

NOTE

Occurrence of *Amblyomma dissimile* on wild crocodylians in southern Mexico

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ABSTRACT: Ticks are common ectoparasites of amphibians and reptiles but very few reports of such parasites on crocodylians exist worldwide. Herein, we report the first detailed observations of *Amblyomma dissimile* Koch, 1844 on the 3 crocodylian species present in Mexico, with the first report of tick parasitism on *Crocodylus acutus* and the second on *Caiman crocodilus chiapasius*. This is also the first report of *A. dissimile* in the state of Quintana Roo. Proportions of infested individuals found in this study ranged from 0.51 to 1.96%, suggesting that tick parasitism in crocodylians is likely opportunistic and occurs when individuals leave the water for terrestrial activities. Tick parasitism does not represent a major threat to crocodylians. The increasing habitat destruction/fragmentation and cattle expansion in southeastern Mexico, however, could increase tick populations and trigger tick parasitism and tick-borne diseases in herpetofauna and other vertebrates, including humans. Thus, studies are needed to better understand these relationships.

KEY WORDS: Tick · Ectoparasitism · Parasite · Spectacled caiman · American crocodile · Morelet's crocodile · *Caiman crocodilus* · *Crocodylus acutus* · *Crocodylus moreletii*

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INTRODUCTION

Ticks are common ectoparasites of reptiles and represent potential pathogens, since they cause anemia or toxicosis, and produce focal ulcerating lesions (Jacobson 2007). They can also be vectors in the transmission of infectious agents to humans and other animal species (Fitzgerald & Vera 2006, Bonnet et al. 2015). While there are numerous reports of tick species infesting Chelonia and Squamata, there are very few reports of tick parasitism on Crocodylia

(Huchzermeyer 2003, Jacobson 2007). Rainwater et al. (2001) and Huchzermeyer (2003) listed 8 records of ticks parasitizing crocodylians, particularly those of Crocodylidae (true crocodiles), but no reports from Alligatoridae or Gavialidae have been achieved. The most common tick genus found on crocodiles is *Amblyomma*; *A. dissimile* Koch, 1844 (Arachnida: Ixodida: Ixodidae) is the primary tick found on reptiles and amphibians in Central and South America, with occasional infestations in mammals (Burridge & Simmons 2003). This species is epidemiologically

important and could play a role in maintaining rickettsial reservoirs in reptile populations (Jongejan 1992, Miranda et al. 2012).

In Mexico, 3 crocodylian species occur: the American crocodile *Crocodylus acutus* Cuvier, 1807, Morelet's crocodile *C. moreletii* Duméril & Bibron, 1851 and spectacled caiman *Caiman crocodilus* Linnaeus, 1758 (the subspecies present in Mexico is *C. c. chiapasius*; Álvarez del Toro 1974). Few ectoparasites or epibionts of *C. acutus* have been reported from Mexico (but see Álvarez del Toro 1974, Cupul-Magaña & Cortés-Lara 2005, Cupul-Magaña et al. 2011, García-Grajales & Buenrostro-Silva 2011, Escobedo-Galván et al. 2012, Charruau & González-Muñoz 2016), and none for *C. moreletii* or *C. c. chiapasius*. Furthermore, only Álvarez del Toro (1974) reported a case of tick parasitism on crocodiles (*C. acutus*) in Mexico, but did not identify the tick species. Herein, we report the first detailed observations of *A. dissimile* on crocodylians of Mexico with the second and first reports of tick parasitism on *C. acutus* and *C. c. chiapasius*, respectively. We also undertook a bibliographic review of tick parasitism reported on crocodylians, and compared our proportions of parasitized individuals with those cited in the literature.

CASE REPORTS

All ticks were collected, preserved in 70% alcohol, and identified as adult male or female *Amblyomma dissimile*, using the taxonomic guide of Guzmán-Cornejo et al. (2011). Ticks were deposited in the parasite collection of El Colegio de la Frontera Sur

(ECOSUR), unidad Chetumal (ECOPa) or in the Colección Nacional de Ácaros of the Universidad Nacional Autónoma de México (CNAC-UNAM).

