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SURVEY FOR 2016

NEAL L. EVENHUIS, EDITOR



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Cover photo male *Argiope trifasciata* (Forsskål) from Kaua'i.

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**RECORDS OF THE
HAWAII BIOLOGICAL SURVEY
FOR 2016**

Editor's Preface

I am pleased to present the annual compilation of *Records of the Hawaii Biological Survey*; this year for the year 2016. The Hawaii Biological Survey, established by the Hawaii State Legislature in 1992 as a program of Bishop Museum, is an ongoing natural history inventory of the Hawaiian Archipelago. It was created to locate, identify, and evaluate all native and nonnative species of flora and fauna within the state; and by State Law to maintain the reference collections of that flora and fauna for a wide range of uses. In coordination with related activities in other federal, state, and private agencies, the Hawaii Biological Survey gathers, analyzes, and disseminates biological information necessary for the wise stewardship of Hawaii's biological resources.

An intensive and coordinated effort has been made by the Hawaii Biological Survey to make our products, including many of the databases supporting the papers published here, available to the widest user-community possible through our web server. Products currently available include taxonomic authority files (species checklists for terrestrial arthropods, flowering plants, nonmarine snails, marine invertebrates, fossil taxa, and vertebrates), bibliographic databases (vascular plants, nonmarine snails, and insects), specimen databases (fungi, fish, invertebrates, portions of the insect collection) and type specimens (entomology; botany—including algae and fungi; and vertebrates), collections data (lists of holdings for select groups of flies as well as Cicadellidae and Pentatomidae), detailed information and/or images on endangered, threatened, and extinct plants and animals; as well as our staff publication lists. Additional reference databases include: the list of insect and spider collections of the world (based on Arnett, Samuelson & Nishida, 1993, *Insect and spider collections of the world*) with links to institutional web pages where known; and the historical world Diptera taxonomists list with names of over 5,800 authors who have described flies.

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World Diptera taxonomist list

<http://hbs.bishopmuseum.org/dipterists/>

The *Records of the Hawaii Biological Survey for 2016* were compiled with reviews by and/or assistance of Clyde Imada (botany), Robert Cowie and Norine Yeung-Hayes (malacology), and Gustavo Spinelli and Art Borkent (entomology). Many of the new records reported here resulted from curatorial projects and field surveys funded by the National Science Foundation, the U.S. Geological Survey Biological Resources Division, the U.S. Fish & Wildlife Service, the Hawaii Department of Transportation, and the Hawaii Department of Land and Natural Resources; they are thanked for their support and partnership of the Hawaii Biological Survey over the years.

We encourage authors with new information concerning flora or fauna occurring in the Hawaiian Islands to submit their data to the editor for consideration for publication in the *Records*. Submission and format of papers must follow our guidelines. Information on submission of manuscripts and guidelines for contributors may be obtained at:

<http://hbs.bishopmuseum.org/guidelines.pdf>

—N.L. Evenhuis, editor

New Plant Records from Kaho‘olawe Island and Midway Atoll

FOREST STARR & KIM STARR

*University of Hawai‘i, Pacific Cooperative Studies Unit, 149 Hawea Pl., Makawao, Maui, Hawai‘i
96768, USA; email: fstarr@hawaii.edu*

The following contributions include fourteen new island records from Kaho‘olawe Island and Midway Atoll. All records are for nonindigenous species. Images of most of the material examined can be seen at starrenvironmental.com. Voucher specimens and collections mentioned in the text are housed in Bishop Museum’s Herbarium Pacificum (BISH), Honolulu, Hawai‘i.

Amaranthaceae

Alternanthera caracasana Kunth

New island record

This low-growing weed of dry disturbed areas in Hawai‘i was previously documented from the islands of Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, and Maui (Wagner *et al.* 1999). It was recently also found on the island of Kaho‘olawe, growing along a dirt path near the camp at Hakioawa.

Material examined. **KAHO‘OLAWE:** Hakioawa, near camp on path, lowland scrub with *Portulaca pilosa*, *Prosopis pallida*, and *Megathyrsus maximus*, not much, 15 ft [5 m] (755,028 E, 2,278,883 N), 13 Dec 2015, Starr & Starr 151213-04.

Atriplex suberecta I. Verd.

New island record

Naturalized in Hawai‘i in dry disturbed areas of French Frigate Shoals and all the main islands, except Ni‘ihau and Kaho‘olawe (Wagner *et al.* 1999; Lorence *et al.* 1995). Previously not recorded from Midway Atoll. First found and collected February 2012 on Sand Island from Bulky Dump to the east along the cart path, where several sprawling patches were observed in the lawn area running along the runway (Aspey 2012). In 2015, despite searches in the same area, no plants were found (Starr & Starr 2015), although it could have been overlooked. A seedbank likely exists.

Material examined. **MIDWAY ATOLL:** Sand Island, along the northern edge of the lawn running along the southern side of the active E-W Runway from the GPS mark to the separation of the cart track from the runway, coastal scrub, several sprawling patches, 10 ft [3 m] (463,235 E, 3,119,757 N), Feb 2012, Aspey *s.n.* (Starr & Starr 150404-05).

Apocynaceae

Stapelia gigantea N.E. Br.

New island record

The Zulu-Giant, or carrion flower, was previously known from dry areas of Hawai‘i on the islands of O‘ahu, Moloka‘i, Maui, and Hawai‘i (Wagner *et al.* 1999; Oppenheimer *et al.* 1999; Wysong *et al.* 2007; Oppenheimer 2010; Parker & Parsons 2012). It is now also reported from the island of Kaho‘olawe, where it was found scattered along the upper portions of the Hakioawa South Trail. It was also observed along the main road, K1, on the Pu‘u Moiwi bypass section.

1. Contribution No. 2017-001 the Hawaii Biological Survey.

2. Research Associate, Hawaii Biological Survey, Bishop Museum, 1525 Bernice Street, Honolulu, Hawaii 96817-2704, USA

Material examined. **KAHO'OLAWE:** Upper Hakioawa, Hakioawa South Trail, lowland disturbed shrubland, with *Prosopis pallida*, *Cenchrus ciliaris*, and *Lantana camara*, few patches here and there along upper part of trail, 450 ft [137 m] (754, 434 E, 2,278,164 N), 13 Dec 2015, *Starr & Starr 151213-06*.

Asteraceae

Eclipta prostrata (L.) L.

New island record

Known previously in Hawai'i from all of the main islands except Kaho'olawe (Wagner *et al.* 1999; Oppenheimer 2003). It is now also documented from the latter island, where it was found growing on the landing platform on the beach by the camp at Hakioawa.

Material examined. **KAHO'OLAWE:** Hakioawa, near ocean by LZ for camp, coastal strand with *Batis maritima* and *Sesuvium portulacastrum*, 1 plant, 5 ft [1.5 m] (755,072 E, 2,278,957 N), 13 Dec 2015, *Starr & Starr 151213-05*.

Caryophyllaceae

Cerastium glomeratum Thuill.

New island record

In Hawai'i, first reported as a new state record from the island of Maui, where it was found scattered in a lawn in Makawao (Starr *et al.* 2004). On Midway Atoll, first reported by Aspey (2012) from a few locations on Sand Island: near the Seaplane Hangar, Catchment Basin, South Beach Cart Path, and Cargo Pier. Starr & Starr (2015) also observed and collected this plant from a moist low spot on the edge of the runway tarmac near the Fire Station. It was not found anywhere else, but given the previously known distribution this ephemeral herb could likely come and go in any moist area on Midway.

Material examined. **MIDWAY ATOLL:** Sand Island, near the Fire Station, on tarmac in moist vegetated spot, coastal/urban with *Sagina japonica*, *Oenothera laciniata*, and *Pseudognaphalium sandwicensium* var. *sandwicensium*, few plants here, 15 ft [5 m] (462,514 E, 3,120,063 N), 30 Mar 2015, *Starr & Starr 150330-02*; Sand Island, Sea Plane Hangar, south side near Fuel Tanks in gaps between concrete slabbing, also observed in a few other locations, including: Cargo Pier, Catchment, S. Beach Trail, several plants in coastal scrub with *Verbesina encelioides*, 15 ft [5 m] (463,671 E, 3,120,517 N), Jan 2012, *Aspey s.n. (Starr & Starr 150404-02)*.

Sagina procumbens L.

