

## **Rediscovery of *Newcombia canaliculata* (Baldwin, 1895) (Gastropoda: Achatinellidae) and *Laminella venusta* (Mighels, 1845) (Gastropoda: Amastridae)<sup>1</sup>**

NORINE W. YEUNG<sup>2,3</sup>

*Hawaii Biological Survey, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai'i 96817, USA; email: norine@bishopmuseum.org*

KEAHI M. BUSTAMENTE

*Field Supervisor, Leeward Haleakalā Watershed Restoration Partnership, 3620 Baldwin Ave., Suite 202/203, Makawao, Hawai'i 96768, USA; email: keahib33@gmail.com*

DAVID R. SISCHO

*Program Coordinator, Department of Land and Natural Resources, Snail Extinction Prevention Program, 1151 Punchbowl Street, Rm. 325, Honolulu, Hawai'i 96813, USA; email: David.R.Sischo@hawaii.gov*

KENNETH A. HAYES<sup>2,3</sup>

*Hawaii Biological Survey, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai'i 96817, USA; email: kenneth.hayes@bishopmuseum.org*

### **INTRODUCTION**

There have been at least 752 native land snail species recognized from the Hawaiian Archipelago, but many of these are already extinct or threatened (Cowie *et al.* 1995). Although extinction estimates as high as 95% have been reported for some families (Régnier *et al.* 2015), it is often difficult to determine if a species is extinct, or just extremely rare and difficult to find (Keith *et al.* 2017), especially without adequate surveys (Hirano *et al.* 2018).

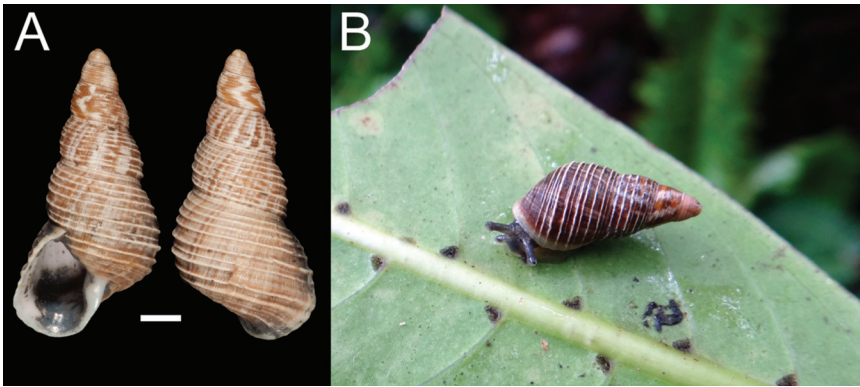
Since the 1980s, most studies of land snails across the archipelago, focused on taxa within the subfamily Achatinellinae (e.g. Thacker & Hadfield 2000; Holland & Hadfield 2004; Cowie & Holland 2008) with a few studies within the Succineidae (Rundell *et al.* 2004; Holland & Cowie 2007; Cowie & Holland 2008). For example, the island of Moloka'i once boasted 85 species from eight families (Cowie *et al.* 1995), and there are only nine described species of *Partulina* on Moloka'i (Cowie *et al.* 1995). Yet, published research from the last half century reporting on land snails of Moloka'i have been almost exclusively focused on achatinelline species (Hadfield & Miller 1989; Kobayashi & Hadfield 1996; Thacker & Hadfield 2000; Holland & Hadfield 2004; Hadfield & Sauffer 2008; Price *et al.* 2015), with few, if any other land snails recorded or mentioned (for exceptions see Rundell *et al.* 2004; Holland & Cowie 2007). While there are numerous and complex factors that have likely played a role in the lack of studies on other land snails broadly, this pattern may be partly explained by the erroneous assumption that most land snails had already suffered the same fate as many of those in the Achatinellinae, an idea that was prevalent among the research and conservation community in Hawaii over the last few decades. This assumption,

---

1. Contribution No. 2018-007 the Hawaii Biological Survey.

2. Research Affiliate, Pacific Biosciences Research Center, University of Hawai'i, 3050 Maile Way, Gilmore 408, Honolulu, Hawai'i 96822, USA

3. Research Collaborator, Smithsonian Institution, National Museum of Natural History, P.O. Box 37012, MRC 163, Washington, DC, 20013, USA



**Figure 1.** **A)** *Newcombia canaliculata* (ANSP 65713), scale bar = 2 mm; purported holotype (Johnson 1996) **B)** Live *Newcombia canaliculata* (BPBM 284174).

