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Phoretic relationship between rodents and pseudoscorpions (Arachnida) in Chiapas, México

Relación forética entre roedores y pseudoescorpiones (Arachnida) en Chiapas, México

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Phoresy is defined as a non-parasitic association between an animal of small body size (phoront) and a large one (dispersal host), where the larger individual transports the smaller one. Rodents are frequently reported as dispersal hosts, of which 39 species are phoretic on 21 species of pseudoscorpion. The present note reports the incidental finding of the relationship between rodents and pseudoscorpions in 2 localities in Chiapas, México. Rodents were collected using Sherman live traps in an evergreen tropical forest at Ocuilapa de Juárez, municipality of Ocozocoautla, Chiapas, México. Pseudoscorpions were removed from the rodents using fine-tipped tweezers, stored in vials with 70 % alcohol, and processed for taxonomic identification. Five *Epichernes navarroi* pseudoscorpions were found associated with 2 species of rodents: *Peromyscus mexicanus* and *Heteromys desmarestianus*. Three pseudoscorpions were found with their chelae clamped to the hair near the base of the tail of *P. mexicanus* and 2 attached to the hair of the left hind leg of *H. desmarestianus*. All recorded arachnids were females; 3 had a newly formed brood sac containing 23 to 25 eggs each. There is an active phoretic relationship between *Epichernes* and the genera *Heteromys* and *Peromyscus*, probably due to their overlapping distribution ranges. This association is likely established in the nest of rodents. This work is the first to record the phoretic relationship between *P. mexicanus*, *H. desmarestianus*, and *E. navarroi*; besides, it is the first time that this pseudoscorpion species is reported for Chiapas, thus broadening its known distribution range in southeastern México.

Key words: *Epichernes*; *Heteromys*; new records; *Peromyscus*; phoresy.

La foresia se define como una asociación no parasítica entre un animal de pequeño tamaño corporal (foronte) y uno grande (hospedero dispersor), cuyo objetivo es el transporte del individuo pequeño por el grande. Los roedores han sido frecuentemente reportados como hospederos dispersores, de los cuales 39 especies están foréticamente asociadas a 21 especies de pseudoescorpiones. La presente nota, reporta el hallazgo casual de la relación entre roedores y pseudoescorpiones en 2 localidades en Chiapas, México. Los roedores fueron colectados usando trampas Sherman en selva alta perennifolia de Ocuilapa de Juárez, Municipio de Ocozocoautla en Chiapas, México. Posteriormente, los pseudoescorpiones fueron retirados de los roedores mediante pinzas de punta fina, almacenados en viales con alcohol al 70 % y procesados para su determinación taxonómica. Se encontraron 5 pseudoescorpiones de la especie *Epichernes navarroi*, asociados a 2 especies de roedores: *Peromyscus mexicanus* y *Heteromys desmarestianus*. En *P. mexicanus* se encontraron a 3 pseudoescorpiones sujetándose con sus quelas al pelo cerca de la base de la cola y en *H. desmarestianus* a 2 pseudoescorpiones sujetándose al pelo de la pata trasera izquierda. Todos los arácnidos encontrados fueron hembras, 3 de las cuales presentaban un saco de crianza de reciente formación, cada uno con 23 a 25 huevos. Existe una relación de foresis activa entre los géneros *Heteromys* y *Peromyscus* con *Epichernes*, la cual probablemente se deba al sobrelapamiento de sus distribuciones. Esta asociación posiblemente se establece en el nido del roedor. Se registra por primera vez a *P. mexicanus* y a *H. desmarestianus* asociados foréticamente con *E. navarroi*; asimismo, es la primera vez que se reporta esta especie de pseudoescorpión para Chiapas, por lo que se incrementa su distribución conocida al sureste de México.

Palabras clave: *Epichernes*; foresia; *Heteromys*; nuevos registros; *Peromyscus*.

