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Article

Wild carnivores (Mammalia) as hosts for ticks (Ixodida) in Panama

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Abstract

This study reports ticks collected from wild carnivores from different habitat types in Panama. We examined 94 individual wild carnivores and we found 87 parasitized by ticks: seven coyotes, six crab-eating foxes, 54 coatis, four raccoons, five ocelots, two pumas, two gray foxes, two skunks, and one each of kinkajou, jaguar, jaguaroundi, greater grison and tayra. We identified 13 species of tick: *Ornithodoros puertoricensis*, *Amblyomma auricularium*, *A. dissimile*, *A. mixtum*, *A. oblongoguttatum*, *A. ovale*, *A. parvum*, *A. pecarium*, *A. tapirellum*, *A. varium*, *Haemaphysalis juxtakochi*, *Ixodes affinis*, *Rhipicephalus sanguineus* s.l. and immatures of *Ixodes* and *Amblyomma*. *Amblyomma ovale* and *A. oblongoguttatum* were the most common species, found on nine and six carnivore species respectively. This is the first report of *A. oblongoguttatum* on *Puma yagouaroundi* and *Procyon lotor*; of *A. dissimile*, *A. pecarium*, *A. tapirellum* and *A. varium* on *Nasua narica*; and *A. auricularium* on *P. lotor*. Our data do not enable us to establish incidence of tick parasitism, but add valuable information to the current knowledge of the tick species that infest wild carnivores in Panama.

Key words: Ticks, wild carnivores, environments, Panama, ticks-host associations

Introduction

Ticks comprise a group of blood-feeding mites that parasitize all classes of terrestrial vertebrates (Labruna *et al.* 2005). Around 188 species have been reported for the Neotropics (Guglielmone *et al.* 2003a, Labruna & Guglielmone 2009), 47 of which are known to occur in Panama (Fairchild *et al.* 1966). Because ticks cause serious economic losses in animal husbandry and have severe effects on human health, most studies focus on synanthropic ticks. As a result, the species that parasitize wild animals remain poorly studied, despite their importance for understanding tick ecology pathogen transmission dynamics (Durden & Keirans 1996, Szabó *et al.* 2003).

The difficulty of capturing wildlife is among the major drawbacks for establishing reliable host-parasitic relationships. This is especially true for wild carnivores, which are usually cryptic and elusive. Carnivores remain difficult to study despite the advent of new technologies, such as camera traps or GPS telemetry enabling the collection of substantial information about their behavior and ecology (Moreno 2006, Moreno *et al.* 2012). Wild carnivores are interesting in the context of parasite ecology, because many species have large home ranges and could be exposed to many species of ticks, depending on preferred habitats and preys (Labruna *et al.* 2005). In contrast to South America (Labruna *et al.* 2005, Martins *et al.* 2011), few studies have reported tick species parasitizing wild carnivores in Central America.

In Panama, Fairchild *et al.* (1966) listed 11 species of ticks that parasitize wild carnivores. Additional data on ticks parasitizing captive and road-killed carnivores were recently collected, including the firsts reports of ticks from Panamanian coyotes (*Canis latrans*) and crab-eating fox (*Cerdocyon thous*) (Bermúdez *et al.* 2013, Murgas *et al.* 2013). In this paper we present new data about ticks collected from wild carnivores in Panama, complementing the sparse information currently available.

Methods

From 2010 to 2014, ticks collected from wild carnivores from different environments throughout Panama were donated to the Instituto Conmemorativo Gorgas de Estudios de la Salud (ICGES) by wildlife researchers (see acknowledgments). We complemented the data with that presented in previous reports (Bermúdez *et al.* 2013, Murgas *et al.* 2013). Collected ticks were preserved in 70% ethanol, except for engorged immature and females, which were kept alive in a controlled environmental incubator (78% RH, 26°C).

Larvae from the engorged females and unfed larvae collected from the carnivores, were infested on naïve rabbits and guinea pigs to facilitate molting; later, nymphs obtained were infested again on rabbits to reach the adult stage. These adults, and the adults obtained from engorged nymphs from the carnivores, were used for morphological identification.

