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Parmarion martensi Simroth, 1893 (Gastropoda: Ariophantidae), an intermediate host of *Angiostrongylus cantonensis* (rat lungworm), on Maui[1]

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Ariophantidae

Parmarion martensi Simroth **New island record**

This Southeast Asian species, sometimes referred to as a semislug (e.g., Qvarnstrom *et al*. 2007) as it bears a small shell, partly or mostly covered by the mantle, atop its slug-like body (Fig. 1), was originally described from Cambodia (Simroth 1893). It was subsequently reported from other parts of Southeast and East Asia (see references in Hollingsworth *et al*. 2007), although the identifications are unconfirmed. The records from American Samoa (Cowie 2001) and Samoa (Cowie & Robinson 2003) were based on a misidentification of *Parmella planata* Adams, 1867 (K.A. Hayes, D.G. Robinson, J. Slapcinsky & N.W. Yeung, unpublished), which is native to Fiji, and, with the exception of the Hawaiian Islands, *Parmarion martensi* has not been reported on other Pacific Islands (Robinson & Hollingsworth 2009). It was first recorded in the Hawaiian Islands, on O'ahu, in 1996 (Cowie 1997) and subsequently on the island of Hawai'i in 2004 (Hollingsworth *et al*. 2007).

Until 2017, *P. martensi* had only been recorded on the islands of O'ahu and Hawai'i in the Hawaiian archipelago (e.g., Cowie *et al*. 2008; Jarvi *et al*. 2012). It has now been reported from Maui, initially anecdotally (without reference to vouchers; Cowie 2017; Howe & Jarvi 2017). We now substantiate its presence on Maui with vouchered speci-

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Fig. 1. *Parmarion martensi* on Maui in June 2017, showing the small shell partially covered by the mantle.

mens collected in April and June 2017. Their identity was confirmed through anatomical examination and by sequencing a portion of the mitochondrially encoded cytochrome *c* oxidase subunit I (MT-COI). These data were compared with the anatomy and sequences from previously collected vouchers on O‘ahu, and material from other parts of the world. All MT-COI sequences of specimens collected from Maui and those previously collected on O‘ahu share 100% identity with GenBank sequence FJ481180, from Taiwan. Additionally, these sequences are identical to unpublished sequences from individuals collected in Malaysia, Taiwan, and the island of Hawai‘i. As yet, *P. martensi* has not been recorded on any other than these three of the Hawaiian Islands. Its potential for future spread is cause for concern, and warrants continued monitoring via surveys.

Parmarion martensi is a host of the rat lungworm, *Angiostrongylus cantonensis* (Chen, 1935) (e.g., Hollingsworth *et al*. 2007; Kim *et al*. 2014). This parasite is the cause of neural angiostrongyliasis (also known as CNS angiostrongyliasis and angiostrongylus eosinophilic meningitis, among other monikers), manifested as eosinophilic meningitis, in humans and other animals (Cowie 2013; Murphy & Johnson 2013; Barratt *et al*. 2016). Although many species of gastropods can act as hosts of *A. cantonensis*, both globally and in the Hawaiian Islands (Kim *et al*. 2014), it has been suggested that *P. martensi* is a particularly important host in the Islands. It is a highly competent host with 78% and 68% of individuals screened by Hollingsworth *et al*. (2007) and Kim et al. (2014), respectively, testing positive for the parasite. It has been verified as a host of *A. cantonensis* on Maui (Yeung, Kim & Hayes, unpubl.).

There are hints that cases of human disease are associated with the spread of *P. martensi* (e.g., Hollingsworth *et al*. 2007; Howe & Jarvi 2017). And it has been suggested that various aspects of its behavior lead to it coming into contact with humans more readily than other gastropod hosts (Hollingsworth *et al*. 2007). However, there are no published studies definitively demonstrating a causal link and although *P. martensi* is probably important in transmission of angiostrongyliasis in the Hawaiian Islands, other hosts should not be ignored in efforts to understand human infection dynamics and implement management interventions. This is especially pertinent given that 16 species of land snails in Hawaii, and species from 46 families of gastropods globally have been recorded as positive for *A. cantonensis* (Kim *et al*. 2014). Although some of these hosts are not as competent as *Parmarion martensi*, these diverse species can act as reservoirs for this nematode to persist in the Hawaiian Islands, thus increasing the potential for transmission.

Collections were made by Kenneth A. Hayes (KAH), Norine W. Yeung (NWY), Jaynee R. Kim (JRK), Keahi M. Bustamente (KMB), Chuong T. Tran (CTT), Jennah R. Bedrosian (JRB), Sigurdur H. Arnason (SHA), and personnel of the Maui Invasive Species Council. All collected material is deposited in the Bishop Museum Malacology Collection. Latitude and longitude coordinates were recorded by GPS.

Material examined: **MAUI**: Hana, no geographical coordinates available, Christine Davis, 5 Apr 2017 (BPBM Malacology 283934); Hana, N20°47.887′ W156°2.181′, KAH, NWY, JRK, KMB, 16 Jun 2017 (283935); Hana, N20°46′37.03″ W55°59′58.59″, KAH, NWY, JRK, KMB, 16 Jun 2017 (283936); Hana, N20°47.183′ W156°0.159′, KAH, NWY, JRK, KMB, 16 Jun 2017 (283937). **O‘AHU**: Punalu‘u, N21°34′57″ W157°53′31.9″, CTT, JRB, SHA, 09 Dec 2006 (282605).

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