further fueled by an already narrow focus on this single subfamily may explain the dearth of survey efforts aimed at understanding the conservation status of Hawaiian land snails more comprehensively. Over the last decade we have built a strong network of conservationists, researchers, and resource managers that have begun to help us fill the gaps in knowledge about Hawaiian land snails. Recent survey efforts (Yeung & Hayes unpublished) have revealed that indeed many Hawaiian land snails have most likely been lost forever. At the same time these efforts have provided a more accurate picture of Hawaiian land snail extinctions, and a better understanding of the conservation status of those that remain has begun to emerge. As Solem (1990) noted, there is still time left to save many species, and through continued and increasing surveys in remote areas, we are realizing the vision of C. Montague Cooke, Jr. and those he inspired (Solem 1990). Here we report the notable rediscovery of two species of endemic snails from two of the most threatened, and frequently studied families in the islands, Achatinellidae and Amastridae. While both species are endemic to Hawai'i, the circumstances and story of their rediscovery is neither unique to Hawai'i, nor as unexpected as they may appear. Like other recent rediscoveries of presumably extinct taxa (Gargominy 2008; Brook 2012; Hirano *et al.* 2018) on Pacific islands, these taxa were found surviving in high elevation, often difficult to access, refugia. Many such refugia may still exist, and as Solem (1990) noted, they may be the last places where these jewels of the Pacific still exist, and if we have any hope of saving them, we have to look, and then act. We hope publishing and extolling such rediscoveries will serve as a reminder that hope still exists.

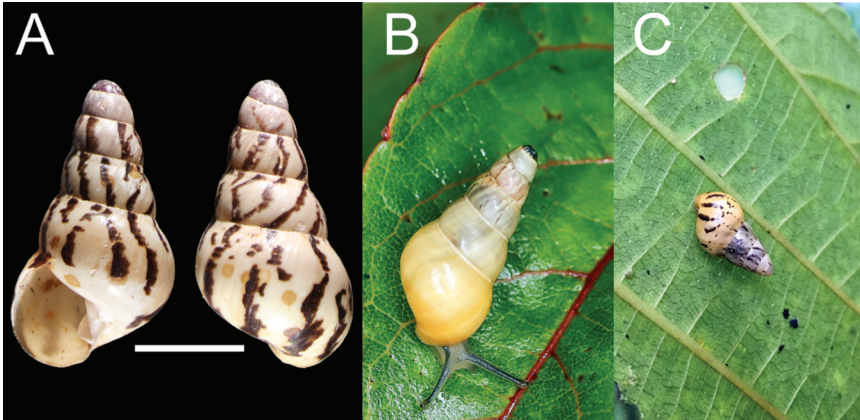
#### **Achatinellidae**

*Newcombia canaliculata* (Baldwin, 1895)

#### **Notable rediscovery**

(Fig. 1)

*Newcombia canaliculata* belongs in the Achatinellinae, a Hawaiian endemic land snail subfamily with 99 species (Cowie *et al.* 1995). It was originally described from “Hālawā” on the island of Moloka'i in 1895 and was subsequently recorded in the same and other localities: Hālawā (BPBM 51611, 24844, 134572, 107588; collection dates: 1912–1931);



**Figure 2.** A) *Laminella venusta* (BPBM 191652), topotypic material as “original type has been destroyed by fire” (Hyatt & Pilsbry 1911: 347–348), scale bar = 5 mm; **B** and **C**) Live adult and subadult *Laminella venusta* (BPBM 284175), respectively.

Kawaikapu (BPBM 59832, 59833, 59835, 59836, 59834A; 1922); Keopukaloa (BPBM 134534–6, 107587, 117325–8, 134570, 184286–9; 1931–1935); Wailau (BPBM 24858, 24862, 51605, 129268; 1912–1933). Other museums (Museum of Comparative Zoology, National Museum of Natural History, Academy of Natural Sciences of Drexler University, Delaware Museum of Natural History, Carnegie Museum of Natural History) have similar records (locality and collection date) and there are no known museum or published records of this species after 1935. In July 2015, Keahi M. Bustamante (KMB), Chris Johns (CJ), and Geena Hill (GH) recorded a *Newcombia* sp. on Moloka‘i. In January 2018, Norine W. Yeung (NWY), Kenneth A. Hayes (KAH), David R. Sischo (DRS), James K. Espaniola and KMB revisited the locality and NWY and KAH identified this species as *Newcombia canaliculata* (Fig. 1B). The population size was not estimated but numerous adults, subadults, and juveniles were recorded at multiple locations, primarily on *olopua*, *Nestegis sandwicensis* (A. Gray) O.Deg., I.Deg. & L.A.S.Johnson (Oleaceae). Eighteen adults were live collected for captive rearing by DRS. The exact locality data are not listed here for conservation purposes but are kept in the State of Hawaii Department of Land and Natural Resources Snail Extinction Prevention Program and Bishop Museum Malacology databases. Tissue samples (BPBM 284175) have been collected and deposited at the Bishop Museum. Any individuals that die in the captive populations will be vouchered at the Bishop Museum (BPBM 284175). *Newcombia canaliculata* and the Maui endemic, *Newcombia cumingi* (Newcomb), are now the only two *Newcombia* species, out of seven described species, known to be extant.

