THERYA NOTES 2024, Vol. 5 : 157-161 DOI: 10.12933/therya_notes-24-164 ISSN 2954-3614

Helminths parasites of heteromyid rodents from semiarid regions of México

Helmintos parásitos de roedores heterómidos de regiones semiáridas de México

Jorge Falcón-Ordaz[1], Mitzi F. Aquino-Camacho[1], Karla Ladrón de Guevara-Barcenas[1], and Jesús A. Fernández[2]*

[1]Laboratorio de Morfología Animal, Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo. Ciudad del Conocimiento, km 4.5 carretera Pachuca-Tulancingo, C. P. 42181, Mineral de la Reforma. Hidalgo, México. E-mail: profe_7864@uaeh.edu.mx (JF-O); aq420254@uaeh.edu.mx (MFA-C); la333646@uaeh.edu.mx (KLG-B).

[2]Universidad Autónoma de Chihuahua. Francisco R. Almada km 1, C. P. 31453, Chihuahua. Chihuahua, México. E-mail: afernandez@uach.mx (JAF).

*Corresponding author

As part of an ongoing project to inventory parasitic helminths of heteromyid rodents in México, various semiarid localities in the country have been sampled since 2002, collecting specimens from the genera *Chaetodipus*, *Dipodomys*, *Heteromys* and *Perognathus*, obtaining a total of 19 helminth species (3 platyhelminthes and 16 nematodes). For the present study, rodent and parasite sampling was carried out during the years 2007, 2008, 2015 and 2017, collecting 60 specimens of the family Heteromyidae (*Chaetodipus* sp., *Dipodomys* sp., *D. merriami*, *D. ornatus*, *Heteromys irroratus* and *Perognathus flavus*) from different semi-arid regions located in the states of Chihuahua, Coahuila, Guanajuato, Hidalgo, México, Puebla and San Luis Potosí. Derived from the dissection of the collected rodents, a total of 11 taxa of helminths were found: 2 cestode species (*Hymenolepis* morphotype 1 and morphotype 2) and 9 nematode taxa (*Capillaria* cf. *americana*, *Heteromyoxyuris otomii*, *Physaloptera* sp., *Protospirura dipodomis*, *Pterygodermatites dipodomis*, *Syphacia* sp., *Trichuris* sp., *T. elatoris* and *Vexillata* sp.). The presence of parasites with a indirect life cycle (*e.g.*, *Hymenolepis* sp. and *Pt. dipodomis*) indicates that an insect species is part of the rodents diet. Seven of the 11 helminths found in this work coincide with those recorded in previous studies. Our results indicates that the biota of the semi-desert areas of México has elements of Nearctic affinity related it to southern United States of America.

Key words: Cestoda; geographic distribution; mammals; Nematoda; Rodentia.

Como parte de un proyecto en desarrollo para inventariar los helmintos parásitos de roedores heterómidos en México, se ha muestreado desde el año 2002 diversas localidades semiáridas del país, colectando los especímenes de los géneros *Chaetodipus*, *Dipodomys*, *Liomys* y *Perognathus,* obteniéndose un total de 19 helmintos (3 platelmintos y 16 nematodos). Para el presente estudio se llevaron a cabo muestreos de roedores y sus parásitos durante los años 2007, 2008, 2015 y 2017, recolectándose 60 especímenes de la familia Heteromyidae (*Chaetodipus* sp., *Dipodomys* sp., *D. merriami*, *D. phillipsii ornatus*, *Heteromys irroratus* y *Perognathus flavus*) de diferentes regiones semiáridas localizadas en los estados de Chihuahua, Coahuila, Guanajuato, Hidalgo, Estado de México, Puebla y San Luis Potosí. Derivado de la disección de los roedores recolectados se encontraron un total de 11 taxa de helmintos: 2 céstodos (*Hymenolepis* morfotipo 1 y morfotipo 2) y 9 nematodos (*Capillaria* cf. *americana*, *Heteromyoxyuris otomii*, *Physaloptera* sp., *Protospirura dipodomis*, *Pterygodermatites dipodomis*, *Syphacia* sp., *Trichuris* sp. *T. elatoris* y *Vexillata* sp.). La presencia de parásitos con ciclo de vida indirecto (*e. g.*, *Hymenolepis* sp. y *Pt. dipodomis*) nos indica que dentro de la alimentación de los roedores existe la presencia de un insecto. Siete de los 11 helmintos encontrados en este trabajo coinciden con los registrados en estudios previos mostrando que la biota de las áreas semidesérticas de México cuenta con elementos de afinidad Neártica que la relacionan con el sur de los Estados Unidos de América.

