

New Records of Alien Gastropoda in the Hawaiian Islands: 1996–2010¹

KENNETH A. HAYES, NORINE W. YEUNG, JAYNEE R. KIM, & ROBERT H. COWIE²
Center for Conservation Research and Training, Pacific Biosciences Research Center,
University of Hawai'i, 3050 Maile Way, Gilmore 408, Honolulu, Hawai'i 96822, USA;
emails: khayes@hawaii.edu, nyeung@hawaii.edu, jaynee@hawaii.edu, cowie@hawaii.edu

The alien nonmarine gastropods of the Hawaiian Islands were cataloged by Cowie (1997) and were reviewed by Cowie (1998a). Subsequent new records (both for the archipelago and for individual islands) were reported by Cowie (1998b, 1999, 2000), Kraus (2003), and, specifically associated with the horticultural industry between 2004 and 2006, by Hayes *et al.* (2007), reviewed and analyzed by Cowie *et al.* (2008). Subsequent surveys, covering 196 sites across the six largest main Hawaiian Islands during 2006–2010, have resulted in the additional new records reported here.

We surveyed 29 locations on Kaua'i, 48 on O'ahu, 13 on Moloka'i, 50 on Maui, 4 on Lāna'i, and 52 on Hawai'i. Sites ranged from highly disturbed lowland habitats dominated by nonnative vegetation to high elevation habitats at which most of the vegetation was native. Also included were a number of horticultural nurseries and agricultural research stations.

A small number of additional records based on collections by collaborators (1996–2007) are also included, as well as 2004–2005 records of *Allopeas clavulinum* that were inadvertently omitted by Hayes *et al.* (2007).

We document here the new state and island records. A more comprehensive analysis and discussion of all records will be published elsewhere.

Collections were made by Kenneth A. Hayes (KAH), Norine W. Yeung (NWY), Jaynee R. Kim (JRK), Robert H. Cowie (RHC), and others as indicated. All collected material, not only that reported here, is deposited in the Bishop Museum (BPBM) Malacology Collection. Catalog numbers are BPBM Malacology Collection numbers. Assignments to families follow Robinson (1999), with the exception of *Bulimulus guadalupensis*, which is assigned to the Orthalicidae following Bouchet & Rocroi (2005) rather than Bulimulidae, which these authors placed as a subfamily of Orthalicidae. Families are treated alphabetically. Latitude and longitude coordinates were recorded by GPS.

Agriolimacidae

Deroceras reticulatum (Müller) (Fig. 1A) **New island records**

This western European slug (Kerney & Cameron, 1979) was previously recorded in the literature only from the islands of Kaua'i and Hawai'i (Cowie, 1997). It is frequently brought to us for identification after being intercepted by State of Hawaii Plant Quarantine officials, especially on shipments of Christmas trees arriving in the islands from the Pacific Northwest of the mainland United States. It is widely seen as an agricultural pest (Barker, 2002). It may have been misidentified in the past, possibly confused with *Deroceras laeve* (Müller), but appears to be widespread and established on all six of the largest main Hawaiian Islands.

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2. Research Associate, Department of Natural Sciences, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai'i 96817-2704, USA.