Case 1: *A. dissimile* and *Crocodylus moreletii*

On 17 August 2011, during a survey of *Crocodylus moreletii* in Chichankanab Lagoon (19° 50' 30" N, 88° 45' 1" W), municipality of José María Morelos, Quintana Roo, Mexico, we captured an adult female (total length [TL] = 152 cm). The crocodile was captured on land beside a small pond. While inspecting this crocodile, we observed an attached adult female tick on the dorsal part of the base of the tail (Fig. 1a). The tick was deposited in ECOPa. Only 1 (1.96%) of 51 captured *C. moreletii* at this study area presented tick parasitism.

Case 2: *A. dissimile* and *C. acutus*

On 27 September 2011, during a survey of *C. acutus* in Punta Sur Ecological Park (20° 16' 25" N, 86° 59' 22" W) on Cozumel Island, municipality of Cozumel, Quintana Roo, Mexico, we captured an adult female (TL = 211 cm) on land near the shore of a small pond. While inspecting the female for injuries and parasites we noticed the presence of an adult female tick attached to the soft tissue between scales on the ventral face of the left hind limb, at the tibial level (Fig. 1b). The tick was deposited in ECOPa. Only 1 (0.51%) of 197 captured *C. acutus* at this study area presented tick parasitism.

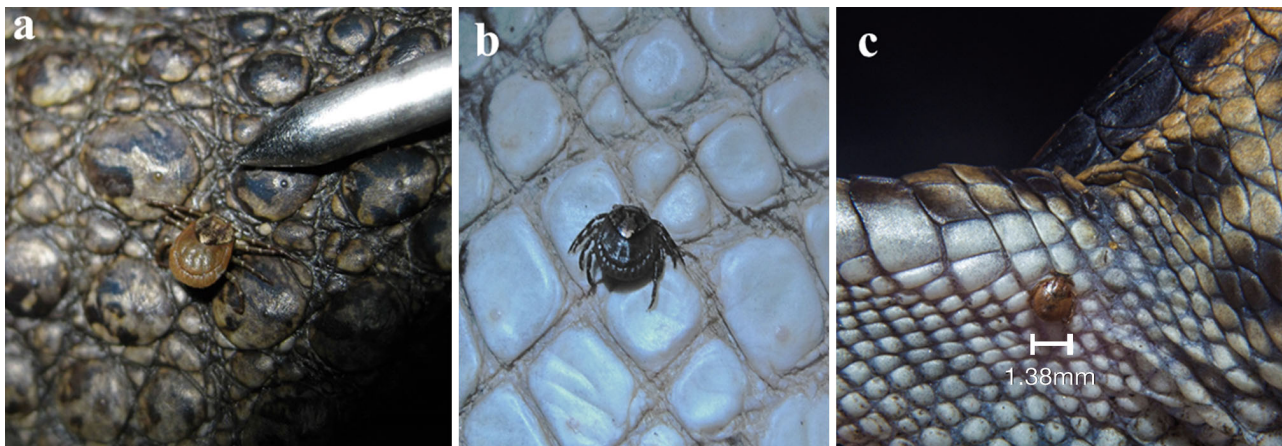


Fig. 1. Adult individuals of *Amblyomma dissimile* attached to the soft tissue between scales of (a) the dorsal part at the tail base of a Morelet's crocodile (Photo: J. R. Cedeño-Vázquez), (b) the left hind limb of an American crocodile (Photo: P. Charruau), and (c) the ventral face at the groin of the right hind limb of a neonate spectacled caiman (Photo: G. A. González-Desales)

Case 3: *A. dissimile* and *Caiman crocodilus chiapasius*

On 30 September 2014, during a nesting survey of *Caiman crocodilus chiapasius* at Isla La Concepción (15°4'6" N, 92°45'8" W), in La Encrucijada Biosphere Reserve, Chiapas, México, we captured 6 newly-born hatchlings and 1 female protecting them in a pond. Once captured and immobilized, individuals were inspected for injuries and parasites and we noted the presence of an adult male tick, attached to the soft tissue between scales of the ventral face of the groin alongside the right hind limb of a neonate (TL = 20.7 cm) (Fig. 1c). The tick was deposited in CNAC-UNAM. Only 1 (1.75%) of 57 captured caimans presented tick parasitism at this study site.

