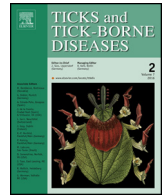




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Short communication

First report of exotic ticks (*Amblyomma rotundatum*) parasitizing invasive cane toads (*Rhinella marina*) on the Island of Hawai'i

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ABSTRACT

Our surveys of 1401 invasive cane toads (*Rhinella marina*) from the Hawaiian islands of Hawai'i, O'ahu, and Maui revealed the presence of an exotic tick, *Amblyomma rotundatum*. Immature and adult female ticks infested three wild adult toads at a single site in the vicinity of a zoo south of Hilo, Island of Hawai'i, Hawai'i, USA. We found no tick-infested toads on O'ahu or Maui. This tick infests cane toads in their native Neotropical range, but it was excluded from Hawai'i when the original founder toads were introduced over 80 years ago. The circumstances of our discovery suggest that *A. rotundatum* was independently and belatedly introduced to Hawai'i with imported zoo animals, and Hawai'i now joins Florida as the second U.S. state where this tick is established.

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1. Introduction

Ever increasing levels of international travel and trade correspond to unprecedented rates of exotic species introductions (Costello and McAusland, 2003). Ticks are particularly adept at stowing away and entering new habitats on their introduced hosts (Keirans and Durden, 2001; Barré and Uilenberg, 2010; BurrIDGE, 2011). Although ticks are generally visible to the naked eye during quarantine inspections, their larval stages can be rather small, and some tick individuals may attach to hosts in sheltered anatomical sites (e.g., within nostrils or ear canals), where they are not easily dislodged or detected (Reeves et al., 2006). Moreover, ticks often remain attached to their hosts for sufficient periods of time (e.g., weeks or months) to endure conventional transit periods for live animals from one locality to another (Barré and Uilenberg, 2010; Luz et al., 2013).

The cane toad (*Rhinella marina*, formerly *Bufo marinus*) is a large bufonid anuran native to the Rio Grande Valley, southern Texas, USA, southwards to the southern Amazon Basin in Brazil, but it also has been translocated to many other localities worldwide in attempts to control insect pests (Lever, 2001). Under either natural

or captive conditions, *R. marina* is a known host for nine species of ixodid ticks and one argasid species (BurrIDGE, 2011; Bermúdez et al., 2013), but of these, only *Amblyomma dissimile* and *A. rotundatum* are frequent and typical parasites (Guglielmone and Nava, 2010). All others seem to be aberrant, occasional, or opportunistic parasites. Tick infestations are common on cane toads throughout their native range (Lampo and Bayliss, 1996) and in some introduced populations in the Caribbean (Newstead, 1909; Kohls, 1969; Drake et al., 2014) and Florida, USA (Oliver et al., 1993; Goddard et al., 2015). Yet, ticks are absent from cane toads in other introduced populations (e.g., Bermuda, Australia, Hawai'i), presumably because importers removed the ticks from the toads before their release in new localities (e.g., a radiogram was sent in 1932 by entomologist Cyril Pemberton to the receivers of the toads in Hawai'i, specifically to warn them to inspect the animals for ticks upon arrival; Turvey, 2013).

In 1932, 149 cane toads arrived on the Island of O'ahu from an introduced source population in Puerto Rico, and the offspring (>600,000 toads) of those Hawaiian immigrants were released on sugar plantations in the larger Hawaiian islands (Hawai'i, Maui, O'ahu, Kaua'i, Moloka'i) between 1933 and 1935 (Easteal, 1981).

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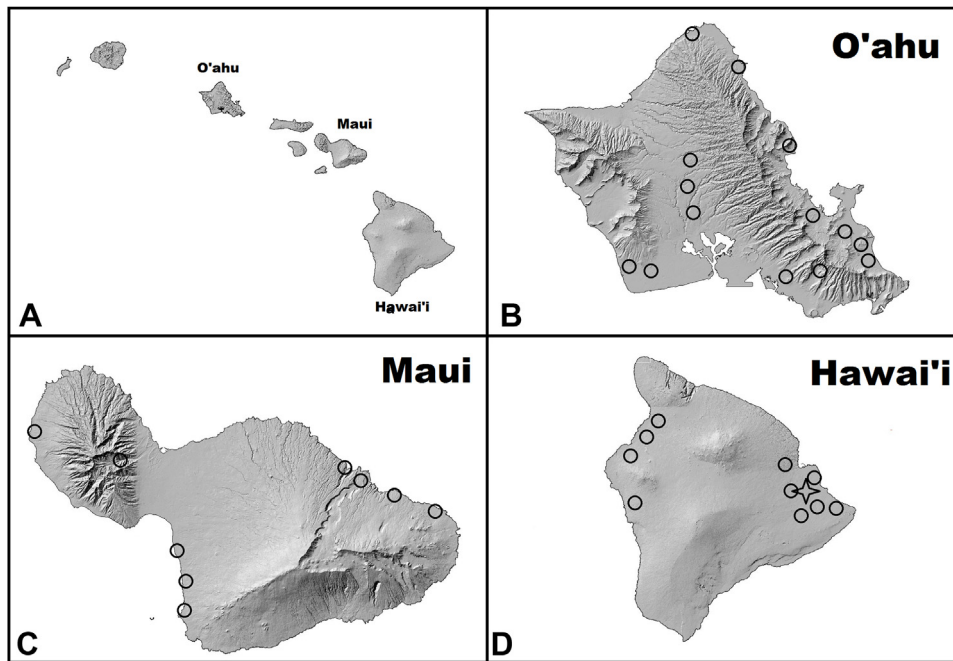


