Reptiles are hosts of a wide variety of protozoan and metazoan parasites (Wilson and Carpenter 1996). Most of these parasites have been recorded through necropsies of specimens, although the diagnosis could be achieved by revealing parasitic elements in feces (e.g., eggs, larvae, oocysts). Even though, the latter non-invasive method only allows detecting intestinal parasites, may be useful for conservation projects, which involve knowing the health status of a reptile population in wildlife (Jorge et al. 2013).

In Mexico, 864 reptile species have been recorded (i.e., 8.7% of the reptiles of the world), of which 57% are endemic (Flores-Villela and García-Vázquez 2014). However, the inventory of their parasites is far from complete, since only a few more than 200 Mexican reptile species have been recorded as hosts of helminths, acari and crustaceans (Paredes-León et al. 2008).

Mexico holds the highest species richness of rattlesnakes, with 42 species (Heimes 2016), but wild populations have declined due to direct hunting and habitat loss caused by the expansion of croplands and urban areas. Particularly, the Mexican dusky rattlesnake, *Crotalus triseriatus* (Wagler, 1830), is restricted to the Trans-Mexican Volcanic Belt, where occupies forested regions heavily impacted (Bryson et al. 2014). This species is considered in the category of “least concern” in the IUCN and it has not received any level of protection by Mexican government due probably to a lack of knowledge in demographic and ecological aspects (Bryson et al. 2014, Sunny et al. 2015).

Translocations have increased for wildlife conservation, including the herpetofauna. One concern associated with conservation translocations is that the released individuals may suffer from parasitic diseases resulting in establishment failure. However, infectious hazards may be mitigated when diseases and/or parasites of translocated species or species at the destination are known (Bobadilla Suarez et al. 2017). Unfortunately, for *C. triseriatus* little is known about its parasites (Paredes-León et al. 2008), even though this information is essential to know the population health of this species and potentially useful in...
future translocation processes of species from one population to another. Our objective was to investigate the occurrence of parasites in feces of *C. triseriatus* to increase parasitological knowledge without affecting wild populations.

This study was conducted in Toluca Valley located in the State of Mexico, a highly anthropized area and considered the fifth largest metropolis in Mexico, with 2.1 million inhabitants (SEDESOL, CONAPO, INEGI 2004). The region has a humid temperate climate, with an annual precipitation of 500–600 mm and a range of average annual temperature between 12 and 15 °C (García 2004, Gobierno del Estado de México 2012). The sampling sites were El Cerrillo located at 5.1 km north of metropolitan area of Toluca City (19°24′27″N; 99°41′40″W; 2615 masl) and the Sierra Morelos Park located on the edge of the metropolitan area of Toluca City (19°18′39″N; 99°41′33″W; 2630 masl).

To capture individuals of *C. triseriatus* and collect individual fecal samples, during 2012 to 2014 we made 24 monthly visits at each study site, where five observers simultaneously walked five linear transects of 800 m long and separated by 300 m in a schedule of 09:00 am–13:00 pm. We capture the rattlesnakes with herpetological hooks and once subjected, we recorded total length (snout-vent length) in centimeters and weight in grams only with descriptive purposes. After we obtained fecal samples of each specimen place them in Eppendorf tubes and we released the rattlesnakes at their capture sites.

Each fecal sample was conserved in 70% alcohol and examined in the laboratory using the flotation technique (Bowman et al. 2004). Approximately 0.5 g of each sample was macerated and mixed with 9.0 ml of 0.8% saline solution. Each homogenized sample was filtered and placed in a vial, which was centrifuged for three minutes at 1500 rpm. After centrifugation, the supernatant was discarded, and a saturated glucose solution was used to re-suspend the pellet. The suspension was centrifuged for five minutes at 1000 rpm and three subsamples of top part of the flotation were obtained and examined by light microscopy. Parasitic elements (i.e., eggs and oocysts) were counted in each subsample to obtain an average per sample and to determine the levels of infection according to Rodríguez-Vivas and Cob-Galera (2013). Analysis of the fecal samples in the laboratory using the flotation technique (Bowman et al. 2004). Approximately 0.5 g of each sample was macerated and mixed with 9.0 ml of 0.8% saline solution. Each homogenized sample was filtered and placed in a vial, which was centrifuged for three minutes at 1500 rpm. After centrifugation, the supernatant was discarded, and a saturated glucose solution was used to re-suspend the pellet. The suspension was centrifuged for five minutes at 1000 rpm and three subsamples of top part of the flotation were obtained and examined by light microscopy. Parasitic elements (i.e., eggs and oocysts) were counted in each subsample to obtain an average per sample and to determine the levels of infection according to Rodríguez-Vivas and Cob-Galera (2013). Analysis of the fecal samples in the laboratory using the flotation technique (Bowman et al. 2004).