In nature, species interact through a wide variety of symbiotic relationships, ranging from predation to mutualism (Goater *et al.* 2014). These include a non-permanent relationship known as phoresy or phoresis, defined as the association between a small animal (phoront) and a large one (dispersal host; Farish and Axtell 1971). The purpose of this interaction is the transportation or dispersal of the phoront to reach new habitats, establish new colonies, and reproduce (Vachon 1940; Farish and Axtell 1971). There are two types of phoresy: active, when the phoront clings or attaches to the body of the host through specialized structures such as chelicerae or claws, and passive, when the phoront places itself under or within a structure or cavity of the host (Vachon 1940; Athias-Binche 1994).

The most common dispersal hosts are arthropods, birds, and mammals (Bartlow and Agosta 2021). Among mammals, rodents have frequently been reported as dispersal hosts of mites, fleas, lice, beetles, moths, and pseudoscorpions (Bartlow and Agosta 2021). The order Pseudoscorpiones includes 4,026 species worldwide (WPC 2022); although the majority are free-living, members of the family Chernetidae are phoronts of rodents (Muchmore 1990b; Muchmore 1992; Villegas-Guzmán and Hernández-Betancourt 2006). In this interaction, rodents provide pseudoscorpions with a temporary habitat and a means of dispersal to reach sites with favorable conditions for their survival and reproduction (Farish and Axtell 1971), while the fur of the rodent serves as a thermoregulated environment for these arthropods (Walter and Proctor 2013).

Pseudoscorpions are small arachnids (0.3–12 mm; Villarreal et al. 2019) who, in free life, inhabit different microhabitats in caves, riverbanks, and coastal environments: under rocks, bark, soil, leaf litter, and fallen logs, as well as in nests of birds and social insects and burrows of small mammals (Muchmore 1990a; Beccaloni 2009). Some also spend part of their life cycle on their dispersal hosts (Beccaloni 2009). The size of these arachnids limits their natural displacement, so they have established a phoretic interaction with rodents and insects (Muchmore 1990a, 1990b). Although they represent a significant proportion of all known arachnid species, studies on their natural history, ecology, and behavior are still scarce (de Araujo-Lira and Tizo-Pedrozo 2017). Little is known about the mechanisms that lead to establishing this symbiotic relationship with a suitable host (Bartlow and Agosta 2021); apparently, pseudoscorpions feed on ectoparasites and other arthropods present in rodent fur (Durden 1991).

The cryptic habits of pseudoscorpions limit their study in natural environments (de Araujo-Lira and Tizo-Pedrozo 2017). Currently, 21 species belonging to 5 genera have been recorded worldwide: *Chiridiochernes, Megachernes, Lasiochernes, Nudochernes*, and *Epichernes*, associated with 39 species of rodents (Beier 1948; Muchmore 1972; Muchmore and Hentschel 1982; Harvey *et al.* 2012). In México, 2 species of the genus *Epichernes* have been reported, namely *E. aztecus* and *E. navarroi*. These are associated with 6 species of rodents (Muchmore and Hentschel 1982; Muchmore 1990b; Villegas-Guzmán and Hernández-Betancourt 2006) and have been found in the north, center, and south of the country (Figure 1a; Table 1). In this study, 2 rodent species are reported for the first time as dispersal hosts of a pseudoscorpion species in Ocuilapa de Juárez, Chiapas, México.

The phoretic interaction in this study was observed in the surroundings of Ocuilapa de Juárez, Ocozocoautla de Espinosa municipality, Chiapas, México, 34 km NW of the state capital, Tuxtla Gutiérrez. Rodents were collected in patches of evergreen tropical forest at 2 localities: 1) 4.7 km NNE of Ocuilapa (16° 53′ 46″ N, 93° 24′ 17″ W), and 2) 5.16 km SSE of Ocuilapa (16° 49′ 17″ N, 93° 22′ 39″ W; Figure 1b), on 7 December 2019, and 6 March 2021. Rodents were collected using Sherman live traps baited with a mixture of oat flakes, peanut butter, and sunflower seeds (Cruz *et al.* 2010). Pseudoscorpions were removed from the rodents with tweezers and stored in vials with 70 % alcohol at room temperature.