Fig. 1. Map of sampling locations (open circles); (A) State of Hawai'i; (B) Island of O'ahu, where we found no ticks on 519 toads surveyed across 14 populations; (C) Island of Maui, where we found no ticks on 189 toads surveyed across nine populations; (D) Island of Hawai'i, where we surveyed 693 toads across 11 populations and found ticks on three toads from one of those populations (four-pointed star).

2. Materials and methods

During 11–17 January 2015 and 3 June–29 July 2015, we inspected cane toads for tick infestations on three islands in the state of Hawai'i. We hand-collected cane toads at night and visually inspected their skins for ticks. After inspections, the toads were euthanized by refrigeration, followed by freezing (Shine et al., 2015). We examined 693 toads from 11 populations on Hawai'i, 189 toads from nine populations on Maui, and 519 toads from 14 populations on O'ahu. We removed all ticks from infested toads, preserved these parasites in 70% ethanol, and identified them at the USDA National Veterinary Services Laboratories (NVSL), Ames, Iowa. The identification process used morphological criteria, published reference materials (Keirans and Durden, 1998; Voltzit, 2007; Martins et al., 2010; Guzmán-Cornejo et al., 2011), and comparison with archived reference specimens from toad hosts. Voucher tick specimens are retained in the NVSL parasitology reference collection (Accession No. 16-022027, Case No. T16-1180).

3. Results

We found ticks on toads at a single site south of Hilo (19.653754°N, 155.073765°W; Fig. 1) on the Island of Hawai'i on 15 July 2015; three (two females and one male) of the 47 toads (6.38%) surveyed at that site were tick-infested. We identified these ticks as 2 females, 7 nymphs, and 1 larva of *A. rotundatum*. Most immatures (Fig. 2A) and both females (Fig. 2B and C) were partially engorged to different degrees. We found no ticks on any cane toad at all other sites in the state of Hawai'i (Fig. 1).

4. Discussion

Published records document only 14 tick species previously collected in the Hawaiian Islands (Joyce, 1980; Goff, 1987; Keirans and Durden, 2001); four of these were closely associated with resident seabirds, and the remainder were either known or suspected to have been introduced by human aegis. The *Amblyomma* ticks dis-

covered in the present study probably fit into the latter category and were confined to a single site, infested only three toads, and consisted of 10 total individuals. These infestations consisted entirely of *A. rotundatum*, a widespread Neotropical tick native to southern Mexico, Central America, northern South America, and many Caribbean islands (Guglielmone et al., 2003), and introduced and established in southern Florida, USA (Oliver et al., 1993).

The list of hosts reportedly used by *A. rotundatum* is long and diverse (Guglielmone and Nava, 2010; Scott and Durden, 2015), but the majority are reptiles and amphibians; rare single records from one bird and several mammal hosts are probably anomalies. Indeed, based upon criteria proposed by Guglielmone and Nava (2010), anuran amphibians are the usual natural hosts for all feeding stages of *A. rotundatum*, with *Boa constrictor* as a second-most-likely host, and bufonids overwhelmingly the most used hosts overall.

The single site where we found ticks was Pana'ewa Rainforest Zoo and Gardens, a small public zoo that exhibits a diverse array of non-native vertebrates. Zoo-keepers informed us (pers. comm.) that they sometimes find ticks on their Asian forest tortoises (*Manouria emys phayrei*), originally imported from Texas in 2000, and on green iguanas (*Iguana iguana*). A subsequent follow-up examination of resident reptiles at the zoo in September 2016 found small numbers of nymphal *A. rotundatum* present on an Asian forest tortoise and a red-footed tortoise (*Chelonoidis carbonaria*). Both wild and captive green iguanas (Dantas-Torres et al., 2008; Guglielmone and Nava, 2010) and captive forest tortoises (USDA unpubl. data) are previously known hosts for *A. rotundatum*, and either could be the local introduction source. The tortoises and iguanas are housed at the Hawaiian zoo in large outdoor enclosures that are surrounded by fencing and vegetation. Cane toads are common in and around the exhibit areas (CMH pers. obs.), allowing ample opportunity for the ticks to spread from the captive zoo animals to the wild cane toads.

Three-host ticks like *A. rotundatum* require the availability of adequate and appropriate separate individual hosts for each of their three active life stages, and according to Guglielmone and Nava (2010), only *B. constrictor* and various anurans are known to serve *A.*

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