DISCUSSION

In Mexico, 8 tick species of the genus *Amblyomma* (*A. dissimile*, *A. rotundatum*, *A. sabanerae*, *A. elaphense*, *A. scutatum*, *A. auricularium*, *A. cajennense* [recently reclassified as *A. mixtum* in Mexico; Nava et al. 2014], and *A. maculatum*) have been reported parasitizing amphibians and reptiles, including toads (*Rhinella marina*), snakes (*Boa constrictor*, *Bogertophis subocularis*, *Spilotes pullatus*, *Crotalus durissus*), lizards (*Ctenosaura acanthura*, *C. similis*, *C. pectinata*,

Iguana iguana, *Phrynosoma* sp.) and turtles (*Terapene carolina*, *Rhinoclemmys pulcherrima*, *R. areolata*, *R. rubida*, *Kinosternon leucostomum*). *A. dissimile* has been found in the Mexican states of Campeche, Chiapas, Ciudad de Mexico (formerly known as Distrito Federal), Guerrero, Jalisco, Michoacán, Nayarit, Oaxaca, Tamaulipas, Veracruz, Tabasco, and Yucatán (Hoffmann 1962, Guzmán-Cornejo et al. 2011). It represents the most common tick species found on reptiles (Guzmán-Cornejo et al. 2011), and occurs in 77.7, 72.7 and 100% of the states in which *C. moreletii*, *C. acutus*, and *C. c. chiapasius* are present, respectively. This is the first record of *A. dissimile* in the state of Quintana Roo.

We found 17 studies reporting tick parasitism on crocodylians, involving 5 and 10 identified species of ticks and crocodylians, respectively (Table 1). In a few cases, ticks and crocodylians were only generically identified. Although tick parasitism has been reported on *C. crocodilus*, our record is the first for the subspecies *C. c. chiapasius* (Table 1). The sole previous report of a tick on *C. acutus* is that of Álvarez del Toro (1974), who mentioned the capture of a 150 cm crocodile infected with male and female ticks at different life stages. The author, however, did not identify the tick species. Thus, our study is the first report of *A. dissimile* parasitism on *C. acutus*. Finally, *A. dissimile* has been reported previously from *C. moreletii* in Belize (Rainwater et al. 2001) (Table 1).

Table 1. Tick species reported in crocodylians worldwide

Tick species	Crocodylian species	Reference(s)
<i>Amblyomma dissimile</i>	<i>Crocodylus moreletii</i>	Rainwater et al. (2001)
		This study
	<i>Crocodylus acutus</i>	This study
	<i>Caiman crocodilus</i>	Serra-Freire & Peralta (1993)
<i>Amblyomma rotundatum</i>		Pietzsch et al. (2006)
		Aitken et al. (1968)
	<i>Caiman crocodilus chiapasius</i>	This study
	<i>Paleosuchus palpebrosus</i>	Morais et al. (2010)
<i>Amblyomma grossum</i> (nomen dubium)	<i>Caiman yacare</i>	Peralta et al. (1995)
	Species not given	Soares de Almeida (2006)
<i>Amblyomma</i> sp.		Neumann (1899)
	<i>Crocodylus johnstoni</i>	Tucker (1995)
	<i>Crocodylus moreletii</i>	Rainwater et al. (2001)
	<i>Crocodylus intermedius</i>	Seijas (2007)
<i>Aponomma exornatum</i>		A. Seijas (pers. comm.)
	Species not given	Schwetzwitz (1927a,b)
	<i>Crocodylus niloticus</i>	Villiers (1955)
		Saratsiotis (1972)
<i>Aponomma flavomaculatum</i>		Matthysse & Colbo (1987)
	<i>Osteolaemus tetraspis</i>	Terenius et al. (2000)
	Species not given	Álvarez del Toro (1974)