New island record

This small herb was first reported as a new state record for Hawai'i from the islands of Lāna'i and Maui in 2003 (Oppenheimer 2003). On Midway Atoll, first collected in 2012 on Sand Island near the Water Catchment area (Aspey 2012). In 2015, it was also found in a moist vegetated spot on the margins of the runway tarmac near the Fire Station.

Material examined. **MIDWAY ATOLL:** Sand Island, near Fire Station on tarmac in moist vegetated spot, coastal/urban with *Pseudognaphalium sandwicensium* var. *sandwicensium*, *Sagina procumbens*, and *Oenothera laciniata*, common here, 15 ft [5 m] (462,512 E, 3,120,064 N), 30 Mar 2015, *Starr & Starr 150330-04*; Sand Island, at Water Catchment, in coastal scrub, 15 ft [5 m] (462,377 E, 3,119,770 N), Jan 2012, *Aspey s.n. (Starr & Starr 150404-04)*.

Euphorbiaceae

Euphorbia hyssopifolia L.

New island record

In Hawai'i, previously reported as naturalized in low dry, disturbed sites on the islands of Midway Atoll, Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, and Hawai'i (Wagner *et al.* 1999; Herbarium Pacificum Staff 1999; Bruegmann 1999; Oppenheimer 2003). Recently, it was also found and collected on the island of Kaho'olawe in the Upper Hakioawa area.

Material examined. **KAHO‘OLAWE:** Upper Hakioawa, near outplantings, lowland scrub with *Dodonaea viscosa*, 950 ft [290 m] (754,155 E, 2,277,356 N), 12 Dec 2015, *Starr & Starr 151212-01*.

***Euphorbia serpens* Kunth**

New island record

First reported as a new state record for Hawai‘i from the island of Kaua‘i (Wagner *et al.* 1997), *E. serpens* has since been documented from West Maui (Oppenheimer 2003), and now from Midway Atoll, where it was found in disturbed coastal sites.

Material examined. **MIDWAY ATOLL:** Sand Island, near Cable Co. building in sandy disturbed site, coastal with *Fimbristylis cymosa*, *Verbesina encelioides*, and *Casuarina equisetifolia*, several plants here, also seen at Brackish Pond, previously misidentified in 2008 on Midway as *E. maculata*, 15 ft [5 m] (462,860 E, 3,121,179 N), 29 Mar 2015, *Starr & Starr 150329-01*.

Fabaceae

***Macropitium lathyroides* (L.) Urb.**

New island record

Cow pea was previously known in Hawai‘i from all the main islands (Wagner *et al.* 1999, Herbarium Pacificum Staff 1996). On Midway Atoll, first found and collected in January 2012 on Sand Island by Nik Aspey, who reported one patch growing on the south side of the most easterly concrete inspection ramp of the Seaplane Hangar (Aspey 2012). In 2015, the location, an unloading dock for gravel and other items, was surveyed, though due to recent control work, was devoid of vegetation. The Aspey collection included fertile material, so a seedbank could potentially persist (Starr & Starr 2015).

Material examined. **MIDWAY ATOLL:** Sand Island, growing against the south side of the most easterly concrete inspection ramp south of the Sea Plane Hangar, coastal scrub/urban, 10 ft [3 m] (463,657 E, 3,120,604 N), Jan 2012, *Aspey s.n.* (*Starr & Starr 150404-07*).

Lamiaceae

***Leonotis nepetifolia* (L.) R. Br.**

New island record

Lion’s ear, originally introduced to Hawai‘i for use in dried floral arrangements and in landscaping, is now naturalized in lowland sites, sometimes forming thickets, on the islands of Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i (Wagner *et al.* 1999; Oppenheimer 2003; Oppenheimer 2010). It is here reported from Kaho‘olawe, where it is growing along the base of a rocky ledge near camp at Hakioawa.

Material examined. **KAHO‘OLAWE:** Hakioawa, near camp, lowland scrub with *Prosopis pallida* and *Megathyrsus maximus*, many plants along the edge of a rocky ledge bordered by Guinea grass, 15 ft [5 m] (754,949 E, 2,278,864 N), 13 Dec 2015, *Starr & Starr 151213-03*.

***Ocimum gratissimum* L.**

New island record

Previously documented in Hawai‘i as naturalized in lowland dry, disturbed habitat on the islands of Ni‘ihau, Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i (Wagner *et al.* 1999; Lorence *et al.* 1995), wild basil is here reported from Kaho‘olawe, where scattered patches grow along the upper section of the South Hakioawa Trail.

Material examined. **KAHO‘OLAWE:** Upper Hakioawa, Hakioawa South Trail, lowland scrub with *Leucaena leucocephala*, *Acacia farnesiana*, *Prosopis pallida*, and *Cenchrus ciliaris*, common along trail, 450 ft [137 m] (754,435 E, 2,278,164 N), 13 Dec 2015, *Starr & Starr 151213-01*.

Stachys arvensis* (L.) L.*New island record**

In Hawai'i, known from all of the main islands except Ni'ihau and Kaho'olawe (Wagner *et al.* 1999), *S. arvensis* was previously recorded by Herbst & Wagner (1992) and noted by Brueggemann in 1995 as rare on Sand Island (Brueggemann 1998). It was not observed in 1999 (Starr & Martz 1999) or 2008. It was collected for the first time in 2012 by Nik Aspey (Aspey 2012), who reported this species reappeared after some trenching along the south side of Peters Ave. north of the Citrus Grove. In 2015, about two dozen plants were further observed in the Community Garden and field by the Cargo Pier (Starr & Starr 2015). Though reported previously, these recent collections represent a new island record for Midway.

Material examined. **MIDWAY ATOLL:** Sand Island, in Community Garden, NE corner, coastal inland/urban with *Carica papaya* and *Rosmarinus officinalis*, couple dozen plants here, also few found in field by Cargo Pier, 15 ft [5 m] (463,074 E, 3,120,896 N), 30 Mar 2015, *Starr & Starr 150330-01*; Sand Island, south side of Peters Ave, north of Citrus Orchard, coastal inland/urban with *Casuarina equisetifolia*, *Citrus* spp., and *Verbesina encelioides*, several plants in a 30–40 ft long stand, 15 ft [5 m] (463,361 E, 3,120,777 N), Jan 2012, *Aspey s.n. (Starr & Starr 150404-01)*.

Portulacaceae***Portulaca pilosa* L.****New island record**

In Hawai'i, this small succulent plant is documented from dry coastal sites on all the main islands except Lāna'i and Kaho'olawe (Wagner *et al.* 1999). It is now also known from Kaho'olawe, where scattered plants were found growing on a rocky ledge just outside of camp at Hakioawa.

Material examined. **KAHO'OLAWE:** Hakioawa, near camp along rocky wall, lowland scrub/camp in association with *Prosopis pallida*, *Cenchrus ciliaris*, *Leonotis nepetifolia*, and *Ageratum conyzoides*, 15 ft [5 m] (755,028 E, 2,277,833 N), 13 Dec 2015, *Starr & Starr 151213-02*.

Solanaceae***Solanum torvum* Sw.****New island record**

Turkey berry is a Federal and Hawai'i State Noxious weed (USDA 2016). In Hawai'i, it was previously documented from the islands of Kaua'i, O'ahu, Maui, and Hawai'i, where this large thorny shrub can form dense thickets in lowland disturbed sites, such as pastures and waterways (Wagner *et al.* 1999; Oppenheimer *et al.* 1999; Starr *et al.* 2003; Frohlich & Lau 2012). Turkey berry is also cultivated for its edible fruits used in curries, which was the reason it was introduced to Midway Atoll. This species was first observed and collected on Midway in 2008 from the Community Garden, where there were a few large plants and several seedlings nearby (Starr & Starr 2008). Plants were also observed at a residence. Removal was recommended. By 2015, all the plants had been successfully controlled, except for a couple next to the Community Garden that appeared to have grown back from very large stumps. These were treated again, but had gone to fruit, so a seed-bank likely exists (Starr & Starr 2015).

Material examined. **MIDWAY ATOLL:** Sand Island, Community Garden, coastal urban/garden with *Carica papaya* and *Musa ×paradisiaca*, 15 ft [3 m] (463,101 E, 3,120,879 N), 1 Jun 2008, (*Starr & Starr 080601-12*).

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while on Midway and Kaho‘olawe, and the Bishop Museum Herbarium Pacificum staff and volunteers for curating vouchers and publishing new records.

