DEVELOPING SCARAB BEETLE IDENTIFICATION TOOLS FOR HAWAII AND THE PACIFIC

A Thesis by

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The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Science with a major in Biological Sciences.

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Mary Liz Jameson, Committee Chair

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David Hughes, Committee Member

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Gregory Houseman, Committee Member

DEDICATION

To Hawaiian insects and the entomologists who love them

“Sometimes you're the windshield. Sometimes your the bug.”

— Mark Knopfler

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ABSTRACT

The last decade has seen the arrival of a number of pest scarabs (Coleoptera: Scarabaeidae) to the state of Hawaii and the US territory of Guam. Despite the arrival of such injurious species as the coconut rhinoceros beetle (***Oryctes rhinoceros***) and the masked chafer (***Cyclocephala pasadenae***) there remains no comprehensive resource pertaining to scarabs of the American Pacific or their identification.

To allow for the ready identification of the 71 scarabs known from Hawaii and the 21 species reported from Guam an all-inclusive online "tool" was created in collaboration with the United States Department of Agriculture and Plant Protection and Quarantine (USDA PPQ) division. The tool was created from the assemblage of several distinct subcomponents: 1) A species checklist compiling all scarabaeoids (Coleoptera: Scarabaeoidea) recorded from Hawaii, with a second checklist for Guam. 2) "Fact sheets" or species pages that assemble relevant information for each species created by examination of preserved specimens and an exhaustive review of published literature. 3) Extensive imaging of relevant species supporting image-based identification for the fact sheets. 4) Creation of an image-based matrix key that facilitates the identification of specimens.

The completed tool will fill the gap in taxonomic knowledge regarding Hawaiian and Guamanian scarabs, allowing port screeners, quarantine workers, and other end users to correctly and efficiently identify specimens. The complete, peer-reviewed identification tool was released in February 2016. The web-application and mobile-application identification tools may be accessed on the USDA-ITP (Identification Technology Program) ID Tools web site: http://idtools.org.

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LIST OF ABBREVIATIONS

C	Celsius
CRB	coconut rhinoceros beetle
cm	centimeters
FSM	Fact Sheet Manager
ITP	Identification Technology Program
mm	millimeters
PPQ	Plant Protection and Quarantine
sp.	species (singular)
spp.	species (plural)
USDA	United States Department of Agriculture

Chapter 1

Introduction

Scarabs as Pests

The family Scarabaeidae contains a number of well known and invasive pest species (Jackson and Klein, 2006). These pest scarabs include both generalist such as *Popillia japonica*, the infamous Japanese beetle, and more specialized pests such as the *Oryctes rhinoceros*, the coconut rhinoceros beetle. The economic importance of scarabs is highlighted by both of these species. The Japanese beetle is regarded as the single most destructive insect pest of lawns, gardens, and golf courses in the eastern U.S. (Klein, 2008). Indeed in 2000, the USDA estimated that $US 450 million were spent annually in the U.S. on control of *P. japonica* (Potter and Held, 2002). The coconut rhinoceros beetle, too, causes significant damage with palm damage costs exceeding $US 2.5 million between 2007-2009 just on the tiny island of Guam (Moore, 2009).

Many of the most destructive pest scarabs are also invasive species that have now been widely spread by human activity. The previously mentioned Japanese beetle was spread to the eastern U.S. from Japan via commercial shipments of iris bulbs (Klein, 2008). Other widespread scarab species include *Maladera castanea* (the Asian garden beetle) (Ahrens, 2007; Skelley, 2012) and *Anomala orientalis* (the oriental beetle), both introduced to the U.S. from eastern Asia (Reding and Klein, 2006). In the Indo-pacific *Protaetia fusca* (the mango flower beetle) (Woodruff, 2006) and closely related *Protaetia orientalis* (the oriental flower beetle) (LeBlanc et al., 2013) have been spread via human activity, as has the destructive coconut rhinoceros Beetle (Molet, 2013; Bedford, 2015).

The range of crops and plants damaged by scarab pests is considerable. The

Japanese beetle is known to damage over 300 different species of plants (Vittum et al., 1999), including both agricultural and horticultural species. Other broad generalists include *Adoretus sinicus,* the Chinese rose beetle, which has been recorded feeding on over 500 species of plants (Hession et al., 1994). The larvae of many scarabs (often referred to as grubs) are major turf grass pests, feeding on the roots of grasses and thereby killing the entire plant. Major turf grass pests include the *Phyllophaga* (Watschke et al., 1994) and *Holotrichia* species, sometimes called May beetles, as well as various members of the subfamilies Dynastinae (Jameson et al., 2009), Rutelinae (Suzuki et al., 1994; Krischik, 2011) and Aphodiinae (Shetlar and Niemczyk, 1999). In the tropics scarabs are also major pests of palms (coconut rhinoceros beetle)(Bedford, 2015) and sugarcane (*Lepidiota* species) (Kuniata and Young, 1992).