The pseudoscorpions were processed following the technique by Wirth and Marston (1968), which consisted of clearing the specimens with 10 % potassium hydroxide, dehydrating, and dissecting them to observe and measure the legs, pedipalp, chelae, and chelicerae. Afterward, permanent slide mounts were prepared using Canada balsam. The species were identified using the key by Muchmore (1992). Additionally, a literature survey was conducted on rodent records as dispersal hosts of pseudoscorpions

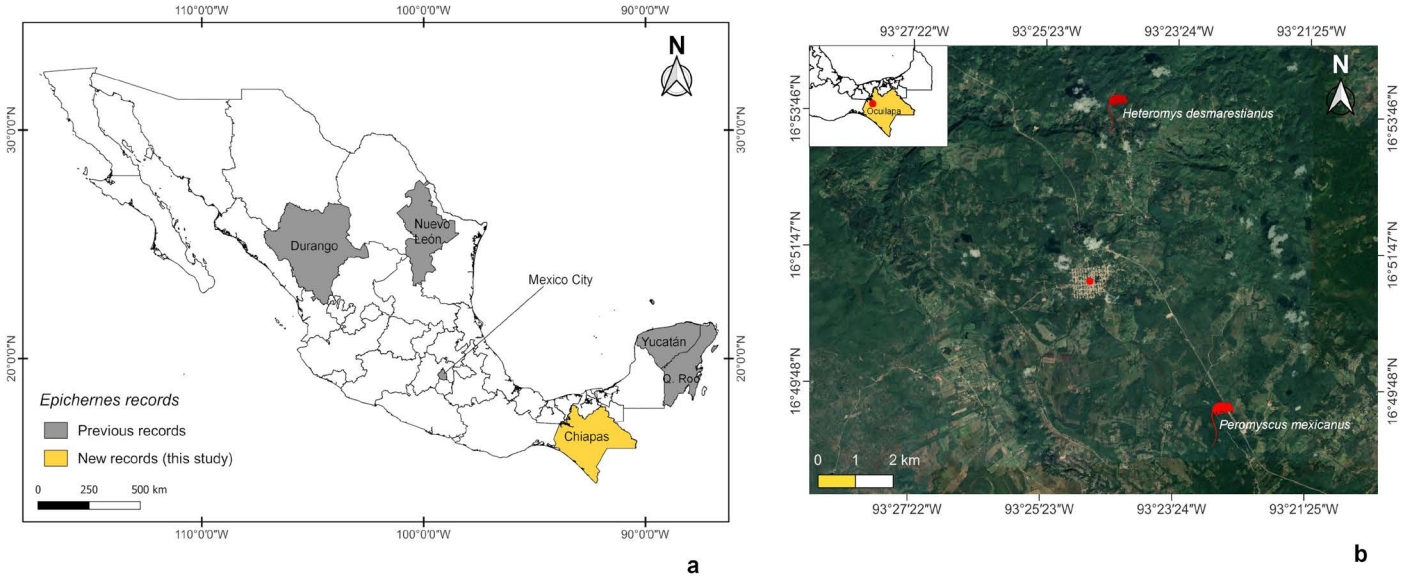

Figure 1. a) Previous records of phoretic interactions between rodents and pseudoscorpions of the genus *Epichernes* in México; b) sampling localities of rodents acting as dispersal hosts for pseudoscorpions in Ocuilapa (red dot), Chiapas, México.

of the genus *Epichernes* in México. Pseudoscorpions were deposited in the Acarology Collection of the Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, in México City. The rodents were identified using specialized keys (Álvarez-Castañeda *et al.* 2017) and deposited in the Mammal Collection of El Colegio de la Frontera Sur, San Cristóbal de Las Casas, Chiapas.

Five pseudoscorpion specimens were found on two rodent species: *Peromyscus mexicanus* (ECO-SCM 9867) and *Heteromys desmarestianus* (ECO-SCM 9510; Figure 2a, 2b). In *P. mexicanus*, pseudoscorpions had their chelae clamped to the hair near the base of the tail (Figure 2a); in *H. desmarestianus*, they were attached to the middle part of the hair of the left hind leg (Figure 2b). Three pseudoscorpions were