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The Status of *Argiope trifasciata kauaiensis* (Araneae: Araneidae) on Kaua‘i, Hawai‘i

JAMES W. BERRY¹

Dept. of Biological Sciences, Butler University
Indianapolis, Indiana 46208, USA; email: berryjw@ufl.edu

ADAM WILLIAMS

Hawaii Department of Land and Natural Resources,
Division of Forestry & Wildlife, Lihue, Hawai‘i 96766, USA

Argiope trifasciata (Forsskål), the banded garden spider (Fig. 1), is an orb weaver found over much of the Earth — common in the Americas, Australia, northern Africa, and the Iberian Peninsula, but not reported from other parts of Europe and Japan. In 1900, on an expedition by the Royal Society of London to Kaua‘i in the Sandwich Islands (Hawaiian Islands), a female *Argiope* was collected and was described in *Fauna Hawaiiensis* by Simon as *Argiope avara kauaiensis*. Although females are quite common, no males were collected at that time — or at any time since. As a consequence, there are no male specimens of the species from Kaua‘i in any of the major museums (Bishop Museum, American Museum of Natural History, British Museum, etc.). Without seeing the male, Levi (1983: 286) synonymized this species with the widespread *Argiope trifasciata*.



Figure 1. Habitus of female *Argiope trifasciata* (Forsskål) from Kaua‘i.

1. Current address: 325 NW 28th Terrace, Gainesville, Florida 32607-2513, USA.



Figure 2. Habitus of male *Argiope trifasciata* (Forsskål) from Kaua'i.

Kaua'i, the second oldest of the main Hawaiian Island chain at 4.7 my (Clague, 1996), comprises 552 square miles (331 km²) of varied volcanic island topography. Its elevations range from sea level to Kawaikini Peak at 5148 ft (1569 m). Recently, Spagna *et al.* (2015) noted that percent endemism increases monotonically with increasing elevation which reinforced the authors' decision to search the higher elevations of Kaua'i intensively for the never-described male *Argiope trifasciata kauaiensis*. In more than 25 years of collecting experience on Hawai'i Island, Kaua'i, and to a lesser extent O'ahu and Maui, the authors have collected no *Argiope trifasciata kauaiensis*, and only one specimen of *Argiope trifasciata* outside the higher elevations of Kaua'i. *Argiope appensa* (Walckenaer) is commonly collected in all the above counties.

The reproductive organs of the *Argiope* females are sufficiently generalized that correct identifications to species-level are difficult. Significantly, the Kaua'i females have some morphological differences from specimens of *Argiope* found in other locations in the world. Levi (1983) concluded, based on the information available at that time, that the specimens found on Kaua'i represented only a color morph and were treated as *A. trifasciata*. Levi did not examine Simon's 1900 *Argiope avara kauaiensis* specimen; however, it appears he did examine other *Argiope trifasciata* specimens from the Bishop Museum. The late Dr. Joseph Beatty (pers. comm.), after observing the Kaua'i females in their environment, believed that they were sufficiently different to merit raising them to *Argiope kauaiensis*. Suman (1964), who also had the opportunity to see this species in Hawai'i, listed it as *kauaiensis* in his catalog of Hawaiian spiders.

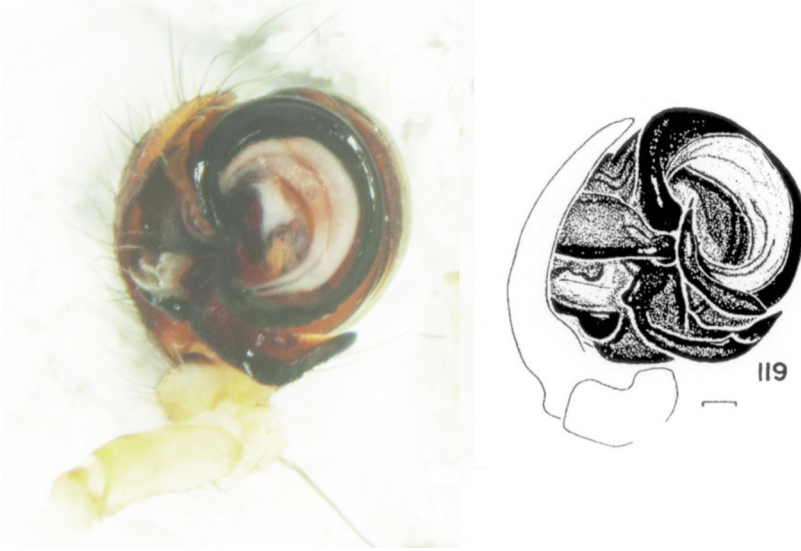


Figure 3. Comparisons of male pedipalps of *Argiope trifasciata* (Forsskål). (Left) Kauai specimen; (Right) from Levi (1983). Courtesy of Museum of Comparative Zoology, Harvard University.

METHODS

We made a collecting net (60 x 45 x 45 cm) from stiff wire, cloth netting, and a bamboo pole 4 m long. The long pole was required because the webs of this spider are usually 3–4 m above the ground. In searching for specimens, we walked the trails of the Koke'e State Park (21.930°N, 159.605°W), Waimea Canyon State Park, and private land, such as the Kahili Mountain Trail (21.96328°N, 159.48661°W) at Kahili Mountain Park for almost three weeks. The first male and female found were kept alive and observed for a day or so, photographed (Figs. 1, 2), then preserved in 70% ethanol. Collection permits were obtained from the Hawaii Department of Land and Natural Resources (Division of Forestry and Wildlife; and the Division of State Parks), and the Natural Area Reserves System. Vouchers of specimens will be deposited in the Bishop Museum, Honolulu.

RESULTS

The sexes: To date, we have collected many adult females but only three mature males. Upon microscopic examination, we determined that the palp of the Kaua'i male was identical (Fig. 3) to the palp of *Argiope trifasciata* from other locations as illustrated by Levi (1983), but various characteristics of the Kaua'i female are different. Normally, the determination that the Kaua'i male is similar to those of other locations would settle the question — the Kaua'i *Argiope* is *A. trifasciata* — but when we look at the habitus of the female, we see a somewhat different picture. We found a male in the web (about 4 m above the ground) with a female, so there is little doubt that the male and female are paired correctly. More recently (December 2015), we collected another male, also in the female's web.

Female shape and color: Normally species are not described based on color, but it should be taken into consideration. Conspicuous grey hairs on the dorsal side of the cephalothorax cause local residents to refer to them as the “spooky spider” or the “large grey spider.” Simon (1900) eloquently and accurately described the Kaua’i female — including the almost round, marble-like abdomen (Fig.1). Kaston (1952) said that *A. trifasciata* has a more pointed abdomen. Levi (1983) said that “the dorsum of the abdomen is black with a light anterior resembling *Argiope bougainvilla* (Walckenaer) from the Solomon Islands and *Cyrtophora moluccensis* (Forsskål).

Female web location: Females are frequently found on webs built high above the ground, often between high tension power wires at 10–12 m or stretched between leafless limbs. At the very top of knife-edge ridges, they can be found in webs that are 2–5 m above the ground and continuously exposed to strong winds blowing up the ridge —estimated at 30 kph (20 mph), but they seem to be able to withstand the winds without damage.

Elevation: In 1988, we found one male that we identified as *Argiope trifasciata* in a Kaua’i orchard at 30m elevation. At the time, we assumed it to be the male of the widespread and characteristic *Argiope trifasciata*. A male found recently with the Kaua’i female was at 381 m elevation. Most of the potential *kauaiensis* specimens have been found at elevations from 400–1000 m. In some locations at high elevation (~1000 m), they are fairly common. Recently one of us (AW) collected a mature male and saw several apparently mature males and females at 760 m elevation along the Na Pali coast. At the Circle Bog in the Alaka’i Swamp (1300 m), metallic blue-black females were readily found.

Egg case: Bradley (2013) stated that *A. trifasciata* typically has a cream-colored egg case, but we have found about a dozen empty egg cases that were green.

Season: It appears that *A. trifasciata kauaiensis* is present year-round. We have taken adult females from January to April and September to October, and three adult males in February, September and December. According to Bradley (2013), in North America, males are present summer through autumn, females from late summer throughout November.