Palabras clave: Cestoda; distribución geográfica; mamíferos; Nematoda; Rodentia.

México has an area of 1,972,547 km^2, half of which consists of desert and semiarid regions. These areas cover most of the Baja California peninsula, large portions of the coastal plain and the low mountains of Sonora, nearly all of Coahuila and Nuevo León, part of Tamaulipas, and significant portions of Zacatecas, San Luis Potosí, the northeastern region of Guanajuato, Aguascalientes, and nearly all of Querétaro. Desert and semiarid regions are also found across parts of Hidalgo, Puebla, and a small portion of Oaxaca (Tarango 2005; Ceballos *et al.* 2014).

In México, 243 species of rodents have been recorded, 67 of which are found in the country's arid and semiarid zones (Ceballos *et al.* 2014). The most abundant family is Cricetidae, with 31 species, followed by Heteromyidae with 25 species, Sciuridae with 10 species, and Geomyidae with 2 species (Ceballos *et al.* 2014). México is the center of diversity for the Heteromyidae family, which is distributed in both the Nearctic and Neotropical zones. Many members of this family are adapted to arid and semiarid zones, with their highest diversity found in deserts. The

family comprises 5 genera (*Chaetodipus*, *Dipodomys*, *Heteromys*, *Microdipodops*, and *Perognathus*) and includes approximately 63 species, 36 of which are found in México, distributed across 4 genera (excluding *Microdipodops*). Of these, 25 species are recorded in arid and semiarid zones (Alexander and Riddle 2005; Ceballos *et al.* 2014; Fernández *et al.* 2014; IUCN 2023).

The study of parasitic helminths in rodents of the Heteromyidae family began in México in 1970 with the description of *Brachylaima bravoe*, a parasite of *Liomys* (now *Heteromys*) *pictus* from Chamela, Jalisco (Caballero-Deloya 1970). Since then, taxonomic studies have been conducted on parasitic helminths of this family, with a total of 31 helminth species recorded (2 Trematoda, 3 Cestoda, and 26 Nematoda). These include 15 species found in *Dipodomys*, 14 in *Heteromys*, 7 in *Chaetodipus*, and 4 in *Perognathus* (Preisser and Falcón-Ordaz 2019). The majority of the heteromyid helminth species (21 species) have been recorded in the desert and semi-desert areas of Durango, Guanajuato, Hidalgo, Puebla, San Luis Potosí, Tlaxcala, Veracruz, and Zacatecas (Lamothe-Argumedo *et al.* 2005; García-Prieto *et al.* 2008; Falcón-Ordaz *et al.* 2012; Martínez-Salazar *et al.* 2016; Iturbe-Morgado *et al.* 2017). Therefore, it is important to continue studying the biodiversity of helminths in this biological system. Here, we present an update on the diversity of helminth species found parasitizing heteromyid rodents distributed in the arid and semiarid areas of México.

In June 2007, July 2008, December 2015, and May, August, October, and December 2017, a total of 60 rodent specimens belonging to the family Heteromyidae were collected in 11 semiarid localities across Chihuahua, Coahuila, Guanajuato, Hidalgo, State of México, Puebla, and San Luis Potosí states in México (Table 1; Figure 1). Rodent capture and handling followed approved methods issued by the American Society of Mammalogists (Kelt *et al.* 2010; Sikes and the Animal Care and Use Committee of the American Society of Mammalogists 2016). Collection permits granted to J. A. Fernández (FAUT-036) were issued by SEMARNAT (Secretaría de Medio Ambiente y Recursos Naturales). The collected specimens were euthanized, and their viscera were preserved in 70 % alcohol or 4 % formalin until further examination. Cestodes and nematodes were stored in 70 % alcohol, with cestodes stained using Delafield's hematoxylin and mounted on slides in Canada balsam. Nematodes underwent morphological study using a mixture of glycerin and 70 % alcohol (2:1) for taxonomic identification.