A total 16 Mexican dusky rattlesnakes were caught, 6 in El Cerrillo with 46–66 cm (56.42 ± 6.56) and 71–270 g (190.17 ± 73.7), and 10 in Sierra Morelos Park with 43–67 cm (55.03 ± 7.47) and 70–350 g (202.78 ± 78.19). Ten of the 16 fecal samples showed the presence of parasitic elements: nematode eggs of Capillariidae sp. and coccidian oocysts of *Eimeria* sp. Ixobioides sp., and *Opionyxus naticris* (Gervais, 1844) were recorded in *C. triseriatus*. Thus, findings of Capillariidae sp. and *Eimeria* sp. represent new host records and this study is the first on the parasites of wild reptilians in Mexico using fecal samples.

The eggs of Capillariidae sp. found in *C. triseriatus* were not identified at specific level, since capillarid eggs are morphologically almost identical even among species of different genera (see Moravec 1994). Therefore, we cannot know if the nematode is a parasite or a pseudoparasite for Mexican dusky rattlesnakes, i.e., a parasite of the rodents on which hosts feed (personal observation of hair follicles in all fecal samples). In this context, Fuehrer (2014) recognized that endo- and ectoparasites of potential prey animals can be recorded as transiting parasites in the intestinal tract of reptiles, for example eggs of *Capillaria hepaticum* (Bancroft, 1893), a parasite species in mammals, have been documented in fecal samples from reptiles fed with infected rodents. On the other, Šlapeta et al. (2018) pointed out that the nematodes of *Capillaria* (Zeder, 1800) are the only known trichurids affecting reptiles, infecting primarily the intestine and secondarily other organs as the liver and gonads. It is known that their life cycle is direct, unfortunately the life cycles of snakes capillarids have not been investigated (Anderson 2000).

An examination of fecal samples of captive reptiles, including specimens of *Crotalus Linnaeus*, 1758, from Campania region in southern Italy revealed the most frequent parasites were species of groups of Oxyurida, *Rhadbias Stiles & Hassall*, 1905, *Kalicephalus* Molin, 1861, *Capillaria* and *Eimeriidae Minchin*, 1903 (Rinaldi et al. 2012). The oocysts of *Eimeria* sp. were not identified at specific level, because we did not observe some taxonomic characteristics. But it is known that *Eimeria* Schneider, 1875 is the most numerous group of snake coccidian with more than 80 species, which differ in both the morphology of exogenous stages (oocysts) and in endogenous development (Modrý 2004). Most species of *Eimeria* inhabit the intestine of reptiles, which become infected after ingesting oocysts. Schizogony occurs in the epithelial lining of intestine, depending on parasite species. Oocysts are shed with the feces following gametogony. The pathologic effects of coccidian appear mild for most reptiles; however, more severe cases resulting in epithelial ulceration and fibrosis, and septicemia from the loss of epithelial integrity, may occur (Mitchell 2007).
Parasites of Crotalus triseriatus

Jorge et al. (2013) found the detectability of nematodes was significantly lower in feces than in the intestine of reptiles, suggesting a large number of fecal samples and temporal replication to increase the likelihood of detection of intestinal parasites. Undoubtedly, parasitological studies based solely on feces most probably underestimate the true species richness present in a given host population and/or locality. However, such studies may be important for wildlife conservation purposes mainly when the translocations are employed, since the released individuals or individuals within the destination ecosystem may suffer from parasitic disease linked to the translocation process (Bobadilla Suarez et al. 2017). Specifically, it has been shown the vulnerability of populations of C. triseriatus in the Toluca Valley, due to the proximity to urban areas (Sunny et al. 2015), therefore, a complete parasitological record would aid wellbeing of snakes by receiving appropriate treatment plan and/or quarantine procedures. That allow to move the rattlesnakes outside the urban area, without the danger of infecting other populations with any diseased.