### Amastridae

*Laminella venusta* (Mighels, 1845)

### Notable rediscovery

(Fig. 2)

*Laminella venusta* belongs in the Amastridae, a Hawaiian endemic land snail family with 325 described species. Prior to this report, only 20 extant species of Amastridae were left

(Régnier *et al.* 2015; Hayes, Chung, Yeung, unpublished). However, the rediscovery of *Laminella venusta* brings the total number of extant amastrid species to 21, and it is the only extant amastrid known from Moloka'i. There were 14 described *Laminella* species and, until recently, only two, *Laminella sanguinea* (Newcomb) (O'ahu endemic) and *L. aspera* Baldwin (Maui endemic), were considered extant (Régnier *et al.* 2015). *Laminella venusta* was originally described from O'ahu. However, Hyatt & Pilsbry (1911: 348) provided localities only on Moloka'i and stated that "no such shell occurs on Oahu". This species has been recorded on various Moloka'i localities such as: East 'Ōhi'a Gulch (BPBM 134425; 1931); Kalua'aha (BPBM 24814, 24092, 24103, 24780, 24793; 1912); Kamalō (BPBM 36855; 1913); Mapulehu (BPBM 24164, 24819, 24824, 51636, 102902, 102903, 191652, 191658; 1912–1943); 'Ohi'alele (BPBM 47000, 47014; 1919); Oloku'i (BPBM 24863, 24864; 1912); Ualapue (BPBM 24223, 24235; 1912). Other museums (Museum of Comparative Zoology, National Museum of Natural History, Florida Museum of Natural History, Academy of Natural Sciences of Drexler University, Delaware Museum of Natural History, Denver Museum of Nature and Science, Carnegie Museum of Natural History, Illinois Natural History Survey) have similar records (locality and collection date) with the last known museum record in 1967 (UF167339). During the reconnaissance survey for *Newcombia canaliculata* (Baldwin) in January 2018, nine *Laminella venusta* (Figs. 2B, C) individuals were discovered on a *hāhā*, *Cyanea* cf. *solenocalyx* Hillebr. (Campanulaceae). Previous records (BPBM 24164, 24092, 24223) have reported this species on *olonā*, *Touchardia latifolia* Gaudich (Urticaceae). Because of the imminent threat from rat predation, the omnivorous snail [*Oxychilus alliarius* (Miller)], and predatory flatworms, in the area with these snails, all individuals were collected for captive rearing by DRS. Tissue samples (BPBM 284175) have been collected and deposited at the Bishop Museum, and any individuals that die in the captive population will be vouchered as well (BPBM 284175). The exact locality data are not listed here for conservation purposes but are kept in the State of Hawaii Department of Land and Natural Resources Snail Extinction Prevention Program and Bishop Museum Malacology databases.

#### ACKNOWLEDGMENTS

We thank the State of Hawaii Department of Land and Natural Resources (James K. Espaniola and Dr. Fern Duvall), and The Nature Conservancy for logistical support and access to lands. Regina Kawamoto and Jaynee R. Kim assisted with depositing material in the Bishop Museum. Daniel Chung, Carl Christensen (Bishop Museum Malacology), and Rob Cowie (University of Hawai'i at Mānoa) provided insightful conversations and serve as a wealth of information regarding the historical distributions, identities, and biology of Hawaiian land snails. Additional thanks to Jaynee R. Kim (Bishop Museum Malacology) for manuscript edits and comments and Kimberly Lactoen (Bishop Museum Malacology) for BPBM shell imaging. Thank you to the Academy of Natural Sciences of Drexel University Malacology Collection for shell images of *Newcombia canaliculata*. This work was supported in part by a National Science Foundation grants to NWY, KAH, and John Slapcinsky (DEB-1656254, 1656231).