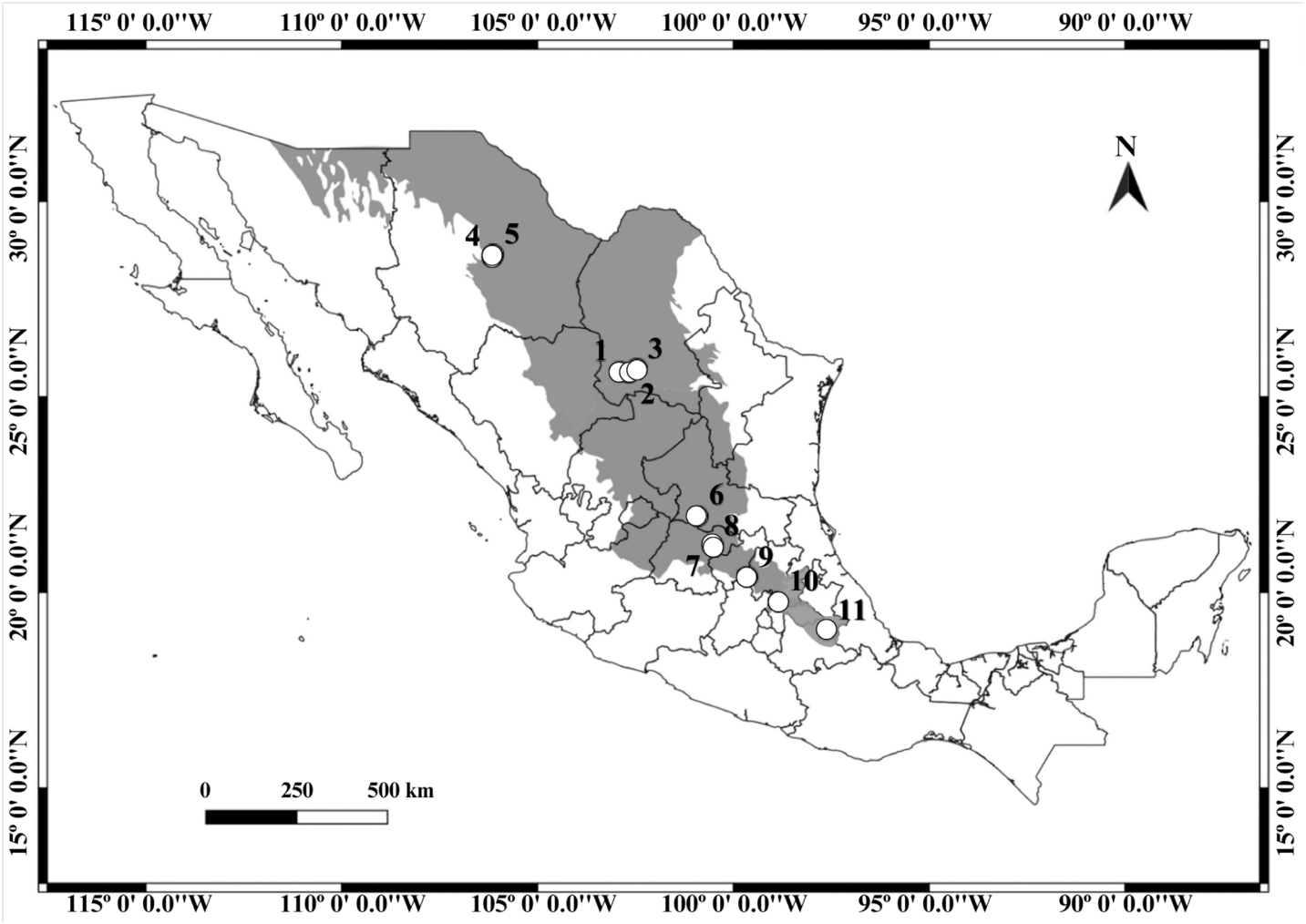

Figure 1. Map of semiarid areas of México (area shaded gray) showing the localities studied (codes in Table 1 in the Localities column).

Table 1. Localities in the arid and semiarid zones of México where rodents were collected for the helminth parasite survey. The characterization of the infection is also presented. The accession number of helminth in the Colección Nacional de Helmintos (CNHE) is show, n/d = not deposited. * Indirect life cycle; †Direct life cycle; ‡ Small and large intestine; § Stomach; || Intestinal cecum; # New host; ¶ New locality.