The incidence of tick parasitism in crocodylian populations is very low. Proportions of infested individuals found in this study ranged from 0.51 to 1.96%, which are similar to those reported in other populations (range: 0.25 to 10.0%) (Table 2). These few cases of ticks parasitizing crocodylians suggest that no ticks are obligate ectoparasites of crocodylians (Tucker 1995, Huchzermeyer 2003). Tick infestation in crocodylians is likely opportunistic, occurring when individuals leave the water to engage in terrestrial activities (e.g. sun basking, nesting, land travel); ticks are likely lost when hosts return to the water. Ticks can transmit diseases to hosts and cause severe illness or death in people and animals (Díaz 2010, McCoy & Boulanger 2015). Even though crocodiles are very resistant and possess an extraordinary capacity to recover from severe injuries, they are not immune to the whole spectrum of pathogens, and are particularly vulnerable when adverse environmental conditions cause weakness and stress (Huchzermeyer 2003). The tick-infested American crocodile captured by Álvarez del Toro (1974) was very thin and ulcerated in the places where ticks were clustered. Although it is possible that these ticks were taking advantage of existing ulcers and not causing them, they are likely capable of affecting crocodile health. Furthermore, Álvarez del Toro (1974) suggested this case of parasitism was due to the presence of cattle in the area where the crocodile was captured. The role of crocodiles in the enzootic cycle of diseases transmitted by ticks is uncertain, but some species of lizards act as reservoir hosts of *Rickettsia helvetica*, a bacterium that causes fever and meningitis in humans (Fournier et al. 2000, Nilsson et al. 2010, Tjisse-Klasen et al. 2010). Although *A. dissimile* is a primary parasite of amphibians and reptiles (Burridge & Simmons 2003), it also parasitizes mammals and birds, and is known to transmit *Ehrlichia ruminantium* (*Rickettsiales*), a bacterium causing heartwater, a severe disease of cattle, goats, sheep, and other ungulates (Jongejan 1992, Guglielmo & Nava 2010, Scott & Durden 2015).

Although tick parasitism does not represent a major threat to crocodylians, increasing habitat destruction/fragmentation and expansion of cattle ranching in southeast Mexico could increase tick populations, and trigger tick-parasitism and tick-borne diseases in herpetofauna and other verte-

Table 2. Reported proportions of tick-infested individuals in wild crocodylian populations

Crocodylian species	Proportion of infested individuals	Reference(s)
<i>Caiman jacare</i>	1/129 (0.78%)	Soares de Almeida (2006)
<i>Caiman crocodilus chiapasius</i>	1/57 (1.75%)	This study
<i>Paleosuchus palpebrosus</i>	1/10 (10.0%)	Morais et al. (2010)
<i>Crocodylus intermedius</i>	3/199 (1.51%)	Seijas (2007)
<i>Crocodylus acutus</i>	1/197 (0.51%)	This study
<i>Crocodylus moreletii</i>	1/51 (1.96%)	This study
	2/795 (0.25%)	Rainwater et al. (2001) T. Rainwater (pers. comm.)

brates, including humans. Further studies are required to understand these relationships.

Note added in proof: In addition to the information given in Table 2, Rodríguez-Vivas et al. (2016) also recorded ticks *Amblyomma mixtum* (1 female) and *Amblyomma rotundatum* (1 female) on *Crocodylus acutus* from Tizimin municipality of Yucatan State, Mexico.

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LITERATURE CITED

- Aitken THG, Worth CB, Jonkers AH, Tikasingh ES, Downs WG (1968) Arbovirus studies in Bush Bush Forest, Trinidad, WI, September 1959 – December 1964: II. Field program and techniques. *Am J Trop Med Hyg* 17: 237–252
- Álvarez del Toro M (1974) Los Crocodylia de Mexico. Instituto Mexicano de Recursos Naturales Renovables, México, DF
- Bonnet S, George JC, Boulanger N (2015) L'interface tique-hôte et la transmission des pathogènes. In: McCoy KD, Boulanger N (eds) *Tiques et maladies à tiques biologie, écologie évolutive, épidémiologie*. Institut de Recherche pour le Développement, Marseille, p 165–191
- Burridge MJ, Simmons LA (2003) Exotic ticks introduced into the United States on imported reptiles from 1962 to 2001 and their potential roles in international dissemination of diseases. *Vet Parasitol* 113:289–320
- Charruau P, González-Muñoz R (2016) Epibiont sea anemones inhabiting the American crocodile *Crocodylus acutus*. *Mar Biodiv* 46:11–12
- Cupul-Magaña FG, Cortés-Lara MC (2005) Primer registro de epibiontes en ejemplares juveniles de *Crocodylus*

