dissuaded by the mother's attitude. When the squirrels were clearly out of reach, the rattlesnake turned around and retreated from the encounter.

Interestingly enough, before leaving the site the mother squirrel approached us to a close distance (~ 50 cm) and tried to interact either to ask for help or warn about the danger. To clarify this behavior, we interviewed the gardeners that commonly work in this place, and they mentioned that they typically find rattlesnakes there; however, they are warned by the squirrels close to them, which make a loud click with their snouts and move their tails with the same pattern described to warn of the presence of the snake.

Previous studies have shown that ground squirrels warn other individuals of the same species about rattlesnakes (Swaisgood *et al.* 1999; Owings *et al.* 2001); however, this data suggests that this warning behavior can extend to other species like humans (although this needs to be proved by further studies).

Rock squirrels and ground squirrels, in general, have complex and effective strategies to confront rattlesnakes (Owings *et al.* 2001; Clucas *et al.* 2008); however, this observation suggests that their behavior is equally well developed to protect their younglings. In our opinion, four aspects of this encounter should be carefully considered. First, the mother was able to guide the youngling despite it was unable to see by using scent, a valuable ability in this case, and if the attack was performed in the dark, for example, inside a burrow (notice that rattlesnakes can detect heat, therefore, are less affected by the darkness; Ebert and Westhoff 2006). Second, the mother retreated laterally to a high ground despite being able to go backward on an open field; this appears to be a calculated move since rock squirrels are great climbers while rattlesnakes generally are found on the ground, therefore making a pursuit by

Figure 2. Mother squirrel (*Otospermophilus variegatus*) protecting offspring from rattlesnake (*Crotalus molossus*) attack in Pedregal de San Ángel Ecological Reserve, located inside México City, México. Photography and video by: S. I. González-Jaramillo. The video can be seen at this link: https://www.instagram.com/reel/CtqJ5RgsdYW/?igshid=MzRlODBiNWFlZA%3D%3D.

Figure 3. Mother squirrel (*Otospermophilus variegatus*) moving her tail up and down and to the sides during a rattlesnake (*Crotalus molossus*) attack in Pedregal de San Ángel Ecological Reserve, located inside México City, México. Notice that the juvenile is hiding behind the mother and apparently following her scent. Photography by: S. González-Jaramillo.

the rattlesnake very unlikely. Third, the mother had a well-established safe distance from the rattlesnake 2-2.5 m; at this distance, it stopped the confrontation while surrounding it always kept a safe distance from the danger. It is not clear why the squirrel chose this distance and whether this is based on the personal experience of the individual or not, but, given the normal attack range of a rattlesnake of 50 cm (Owings *et al.* 2001), a 2 m distance appears to be quite safe. And fourth, the attempt of interaction with human observers suggests (although more research is needed on this topic) that rock squirrels are willing to work together with other species to confront the common enemy.

In conclusion, we observed an efficient and elaborated behavior of the rock squirrel to save its youngling which suggests that the defense of the offspring against rattlesnakes is well-developed conduct in this species, and future studies on this interaction should be performed.

Acknowledgements

We are thankful to the gardeners who shared their experience about squirrel rattlesnake interactions, to I. Castellanos-Vargas for technical support, to the SEREPSA working team for the permits granted. This research was performed as a part of S. I. González-Jaramillo PhD. research at Posgrado en Ciencias Biologicas and financially supported by a CONACYT scholarship. Two anonymous reviewers helped improve the text.

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Associated editor: José F. Moreira Ramírez.
Submitted: May 12, 2023; Reviewed: June 23, 2023.
Accepted: July 1, 2023; Published on line: July 14, 2023.