Material examined: **O‘AHU:** Ka‘ala helicopter landing zone, Wahiawā, N21°30.670', W158°08.963', W. Weaver, 24 Oct 2006 (275953); Nike site, Wahiawā, N21°32.766', W158°11.714', M. Keir, 24 Oct 2006 (275954); Ka‘ala, Wahiawā, no coordinates, Army personnel, 23 May 2007 (275965); Top of Mānoa Cliffs Trail on Mānoa side, Honolulu, N21°20.460', W157°48.474', RHC, 27 Feb 2008 (270756); Top of Kōnāhuanui Ridge, Honolulu, N21°21.202', W157°47.325', KAH, JRK, A.F. Johnson, 26 Apr 2008 (270777); End of Pauoa Flats Trail, Honolulu, N21°20.727', W157°48.373', KAH, JRK, A.F. Johnson, 26 Apr 2008 (270780); Mt. Ka‘ala bog, end of boardwalk, Wahiawā, N21°30.154', W158°08.960', KAH, NWY, T.J. Skelton, 3 Sep 2008 (274174); Mt. Ka‘ala bog near Natural Area Reserve, Wahiawā, N21°30.436', W158°08.634', KAH, NWY, T.J. Skelton, 3 Sep 2008 (274183). **MOLOKA‘I:** Kamakou Preserve, Kaunakakai, N21°07.542', W156°55.132', KAH, W.M. Meyer, M.M. Parker, C.T. Tran, 27 Jun 2006 (282585); Kamakou Preserve, Kaunakakai, N21°06.988', W156°55.077', KAH, NWY, JRK, T.J. Skelton, C.H. Yee, 15 Nov 2008 (274261); Entrance to Pēpē‘ōpae Bog Trail, Kaunakakai, N21°07.093', W156°54.489', KAH, NWY, JRK, T.J. Skelton, C.H. Yee, 15 Nov 2008 (274263); Kamakou Preserve, Kaunakakai, N21°07.235', W156°55.127', KAH, NWY, JRK, T.J. Skelton, C.H. Yee, 15 Nov 2008 (274269). **LĀNA‘I:** Top of Lāna‘i, Department of Land and Natural Resources land, Lāna‘i City, N20°48.796', W156°52.541', KAH, NWY, JRK, T.J. Skelton, 25 Oct 2008 (274249). **MAUI:** Haleakalā National Park, crater floor, Kula, no coordinates, P. Krushelnycky, 1 Aug 1996 (275932); Haleakalā National Park, Pu‘u O Ili, N20°45', W156°14', P. Krushelnycky, 1 May 2002 (275933 - 275935), 1 Oct 2002 (275936 - 275941), 20 Jul 2003 (275942-275946), 24 Jul 2004 (275948 - 275951), 28 Aug 2004 (275952); Central Pali Trail, Kīpahulu, Kula, N20°42.177', W156°05.400', S. Joe, 22 Jul 2003 (275947); Between Pukalani and Makawao Avenue, right side heading east (Kaupea), Makawao, N20°50.642', W156°19.304', KAH, S.H. Arnason, J.R. Bedrosian, M.M. Parker, 8 Apr 2007 (283033); Kula Forest Reserve, Polipoli State Park, Waiakoa Loop Trail, Kula, N20°43.147', W156°17.888', KAH, NWY, JRK, T.J. Skelton, 12 Sep 2008 (274188); Just outside Kula Forest Reserve, on Hunalani Farm, 50 m in from road, Kula, N20°43.468', W156°18.559', KAH, NWY, JRK, T.J. Skelton, 12 Sep 2008 (274191); Corner of Kula Highway and Highway 377, Kula, N20°44.275', W156°20.000', KAH, NWY, JRK, T.J. Skelton, 12 Sep 2008 (274199); ‘Ulupalakua, N20°37.981', W156°21.540', KAH, NWY, JRK, T.J. Skelton, 13 Sep 2008 (274211); On road above Kanaio Natural Area Reserve, ‘Ulupalakua, N20°37.859', W156°21.350', KAH, NWY, JRK, T.J. Skelton, 13 Sep 2008 (274237); Waihou Spring Trail in the tree growth research area, Makawao, N20°48.299', W156°17.206', KAH, NWY, JRK, T.J. Skelton, 13 Sep 2008 (274307); ‘Iao Valley Spring Trail, Wailuku, N20°52.767', W156°33.263', KAH, NWY, JRK, T.J. Skelton, 14 Sep 2008 (274302); Haleakalā National Park, Hōlua cabin, Kula, N20°44.503', W156°13.082', KAH, NWY, JRK, T.J. Skelton, 24 Oct 2008 (274242); Haleakalā National Park, Kula, N20°45.127', W156°12.793', KAH, NWY, JRK, T.J. Skelton, 24 Oct 2008 (274244); Tedeschi Winery, Kula, N20°38.891', W156°23.371', KAH, NWY, JRK, 6 Feb 2009 (274331); Pu‘u Kukui trail, Kapalua, N20°55.612', W156°36.419', KAH, JRK, RHC, T.J. Skelton, 7 Feb 2009 (274288); Kapalua, N20°56.347', W156°37.894', KAH, NWY, JRK, RHC, T.J. Skelton, 8 Feb 2009 (274296); Maui Floral, Kula, N20°44.788', W156°19.066', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 27 Mar 2010 (274346); Paradise Flower Farms, Kula, N20°45.255', W156°18.691', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 27 Mar 2010 (274359); Rainbow Acres Nursery, Kula, N20°48.722', W156°17.089', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 27 Mar 2010 (274366); Enchanting Floral Gardens, Kula, N20°47.574', W156°19.589', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 27 Mar 2010 (274376); Maui Invasive Species Council Agricultural Site, Makawao, N20°50.228', W156°17.660', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 28 Mar 2010 (270842); Gobles Flower Farm, Kula, N20°41.417', W156°22.581', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 28 Mar 2010 (274381); Ali‘i Kula Lavender Farm, Kula, N20°44.009', W156°19.153', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 28 Mar 2010 (274385); Native Nursery LLC, Kula, N20°45.461', W156°20.718', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 29 Mar 2010 (275074); Proteas of Hawai‘i, Kula, N20°45.480', W156°19.305', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 29 Mar 2010 (275081); **HAWAII:** Kīpuka ‘Āināhou Sanctuary, Huluhulu, N19°41' W155°27', P. Krushelnycky, 22 Aug 2005 (275955 - 275964).