- acutus* en el medio silvestre. *Caldasia* 27:147–149
- Cupul-Magaña FG, Rubio-Delgado A, Escobedo-Galván AH, Reyes-Núñez C (2011) First report of the marine barnacles *Lepas anatifera* and *Chelonibia testudinaria* as epibionts on American crocodile (*Crocodylus acutus*). *Herpetol Notes* 4:213–214
- Díaz JH (2010) Ticks, including tick paralysis. In: Mandell GL, Bennett JE, Dolin R (eds) *Mandell, Douglas, and Bennett's principles and practice of infectious diseases*. Elsevier, Philadelphia, PA, p 3649–3662
- Escobedo-Galván AH, Gaviño-Rodríguez JH, Reyes-Herrera EA, Quijano-Scheggia SI, García-García M (2012) Occurrence of *Amphibalanus amphitrite* (Darwin, 1854) (Cirripedia, Balanidae) on *Crocodylus acutus* (Reptilia, Crocodylia) in Colima, Mexico. *Crustaceana* 85: 1145–1148
- Fitzgerald KT, Vera R (2006) Acariasis. In: Mader DR (ed) *Reptile medicine and surgery*, 2nd edn. Elsevier, St. Louis, MO, p 720–738
- Fournier PE, Grunnenberger F, Jaulhac B, Gastinger G, Raoult D (2000) Evidence of *Rickettsia helvetica* infection in humans, eastern France. *Emerg Infect Dis* 6:389–392
- García-Grajales J, Buenrostro-Silva A (2011) Infestación y distribución corporal de sanguijuelas en el cocodrilo Americano (*Crocodylus acutus* Cuvier 1807) (Reptilia: Crocodylidae) del estero La Ventanilla, Oaxaca, México. *Acta Zool Mex* 27:565–575
- Guglielmone AA, Nava S (2010) Hosts of *Amblyomma dissimile* Koch, 1844 and *Amblyomma rotundatum* Koch, 1844 (Acari: Ixodidae). *Zootaxa* 2541:27–49
- Guzmán-Cornejo C, Robbins RG, Guglielmone AA, Montiel-Parra G, Pérez TM (2011) The *Amblyomma* (Acari: Ixodida: Ixodidae) of Mexico: identification keys, distribution and hosts. *Zootaxa* 2998:16–38
- Hoffmann A (1962) Monografía de los Ixodoidea de Mexico: Parte I. *Rev Soc Mex Hist Nat* 23:191–308
- Huchzermeyer FW (2003) *Crocodyles: biology, husbandry and diseases*. CABI Publishing, Wallingford
- Jacobson ER (2007) *Infectious diseases and pathology of reptiles: color atlas and text*. CRC Press, Boca Raton, FL
- Jongejan F (1992) Experimental transmission of *Cowdria ruminantium* (*Rickettsiales*) by the American reptile tick *Amblyomma dissimile* Koch, 1844. *Exp Appl Acarol* 15: 117–121
- Matthysse JG, Colbo MH (1987) *The ixodid ticks of Uganda*. Entomological Society of America, College Park, MD
- McCoy KD, Boulanger N (2015) *Tiques et maladies à tiques biologie, écologie évolutive, épidémiologie*. Institut de Recherche pour le Développement, Marseille
- Miranda J, Portillo A, Oteo JA, Mattar S (2012) *Rickettsia* sp. strain colombianensis (*Rickettsiales: Rickettsiaceae*): a new proposed *Rickettsia* detected in *Amblyomma dissimile* (Acari: Ixodidae) from iguanas and free-living larvae ticks from vegetation. *J Med Entomol* 49:960–965
- Morais DH, Strüssmann C, de Carvalho VT, Kawashita-Ribeiro RA (2010) First record of *Amblyomma rotundatum* Koch, 1844 (Acari: Ixodidae) parasitizing *Paleosuchus palpebrosus* Cuvier, 1807 (Reptilia: Crocodylidae), in the western border of Pantanal, Mato Grosso do Sul, Brazil. *Herpetol Notes* 3:133