Phyllum	Family	Helminths collected (Intensity)	Host (Sample size of hosts/number of host infected).	Localities (numbers represent localities on Figure 1)	Prevalence %	Mean intensity	Abundance	CNHE
Platyelmintes	**Hymenolepididae**							
	Hymenolepis morphotype 1*‡#¶	1	*Heteromys irroratus* (3/1)	Cerro Gordo, Santiago Tolman, Mpio. Otumba, State of México (10)	33.33	1	0.33	n/d
	Hymenolepis morphotype 2*‡ #¶M232	5	*Heteromys irroratus* (3/1)	1 km. S Sta. Cruz Coyotepec, Mpio. San Juan Atenco, Puebla (11)	33.3	5	1.66	n/d
	Capillaridae							
	Capillaria cf. *americana* † ||#¶	5	*Dipodomys phillipsii ornatus* (2/1)	2.5 km al SE de Mineral De Pozos, Mpio. Mineral De Pozos, Guanajuato (7)	50	1	2.5	11804
	Oxyuridae							
	Syphacia sp. † ||#¶	122	*Dipodomys merriami* (6/1)	4.6 km S Ejido Mayran, Mpio. San Pedro de las Colonias, Coahuila (1)	16.66	122	20.33	n/d
	Heteromyoxyuris otomii † ||¶	115	*Perognathus flavus* (3/3)	12.6 km al SE de Mineral De Pozos, Cuarto Blanco, Mpio. Dr. Mora, Guanajuato (8)	100	38.33	38.33	n/d
	Ornithostrongylidae							
	Vexillata sp. †‡¶	137	*Heteromys irroratus* (3/1)	Ejido Gavillero, Mpio. Huichapan, Hidalgo (9)	33.33	137	45.66	n/d
	Rictularidae							
	Pterygodermatites dipodomis *‡¶	5	*Dipodomys merriami* (10/1)	Ejido 4 de Marzo, Mpio. Parras, Coahuila (2)	10	5	0.5	11796
	Spirocercidae							
	Protospirura dipodomis *§¶	2	*Dipodomys merriami* (6/2)	4.6 km S Ejido Mayran, Mpio. San Pedro de las Colonias, Coahuila (1)	33.33	1	0.33	11794
Nematoda		26	*Dipodomys merriami* (10/5)	Ejido 4 de Marzo, Mpio. Parras, Coahuila (2)	50	5.2	2.6	11795, 11798, 11799
		5	*Dipodomys merriami* (6/2)	5 km S Ejido Talia, Mpio. Parras, Coahuila (3)	33.33	2.5	0.83	11797
		12	*Dipodomys merriami* (2/2)	15km NE Villa de Reyes, Mpio. Villa de Reyes, San Luis Potosí (6)	100	6	6	11805
	Physaloptera sp. * § #¶M366	24	*Chaetodipus* sp. (2/1)	Granjas Universitarias, Chihuahua (4)	50	24	12	8198
	Trichuridae							
	Trichuris elatoris † || #¶M371	3	*Dipodomys* sp. (2/1)	Chihuahua, Chihuahua (5)	50	3	1.5	n/d
	Trichuris sp. † || #¶M381	8	*Dipodomys phillipsii ornatus* (2/1)	2.5 km al SE de Mineral De Pozos, Mpio. Mineral De Pozos, Guanajuato (7)	50	8	4	n/d

For scanning electron microscopy (SEM), 2 nematodes were dehydrated, critical-point dried, coated with a gold-palladium mixture (QUORUM Q150R), and examined with a Hitachi S-2460 N scanning electron microscope at 15 kV. The collected helminths were deposited in the Colección Nacional de Helmintos (CNHE) at the Instituto de Biología, UNAM, while mammal specimens (skin and skull) were deposited in the Colección de Mamíferos at the Facultad de Zootecnia and Ecología of the Universidad Autónoma de Chihuahua (UACH-M) and the Colección Nacional de Mamíferos (CNM), UNAM. Prevalence, intensity, and abundance values were calculated following the methodology of Bush *et al.* (1997).

Out of the 60 rodent specimens examined, 23 (38.33 %) were observed to be parasitized by helminths. A total of 470 worms were collected, representing 11 taxa of helminths from 2 phyla (Platyhelminthes and Nematoda), spanning 7 families (Hymenolepidae, Capillaridae, Oxyuridae, Ornithostrongylidae, Rictularidae, Spirocercidae, and Trichuridae (Table 1; Figure 2).