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**Table 1. Infection levels of parasitic elements in feces of Crotalus triseriatus from two localities in the State of Mexico, Mexico. Range of oocysts/eggs per gram of feces and infection levels slightly modified of Rodríguez-Vivas and Cob-Galera (2005): 2–9 very low (+), 8–18 Low (++), 20–30/10–15 Medium (+++), 32–50 High (++++).**

| Localities          | Host       | Collection date | Eimeria sp. | Capillariidae sp. |
|---------------------|------------|-----------------|-------------|-------------------|
| SMP1                | 43.0 cm    | May 26, 2012    | +           | Negative          |
| SMP2                | 57.0 cm    | July 12, 2012   | Negative    | Negative          |
| SMP3                | 63.0 cm    | September 15, 2012 | Negative     | Negative          |
| SMP4                | 59.0 cm    | September 15, 2012 | ++           | Negative          |
| SMP5                | 53.0 cm    | April 27, 2014  | ++           | Negative          |
| SMP6                | 53.0 cm    | September 20, 2014 | Negative    | Negative          |
| SMP7                | 51.8 cm    | October 18, 2014 | +++          | Negative          |
| SMP8                | 55.0 cm    | August 30, 2014 | +++          | Negative          |
| SMP9                | 67.0 cm    | November 01, 2014 | ++++         | Negative          |
| SMP10               | 58.5 cm    | November 01, 2014 | ++++        | Negative          |
| CE1                 | 66.0 cm    | October 20, 2012 | ++++        | Negative          |
| CE2                 | 54.5 cm    | December 08, 2012 | +++         | +                  |
| CE3                 | 54.0 cm    | December 08, 2012 | +           | Negative          |
| CE4                 | 55.0 cm    | August 30, 2014  | +           | Negative          |
| CE5                 | 58.0 cm    | November 08, 2014 | +++         | Negative          |
| CE6                 | 59.0 cm    | November 08, 2014 | Negative    | Negative          |

**Figures 1–2. Parasitic elements in feces of Crotalus triseriatus from Mexico: (1) Egg of Capillariidae sp. with one larva (L), brown color, thick and rough wall (W), one operculum at each pole (Op), which are asymmetrical. (2) Sporulated oocyst of Eimeria sp., spheroidal type, rough outer wall (W), absence of micropyle, ovoid sporocysts (S). Scale bars: 10 µm.**
Table 2. Records of metazoan parasites for *Crotalus* spp. in Mexico.