Despite their clear importance and economic consequence there is no comprehensive tool useful for identifying scarabs on a worldwide scale. This is, in part, because of the sheer diversity of scarabs, with estimates placing the number of scarab species at 31,000 (Jameson and Ratcliffe, 2002). The impracticality of treating such a great number of species within a single key means identification on a global level is impeded by the limits of available keys, with most such materials being restricted to narrow taxonomic groups and/or specific geographic regions. Identification is further hampered by a dearth of taxonomic expertise, even when compared to other high diversity Coleoptera taxa.

Scarabs in Hawaii and Guam

The issues inherit in accurately identifying global scarabs are particularly acute in Hawaii where 66 of the 71 scarabaeoid species recorded are exotic non-natives. These adventive beetles originate from every corner of the globe and are not covered by any existing key as a discrete fauna. These exotic scarabs consist of a number of serious pests including the Chinese rose beetle and the coconut rhinoceros beetle. It has been estimated that a new non-native species reaches Hawaii approximately every two weeks (Asquith, 1995) and, indeed, at least four new scarab pests have reached Hawaii over the last decade (Jameson et al., 2009; Hawaii Department of Agriculture, 2014; pers. comm., 2016).

The recent introduction of the coconut rhinoceros beetle illustrates the perils posed by exotic scarabs in Hawaii. First recorded in December 2013 on Pearl Harbor-Hickham Joint Military Base (State of Hawaii Department of Agriculture, 2014), the coconut rhinoceros beetle (or CRB) is a serious pest of cultivated palms. Despite intensive containment efforts, the CRB spread beyond the military base within four months (Davis, 2014). The species is of great concern to the state as it is known to cause 50% mortality in afflicted coconut trees (Gressitt, 1953), with obvious implications for the agriculture, horticulture, and by extension, tourism.

Likewise, scarabs are also of considerable conservation concern in Hawaii and Guam. The few native species are in great need of further study and appear to have suffered substantial declines over the past century (Paulsen and Hawks, 2014). Consequently, it appears that while once abundant across their native range (Van Dyke, 1922; Hawaiian Entomological Society, 1915) two of Hawaii's native *Apterocylcus* stag beetles may now be extinct (Paulsen and Hawks, 2014). Exotic species are also of conservation concern, with scarabs such as the Chinese rose beetle known to feed on endangered native plants including kauila (*Colubrina oppositifolia*) and Kauai hau kuahiwi (*Hibiscadelphus distans*) (Howarth, 1985). On Guam, the oriental flower beetle is known to damage the endangered Micronesian cycad (*Cycas micronesica*) (Marler and Muniappan, 2006).

Purpose and Intent

Despite the presence of a large and growing number of scarab pest species in the state of Hawaii, no comprehensive identification guide allows insect identifiers or quarantine screeners to separate pest species from non-pests or detect new invasive scarabs. The purpose and intent of this project was to develop tools to address this critical gap with flexible, interactive identification tools for Hawaiian and Guamanian scarab beetles. Because the levels of entomological expertise vary significantly between likely users, the tool focused on providing easy-to-use, image-based identification that requires only limited prior entomology experience. The tool offers a flexible, multi-tiered identification process where users select diagnostic characters that will generate a list of species that possess matching features. Users are able to retrieve detailed species pages with images, diagnoses, maps, and host data. The tools include all scarabs recorded from Hawaii as well as those with a high potential for introduction based on known invasive status elsewhere in the Pacific.

An easy-to-use, interactive identification guide can reduce the spread of economically destructive invasive scarab species in Hawaii. No current means of screening or identification of scarabs is available for the state. The project benefits Hawaii-based United States Department of Agriculture department of Plant Protection and Quarantine (USDA PPQ) staff by creating the first and only resource dedicated to established scarab species and potential invasive scarabs in the state.