The highest species richness of parasites was observed in 2 rodent species, each harboring 3 species of helminths. *Heteromys irroratus* from Hidalgo, State of México, and Puebla was parasitized by 2 morphotypes of the genus *Hymenolepis*, and *Vexillata* sp.; meanwhile, *Dipodomys mer-*

riami, from 3 localities in Coahuila and 1 in San Luis Potosí, was found parasitized by *Protospirura dipodomis*, *Pterygodermatites dipodomis*, and *Syphacia* sp. In Guanajuato, 2 nematode taxa, *Capillaria* cf. *americana*, and *Trichuris* sp., were collected from *D. phillipsii ornatus*. Three additional species of rodents were found parasitized by 1 taxa of nematode each: *Chaetodipus* sp. with *Physaloptera* sp., *Dipodomys* sp. with *T. elatoris*, both rodents collected in Chihuahua; and *Perognathus flavus* from Guanajuato with *H. otomi*.

The species and genera that exhibited the highest abundance at a locality (Table 1) were *H. otommi*, *Syphacia* sp., and *Vexillata* sp. with 115, 122, and 137 individual worms, respectively. It is noteworthy that *Syphacia* sp. and *Vexillata* sp. were collected from a single individual rodent each, while *H. otomii* was found in all 3 *P. flavus* individuals collected. *Protospirura dipodomis* also displayed high abundance with 45 individual worms, distributed across 4 localities (3 in Coahuila and 1 in San Luis Potosí). Other species of helminths were less abundant and were only found in 1 individual rodent each (Table 1).

In this study, we identified 6 species of helminths with monoxenous (direct) life cycles and 5 species with heteroxenous (indirect) life cycles. The presence of the parasites with monoxenous cycles suggests that their transmission is a result of caecotrophy, a behavior observed in animals that consume feces (Iturbe-Morgado *et al.* 2017). On the other hand, the presence of parasites with indirect life cycles, such as *Hymenolepis* morphotypes 1 and 2, *P. dipodomis*, *Pt. dipodomis*, and *Physaloptera* sp., indicates the presence of intermediate hosts like beetles, cockroaches, crickets, or grasshoppers. This suggests that the rodents parasitized by helminths with indirect life cycles likely have a diet that