The taxonomic keys of Fairchild *et al.* (1966) were used for tick species identification; however, we followed the taxonomic criteria of Nava *et al.* (2014) for the *Amblyomma cajennense* species group. In addition, we identified 22 nymphs using DNA barcoding, by amplifying the 5´region of the COI mitochondrial gene using standard invertebrate primers (LCO1490 and HCO2198; Folmer *et al.* 1994). Sequences were compared with those belonging to adult ticks from Panama that were identified to species morphologically and whose sequences have been deposited in BOLD. Voucher specimens of each species were deposited in the Dr. Eustorgio Méndez Zoological Collection of ICGES or remain at the Smithsonian Tropical Research Institute (STRI).

Results and Discussion

Of the 95 individual carnivores examined in different habitat types, ticks parasitized 87, belonging 14 of the 22 species of wild carnivores present in Panama: three out of four species of wild canids, four of six species of felids, two of four species of mustelids, four of seven species of procyonids and the single species of Mephitidae (*Conepatus semistriatus*). The site characteristics where wild carnivores were examined are listed in Table 1.

A total of 13 tick species were collected, one Argasidae, *Ornithodoros puertoricensis*, and 12 Ixodidae, *Amblyomma auricularium*, *A. dissimile*, *A. mixtum*, *A. oblongoguttatum*, *A. ovale*, *A.* ci. *parvum*, *A. pecarium*, *A. tapirellum*, *A. varium*, *Haemaphysalis juxtakochi*, *Ixodes affinis*, and *Rhipicephalus sanguineus* s.l. In addition, many immatures of *Ixodes* and *Amblyomma* were collected. Adults of *A. oblongoguttatum*, *A. ovale*, *A. tapirellum* and *A. mixtum* were molted to the adult stage in the laboratory. In addition, by comparing DNA barcoding of adults morphologically identified and immatures it was possible to recognize nymphs of *A. oblongoguttatum*, *A. pecarium* and *A. tapirellum*. We also found engorged females of *A. ovale* and *A. oblongoguttatum* on different hosts, and a partially engorged *A. dissimile* female was collected from a coati. In addition, six mating pairs of *I. affinis* were collected from ocelots. Table 2 provides the number, stage and sex of ticks recorded from each host species.

TABLE 1. Habitat characteristics for sites where wild carnivores were examined for ticks in Panama.

FAMILY/Species	No.	Sites characteristics
CANIDAE		
Canis latrans	3	Pastures
	2	Road near secondary forest
	4	Road near pastures
Cerdocyon thous	2	Road near pasture
	4	Road near secondary forest
Urocyon cinereoargenteus	2	Road near rural areas
	2	Rural areas
FELIDAE		
Leopardus pardalis	5	Primary rain forest
	1	Road near secondary forest
Panthera onca	1	Primary rain forest
Puma concolor	2	Primary rain forest
Puma yagouaroundi	2	Road near pasture
MUSTELIDAE		
EyraBarbara	1	Primary rain forest
Galictis vittata	1	Road near secondary forest
MEPHITIDAE		
Conepatus semistriatus	2	Road near secondary forest
	1	Secondary rain forest
PROCYONIDAE		
Nasua narica	2	Road near secondary forest
	2	Road near primary rain forest
	2	Secondary rain forest
	48	Primary rain forest
Procyon lotor	3	Rural areas
Procyon sp	1	Near secondary rain forest
Potos flavus	1	Rural area
	1	Primary rain forest

Various factors can influence a host's level of parasitism by ticks. Each wild carnivore species has different activity patterns and behavior such as foraging (including hunting), reproduction, resting and grooming. Some species of mustelids and felids avoid human presence, while other species (e.g. coyotes and raccoons) have high tolerance to human activity (Sunquist & Sunquist 2002, Hunter 2012). Each tick species is adapted to thrive under specific environmental conditions (e.g. weather, microclimate and type of vegetation), which limits its distribution to specific habitat types, and also affects its ability to survive under new conditions or establish in new sites (Fairchild *et al.* 1966, Estrada-Peña *et al.* 2013). Furthermore, depending on the species and life stage, ticks have adopted different strategies for finding their hosts: some are endophilic (i.e. live in host burrows and nests), while others are exophilic (i.e. seek or wait for hosts on vegetation) (Walker *et al.* 2003).