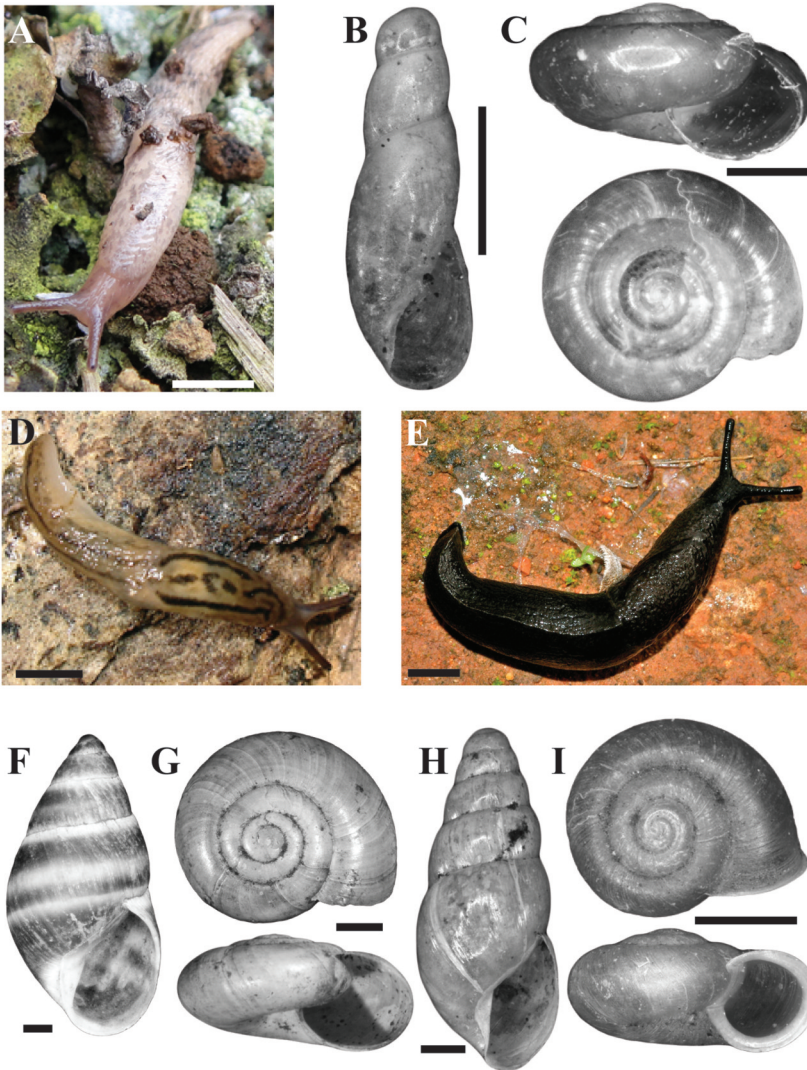


Figure 1: Alien land snails. **A**, *Deroceras reticulatum*, **B**, *Cecilioides aperta*, **C**, *Zonitoides arboreus*, **D**, *Lehmannia valentiana*, **E**, *Milax gagates*, **F**, *Bulimulus guadalupensis*, **G**, *Oxychilus alliaris*, **H**, *Allopeas clavulinum*, **I**, *Vallonia pulchella*. Scale bars for slugs = 5 mm; and for shells = 1 mm. All photos are of specimens in Hawai‘i except *Milax gagates* from Spain (Photo by Joaquín Ramírez).