#### LITERATURE CITED

- Brook, F.** 2012. Report on the land snail fauna of Upland Savai'i, pp. 139–173 *In*: Atherton, J. & Jefferies, B. (eds.), *Rapid Biodiversity Assessment of Upland Savai'i, Samoa*. Secretariat of the Pacific Regional Environmental Programme, Apia, Samoa. 176 pp.

- Cowie, R.H. & Holland, B.S.** 2008. Molecular biogeography and diversification of the endemic terrestrial fauna of the Hawaiian Islands. *Philosophical Transactions of the Royal Society B: Biological Sciences* **363**: 3363–3376.
- Cowie, R.H., Evenhuis, N.L. & Christensen, C.C.** 1995. *Catalog of the native land and freshwater molluscs of the Hawaiian Islands*. Backhuys Publishers, Leiden.
- Gargominy, O.** 2008. Beyond the alien invasion: a recently discovered radiation of Nesopupinae (Gastropoda: Pulmonata: Vertiginidae) from the summits of Tahiti (Society Islands, French Polynesia). *Journal of Conchology* **39**(5): 517–536.
- Hadfield, M.G. & Miller, S.E.** 1989. Demographic studies on Hawaii's endangered tree snails: *Partulina proxima*. *Pacific Science* **43**: 1–16.
- Hadfield, M.G. & Saufier, J.E.** 2008. The demographics of destruction: isolated populations of arboreal snails and sustained predation by rats on the island of Moloka'i 1982–2006. *Biological Invasions* **11**: 1595–1609.
- Hirano, T., Wada, S., Mori, H., Uchida, S., Saito, T. & Chiba, S.** 2018. Genetic and morphometric rediscovery of an extinct land snail on oceanic islands. *Journal of Molluscan Studies*. doi:10.1093/mollus/eyy003
- Holland, B.S. & Cowie, R.H.** 2007. A geographic mosaic of passive dispersal: population structure in the endemic Hawaiian amber snail *Succinea caduca* (Mighels, 1845). *Molecular Ecology* **16**: 2422–2435.
- Holland, B.S. & Hadfield, M.G.** 2004. Origin and diversification of the endemic Hawaiian tree snails (Achatinellidae: Achatinellinae) based on molecular evidence. *Molecular Phylogenetics and Evolution* **32**: 588–600.
- Hyatt, A. & Pilsbry, H.A.** 1911. *Manual of Conchology. Structural and systematic. With illustrations of the species*. Second series: Pulmonata. Vol. XXI. Achatinellidae (Amastrinae). Academy of Natural Sciences, Philadelphia. xxii + 387 pp., 56 pls.
- Johnson, R.I.** 1996. Types of land and freshwater mollusks from the Hawaiian Islands in the Museum of Comparative Zoology. *Bulletin of the Museum of Comparative Zoology* **155**: 159–214.
- Keith, D.A., Butchart, S.H., Regan, H.M., Harrison, I., Akçakaya, H.R., Solow, A.R. & Burgman, M.A.** 2017. Inferring extinctions I: a structured method using information on threats. *Biological Conservation* **214**: 320–327.
- Kobayashi S.R. & Hadfield M.G.** 1996. An experimental study of growth and reproduction in the Hawaiian tree snail *Achatinella mustelina* and *Partulina redfieldi* (Achatinellinae). *Pacific Science* **50**: 339–354.
- Price, M.R., Sisco, D., Pascua, M.A. & Hadfield, M.G.** 2015. Demographic and genetic factors in the recovery or demise of *ex situ* populations following a severe bottleneck in fifteen species of Hawaiian tree snails. *PeerJ* **3**: e1406.
- Régnier, C., Bouchet, P., Hayes, K.A., Yeung, N.W., Christensen, C.C., Chung, D.J.D., Fontaine, B. & Cowie, R.H.** 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation Biology* **29**: 1715–1723.
- Rundell, R.J., Holland, B.S. & Cowie, R.H.** 2004. Molecular phylogeny and biogeography of the endemic Hawaiian Succineidae (Gastropoda: Pulmonata). *Molecular Phylogenetics and Evolution* **31**: 246–255.
- Solem, A.** 1972. *Tekoulina*, a new viviparous tornatellinid land snail from Rarotonga, Cook Islands. *Journal of Molluscan Studies* **40**(2): 93–114.

- Solem, A.** 1990. How many Hawaiian land snail species are left? And what we can do for them. *Bishop Museum Occasional Papers* **30**: 27–40.
- Thacker, R.W. & Hadfield, M.G.** 2000. Mitochondrial phylogeny of extant Hawaiian tree snails (Achatinellinae). *Molecular Phylogenetics and Evolution* **16**: 263–270.