Material examined. HAWAIIAN ISLANDS: **Hawai’i:** Route #130, mile marker 88; tree shaking, 1 Feb 1997, J.W. & E.R. Berry, 1 male. **Kaua’i:** Kapa’a, Kawaiha’a Road, in orchard, 12 Jan 1988, J.W. Berry, 1 male; Koke’e State Park, Mohihi Road, in overhead power lines, elev. 3500 ft [1067 m], 31 Jan 1998, J.W. & E.R. Berry, 1 female; Kahili Mountain Trail, N21.96379°, W159.48758°; elev. 1250 ft [381 m], 20 Feb 2014, 1 male, 1 female; on road bank N22.128, W159.643; elev. 3500 ft [1067 m], 23 Feb 2014, J.W. & E.R. Berry, 3 females; Alaka’i Swamp, Circle Bog, N.22.124°, W159.877°, 27 Feb 2014, J.W. & E.R. Berry and Adam Williams, 1 immature specimen (~3-4 instar); Alaka’i Swamp, Circle Bog, N22.124°, W159.877°, elev. 4369 ft [1332 m], 27 Feb 2014, J.W. & E.R. Berry and Adam Williams, 1 female; MICHIGAN: Livingston County: E.S. George Reserve, Grids L, K + J-15, 12 Aug 1954, H.K. Wallace, 3 males, 2 females; same data, 22 Aug 1954, H.K. Wallace, 1 male.

DISCUSSION

Simon (1900) was probably correct when he listed the Kaua’i *Argiope* as a subspecies; and, as the World Catalog of Spiders (2017) accepts *Argiope trifasciata kauaiensis*, it is unnecessary for us to make any taxonomic changes at this time. Whether or not the female morphological changes signal some genetic drift toward speciation will probably be determined only by future DNA work.

At this point we have more questions than answers. What has pushed the species to very high elevations? How does one account for the high numbers at high elevations? Why are the males so rare?

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Notes on Three Erroneous Referrals of Non-Hawaiian Fossil Nonmarine Gastropods to Endemic Hawaiian¹ Genera and Species

CARL C. CHRISTENSEN²

Bishop Museum, 1525 Bernice Street, Honolulu, Hawai‘i 96817-2701;
email: carl@bishopmuseum.org

Several recent instances have come to light in which paleontologists unfamiliar with Hawaiian nonmarine mollusks have relied on superficial similarities in shell morphology to assign non-Hawaiian fossil species to genera or species endemic to the Hawaiian Islands notwithstanding obvious biogeographic and stratigraphic inconsistencies. Three of these are identified here to preclude the possibility that they could be the source of future unwarranted biogeographical inferences.

Achatinellidae

?*Newcombia delicata* Youluo, 1978

This species was described from fossil material from the early Tertiary of Bohai, northern China (Youluo 1978: 137–138, pl. 25, figs. 21, 22). The description of ?*N. delicata* compared it to *N. plicate* [sic] (Pfeiffer, 1848), now regarded as a synonym of *N. lirata* (Pfeiffer, 1853) (Cowie *et al.* 1995). While the overall appearance of the shell of ?*N. delicata* does somewhat resemble that of *N. lirata* in form and sculpture, the former is much smaller in size than any species of *Newcombia* (2.95 mm in height vs. 12.5–25.0 mm in *Newcombia* according to Schileyko 1998: 46). Furthermore, its description fails to differentiate it from several genera of Planorbidae (cf. *Glyptophysa* Crosse, 1872, *Pseudophysa* Yen, 1938, and *Bulinus* (*Pyrgophysa*) Crosse, 1879) reported by Youluo (1978) to be present in the Bohai material. The Achatinellidae are best characterized by anatomical characters (Pilsbry & Cooke 1912–1914; Cooke & Kondo 1961; Schileyko 1998), unavailable in fossil material such as ?*N. delicata*. Nevertheless, the statement that the apex of the shell of ?*N. delicata* is smooth (“壳顶小而光滑” [“top of shell small, smooth”]; Youluo 1978: 137) distinguishes it from *Newcombia*, in which the embryonic shell bears what are described as “comparatively coarse spirals” (Pilsbry & Cooke 1912–1914: 1, pl. 1, figs. 9, 12) or “distinct spiral cords” (Schileyko 1998: 46). Placement of the Chinese species in *Newcombia* is undoubtedly incorrect and the range of the genus, properly understood, is limited to the Hawaiian Islands. Species of *Newcombia* are known to inhabit, or formerly to have inhabited, the islands of Kaua‘i, Moloka‘i, and Maui (Pilsbry & Cooke 1912–1914; Cowie *et al.* 1995; Gage 1996; Severns 2009).

1. Contribution 2017-003 to the Hawaii Biological Survey.

2. Research Associate, Hawaii Biological Survey, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai‘i 96817-2704, USA.

Amastridae

Amastra (Amastra) patrulei Moisescu, 1982

This species was described from the Oligocene of Transylvania, Romania (Moisescu 1982: 93–94, pl. 3, figs. 10a, 10b, 11a, 11b, pl. 4, figs. 1a–13b). As with the Achatinellidae discussed above, the most distinctive characters of the Amastridae are in the soft anatomy (Hyatt & Pilsbry 1911; Schileyko 1998), unknown in this fossil species. The description and accompanying figures of the poorly preserved type material show no conchological characteristics specific to the Amastridae or to *Amastra* (*s.s.*) and, although the description refers to the presence of a columellar callus (“*un cal collumellaire*”) or columellar fold (“*un plis collumellaire*”) (Moisescu 1982: 93), none of the figured specimens show the “spiral [columellar] lamella that penetrates the “*about a half whorl*” characteristic of *Amastra* (*s.l.*) (Hyatt & Pilsbry 1911: 134; emphasis in original) or the “thin, sharp, high” columellar lamella characteristic of *Amastra* (*s.s.*) (Schileyko 1998: 54). The Romanian snail’s maximum shells height of 3.6 mm is much smaller than the 9 to 36 mm shells of species of *Amastra* (*s.s.*) (Schileyko 1998: 54). All other species reported from the same site are of aquatic or marine taxa (*Hydrobia* Hartmann, 1821; *Kleinella* Adams, 1860; *Pseudamnicola* Paulucci, 1878; and *Stenothyrella* Wenz, 1939), and “*Amastra*” *patrulei* could belong to any of several families of small to minute prosobranchs. Placement in *Amastra*, a genus of pulmonate land snails otherwise restricted to the Hawaiian Islands, is without foundation and is undoubtedly erroneous.

Vertiginidae

Nesopupa (Nesodagys) wesleyana Ancey, 1904

Huang & Guo (1991) and Wang & Guo (1991) reported the supposed occurrence of the Hawaiian endemic species *Nesopupa (Nesodagys) wesleyana* Ancey (1904), as a fossil in the Cenozoic of Shanxi, China. The discussion of *N. wesleyana* in the systematic review (Wang & Guo 1991:113) cites “pl. 29, fig. 12” in Pilsbry & Cooke (1918–1920) in support of the identification (apparently an error for pl. 29, figs. 1 and 2; pl. 29, fig. 12 is of another species, *Nesopupa (Limbatipupa) oahuensis* Cooke & Pilsbry in Pilsbry & Cooke, 1920). Figures of the supposed *N. wesleyana* (Wang & Guo 1991, pl. 23, figs. 16 & 17) are of a vertiginid consistent with either *Nesopupa* or *Vertigo* Müller, 1773, one species of the latter of which is also present in the same deposit. The illustrated specimen appears to have six apertural lamellae, including weak supracolumellar and columellar lamellae. *N. wesleyana* is distinguishable in that it has a strong columellar lamella and lacks the supracolumellar lamella, and the assignment of the Chinese material to the Hawaiian species is undoubtedly erroneous. *N. wesleyana* and its various subspecies have been reported from all of the main Hawaiian Islands except Ni‘ihau (Pilsbry & Cooke 1918–1920; Cowie *et al.* 1995).