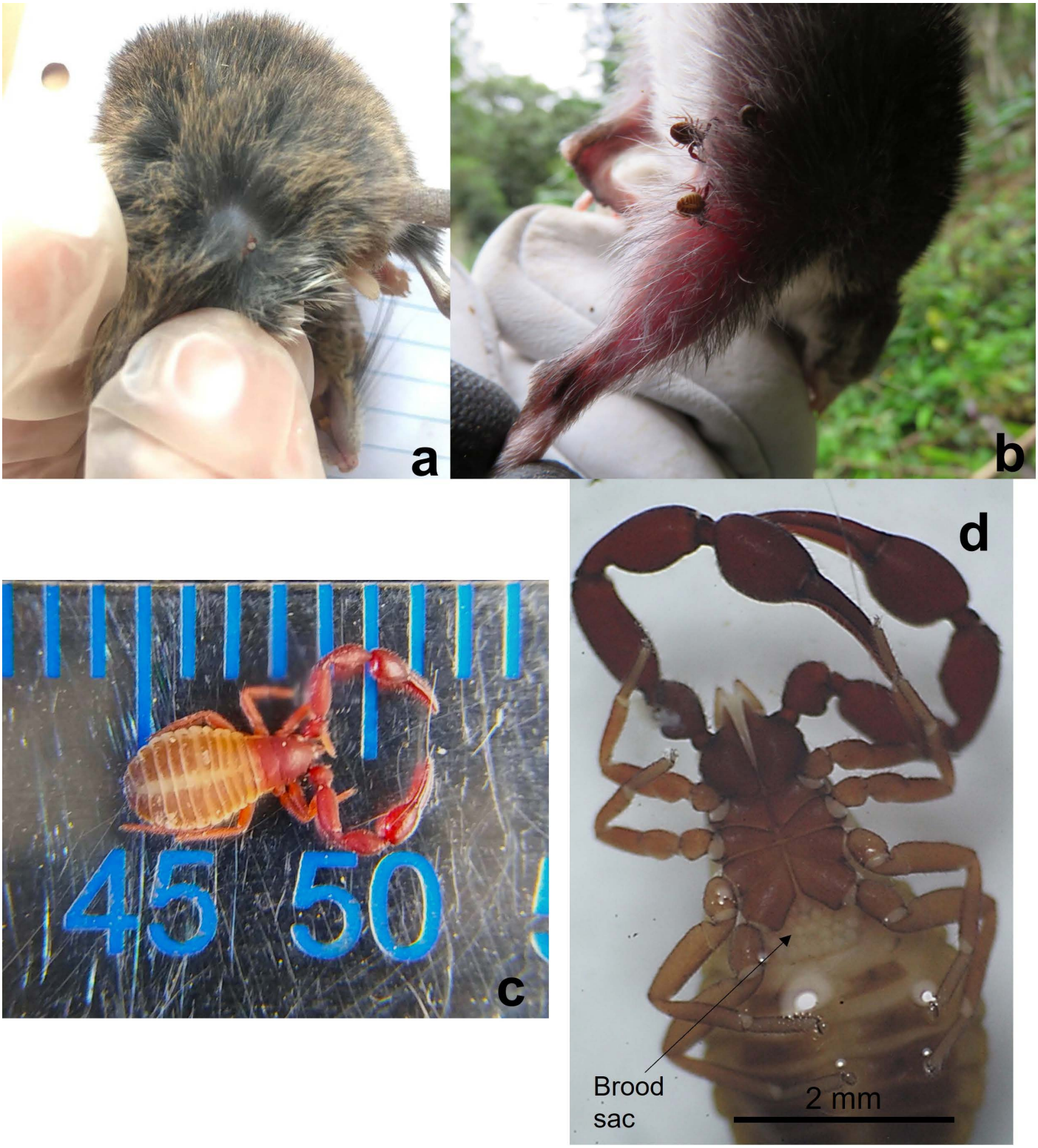

Figure 2. a) *Peromyscus mexicanus* transporting *Epichernes navarroi*; b) *Heteromys desmarestianus* transporting *E. navarroi*; c) female *E. navarroi* in dorsal view; d) female *E. navarroi* with the brood sac containing 25 eggs, collected in Ocuilapa, Chiapas, México. Photographs captured by G. Tapia-Ramírez (a), A. Hernández-Núñez (b, c), and G. Villegas-Guzmán (d).