TABLE2. Ticks recorded from carnivores in Panama.

HOST / Family Canidae	Prevalence (n/N=%)	TICKS	Frequency Ticks/host	Stages
Canis latrans	7/9=77.7	*Amblyomma mixtum*	1/9	4♂(1[a]), 3♀(1[a])
		Amblyomma oblongoguttatum	2/9	29♂, 16♀(2[b])
		Amblyomma ovale	5/9	5♂(1[a]), 5♀(1[b])
		Amblyomma parvum	2/9	3♂
		Haemaphysalis juxtakochi	1/9	3N
		Ornithodoros ci. *puertoricensis*	1/9	2L
Cerdocyon thous	6/6=100	*Amblyomma oblongoguttatum*	2/6	2♂(1[a])
		Amblyomma ovale	5/6	4♂, 3♀
		Amblyomma sp.	4/6	4L, 8N
		Haemaphysalis juxtakochi	1/6	2N
		Rhipicephalus sanguineus s.l.	1/6	2♂
Urocyon cinereoargenteus	2/4=100	*Amblyomma* ci. *Parvum*	1/4	1♂
		Rhipicephalus sanguineus s.l.	1/4	2♂
Family Felidae				
Leopardus pardalis	5/6=83.3	*Amblyomma ovale*	3/6	5♀, 7♂
		Ixodes affinis	4/6	12♂,8♀ (+6♀/♂[c])
Panthera onca	1/1=100	*Ixodes affinis*	1/1	1♂
		Amblyomma ovale	1/1	1♂
Puma concolor	2/2=100	*Amblyomma ovale*	2/2	1♀
Puma yagouaroundi	2/2=100	*Amblyomma oblongoguttatum*	1/2	1♀
		Rhipicephalus sanguineus s.l.	1/2	2♀
Family Mustelidae				
Eyra Barbara	1/1=100	*Amblyomma ovale*	1/1	1♀
		Amblyomma sp.	1/1	2L, 1N
Galictis vittata	1/1=100	*Amblyomma ovale*	1/1	1♂
Family Mephitidae				
Conepatus semistriatus	2/3=66	*Amblyomma* sp	1/3	2L
		Ixodes sp.	1/3	1L
Family Procyonidae				
Nasua narica	54/54=100	*Amblyomma dissimile*	1/54	1♀[b]
		Amblyomma varium	1/54	1♀
		Amblyomma oblongoguttatum	8/54	7♂, 5♀(1[b]), 1N[d]
		Amblyomma ovale	19/54	62♂(3[a]), 71♀
		Amblyomma pecarium	6/54	6N[d]
		Amblyomma tapirellum	14/54	1♂, 15 N[d]
		Amblyomma sp	43/54	302L, 83N
Procyon sp	1/1=100	*Amblyomma mixtum*	1/1	1♂[a]
		Amblyomma oblongoguttatum	1/1	2♀[a]
Procyon lotor	3/3=100	*Amblyomma auricularium*	1/3	1♂[a]
		Amblyomma oblongoguttatum	1/3	1♀(1[b])
		Amblyomma ovale	2/3	3♀(1[a]), 2♂(1[a])
		Amblyomma tapirellum	1/3	♀[a]
Potos flavus	1/2=50	*Amblyomma* sp.	1/2	3L

[a]Molted in laboratory.
[b]Engorged and partially engorged females.
[c]In mating.
[d] Identified by DNA barcoding.

Rhipicephalus sanguineus s.l. and *A. mixtum* are common in both rural and disturbed areas, and are strongly associated with domestic animals and synanthropic wildlife (Guglielmone *et al.* 2003a). *Rhipicephalus sanguineus* s. l. colonized the Americas with the introduction of Old World dogs during the European colonization, and currently parasitize dogs in all kinds of human environments, even thriving in highly urbanized cities (Guglielmone *et al.* 2003, Moraes-Filho *et al.* 2011). In rural towns, wandering dogs could disperse engorged specimens of *R. sanguineus* s. l. to peridomestic areas, and hunting dogs may introduce this tick into secondary or primary forest. Because *R. sanguineus* s. l. did not evolve in Neotropical ecosystems, further study is needed to determine pathways by which this tick might move from domesticated to wild animals. Under these conditions, wildlife is susceptible to being parasitized by *R. sanguineus* s.l. (Labruna *et al.* 2005, Bermúdez *et al.* 2010).