Ferussaciidae

Cecilioides aperta (Swainson) (Fig. 1B)

New island record

Previously recorded only from the islands of O‘ahu and Hawai‘i, but probably a synonym of *C. baldwini* (Ancey), though never formally synonymized, and therefore probably also

previously on Kaua'i and Maui as well as O'ahu and Hawai'i (Cowie, 1997). This is the first formal record of *C. aperta* from Maui. This species is thought to be native to the West Indies but has been spread widely by human activities (Solem, 1964), and has probably been in the Hawaiian Islands for a long time, though probably only subsequent to Western discovery of the Islands (Christensen, 1984).

Material examined: **MAUI:** Kapalua, N21°0.672', W156°38.487', KAH, S.H. Arnason, J.R. Bedrosian, M.M. Parker, 7 Apr 2007 (282991).

Gastrodontidae

Zonitoides arboreus (Say) (Fig. 1C)

New island record

Previously only recorded from O'ahu, Maui, and Hawai'i (Cowie, 1997), this species is common and widespread and probably occurs on all islands. This is the first record from Kaua'i. A pest in orchid nurseries (Hollingsworth *et al.*, 2003), it is now widespread in forest habitats.

Material examined: **KAUA'I:** Kōke'e Road, right side, Waimea, N22°01.297', W159°41.533', KAH, J.R. Bedrosian, W.M. Meyer, M.M. Parker, 24 Mar 2007 (282849); Right side of Moi Road, near cemetery, Hanapēpē, N21°54.622', W159°35.633', RHC, S.H. Arnason, B.S. Holland, C.T. Tran, 25 Mar 2007 (282873).

Limacidae

Lehmannia valentiana (Férussac) (Fig. 1D)

New island records

This Iberian species (Kerney & Cameron, 1979) is now widespread as a result of human activities (Barker, 1999). It was first recorded in the Hawaiian Islands as the junior synonym *Limax poirieri* Mabille in 1982 from Maui (Cowie, 1997). Although not abundant, this slug species is widespread in the Islands, and on the basis of the present records, is now present on all six of the largest islands.

Material examined: **KAUA'I:** Alaka'i Swamp Trail, Kā'ana, N22°08.448', W159°37.381', KAH, JRK, A.F. Johnson, C.H. Yee, 3 May 2008 (270783); **O'AHU:** Mt Ka'ala, Wahiawā, no coordinates recorded, K. Kewelo, 14 Apr 2004 (275922), S.M. Joe, 9 Sep 2008 (275927); Mt Ka'ala, Wahiawā, N21°30.218', W158°08.510', J. Gustine, 26 Apr 2006 (275923 - 275924); Mt Ka'ala, Wahiawā, N21°29.342', W158°07.944', M. Keir, 26 Oct 2006 (275925); Mt Ka'ala, Wahiawā, no coordinates recorded, collector not known, 23 May 2007 (275926); Mt Ka'ala, bog end of boardwalk, Wahiawā, N21°30.154', W158°08.960', KAH, NWY, T.J. Skelton, 3 Sep 2008 (274173); **MOLOKA'I:** Entrance to Pēpē'ōpae Bog Trail, Kaunakakai, N21°07.093', W156°54.489', KAH, NWY, JRK, T.J. Skelton, C.H. Yee, 15 Nov 2008 (274264); Kamakou Preserve, Kaunakakai, N21°07.235', W156°55.127', KAH, NWY, JRK, T.J. Skelton, C.H. Yee, 15 Nov 2008 (274270); **HAWAII:** Waimea Lodge area, Waimea, N20°01.325', W155°40.135', KAH, C.T. Tran, 12 Feb 2006 (282556); Grass area along side of road and cattle fence, Kalaoa, N19°45.631', W155°50.529', KAH, NWY, W.M. Meyer, M.M. Parker, 13 Jun 2008 (270806); Kohala Forest Reserve, Waimea, N20°02.887' W155°40.426', KAH, NWY, W.M. Meyer, M.M. Parker, C.H. Yee, 14 Jun 2008 (270917); Just north of Honua'ula Forest Reserve, Kalaoa, N19°42.924', W155°55.366', KAH, NWY, W.M. Meyer, C.H. Yee, 15 Jun 2008 (270830); 19-4127 Kalani Honua Loop, Volcano, N19°26.029', W155°14.527', KAH, NWY, JRK, T.J. Skelton, 20 Aug 2008 (270881); 'Ōla'a Forest Reserve, off Wright Road, Volcano, N19°27.728', W155°14.875', KAH, NWY, JRK, T.J. Skelton, 22 Aug 2008 (270908); University of Hawai'i College of Tropical Agriculture and Human Resources Volcano Research Station, Volcano, N19°04.943', W155°45.452', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 9 Apr 2010 (275104); University of Hawai'i College of Tropical Agriculture and Human Resources, Mealani Research Center, Waimea, N20°02.374', W155°36.452', KAH, NWY, JRK, T.J. Skelton, S. Sugiura, 9 Apr 2010 (275113).