| Parasite                  | Stage | Habitat          | Host                  | State            | Reference                          |
|---------------------------|-------|------------------|-----------------------|------------------|------------------------------------|
| **Cestoda**               |       |                  |                       |                  |                                    |
| *Mesocestoides* sp.       | Tetratridium | Body cavity | *C. enyo* (Cope, 1861) | Baja California Sur | Goldberg et al. (2003)            |
|                           |       |                  | *C. molossus* Baird & Girard, 1853 | Undetermined     | Goldberg and Bursey (1999)        |
|                           |       |                  | *C. price Van Denburgh, 1895* |                  |                                    |
|                           |       |                  | *C. willardi Meek, 1905* |                  |                                    |
| **Oochoristica sp.**      | Adult | Intestine        | *C. basiliscus* (Cope, 1864) | Chihuahua, Sonora | Goldberg and Bursey (2000)        |
| **Ophiotaenia perspicua** | Adult | Intestine        | *C. cinerens* | Colima | Paredes-León et al. (2008) |
| **Acanthocephala**        |       |                  | *C. basiliscus* | Chihuahua, Sonora | Goldberg and Bursey (2000)        |
| **Oligacanthorhynchidae sp.** | Cystacanth | Body cavity | *C. basiliscus* | Michoacán | Goldberg et al. (2006)            |
|                           |       |                  | *C. enyo* | Baja California Sur | Goldberg and Bursey (2003)        |
|                           |       |                  | *C. lepidus* (Kennicott, 1861) | Undetermined     | Goldberg and Bursey (1999)        |
|                           |       |                  | *C. tigris* Kennicott, 1859 |                  |                                    |
| **Nematoda**              |       |                  |                       |                  |                                    |
| *Hastospiculum onchocercum* | Adult | Stomach         | *C. tzabcan* Klauber, 1952 | Quintana Roo | Carbajal-Márquez et al. (2018)    |
| *Hexametra boddaertii* (Baird, 1860) | Adult | Body cavity | *C. basiliscus* | Yucatán | Carabajal-Márquez et al. (2018)    |
| *Kalicephalus inermis coronellae* | Adult | Intestine | *C. basiliscus* | Sinaloa | Goldberg et al. (2006)            |
| *Kalicephalus inermis macrovulvus* (Caballero, 1954) | Adult | Intestine | *C. molossus* | Ciudad de México | Goldberg and Bursey (1999)        |
| *Ophidascaris labiaporillosa* Walton, 1927 | Adult | Post vena cava | *C. basiliscus* | Colima | Telford (1965)                    |
| *Ozolaimus ctenosauri* Caballero, 1938 | Adult | Body cavity | *C. molossus* | Durango | Klauber (1972)                    |
| **Physocephalus sp.**     | Larva | Mesentry         | *C. michelli* (Cope, 1861) | Baja California | Goldberg et al. (2013)            |
| **Travassoscaris araujoi* (Schneider, 1866) | Adult | Liver | *C. tzabcan* | Quintana Roo | Carabajal-Márquez et al. (2018)    |
| **Acari**                 |       |                  |                       |                  |                                    |
| *Amblyomma dissimile* Koch, 1844 | Adult | Body surface | *C. durissus Linnaeus, 1758 | Guerrero | Paredes-León et al. (2008)        |
| *Argasidae sp.*           | Adult | Body surface | *C. triseriatus* | Chihuahua | Gatica-Colima et al. (2014)       |
| *Ixobioides sp.*          | Adult | Body surface | *C. triseriatus* | Ciudad de México | Paredes-León et al. (2008)        |
| *Ophionyssus natrix*      | Adult | Body surface | *C. durissus* | Ciudad de México | Paredes-León et al. (2008)        |
|                           |       |                  | *C. cereas cercobombus* Savage & Cliff, 1953 | Nuevo León | Rodríguez and Lazcano (1992)      |
|                           |       |                  | *C. lepidus* Kennicott, 1861 | Puebla | Paredes-León et al. (2008)        |
|                           |       |                  | *C. atrox Baird & Girard, 1853 |                  |                                    |
|                           |       |                  | *C. raus Cope, 1865* |                  |                                    |
| **Ornithodoros turicata* (Dugès, 1876) | Larva |                  | *C. michelli* | Baja California | Gutsche and Mutschmann (2011)      |
|                           |       |                  | *C. ruber Cope, 1892* |                  |                                    |
| **Crustacea**             |       |                  |                       |                  |                                    |
| *Porocephalus basiliscus* Riley & Self, 1979 | Adult |                  | *C. basiliscus* | Colima | Riley and Self (1979)             |
| *Porocephalus crotali* Humbolddt, 1812 | Adult |                  | *C. atrox* | Nuevo León | Pala and Julia (1983)             |
|                           |       |                  | *C. basiliscus* | Colima | Pala and Julia (1983)             |
|                           |       |                  | *C. catalinensis* Cliff, 1954 | Santa Catalina Island, Baja California Sur | Goldberg et al. (2003)         |
|                           |       |                  | *C. culminatus* Klauber, 1952 | Guerrero | Pala and Julia (1983)             |
|                           |       |                  | *C. durissus* | Tamaulipas | Pala and Julia (1983)             |
|                           |       |                  | *C. tzabcan* | Campeche, Quintana Roo | Carabajal-Márquez et al. (2018) |
| *Porocephalus tortugensis* Riley and Self, 1979 | Adult |                  | *C. tortugensis* Van Denburgh & Slevin, 1921 | Tortuga Island-Baja California Sur | Riley and Self (1979)         |
| *railletii crotalii* Ali, Riley and Self, 1984 | Adult | Lung | *C. ruber* | Pond Island, Baja California | Ali et al. (1984)            |
| *railletii furcocercum* (Diesing, 1836) | Adult | Lung | *C. atrox tortugensis* Baird & Girard, 1853 | Tortuga Island-Baja California Sur | Ali et al. (1984), Klauber (1972) |
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