In contrast, *A. mixtum* is a native species that prefers dry habitats such as shrubs and herbaceous patches (Fairchild *et al.* 1966, mentioned as *A. cajennense*). Currently, logging of native forest has caused the expansion of this type of vegetation along the Pacific slopes of Panamanian lowlands, which has favored the dispersion of *A. mixtum*. Immatures and adults of this species are considered to be catholic parasites, because they feed from different groups of vertebrates in these areas. Thus, finding mid-sized carnivores parasitized by *R. sanguineus* s.l. suggests their presence near to human dwellings, while parasitism by *A. mixtum* in these mammals is related to their presence in landscape dominated by pastures or shrubs.

In degraded dry areas, *A. auricularium*, *A. parvum* and *O. puertoricensis* were found on wild carnivores. The regular hosts of *A. auricularium* are armadillos, with only occasional findings on other groups of mammals (Guglielmone *et al.* 2003b). However, both *A. parvum* and *O. puertoricensis* appear to be generalist ticks, because they have many species of hosts reported along their entire distribution. In the case of *A. parvum*, 46 species of mammals are reported as hosts (Nava *et al.* 2008), and the hosts of *O. puertoricensis* include more than 20 species of mammals, one bird, two reptiles and one toad, which can be attributed to their nidicolous behavior (Endris *et al.* 1989, Bermúdez *et al.* 2013).

Amblyomma ovale, A. oblongoguttatum and *I. affinis* seem to have wild carnivores among their preferred hosts in primary and secondary rain forests (Guglielmone *et al.* 2003a, Labruna *et al.* 2005). In this study, this was demonstrated by the presence of many immature and adults of these species, including engorged females, and by the finding of mating pairs of *I. affinis* on ocelots. These tick species exhibit an opportunistic behavior with their environment, tolerating a certain degree of anthropogenic disturbance, that permits feeding from domestic mammals in small towns adjacent to forests (Bermúdez & Miranda 2011, Szabó *et al.* 2012, Murgas *et al.* 2013). The plasticity of *A. ovale* and *A. oblongoguttatum* explains their parasitism on felids, coatis and mustelids in both intact and degraded forest, but also on coyotes, gray foxes and raccoons in rural environments.

Our records of adults of *A. varium* and *A. dissimile* on *N. narica* are notable, as adults of these ticks are typically parasites of sloths and ectothermic vertebrates, respectively (Fairchild *et al.* 1966, Guglielmone *et al.* 2003a, Guglielmone and Nava 2010). Secondary and primary forests are the preferred habitat for *A. varium*, and *A. dissimile*. Thus, coatis parasitized with these ticks may reflect an opportunistic parasitic behavior in response to the presence of these hosts in the habitat. To find *A. dissimile* on endothermic vertebrates is an unusual event, especially a partially engorged female (Guglielmone and Nava 2010).

Forested areas allow immatures of other tick species to parasitize wild carnivores, as shown by our data. In the case of *H. juxtakochi*, its principal hosts as adults are Artiodactyla, but the immature stages are eclectic parasites (Fairchild *et al.* 1966, García *et al.* 2014). To our knowledge, these are the probably first records of carnivores as hosts for nymphs of both *A. tapirellum* and *A. pecarium*.

Although both species have been recorded previously from Panama (Dunn 1933), there is little information about their hosts of the immature life stages.

In addition to data presented in this study, Fairchild *et al.* (1966) reported: *Ixodes rubidus* on *Mustela frenata*, *Bassaricyon gabii*, *C. semistriatus* and *Eyra barbara*; *Ixodes boliviensis* on puma, jaguar, raccoon and coati; *Amblyomma naponense* on crab-eating raccoon and coati, and unidentified *Ixodes* ticks on Neotropical river otter *Lutra annectes* (probably *Lontra longicaudis*) in Panama.