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***Conoderus posticus* (Eschscholtz) (Coleoptera: Elateridae), a new state record for Hawai‘i, and a key to local species¹**

PAUL J. JOHNSON²

Insect Biodiversity Lab, Box 2207A, South Dakota State University, Brookings, South Dakota 57007, USA; email: paul.johnson@sdsstate.edu

CASSANDRA OGURA-YAMADA AND PAUL D. KRUSHELNYCKY²

Department of Plant and Environmental Protection Sciences, University of Hawai‘i at Mānoa, 3050 Maile Way, Honolulu, Hawai‘i 96822, USA; email: cso@hawaii.edu, pauldk@hawaii.edu

G. ALLAN SAMUELSON²

Bishop Museum, 1525 Bernice Street, Honolulu, Hawai‘i 96817-2704, USA; email: alsam@bishopmuseum.org

The Hawaiian Islands have 65 species of Elateridae (Coleoptera) reported, of which 45 are native and endemic (Nishida 2002). An additional eight species are reported as quarantine interceptions or were intentional or other introductions and not known to be established. However, 13 species are confirmed as adventive and are, or were, established. These latter species include four species of *Conoderus* Eschscholtz, three from southern Pacific regions and one from Neotropical areas. *Heteroderes flavicans* (Candèze) from Australia was generically transferred by Calder (1996), but was historically treated as a *Conoderus* for Hawai‘i records. Here, we report a fifth species of *Conoderus*, *C. posticus* (Eschscholtz) as new to Hawai‘i and established on O‘ahu. This is the fourth species of click beetle adventive to Hawai‘i from the Americas, with *Aeolus livens* (LeConte) (Johnson & Lin 1998), *Chalcolepidius erythroloma* Candèze (Johnson 2001), and *Conoderus amplicollis* (Gyllenhal) (Beardsley 1977).

The specimens reported below are deposited at the University of Hawaii at Mānoa Insect Museum (UHIM), the Bernice P. Bishop Museum (BPBM), and the senior author’s collection (PJJC), as indicated.

Coleoptera: Elateridae

***Conoderus posticus* (Eschscholtz)**

New state record

(Fig. 1)

This click beetle has a wide distribution through South America east of the Andes, from northern Argentina and through the Lesser Antilles to the Turks and Caicos Islands of the Lucayan Archipelago. It was originally described (Eschscholtz 1822) from Santa Catharina, Brasil, then transferred to *Monocrepidius* Eschscholtz (1829). Schenkling (1925) and Blackwelder (1844) recorded it from most of its known range.

1. Contribution No. 2017-004 to the Hawaii Biological Survey.

2. Research Associate, Hawaii Biological Survey, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai‘i 96817-2704, USA.

Material Examined: The three specimens examined are female. HAWAIIAN ISLANDS: **O‘ahu:** Wai‘anae Mtns, Honouliuli Forest Reserve, ‘Ēkahanui, 600 m, N21.4396°, W158.0929°, 30 Apr 2015, C. Ogura-Yamada & P. Krushelnycky, litter / coll.# SP100, spec/lot# COSP3114 (1, BPBM); N. Wai‘anae Mtns, Kahanahāiki Valley, 650 m, N21.5375°, W158.1935°, 2 May 2015, C. Ogura-Yamada & P. Krushelnycky, pitfall / coll.# SP134, spec/lot# COSP3508 (1, UHIM); N. Wai‘anae Mtns, Kahanahāiki Valley, 650 m, N21.5375°, W58.1935°, 2 May 2015, C. Ogura-Yamada & P. Krushelnycky, pitfall / coll.# SP135, spec/lot# COSP7029 (1, PJJC). The two collection sites are in mesic montane forests supporting a mixture of native and alien vegetation, with annual rainfall averaging from 1210–1384 mm per year (Giambelluca *et al.* 2013)

As females, these specimens exhibit the slight sexual dimorphism found in most species of *Conoderus*. Aside from the genital structures, these dimorphic traits include a slightly narrower pronotum (Fig. 1) in dorsal aspect than typical males that have a wider pronotum anterad and with broadly arcuate lateral margins.

The fact that the three recovered specimens to date are from two widely separated localities indicates that an established population is present on O‘ahu and that *C. posticus* should be considered newly recognized as introduced to Hawai‘i.

KEY TO THE *CONODERUS* AND *HETERODERES* OF HAWAI‘I

[*Heteroderes flavicans* is included due to its historical assignment to *Conoderus*]

1. Pronotum with hind angles bearing two strong divergent dorsal carinae 2
- . Pronotum with hind angles bearing a single strong dorsal carina 5

2. Legs pale yellow, contrasting to dark, infuscate to black integument of body 3
- . Legs concolorous to or slightly paler than body integument 4

3. Pronotum depressed discally; punctures large, coarse, often confluent, interspaces densely microreticulate and dull in sheen. Elytral intervals flat
 *Conoderus amplicollis* (Gyllenhal)
- . Pronotum shallowly convex; punctures moderate in size, distinctly separate, interspaces shining. Elytral intervals shallowly convex, at least basally
 *Conoderus exsul* (Sharp)

4. Pronotum short, broadly arcuate at lateral margins; disc shallowly convex, densely punctured, integument dull in sheen; hind angle apices reflexed. Elytra pubescence evenly distributed *Heteroderes flavicans* (Candèze)
- . Pronotum distinctly longer than wide, strongly convex, punctures evenly spaced, interspaces shining; hind angle apices straight. Elytral pubescence denser, appearing vittate, on alternating intervals *Conoderus eveillardii* (LeGuillou)

5. Elytra concolorous, except occasional pale highlights along basal margins. Pronotum finely, densely, often instinctly punctured *Conoderus pallipes* (Eschscholtz)
- . Elytra maculate at midlength or more extensively. Pronotum moderately punctured with shallow, discrete punctures, interspace areas shining
 *Conoderus posticus* (Eschscholtz)



Fig. 1. *Conoderus posticus* from Kahanahāiki Valley, dorsal aspect.

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An Unusual Capture of the Bluntnose Sixgill Shark, *Hexanchus griseus* on a Pelagic Longline in the Hawaiian Longline Fishery with Comments on the Worldwide Genetic Population Structure

GERALD L. CROW

*Waikiki Aquarium, University of Hawai'i at Manoa, 2777 Kalakaua Ave., Honolulu, Hawai'i
96815, USA; email: gcrow@hawaii.edu*

ROBERT L. HUMPHREYS, JR. (RETIRED)

*NOAA Pacific Islands Fisheries Research Science Center, Fisheries and Monitoring Division,
1845 Wasp Boulevard, Bldg. 176, Honolulu, Hawai'i 96818, USA*

GAVIN J. P. NAYLOR

Dickinson Hall, 1659 Museum Road, University of Florida, Gainesville, Florida 36211, USA

AARON EMANUEL

*Longline Observer Program, NOAA Pacific Islands Regional Office,
1845 Wasp Boulevard, Bldg. 175, Honolulu, Hawai'i 96818, USA*

On 1 May 2016, a large, dark female shark (270 cm TL, 90.5 kg), with green eyes and six gill slits was captured in the Hawaiian longline fishery region (1900 km north east of the Big Island of Hawai'i) at a bottom depth of over 3000 m. A longline for bigeye tuna (*Thunnus obesus*) was set 30 Apr 2016 at 0833, and based on the hook number, the depth of capture was estimated between 100 and 200 m. Retrieval started the same day at 1748 and was completed at 0508 (1 May 2016). Based on the unusual nature of the specimen, the shark was retained and frozen onboard ship. The frozen shark was evaluated on 22 Jul 2016 for 60 morphological parameters plus teeth shape and row number. There were no visible stomach or intestinal food contents, no follicles present in the ovary, and the uterus appeared thread-like. The shark was clearly an immature female. A portion of the lower jaw and skin flank tissue was deposited in the Bernice P. Bishop Museum accession number BPBM 41330. Muscle tissue was removed for later DNA species verification, and photographs were taken (Figure 1). Based on the six gill slits, a single dorsal fin origin posterior to the pelvic fin base, and six rows of lower jaw comb-shape teeth, the specimen was identified as *Hexanchus griseus* the bluntnose sixgill shark (Compagno 1984; Ebert *et al.* 2013a).

The bluntnose sixgill shark (BSS), *Hexanchus griseus* (Bonnaterre, 1788) has been reported worldwide from the Atlantic, Indian, and Pacific oceans, and the Black and Mediterranean seas from the surface to 2500 m (Compagno 1984; Kabasakal 2004; Ebert *et al.* 2013b). This species is described as demersal, occurring on the continental shelves, slopes, seamounts, and submarine ridges (Compagno 2002; Barnett *et al.* 2012). It typically occurs in shallow, cold temperate water and inhabits deeper depths in subtropical and tropical waters. It was suggested that the BSS moved into the subtropics and tropics via isothermic submergence (Hubbs 1952).



Figure 1. Photographs of the Hawai'i *Hexanchus griseus* frozen specimen: **A.** dorsal body length of female 270 cm TL. **B.** horizontal view of the head region. **C.** distinctive comb-shaped lower-jaw tooth pattern.