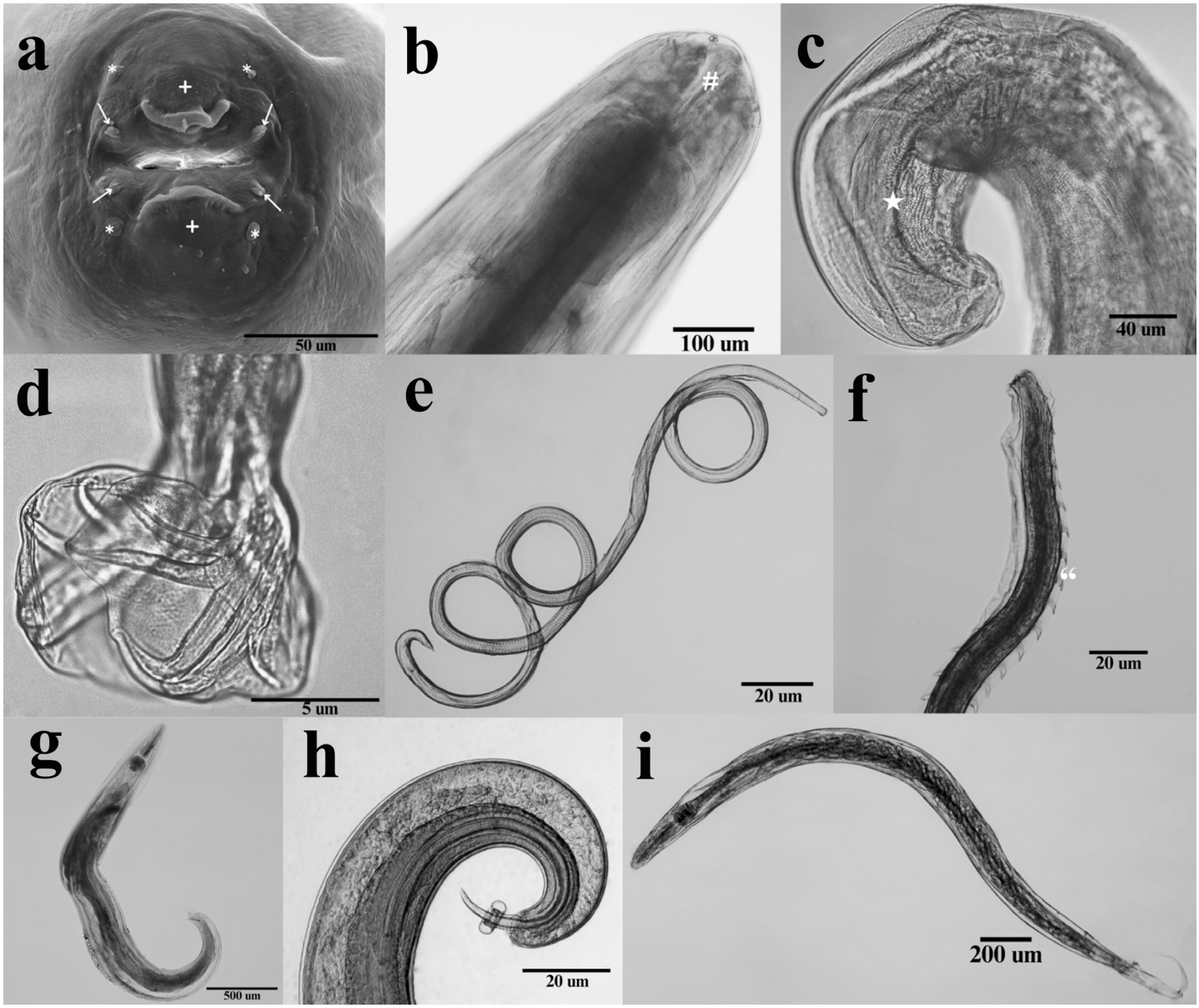

Figure 2. Some species of nematodes collected. a - c. Male of *Protospirura dipodomis*. a) Scanning electron micrograph. Oral opening in face view (→ teeth; + pseudolabium, * papilla). b) Anterior end with an oral cavity (#). c) Posterior end showing caudal papilla (☆). d - e) *Vexillata* sp. d) Male caudal bursa, lateral view. e) Female, whole worm. f) Male of *Pterygodermatites dipodomis* showing the combs in the anterior end (“). g) Male, whole worm of *Heteromyoxyuris otomi*i. h) Posterior end of male of *Trichuris elatoris* showing the spicule sheath. i). Female, whole worm of *Syphacia* sp.

includes insects (Decker *et al.* 2001; Fedynich *et al.* 2001; Iturbe-Morgado *et al.* 2017).

Preisser and Falcón-Ordaz (2019) have been the only authors to date compiling records of 19 parasitic helminths (3 platyhelminths and 16 nematodes) in rodents of the family Heteromyidae in the semiarid regions of México. Some of these helminths such as *H. longejector*, *Pt. dipodomis*, and *T. elatoris*, are distributed among several host species throughout this region, including rodent species belonging to the genera *Chaetodipus* and *Dipodomys*. This host distribution can potentially be explained by co-evolution by descent, indicating that their ancestors were associated with each other in the past, and species inherited this association (Falcón-Ordaz *et al.* 2012; Iturbe-Morgado *et al.* 2017).

Although most helminth species had previously been collected from various locations in the semi-desert areas of México (Table 1), all records in this study represent new locations, expanding the geographic distribution of all species. It is noteworthy that *Capillaria* cf. *americana* has been discovered for the first time in México, and the genus *Syphacia* is parasitizing a species of *Dipodomys* for the first time as well.

With this study, the species richness of helminths parasitizing rodents of the family Heteromyidae has expanded to include 3 platyhelminths and 20 nematode species, with *D. merriami* hosting 13 species, while *Chaetodipus* sp., *D. ornatus*, and *H. irroratus* have been recorded with 5 species each (Preisser and Falcón-Ordaz 2019). Based on the composition of the helminth biota found in this study and previous works, it is possible to infer that the semi-desert region of México shares elements of Nearctic affinity, particularly with southwestern United States (New Mexico and Texas), as indicated by the presence of *Hymenolepis* sp., *P. dipodomis*, *Pt. dipodomis*, and *Trichuris* sp. (Decker *et al.* 2001; Falcón-Ordaz *et al.* 2012).