Chapter 2

Methods and Materials

Included Taxa

Species included in the online tool (referred to as "entities" by the USDA) were selected based upon the goals of the project – development of a comprehensive identification tool for all scarabaeoids known from Hawaii and Guam. Special attention was also paid to species that, while not yet recorded from the islands, have a high likelihood of being found in the future. To determine which species have been recorded from Hawaii and Guam, an exhaustive review of published literature was undertaken, starting with the last published checklist of Hawaiian arthropods (Nishida, 2002). This literature search was underpinned by extensive examination of preserved materials collected from Hawaii and Guam. Indeed, through careful examination of preserved specimens several new state records were established.

Determining which species were likely to arrive in Hawaii or Guam in the future likewise entailed a detailed literature search. Special attention was paid to species such the taro beetles (*Papuana* species) that are important adventive pests elsewhere in the Pacific. Further, species not yet established widely in Pacific but nonetheless with a known history of rapid adventive spread (such as *Hybosorus roei*) were also included.

It should be noted that in several cases "entities" included in the identification tool were at higher taxonomic levels than species. This includes generic-level entries for the aforementioned taro beetles, as well as generic-level entries for the *Oryctes* and *Xylotrupes* rhinoceros beetles. A subfamily-level entity was created for the Aphodiinae (sometimes referred to as the small dung beetles) due to severe taxonomic confusion within that group. Checklists of these 71 taxa were developed for Hawaii and Guam (Tables 1 and 2 of Appendix A).

Specimen Acquisition

After determining which species were to be included in the online tool it was necessary to acquire authoritatively identified specimens of the said species. The acquisition of such specimens served several functions:

1) Creation of an authoritative (if temporary) collection of comparative reference material for identifying newly collected (or old, unidentified) specimens from Hawaii and Guam. This reference collection included representatives of all entities included in the tool whenever possible.
2) Utilization of comparative series for determination of consistent characters and states needed for species level identification. The determination of such characters was critical for successful creation of the online matrix key.
3) Curating and preparing specimens for photomontage.
4) Resolution of dubious, unclear or erroneous historical identifications by examination of type specimens. Loaned type specimens included *Microserica guamensis, Holotrichia bipunctata, Holotrichia mindanoana, Lepidiota carolinensis, Ataenius pacificus, Ataenius yasamatsui, Ataenius vandykei, and Ataenius nocturnus*.

Specimens were borrowed as loans from a number of institutions including: the Bernice P. Bishop Museum, Honolulu, HI, USA; University of Guam, Mangilao, Guam, USA; the Florida State Collection of Arthropods, Gainesville, FL, USA; W. D. Perreira

Personal Collection, Honolulu, HI, USA; Snow Entomological Museum, University of Kansas, Lawrence, KS, USA; University of Hawaii-Hilo, HI, USA; University of Hawaii-Manoa Insect Museum, HI, USA; University of Nebraska State Museum, Lincoln, NE, USA; Hawaiian Department of Agriculture, Hilo, HI, USA; United States National Museum of Natural History, Washington, DC, USA; and the Wichita State University Collection, Wichita, KS, USA.

Specimen Imaging

Using a Leica IC80 HD digital camera, and Leica Application Suite version 3.8.0, photomontage images were taken for all entities included in the key for which specimens were available. Standard shots included dorsal and lateral habitus images for all available species. Most species also included special images highlighting morphological characters useful for distinguishing the entity from similar scarabs or, for sexually dimorphic species, differentiating males and females. Examples include photographs of the head or pronotal armature/sculpting, form of the front tibia, male genitalia, form of the pygidium, etc. A total of 434 photographs were taken and images were edited (contrast increased, background removed) as needed using Photoshop CS3 (primarily by technician Emmy Engasser).

Images were uploaded to the USDA's "Bugwood" online image library (primarily by technician Jackie Baum). Photographs were also incorporated into the appropriate fact sheets via FSM (Fact Sheet Manager) online software.

Fact Sheets

Using the USDAs online FSM software "fact sheets" were created to accompany every entity included in the tool. Each fact sheet was created after careful consultation of published literature and examination of relevant loan specimens. With the intention of providing a condensed summation of information relevant to USDA PPQ identifiers, port screeners and other potential end users.

All components of the identification tool (fact sheets, images, maps, introductory information) were peer reviewed prior to final release. The reviews took place in two separate rounds, each review round having four reviewers chosen for their expertise in entomology, invertebrate conservation, or Hawaiian invertebrates. The first round asked the reviewers to evaluate the fact sheets and introductory pages. The second round of reviews again asked the reviewers to examine the fact sheets and introductory pages, but also focused upon the usability of the matrix key (the key not being available in the first review round). All reviewer comments were considered and changes were made to the tool as neccesary.