In the Hawaiian Archipelago, the BSS has been documented from Hancock Seamount to the island of Hawai'i (Humphreys *et al.* 1984; Chave & Malahoff 1998). On O'ahu's southwestern coastline, 20-BSS (273–378 cm TL) were captured in shark control programs from 1959 to 1969, on bottom longline sets at depths of 110–366 m (Crow *et al.* 1996). In the 1967–1969 control program, BSS were typically captured at bottom depths of 330–366 m, with eight sharks captured on 105 hooks (Crow *et al.* 1996). Submersible observations of BSS around the main Hawaiian Islands have been at depths of 500 to 1440 m (Chave & Jones 1991; Chave & Mundy 1994), and free vehicle cameras have recorded BSS off Lisianski at 500 m and NW O'ahu at 1000 m (Yeh & Drazen 2009). Recent satellite telemetry tracks of four BSS (266–333 cm TL) in Hawai'i revealed a median daytime depth of 614 m and a median nighttime depth of 292 m (Comfort & Weng 2014). Generally, these sharks dove abruptly at dawn and remained deeper during

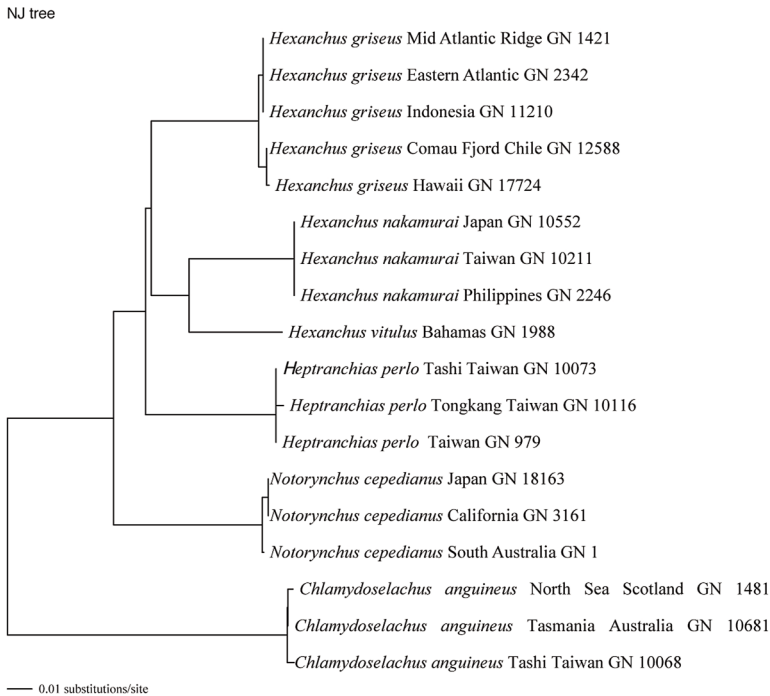


Figure 2. Updated Hexanchiformes phylogenetic tree for specimens of *Hexanchus griseus* in the Chondrichthyan Tree of Life database utilizing the NADH2 gene (www.sharksrays.org).

the day, with daytime activity rates at 1.3 m/min and nighttime rates at 2.2 m/min (Comfort & Weng 2014). The depth range of BSS in Hawaiian waters is typically below the thermocline, 100–400 m (Chave & Mundy 1994; Crow *et al.* 1996), at a maximum water temperature range of 5.4–20.6 °C, and generally below 16 °C (Comfort & Weng 2014). In Hawai‘i, the BSS is present within and outside the oxygen minimum zone (OMZ) (Yeh & Drazen 2009), a zone at bathyal depth ranges of 200–1000 m and with oxygen concentrations of <1 mg/L (Levin 2003). The OMZ is created through biochemical oxygen consumption with limited water circulation (Wyrtki 1962). In Hawai‘i, faunal species richness decreases at about 500–1000 m within the OMZ (Yeh & Drazen 2009). Immature BSS in Hawai‘i occur in the OMZ during daytime hours and ascend into the thermocline during the night (Comfort & Weng 2014).

Age at maturity, and detailed reproductive biology such as the reproductive cycle are largely unknown. The BSS reaches maturity at a fairly large size, with males at 300 to 315 cm TL (Crow *et al.* 1996; Capape *et al.* 2004; Barnett *et al.* 2012) and females at 400 to 420 cm TL (Capape *et al.* 2004; Barnett *et al.* 2012). Size at birth worldwide ranges from 56–74 cm TL (Capape *et al.* 2004; Ebert *et al.* 2013b) with a large range of embryos at 47–108 (Ebert *et al.* 2013b).

This is the first longline fishery report of BSS captured in the Hawaiian Islands. Worldwide longline captures of the BSS on pelagic longlines are rare and have been reported from off southern Brazil at depths of 60–120 m (Amorim *et al.* 1998), in Italian longline fisheries (Natale 1998), and the Venezuelan longline fishery in 1994–2000 caught four BSS that ranged in size from 97–119 cm TL (Arocha *et al.* 2002).

In order to ensure correct species identification with the challenges of small sample sizes, ontogenetic changes in morphology, and cryptic speciation, a small sample of dorsal flank muscle tissue was removed from the Hawai'i BSS specimen. The tissue was sent to the College of Charleston for mitochondrial (mt) DNA isolation and sequencing. The mtDNA sequence was referenced against the Chondrichthyan Tree of Life—a genetic database that uses DNA sequences of the NADH2 gene to verify species identification and provide a window into population boundaries of sharks and rays (Naylor *et al.* 2012). The NADH2 sequence is a fast-evolving protein-coding gene that can distinguish between closely related species, cryptic species, and geographic variants and should be used with morphometric, meristic and voucher specimen retention (Naylor *et al.* 2012). The BSS database contains samples from the mid Atlantic ridge, eastern Atlantic, Indonesia, Comau Fjord (Chile), and Hawai'i (Figure 2). The Hawai'i sequences differ from Atlantic and Indian oceans' BSS by two base pairs or less and are about 1 to 3% different worldwide. The sequences from the eastern Pacific, Chilean and central Pacific Hawai'i are virtually identical. The sequences currently in the database reveal one BSS worldwide species.

CONSERVATION

Based on the large size at first reproduction and the assumption that BSS is not capable of sustaining sport or commercial fishing, the International Union for Conservation of Nature lists this shark as near threatened, globally (Camhi *et al.* 2009). In Hawai'i, with the absence of sport or commercial fishing at the primary demersal population depth, the BSS remains fairly abundant. However, any habitat alteration relating to deep sea mining or fishing changes in Hawaiian waters could rapidly alter the population as is reported for sharks globally (Worm *et al.* 2013). A bottom longline fishery on Hancock Seamount for the pelagic armorhead (*Pseudopentaceros wheeleri*) resulted in a large bycatch of the dogfish shark *Squalus cf. mitsukurii* (Wilson & Seki 1994). The fishery had an estimated 50% decline in catch rate from 1985–1988 for this squalid species (Wilson & Seki 1994). Currently, we know very little about the population structure of deep-sea sharks in Hawai'i making it hard to provide any advice for potential management.

CONCLUSIONS

This is the first report of a BSS from the Hawai'i longline observer program since the program's inception in 1994. Based on 97–270 cm TL size of specimens captured worldwide on pelagic longlines (Arocha *et al.* 2002; this report), immature specimens appear to utilize the pelagic environment to feed and possibly disperse. The satellite telemetry data reveal a more vagile species in the subtropics than was originally thought based on somewhat sluggish movements around video bait stations (Comfort & Weng 2012). The genetic sequence database supports a worldwide population in the Atlantic, Indian, and Pacific oceans that retains connectivity by immature individuals actively utilizing the pelagic zone and adults utilizing demersal habitats at seamounts, islands, and atolls that can serve

as either stepping stones for dispersal or “oases” for sustained biodiversity (Crow *et al.* 1996; Kvile *et al.* 2014). The BSS is a worldwide, large, active predator that is common in Hawai‘i benthic habitats but is potentially vulnerable to habitat destruction or fishing pressure.

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The Afrotropical biting midge, *Forcipomyia* (*Forcipomyia*) *biannulata* (Diptera: Ceratopogonidae) established in the United States¹

WILLIAM L. GROGAN, JR.