- Nava S, Beati L, Labruna MB, Cáceres AG, Mangold AJ, Guglielmone AA (2014) Reassessment of the taxonomic status of *Amblyomma cajennense* (Fabricius, 1787) with the description of three new species, *Amblyomma tonelliae* n. sp., *Amblyomma interandinum* n. sp. and *Amblyomma patinoi* n. sp., and reinstatement of *Amblyomma mixtum* Koch, 1844, and *Amblyomma sculptum* Berlese, 1888 (Ixodida: Ixodidae). *Ticks Tick Borne Dis* 5:252–276
- Neumann LG (1899) Révision de la famille des ixodidés (3^e mémoire). *Mém Soc Zool France* 12:107–294
- Nilsson K, Elfving K, Pahlson C (2010) *Rickettsia helvetica* in patient with meningitis, Sweden, 2006. *Emerg Infect Dis* 16:490–492
- Peralta ASL, Amorim M, Gazeta GS, Serra-Freire NM (1995) Jacaré coroa e iguana: dois novos hospedeiros para *Amblyomma rotundatum* no Parque do MPEG. In: Congresso da Sociedade de Zoológicos do Brasil 19. Anais da Sociedade de Zoológicos do Brasil, Foz do Iguaçu, p 20
- Pietzsch M, Quest R, Hillyard PD, Medlock JM, Leach S (2006) Importation of exotic ticks into the United Kingdom via international trade in reptiles. *Exp Appl Acarol* 38:59–65
- Rainwater TR, Platt SG, Robbins RG, McMurry ST (2001) Ticks from a Morelet's crocodile in Belize. *J Wildl Dis* 37: 836–839
- Rodríguez-Vivas RI, Apanaskevich DA, Ojeda-Chi MM, Trinidad-Martínez I, Reyes-Novelo E, Esteve-Gassent MD, Pérez de León AA (2016) Ticks collected from humans, domestic animals, and wildlife in Yucatan, Mexico. *Vet Parasitol* 215:106–113
- Saratsiotis A (1972) Contribution à l'étude morphologique et biologique du genre *Aponomma* Neumann, 1899 (Acariens: Ixodidae). *Acarologia* 13:476–495
- Schwetz J (1927a) Contribution à l'étude des Ixodidae (tiques) du Congo belge (d'après les collections du Musée Royal d'Histoire Naturelle de Bruxelles) (deuxième note). *Rev Zool Afr* 15:73–80
- Schwetz J (1927b) Études et notes d'entomologie médicale sur le Katanga (élevage, tsé-tsé, tiques et moustiques). In: Comité Spécial du Katanga, Office de Publicité, Brussels, p 117–124
- Scott JD, Durden LA (2015) *Amblyomma dissimile* Koch (Acari: Ixodidae) parasitizes bird captured in Canada. *Syst Appl Acarol* 20:854–860
- Seijas AE (2007) Heridas y parásitos en cocodrilos del Orinoco (*Crocodylus intermedius*) en un río altamente impactado por actividades humanas. *Interciencia* 32: 56–60
- Serra-Freire NM, Peralta ASL (1993) Primeiro registro do parasitismo do *Caiman crocodilus crocodilus* por *Amblyomma dissimile* no Brasil. *Rev Bras Parasitol Vet* 2: 105–108
- Soares de Almeida R (2006) *Trypanosoma* sp. (Protozoa: Kinetoplastida), em *Caiman yacare* (Crocodylia: Alligatoridae), no Pantanal de Mato Grosso do Sul – Região Miranda Abobral. MSc thesis, Universidade Federal de Mato Grosso do Sul, Campo Grande
- Terenius O, Mejlon HA, Jaenson TGT (2000) New and earlier records of ticks (Acari: Ixodidae, Argasidae) from Guinea-Bissau. *J Med Entomol* 37:973–976
- Tijssen-Klasen E, Fonville M, Reimerink JHJ, Spitzen-van der Sluijs A, Sprong H (2010) Role of sand lizards in the ecology of Lyme and other tick-borne diseases in the Netherlands. *Parasit Vectors* 3:42
- Tucker AD (1995) First record of parasitism by a tick on an Australian freshwater crocodile. *Mem Queensl Mus* 38: 686
- Villiers A (1955) Note sur quelques Ixodidae et Gramasidae parasites de vertébrés rencontrés en Afrique Occidentale Française. *Bull Inst Fr Afr Noire Série A* 17:444–454