The fact sheets were organized into a number of sub-sections:

1) Species Name: The most current scientific name of the species (or genus) in question.

2) Taxonomy: Basic taxonomic information on the entity including family, subfamily, genus, and species epithet.

3) Adult Diagnosis: A short description of morphological traits useful for identifying adult forms of the species in question (based upon first hand examination of specimens and information derived from taxonomic and systematic treatises).

4) Larval Diagnosis: A short description of morphological traits useful for identifying larval forms of the species in question. Many scarab species lack described larvae, thus this section often refers to generic level identification (noted within the description).

5) Native Range: As implied, this section details the native range of the entity. For widespread adventive species, locations to which the species has spread are also noted.

6) Plant Host(s): A list of plants damaged by the species, including both common and scientific plant names. This section is meant as a summation of plant hosts and is not comprehensive because some Hawaiian/Guamanian scarabs are known to feed on 500+ plant species.

7) Life History: A succinct summation of the species natural history, if known, with a focus on reproduction and life cycle.

8) Pest Potential: This section provides information about pest status, and formal government lists, quarantines, or restrictions that are imposed on the species.

9) Status in Hawaii: A list of the Hawaiian islands where the species is established. If the species is not established, an indication of the island(s) where it has been reported.

10) Status in Guam: Similar to “Status in Hawaii”, this section provides information on whether the species is reported or established on Guam.

11) Potential Distribution and Dispersal Pathway: Potentially important to USDA PPQ workers, a summary of pathways and mechanisms by which the species has (or might have) dispersed, is provided. Details such as aircraft mediated dispersal are noted, as well as information pertaining to movements via hitchhiking on nursery plants, farm equipment, etc.

12) Similar Species: One of the most important fields in the fact sheets, this section provides specific means of distinguishing the species from physically similar (and often related) scarabs. The section describes key morphological characters that can be used to distinguish the entity from other Hawaiian or Guamanian scarabs.

13) Other Names (Synonyms): A list of other scientific names under which the species has been known.

14) iNaturalist Project: A link to our citizen science initiative that allows the public to report scarab species. This serves as one mechanism to track the spread of invasive scarab beetles.

Key Characters

All entities were examined for distinct morphological characters useful for species level diagnosis. A premium was placed upon easily visible, easy to score characters because many end users are expected to possess limited entomological training. Emphasis was also placed on numeric characters to reduce errors caused by interpretation. When interpretive characters were used, efforts were made to consider different ways individual key users might score these characters.

Introductory and Supplemental Content

Introductory and supplementary resources were also included within the online tool. These include:

1) About: Here, basic goals of the project and tool were stated as were the methods and standards used in creating the tool. Technical details such as legal information, citation information, and author information were included.

2) Scarabs: This section detailed basic background on scarabs beetles including identification, economic importance, and importance in Hawaii and Guam. Short videos that show important scarab behaviors and labeled images of scarab anatomy are provided.

3) Glossary: Terminology used in the tool was derived from taxonomic sources (e.g, Ratcliffe and Paulsen, 2008; Torre-Bueno, 1989) and occasionally supplemented with illustrations.

Peer Review

As required for all USDA research, all components of the identification tool (fact sheets, images, maps, introductory information) underwent two, separate peer reviews prior to release of the ID tool. A pool of reviewers was selected based on their expertise in entomology, invertebrate conservation, scarab taxonomy, or Hawaiian invertebrates. For both iterations of the review process, four scientists provided suggestions. For first review, which was mediated by Jameson, peer reviewers were asked to evaluate the fact sheets and introductory pages. For the second review, which was mediated by the USDA-ITP, reviewers were asked to provide suggestions on the fact sheets, introductory pages, the matrix key (the key not being available in the first review round). Reviewers accessed the Scarab ID Beta web site through the USDA portal and with a password. All reviewer comments were considered and changes were made to the tool as neccessary.

Website Development and Mobile App Development

Content was uploaded into the appropriate USDA portal, including FSM and Bugwood. Creation of the tool website was undertaken by our USDA PPQ ITP (Identification Technology Program) collaborator Amanda Redford. Inclusion of the introductory and supplemental content likewise fell to the ITP collaborator, as did upload of the behavior videos and introductory anatomy images. Development of the smartphone applications was contracted to Identic Pty Ltd - Identification Tools and Software Development (Australia). Identic created the Android and iPhone platform versions of the tool.