Milacidae***Milax gagates*** (Draparnaud) (Fig. 1E)**New island record**

This European slug species has been present in the Hawaiian Islands since at least 1897; it was previously known only from Maui and Hawai'i (Cowie, 1997). It appears to be a high elevation species, now recorded from the highest peak on O'ahu. It is a major agricultural pest in Europe (Barker, 2002).

Material examined: O'AHU: Mt. Ka'ala, Wahiawā, N21°30.218', W158°08.510', J. Gustine, 26 Apr 2006 (275928–275929); Mt. Ka'ala, Wahiawā, no coordinates recorded, S.M. Joe, 23 Jan 2007 (275930); Mt. Ka'ala boardwalk, Wahiawā, no coordinates recorded, S.M. Joe, 9 Sep 2008 (275931).

Orthalicidae***Bulimulus guadalupensis*** (Bruguère) (Fig. 1F) **New state record**

This species originated in the Caribbean, where it is widespread, especially in disturbed habitats, (Robinson *et al.*, 2009). It has been introduced to Florida, probably in association with agricultural or horticultural plants, and has been recorded in abundance in lawns and among ornamental plants in a residential area (Thompson, 1976), as was the present material. It is likely that it was introduced via the horticultural trade. The only two localities at which the species has been found in the Hawaiian Islands were close together and were also the only two localities at which *Vallonia pulchella* was found (see below). Although described originally from the island of Guadeloupe, Bruguère's original spelling is retained because it is not clear that either the 'a' rather than 'e' or the 'u' rather than 'ou' were inadvertent errors (International Code of Zoological Nomenclature, Article 32.5).

Material examined: O'AHU: 6416 101st Street, 'Ewa Beach, N21°19.421', W157°58.922', KAH, NWY, JRK, RHC, B.S. Holland, 20 Jan 2009 (274138); 6284 Ibis Avenue, 'Ewa Beach, N21°19.692', W157°58.715', KAH, NWY, JRK, RHC, B.S. Holland, 20 Jan 2009 (274152).

Oxychilidae***Oxychilus alliarius*** (Miller) (Fig. 1G)**New island records**

This western European species (Kerney & Cameron, 1979) is a facultative predator of other snails (Meyer & Cowie, 2010). It is known as the 'garlic snail' because of its ability to emit a strong smell of garlic when irritated. It was first recorded in the Hawaiian Islands in 1937 (Cowie, 1997), based on specimens in the Bishop Museum from Waimea, Island of Hawai'i. Subsequently, it was recorded in abundance on both Hawai'i and Maui (Cooke & Baker, 1947) where it was considered a threat to native species (Severns, 1984). It was later recorded from Kaua'i and Moloka'i (Cowie, 1997). Meyer & Cowie (2010) reported it from O'ahu but without reference to voucher specimens. The present records formally extend its recorded distribution to all six of the largest Hawaiian Islands. It is now one of the most widespread snail species in the Islands.