Table 1. Rodent species recorded as dispersal hosts of pseudoscorpions of the genus *Epichernes* in México. The new records reported in this study are highlighted in *.

Rodent species	Pseudoscorpion species	Locality	References
*Heteromys desmarestianus**	*E. navarroi*	Ocuilapa, Chiapas*	This study*
H. gaumeri	*E. navarroi*	Felipe. Carrillo Puerto, Quintana Roo	Muchmore 1990b
	E. navarroi	Hobonil, Yucatán	Muchmore 1990b
H. irroratus	*E. aztecus*	San Josecito, Nuevo León	Villegas-Guzmán and Hernández-Betancourt 2006
H. pictus	*E. aztecus*	San Juan de Camarones, Durango	Villegas-Guzmán and Hernández-Betancourt 2006
	E. navarroi	San Juan de Camarones, Durango	Villegas-Guzmán and Hernández-Betancourt 2006
Neotomodon alstoni	*E. aztecus*	El Ajusco, México City	Muchmore and Henstchel 1982
*Peromyscus mexicanus**	*E. navarroi*	Ocuilapa, Chiapas*	This study*
P. yucatanicus	*E. navarroi*	Cancún, Quintana Roo	Muchmore 1990b

found on *P. mexicanus* (CAENCB-Psd 337-339) and two on *H. desmarestianus* (CAENCB-Psd 340-341). These arachnids belong to the species *Epichernes navarroi* (Chernetidae; Figure 2c), characterized by 6 to 7 setae on the cheliceral hand; galea with 5 to 6 rami, rallum with 4 denticulated blades; omega-shaped operculum; tubular spermathecae split in two in the anterior region, forming a "V"; tactile setae present on tarsus IV, with 7 to 16 external accessory teeth; length:width ratio of the palpal femur from 2.35 to 2.75 (Muchmore 1990b). All recorded specimens were females; 3 had newly formed brood sacs, each containing 23 to 25 eggs (Figure 2d).

Our results confirm the role of the genera *Peromyscus* and *Heteromys* as dispersal hosts of pseudoscorpions of the genus *Epichernes* in México. The rodent species most frequently reported as dispersal hosts are those of the genus *Heteromys*, with 4 species (Table 1). Therefore, a very close active phoretic relationship is suggested between *Peromyscus* and *Heteromys* with sympatric distributions (Muchmore 1990b, 1992; Villegas-Guzmán and Hernández-Betancourt 2006). Due to the wide distribution of *P. mexicanus* and *H. desmarestianus*, from México to Panamá, new records may be reported of *Epichernes* in Central America besides *Epichernes guanacastensis* whose dispersal host is *H. salvini* in Costa Rica (Muchmore 1992). Additional records of *P. mexicanus*, a common rodent in southern México, would be expected, even in anthropic ecosystems (Trujano-Álvarez and Álvarez-Castañeda 2010).

Although there is no data on when the pseudoscorpion-rodent phoresy is established, contact likely occurs in the burrows of rodents since it is there where the phoront and the dispersal host share the same habitat (Poinar *et al.* 1998). Additionally, the rodent nest provides the pseudoscorpion with food (mites, springtails, and fleas) and a suitable microhabitat to live in (Villegas-Guzmán and Pérez 2005). Thirty-two species of pseudoscorpions were found in the burrows of nine species of field mice of the genus *Neotoma* in the United States and México (Francke and Villegas-Guzmán 2006); these pseudoscorpions were not located on rats but in nests. In the literature, pseudoscorpions are considered nidiphilous, *i.e.*, organisms adapted to life in nests or burrows (Christophoryová *et al.* 2011).

Usually, it is females who perform phoresy. Pseudoscorpions reproduce in nests, and females leave the nest after forming the brood sac, where eggs develop until hatching. Females use the burrowing rodent as a dispersal host to seek better physical-environmental conditions for their offspring (Poinar *et al.* 1998).

Our results represent the first record of *P. mexicanus* and *H. desmarestianus* as dispersal hosts of *E. navarroi* in Chiapas. Also, the presence of this pseudoscorpion species is reported for the first time for the state, thus expanding its distribution range to southeastern México.

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