Acknowledgements

We are grateful to B. Mendoza-Garfias for her assistance in processing samples for the SEM photographs in the Laboratorio de Microscopía y Fotografía de la Biodiversidad I (IB-UNAM) and L. Garcia-Prieto for loaning specimens of the CNHE (IB-CNHE). Thanks to the reviewers for their thoughtful comments that helped improve our manuscript.

Literature cited

Alexander, L. F., and B. R. Riddle. 2005. Phylogenetics of the new world rodent Family Heteromyidae. Journal of Mammalogy 86:366-379.

Bush, A. O., *et al.* 1997. Parasitology meets ecology on its own terms: Margolis *et al*. revisited. Journal of Parasitology 83:575-583.

Caballero-Deloya, J. 1970. Descripción de *Brachylaemus* (*Brachylaemus*) *bravoae* sp., nov., (Trematoda: Digenea) de roedores del Estado de Jalisco, México. Anales del Instituto de Biología, Universidad Nacional Autónoma de México 41:39-44.

Ceballos, G., *et al.* 2014. Diversity and Conservation. Pp. 1-44 *in* Mammals of Mexico (Ceballos, G., ed.). Johns Hopkins University Press. Baltimore, U.S.A.

Decker, K. H., D. W. Duszynski, and M. J. Patrick. 2001. Biotic and abiotic effects on endoparasites infecting *Dipodomys* and *Perognathus* species. Journal of Parasitology 87:300-307.

Falcón-Ordaz, J., *et al.* 2012. Helmintos y Sifonápteros Parásitos de Cinco Especies de Roedores en Localidades de la Cuenca Oriental, en el Centro de México. Acta Zoológica Mexicana (nueva serie) 28:287-304.

Fedynich, A. M., T. Monasmith, and S. Demarais. 2001. Helminth community structure and pattern in Merriam's kangaroo rats, *Dipodomys merriami* Mearns, from the Chihuahuan Desert of New Mexico, U.S.A. Comparative Parasitology 68:116-121.

Fernández, J. A., *et al.* 2014. Conservation status of rodents of the families Geomyidae and Heteromyidae of Mexico. Revista Mexicana de Biodiversidad 85:576-588.

García-Prieto, L., *et al.* 2008. A new species of *Heteromyoxyuris* (Nematoda: Oxyuridae), parasite of *Perognathus flavus* (Rodentia: Heteromyidae) from Mexico. Journal of Parasitology 94:860-865.

Iturbe-Morgado, J. C., *et al.* 2017. Nematofauna of rodents of the Families Heteromyidae and Cricetidae from the Mexican Plateau. Journal of Parasitology 103:127-131.

International Union for Conservation Nature (IUCN). 2023. IUCN Red List categories IUCN. https://www.iucnredlist.org. Accessed on November 20, 2023.

Kelt, D. A., M. S. Hafner, and the American Society of Mammalogists' ad hoc committee for guidelines on handling rodents in the field. 2010. Updated guidelines for protection of mammalogists and wildlife researchers from hantavirus pulmonary syndrome (hps). Journal of Mammalogy 91:1524-1527.

Lamothe-Argumedo, A., R., *et al.* 2005. A New Dicrocoeliid (Digenea: Dicrocoeliinae) Parasite of Rodents from Tlaxcala, Mexico. Journal of Parasitology 91:1410-1412.

Martínez-Salazar E. A., *et al.* 2016. Helminths parasites of some rodents (Cricetidae, Heteromyidae, and Sciuridae) from Zacatecas, Mexico. Revista Mexicana de Biodiversidad 87:1203-1211.

Preisser, W. C., and J. Falcón-Ordaz. 2019. A checklist of the parasitic helminths of cricetid and heteromyid rodents in Mexico. Therya 10:329-341.

Sikes, R. S., and The animal care and use committee of the American Society of Mammalogists. 2016. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92:235-253.

Tarango, A. L. A. 2005. Problemática y alternativas de desarrollo de las zonas áridas y semiáridas de México. Revista Chapingo Serie Zonas Áridas 6:17-21.

Associated editor: Romeo A. Saldaña Vázquez.
Submitted: January 22, 2024; Reviewed: June 10, 2024.
Accepted: June 11, 2024; Published on line: June 19, 2024.