In conclusion, our results add a significant contribution to the current knowledge of tick-host relationships in Panama. Further studies using diverse methodologies are necessary to gain a better understanding of the parasitic relationship between ticks and wild carnivores, including sampling highlands, banks of rivers and forest canopy. Moreover, since ticks are important vectors of pathogens that can affect domestic animals and humans, further ecological research investigating the role of wild carnivores as disease reservoirs is warranted.

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References

Bermúdez, S., & Miranda, RJ. (2011) Distribution of ectoparasites of *Canis lupus familiaris* L. (Carnivora: Canidae) from Panama. *Revista de Medicina Veterinaria y Zoonosis,* 16, 2274–2282.

Bermúdez, S., Miranda, R., & Smith, D. (2010) Ticks species (Ixodida) in the Summit Municipal Park and adjacent areas, Panama City, Panama. *Experimental and Applied Acarology*, 52, 439-448.
http://dx.doi.org/10.1007/s10493-010-9374-8

Bermúdez, S., González, D. & García, G. (2013) Ticks (Acari: Ixodidae, Argasidae) of *Canis latrans* in Panama. *Systematic and Applied Acarology,* 18, 112–115.
http://dx.doi.org/10.11158/saa.18.2.2

Dunn, L. (1933) Two new species of ticks from Panama (*Amblyomma tapirellum* and *A pecarium*). *Parasitology,* 25, 353–358.
http://dx.doi.org/10.1017/s0031182000019557

Durden, L. & Keirans, J. (1996) Host-parasite coextinction and the plight of tick conservation. *American Entomologist,* 42, 87-91.

Endris, R., Keirans J., Robbins, R. & Hess, W. (1989) *Ornithodoros* (*Alectorobius*) *puertoricensis* (Acari: Argasidae): Redescription by scanning electron microscopy. *Journal of Medical Entomology*, 26, 146–154.

Estrada-Peña, A., Gray, J., Kahl, O., Lane, R., & Nijhof, A. (2013) Research on the ecology of ticks and tick-borne pathogens-methodological principles and caveats. *Frontiers in Callular and Infection Microbiology,* 3, 1–11.

Fairchild, G.B, Kohls, G.M, & Tipton, V.J. (1966) The ticks of Panama. *In*: Wenzel, R.L & Tipton, V.J (eds.) *Ectoparasites of Panama*. Chicago, Field Museum of Natural History. pp. 167–219.

Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrijenhoek, R. (1994) DNA primers for amplification of mitochondrial cytochrome c oxidasesubunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology,* 3, 294–299.

García, G., Castro, A., Bermúdez, S., & Nava, S. (2014) Some ecological aspects of free-living *Haemaphysalis juxtakochi* Cooley, 1946 (Acari: Ixodidae) in Panama. *Revista de Medicina Veterinaria y Zootecnia,* 19, 3984–3989.

Guglielmone, A.A., Estrada-Peña, A., Keirans, J.E. & Robbins, R.G. (2003a) *Ticks (Acari: Ixodidae) of the Neotropical Zoogeographic Region.* Special Publication of the International Consortium on Ticks and Tick-borne Diseases-2 Atalanta, Houten, The Netherlands, 173 pp.

Guglielmone, A.A., Estrada-Peña, A., Luciani, C.A., Mangold, A.J. & Keirans, J. (2003b) Hosts and distribution of *Amblyomma auricularium* (Conil 1878) and *Amblyomma pseudoconcolor* Aragão, 1908 (Acari: Ixodida). *Experimental and Applied Acarology*, 29, 131–139.
http://dx.doi.org/10.1023/a:1024251020035

Guglielmone, A. & Nava, S. (2010) Hosts of *Amblyomma dissimile* Koch, 1844 and *Amblyomma rotundatum* Koch, 1844 (Acari: Ixodidae). *Zootaxa,* 2541. 27–49.

Hunter, L. (2011) *Carnivores of the World*. Princeton University Press, Princeton, USA. 420 pp.