Florida State Collection of Arthropods, Florida Department of Agriculture and Consumer Services, Gainesville, Florida 32614, USA; email: william.grogan@freshfromflorida.com

FRANCIS G. HOWARTH²

Distinguished Research Associate, Department of Natural Sciences, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai'i 96817-2704, USA; email: fhowarth@bishopmuseum.org

LAWRENCE J. HRIBAR

Florida Keys Mosquito Control District, 503 107th Street, Marathon, Florida 33050, USA; email: lhribar@keysmosquito.org

INTRODUCTION

The biting and predaceous midge (Diptera: Ceratopogonidae) fauna of the continental United States and Canada is diverse with over 600 recorded species (Borkent & Grogan 2009). Several are primarily mainland Neotropical species that range north of Mexico in Arizona, California, and Texas (Borkent & Spinelli 2000, 2007). In addition, other primarily Neotropical species occurring in the Caribbean Region also inhabit Florida and several adjacent states (Wilkening *et al.* 1985, Grogan *et al.* 2010, Vigil *et al.* 2014).

A few exotic species of Ceratopogonidae have been introduced into the United States during the past 25 years. For example, within the genus *Forcipomyia*, Wirth & Spinelli (1992) documented the Australasian biting midge, *Forcipomyia* (*Forcipomyia*) *swezeyana* Tokunaga & Murachi, in Florida that were reared from decaying *Philodendron* and banana (*Musa*) plants. A decade later, Grogan & Hribar (2006) reported the Neotropical species, *Forcipomyia* (*Phytohelea*) *bromelicola* (Lutz), from adults reared from larvae and pupae inhabiting bromeliads in the Florida Keys. More recently, Grogan *et al.* (2013) reported the wide ranging Old World species, *Forcipomyia* (*Lepidohelea*) *pulcherrima* Santos Abreu, from California, Florida and Hawai'i and provided the first description and photographs of the previously unknown 4th instar larva. Herein, we report on an exotic Afrotropical species, *Forcipomyia* (*Forcipomyia*) *biannulata* Ingram & Macfie, that is now established in the United States.

METHODS

Adults from Hawai'i (Howarth & Preston 2007, Howarth *et al.* 2012) were collected at Mercury Vapor (MV) lights and with Malaise traps. Adults from Florida were collected by light, suction and Lindgren funnel traps, and those from Georgia and Mississippi were collected at lights. Specimens were preserved in 70–75% ethanol, subsequently cleared in a solution of phenol crystals dissolved in 100% ethanol, then dissected and slide-mounted

1. Contribution No. 2017-006 to the Hawaii Biological Survey.

2. Current address: 4033 SW Tunnelwood St., Portland, Oregon 97221, USA

in a mixture of the ethanol-phenol solution and Canada balsam by the methods described by Wirth & Marston (1968). Voucher specimens were compared with slide-mounted specimens of most Nearctic species and several Neotropical species of *Forcipomyia* Meigen, as well as published descriptions of species from both regions. Terminology of adult Ceratopogonidae are those in Downes & Wirth (1981) and Borkent *et al.* (2009).

Voucher specimens are deposited in the Florida State Collection of Arthropods, Gainesville (FSCA); United States National Museum of Natural History, Washington, D. C. (USNM); Museo de La Plata, Argentina (MLPA); Bernice P. Bishop Museum, Honolulu, Hawai'i (BPBM); and the Florida Keys Mosquito Control District, Marathon (FLKC). GIS data of specimens from Hawai'i are all WGS-84 map datum.

RESULTS

Diptera: Ceratopogonidae Subfamily Forcipomyiinae

Forcipomyia (Forcipomyia) biannulata Ingram & Macfie, 1924 (Figs. 1–7)

Forcipomyia biannulata Ingram & Macfie, 1924: 557. Ghana, Nigeria, Malawi. (female, male; figs. male genitalia, hind tibial scale); Macfie 1926: 357 (Tanzania); Macfie 1934: 179 (Malaya); Macfie 1937: 73 (Ethiopia); Macfie 1943: 147 (Egypt); Macfie 1947: 69 (Egypt); Clastrier 1959b: 432 (Réunion; as *F. abonnenci* Clastrier); Clastrier 1960: 515 (Democratic Republic of the Congo; females); Dessart 1961: 315 (in review of species of *Forcipomyia* described by Goetghebuer from Congo; *Forcipomyia bicolorata* Goetghebuer, *F. marginella* Goetghebuer, *F. nigrocosta* Goetghebuer, *F. quatuorguttata* Goetghebuer, *F. pallidula* Goetghebuer, and *F. abonnenci* Clastrier as synonyms); Dessart 1962: 139 (in list of *Forcipomyia* pollinators of Cacao).

Forcipomyia (Lepidohelea) biannulata: Clastrier 1960: 515 (Democratic Republic of the Congo); Clastrier *et al.* 1961: 50 (Chad).

Forcipomyia (Forcipomyia) biannulata: Clastrier & Wirth 1961: 190 (Ethiopia, Gambia, Nigeria); Dessart 1963: 45 (in review of African *Forcipomyia*; in key; figs. legs banding pattern, tibial scale, male genitalia; Egypt, Madagascar, South Africa, Tanzania); Clastrier 1966: 694 (Canary Islands); Wirth & Messersmith 1977: 296 (Mauritius, Seychelles; males, females; figs. male antennal flagellomeres, palpus, hind tibial comb & hind tarsomeres 1–2, genitalia); Wirth *et al.* 1980: 154 (in Afrotropical catalog; distribution); de Meillon & Wirth 1981: 564 (South Africa); de Meillon & Wirth 1989: 207 (Botswana, Zimbabwe); Ghonaim *et al.* 2001: 40 (Egypt).

Forcipomyia bicolorata Goetghebuer, 1935: 150. Congo.

Forcipomyia marginella Goetghebuer, 1935: 156. Congo.

Forcipomyia nigrocosta Goetghebuer, 1935: 158. Congo.

Forcipomyia quatuorguttata Goetghebuer, 1935: 158. Congo.

Forcipomyia pallidula Goetghebuer, 1948: 6. Congo.

Forcipomyia abonnenci Clastrier, 1959a: 340. Senegal.

Diagnosis. Males and females of *F. biannulata* have dark broad apical femoral and narrower sub-basal tibial bands on their hind legs (Fig. 1) that are covered with dense elongate setae that are slightly flattened each with single central striation. In addition, the scutum of both sexes is uniformly dark brown (Fig. 2); the 8th abdominal segment is pale and contrasts conspicuously with adjacent segments; and flagellomeres 11–13 of males and 9–

13 of females (Fig. 3) are relatively short. The genitalia of males (Fig. 4) have an aedeagus with a very low concave basal arch and a moderately slender heavily sclerotized central sclerite with a long sharply pointed apex, and separate parameres, the elongate distal portions of which are thread-like. Females have a few large hastate scales on the dorsum of their mid and hind tibiae (often lost during collecting or when preserved in ethanol), two large ovoid spermathecae (Fig. 5), a yoke-shaped genital sclerite (Fig 6), their wing membranes (Fig. 7) are darkly infuscated and their mandibles lack teeth.

Distribution. Widely distributed in the Afrotropical Region in Africa from Botswana, Chad, Congo, Democratic Republic of the Congo, Egypt, Ethiopia, Gambia, Ghana, Malawi, Nigeria, Senegal, South Africa, Tanzania, and Zimbabwe, on Madagascar, Mauritius, Réunion and the Seychelles. It is also known from the Palearctic or Saharo-Arabian subregion (Holt *et al.* 2013) from the Canary Islands, as well as in Asia from Malaysia (Malaya) where it apparently has been introduced.