Material examined: O'AHU: Wai'anae Range, Mokulē'ia, N21°32.395', W158°11.650', KAH, NWY, JRK, T.J. Skelton, 4 Aug 2008 (270848); Wai'anae Range, Mokulē'ia, N21°32.693', W158°11.680', KAH, NWY, JRK, T.J. Skelton, 4 Aug 2008 (270849); Mt. Ka'ala bog near Natural Area Reserve, edge of forest where grass turns into *Metrosideros polymorpha* forest, Wahiawā, N21°30.436', W158°08.634', KAH, NWY, T.J. Skelton, 3 Sep 2008 (274180); Outside of Nike nursery, Mokulē'ia, N21°32.754', W158°11.685', RHC, NWY, JRK, S. Sugiura, 20 Oct 2009 (270816). LĀNA'I: Top of Lāna'i, Department of Land and Natural Resources land, Lāna'i City, N20°48.796', W156°52.541', KAH, NWY, JRK, T.J. Skelton, 25 Oct 2008 (274245); Road down from the top of Lāna'i, Department of Land and Natural Resources land, Lāna'i City, N20°50.259', W156°53.823', KAH, NWY, JRK, T.J. Skelton, 25 Oct 2008 (274251).

Subulinidae***Allopeas clavulinum* (Potiez & Michaud) (Fig. 1H) New island records**

Subulinidae are notoriously difficult to identify and a number of species have been introduced widely in the islands of the Pacific, including the Hawaiian Islands (Cowie, 2001). Their geographical origins are somewhat obscure but *Allopeas clavulinum* is thought to be native to East Africa (Kerney & Cameron, 1979). It was first recorded in the Hawaiian Islands, from the Island of Hawai'i, in 1906 (Cowie, 1997). Cowie *et al.* (2008) extended the recorded distribution to Kaua'i, O'ahu, and Maui without reference to voucher specimens and Hayes *et al.* (2007) did not include those records so they are provided here. The subspecies *hawaiiense* Sykes is probably a junior synonym (Cowie, 1997), although it has not been formally synonymized, and had been recorded from Kaua'i, O'ahu, Moloka'i, Maui and Hawai'i over a century ago by Pilsbry (1906–1907). This is the first formal record from Moloka'i and the first vouchered records from Kaua'i, O'ahu, and Maui.

Material examined: **KAUA'I:** Kaua'i Hog and Ground Cover, Lihu'e, N21°55.855', W159°28.983', KAH, C.T. Tran, 21 Mar 2005 (281346); Alexander's Nursery, Kuamo'o Road, Kapa'a, N22°03.420', W159°22.878', KAH, C.T. Tran, 21 Mar 2005 (270634); Growing Green Nursery, Lihu'e, N22°05.832', W159°22.112', KAH, C.T. Tran, 22 Mar 2005 (281367); **O'AHU:** Charles Nii Nursery, Hawai'i Kai, N21°18.280', W157°41.718', KAH, C.T. Tran, 26 Feb 2005 (281316); **MOLOKA'I:** Kalaupapa lookout, Kalaupapa, N21°10.528', W157°00.310', KAH, M.M. Parker, C.T. Tran, 27 Jun 2006 (270708); **MAUI:** Ho'olawa Nursery, Ha'ikū, N20°55.875', W156°19.073', KAH, RHC, 15 Dec 2004 (281232); Tropical Gardens of Maui, Wailuku, N20°52.965', W156°31.022', KAH, RHC, 16 Dec 2004 (270626); Kihana Nursery, Kihei, N20°44.248', W156°27.237', KAH, C.T. Tran, 12 Mar 2005 (270633).

Valloniidae***Vallonia pulchella* (Müller) (Fig. 1I)****New state record**

The native range of this species is considered Holarctic (Kerney & Cameron, 1979), although including only Europe and eastern and central North America (Forsyth, 1999). It has been introduced to many places throughout the world (Gerber, 1996; Robinson, 1999). The only two localities at which the species has found in the Hawaiian Islands were close together and were also the only two localities at which *Bulimulus guadalupensis* was found (see above).

Material examined: **O'AHU:** 6416 101st Street, 'Ewa Beach, N21°19.421', W157°58.922', KAH, NWY, JRK, RHC, B.S. Holland, 20 Jan 2009 (274150); 6284 Ibis Avenue, 'Ewa Beach, N21°19.692', W157°58.715', KAH, NWY, JRK, RHC, B.S. Holland, 20 Jan 2009 (274154).

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