Labruna, M., Jorge, R., Sana, D., Jacomo, A., Kashivakura, C., Furtado, M., Ferro, C., Perez, S., Silvera, L., Santos, T., Marques, S., Morato, R., Nava, A., Adania, C., Teixeira, R., Gomes, A., Conforti, V., Azevedo, F., Prada, C., Silva, J., Batista, A., Marvulo, M., Morato, R., Alho, C., Pinter, A., Ferreira, P., Ferreira, F. & Barros-Battesti, D. (2005) Ticks (Acari: Ixodidae) on wild carnivores in Brazil. *Experimental and Applied Acarology,* 36, 149-163.
http://dx.doi.org/10.1007/s10493-005-2563-1

Labruna, M. & Guglielmone, A. (2009) Ticks of New World Tapirs. *Tapir Conservation*, 18, 21–28.

Martins, T., Furtado, M., Jácomo, A., Silveira, L., Sollmann, R., Torres, N. & Labruna, M. (2011) Ticks on free-living wild mammals in Emas National Park, Goiás State, central Brazil. *Systematic & Applied Acarology*, 16, 201–206.

Moraes-Filho, J., Marcili, A., Nieri-Bastos, F., Richtzenhain, L. & Labruna M (2011) Genetic analysis of ticks belonging to the *Rhipicephalus sanguineus* Group in Latin America. *Acta Tropical,* 117, 51–55.
http://dx.doi.org/10.1016/j.actatropica.2010.09.006

Moreno, R. (2006) *Parámetros poblacionales y aspectos ecológicos de los felinos y sus presas en Cana, Parque Nacional Darién, Panamá*. Tesis de Maestría. Instituto Internacional en Conservación y Manejo de Vida Silvestre, Heredia, Costa Rica. 136 pp.

Moreno, R., Kays, R., Giacalone, J, Mares, R, Aliaga-Rossel, E. & Bustamante, A. (2012) Ámbito de hogar y actividad circadiana del ocelote (*Leopardus pardalis*) en la isla de Barro Colorado, Panamá. *Mesoamericana,* 16, 30–39.

Murgas, I., Castro, A. & Bermúdez, SE. (2013) Current status of *Amblyomma ovale* Koch 1844 (Acari: Ixodidae) in Panama. *Ticks and Tick-Borne Diseases,* 4, 164–166.
http://dx.doi.org/10.1016/j.ttbdis.2012.09.002

Nava, S., Szabó, M., Mangold A. & Guglielmone, A. (2008) Distribution, hosts, 16S rDNA sequences and phylogenetic position of the Neotropical tick *Amblyomma parvum* (Acari: Ixodidae). *Annals of Tropical Medicine & Parasitology,* 102, 409–425.
http://dx.doi.org/10.1179/136485908x278883

Nava, S., Beati, L, Labruna, M, Cáceres, A, Mangold, A. J. & Guglielmone A.A. (2014) Reassessment of the taxonomic status of *Amblyomma cajennense* 1 (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 and Tick-Borne Diseases*, 5, 252–76.
http://dx.doi.org/10.1016/j.ttbdis.2013.11.004

Sunquist, M., & Sunquist, F. (2002) *Wild cats of the World*. The University of Chicago Press. 452 pp.

Szabó, M., Labruna, M., Pereira, M. & Duarte, J. (2003) Ticks (Acari: Ixodidae) on wild march-deer (*Blastocerus dichotomus*) from Southeast Brazil: infestations before and after habitat loss. *Journal of Medical Entomology* 40, 268–274.
http://dx.doi.org/10.1603/0022-2585-40.3.268

Szabó, M., Martins, T., Nieri-Bastos, F., Spolidorio, M. & Labruna M (2012) A surrogate life cycle of *Amblyomma ovale* Koch, 1844. *Ticks and Tick-borne Diseases,* 3, 262–264.
http://dx.doi.org/10.1016/j.ttbdis.2012.06.002

Walker, A., Bouattour, A., Camicas, J., Estrada-Peña, A., Horak, I., latif, A., Pegram, R., & Preston, P. (2003) *Ticks of Domestic Animals in Africa: a Guide to Identification of Species*. The University of Edinburgh, 221 pp.

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