Material Examined. UNITED STATES: **FLORIDA:** Brevard Co., Melbourne Village (28.08483°N, 80.66577°W), 8 Oct 2017, F. Soto-Adames, moist leaf litter under palmetto fronds in/through Berlese funnel, many males, females, 4 males, 4 females on slides, also 3 larvae of presumably this species in fluid recovered from same soil sample; Collier Co., Immokalee, 17–24 Jul 2014, Scott Croxton, 26' Tall Suction Trap, 3 males, 3 females; Hernando Co., Brooksville, Child's Rd., Withlacoochee Training Facility, 15 Oct 2013, Hayden, Halbert & Skelley, Light trap, 1 female; Marion Co., 12 km E of Rainbow Springs St. Park, 25 Oct 2013–3 Jan 2014, K. Schnepf, Lindgren Funnel Trap, 1 female; Miami-Dade Co., Pinecrest Chapman Field, 22–29 Aug 2016, H. Escobar, Suction Trap, 1 female; same data except 19–25 Jun 2017, 1 female; Monroe Co., Mainland, Loop Road, 20 Nov 2013, L. Hribar, sweep net, 1 female; Polk Co., Winter Haven, DPI Citrus Arboretum, 16–23 Feb 2017, P. Sieburth, Suction Trap, 1 male; same data except 23 Feb–3 Mar 2017, 3 males; same data except 6–13 Apr 2017, 1 female; same data except 4–11 May 2017, 1 female; same data except 15–22 May 2017, 1 female; same data except 25 May–3 Jun 2017, 1 female; Suwannee Co., 12 km W of White Springs, Lindgren funnel trap, 16 May–20 Jun 2017, Kyle E. Schnepf, 1 female. **GEORGIA:** Liberty Co., 23 km SE of Midway, at light, 23 Jul 2016, K. E. Schnepf, 2 females. **MISSISSIPPI:** Jackson Co., 3.3 km W of AL/MS state line, 18 Sep 2014, K. E. Schnepf, at light, 1 female. **HAWAIIAN ISLANDS:** **Hawai'i I.,** Kurtistown, 290 m, 19°34.8'N, 155°04'W, blacklight in fruit tree orchard, 21 Oct 2007, F.G. Howarth, F.D. Stone, 2 males, 1 female; **Maui I.,** Kahului Airport, 20°54'26"N, 156°25'50"W, Malaise Trap set in *Prosopis pallida*, *Leucaena leucocephala* (aka *keawe-koa haole*) mixed understory woodland, #KA2007-171, 21 Oct 2006–13 Nov 2006, F.G. Howarth, F. & K. Starr, D.J. Preston, H. Laederich, 2 males, 4 females; same data except 20°54'26"N, 156°26'01"W, MV Bulb set in *Prosopis pallida*, *Casuarina equisetifolia*, mixed understory woodland, #KA2007-169, 16 Nov 2006, F.G. Howarth, D.J. Preston, F. & K. Starr & H. Laederich, 3 males, 2 females; **O'ahu I.,** Honolulu, Kalihi, 21°20.6'N 157° 52.6'W, 120 m, @ light, 4–5 Aug 2007, F. G. Howarth, 1 male, same data except on the following dates: 2 Oct 2007, 1 female; 4 Sep 2007, 1 male; 18 Sep 2007, 1 male; 4 Dec 2007, 1 female; 7 Dec 2007, 1 male; 28 Dec 2007, 4 males, 6 females; 1–3 Jan 2008, 5 males, 5 females.

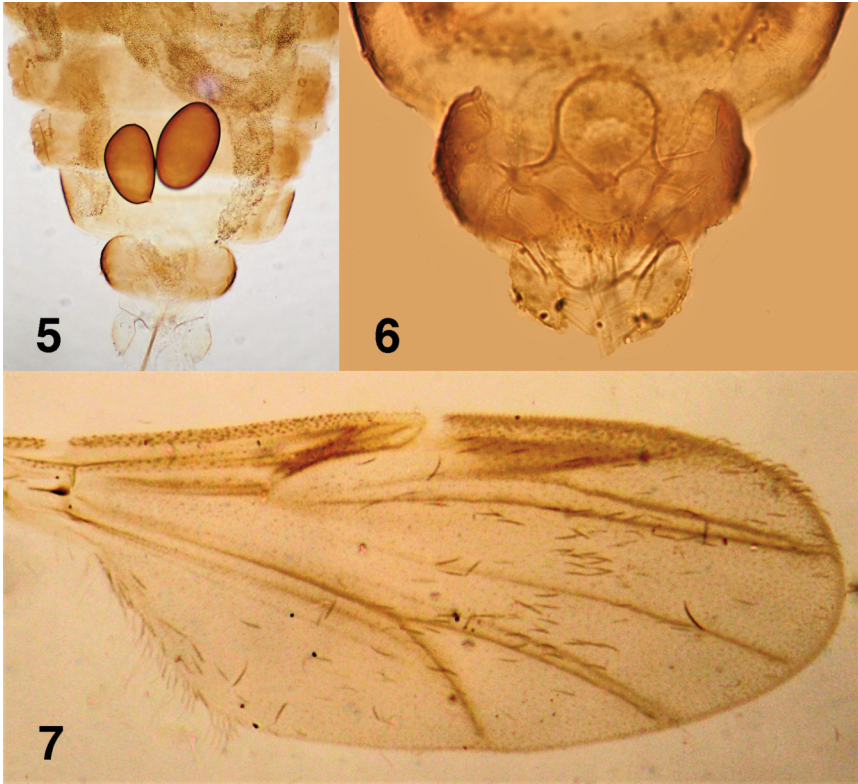
DISCUSSION

Forcipomyia biannulata is very similar to the wide ranging New World species, *F. (F.) genualis* (Loew, 1866), that has also been recorded from the Afrotropical region from the island of São Tomé by Wirth and Soria (1975) and the Seychelles by Clastrier (1983). *Forcipomyia genualis* was subsequently described by Williston (1896) from St. Vincent as *F. propinqua*, and, by Macfie (1938) from Trinidad as *F. raleighi*, and ranges from the USA (Florida, Louisiana), Mexico south to Argentina, the Caribbean region and the



Figures 1–4. *Forcipomyia (Forcipomyia) biannulata*. 1. female hind leg. 2. adult female habitus, lateral view. 3. female head. 4. male genitalia, ventral view.

Galápagos Islands, Ecuador (Borkent & Spinelli 2000, 2007). The early discovery and widespread occurrence in the New World indicates that it is native there and subsequently has become established outside of its native range via human transport. The presumed larval breeding habitat of *F. biannulata* in moist soil (noted above in Material Examined) indicates a probable pathway for the transport of this and other ceratopogonids in soil via the plant trade. For example, Grogan *et al.* (2013) reported that adults and associated larvae of *Forcipomyia pulcherrima* Santos Abreu, 1918 were intercepted by personnel of the Florida Department of Agriculture and Consumer Services from the soil of potted orchids, which had originated from a plant nursery in San Joaquin Co., California.



Figures 5–7. *Forcipomyia (Forcipomyia) biannulata*. **5.** apex of female abdomen and spermathecae, ventral view. **6.** apical region of female abdomen and genital sclerite, ventral view. **7.** female wing.

Additional species of ceratopogonids may be present outside their native ranges but not yet detected. Biting midges are small and often overlooked in biological surveys. Yet many species are important components of ecosystems. This article accents the value of having a broad taxonomic background, which enabled the recognition of this species as newly introduced. This study also demonstrates the value of intensive biological surveys (e.g., Howarth *et al.* 2012) that document the distribution of native species as well as to detect newly established non-native species.

Males and females of *F. genualis* differ from those of *F. biannulata* by having dark apical femoral and basal tibial bands on all legs, but these bands are longest on hind legs and much shorter on mid and fore legs. These dark banded sections of the femora and tibiae are covered in broad, flattened, striated scales. In addition, the scutum of both sexes are brown with two long, broad central yellowish stripes and in some specimens, two shorter, narrow yellowish lateral stripes; abdominal segment 8 is dark; and flagellomeres 11–13 of males and 9–13 of females are more elongate than in *F. biannulata*. Males of *F. genualis* have an aedeagus with a deeper concave basal arch, which has two central elongate heavily sclerotized sclerites; and relatively short parameres with slender distal por-

tions and tips that overlap. Females also lack mandibular teeth as do females of *F. biannulata*, but females of the former species have dense broad abdominal scales similar to those on their legs and two small pyriform spermathecae. Saunders (1957, as *F. raleighi*) and Clastrier (1983) provided excellent illustrations of the adults of *F. genualis*, including pigmented patterns on their thoraces, female antennal flagellum, palpus, genital sclerotization and spermathecae, as well as male genitalia.

Two other species of *Forcipomyia* with dark bands on their femora and tibiae could also be confused with *F. biannulata* in the Americas, *F. (Microhelea) eriophora* (Williston) which ranges from Florida to Panama and in the Caribbean region, and, *F. (Microhelea) fuliginosa* (Meigen), a cosmopolitan worldwide species. However, adult females of both of these species have large mandibles with numerous fine teeth and are ectoparasites of the larvae of Lepidoptera (Wirth 1972). They also differ from females of *F. biannulata* in having greatly swollen 3rd palpal segments and yellowish antennal flagellomeres 2–8. Finally, males of both of these ectoparasitic species differ from males of *F. biannulata* in having parameres that are fused basally with much shorter distal portions.

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