Chapter 3

RESULTS

USDA-ITP Identification Tools

The complete, peer-reviewed and beta-reviewed web-application identification tool was released in February 2016, and the complete, peer-reviewed and beta-reviewed mobile-application identification tool was released in March 2016. All versions are publicly available and free. The web-application and mobile-application identification tools may be accessed on the USDA-ITP (Identification Technology Program) ID Tools web site: http://idtools.org. A direct link to the web-application is accessible here: http://idtools.org/id/beetles/scarab/scarab_id.php. A direct link to the Android mobile-application is accessible here: https://play.google.com/store/apps/details?id=com.lucidcentral.mobile.aphis.scarab_id&hl=en. A direct link to the iPhone mobile-application is accessible here: https://itunes.apple.com/us/app/hawaiian-scarab-id/id1090794511?mt=8. The complete matrix key for identification can be accessed here: http://idtools.org/id/beetles/scarab/key.php

Suggested citation for the tool is: Dunlap, Joshua B., Mary Liz Jameson, Emmy L. Engasser, Paul E. Skelley, Amanda J. Redford. 2015. *Scarab and Stag Beetles of Hawaii and the Pacific*. USDA APHIS Identification Technology Program (ITP). Fort Collins, CO. URL: http://idtools.org/id/beetles/scarab. Accessed month day, year.

Fact Sheets

Adoretus compressus

Common name(s)

rose beetle, compressed rose beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Adoretus* **Species**: *Adoretus compressus* (Weber, 1801)

Adult diagnosis

Total body length 10.0–12.0 mm (0.39–0.47 in). Body elongate oval. Color brownish with numerous distinctive, cream-white setae; setae sometimes missing in worn specimens. Front tibia with 3 teeth at lateral margin; teeth may be worn in older specimens. Last sternite of female with apex rounded posteriorly; weakly quadrate in male.

Larval diagnosis

Undescribed. For *Adoretini* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia entirely fused. Lacinia of maxilla with 3 unci. Mandible with a ventral, oval, stridulatory area consisting of transverse, granular ridges. Maxillary stridulatory area with 8 or more, sharp, recurved teeth. Plegmatia present. Haptomerum of epipharynx with a dense, transverse, comb-like row of 6–9 heli. Last antennal segment with a single, dorsal sensory spot. Raster with a subtriangular teges of hamate setae; palidia absent.

Native range

Asia, Africa. This beetle is widespread in the Old World tropics, with records from South Africa, India, Sri Lanka, Malaysia, Mauritius, Thailand, Indonesia, and Papua New Guinea (McQuate and Jameson, 2011).

Plant host(s)

This species has been recorded feeding on a range of economically important plants including lychee (*Litchi chinensis*) (McQuate and Jameson, 2011), rambutan (*Nephelium lappaceum*) (Muniappan, 2012), rice (*Oryza* spp.) (International Rice Research Institute, 1986), corn (*Zea mays*) (CIMMYT, 1989), oil palm (*Elaeis guineensis*), banana (*Musa* spp.), rose (*Rosa* spp.), grape (*Vitis* spp.), okra (*Abelmoschus esculentus*), cotton (*Gossypium* spp.), sweet potato (*Ipomoea batatas*), coffee (*Coffea* spp.), cocoa (*Theobroma cacao*), and tea (*Camellia sinensis*) (Muniappan, 2012).

Life history

Poorly known: This species is a generalist folivore with the nocturnal adults feeding on a broad range of host plants (Pena et al., 2002). Similar to *Adoretus sinicus*, host plants often show characteristic lace-like leaf damage to the leaves (Muniappan, 2012). Eggs are laid in soil, often around plant roots. A report of five larval instars is likely erroneous (Pena et al., 2002).

Pest potential

Significant. This species is a clear biosecurity hazard. It is known to feed on a wide range of economically important plant species and is closely related to species with clear histories of invasive establishment (McQuate and Jameson, 2011). Damage from adult feeding can be significant enough to substantially lower fruit crop yields (Pena et al., 2002).

Status in Hawaii

Established. Nishida (2002) recorded this species from Oahu. Because of the great difficulty in separating this species from the common and extremely similar *Adoretus sinicus*, its abundance on the island is unclear.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species is attracted to lights at night, and it is likely that it would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Further, it is possible that adults or larvae could be transported in the movement of nursery plants.

Similar species

This species is extremely similar to the closely related *Adoretus sinicus*. The two species cannot reliably be separated based on external morphology. Identification requires dissection and examination of the male genitalia.

Other names (synonyms)

Adoretus umbrosus Burmeister

Adoretus sinicus

Common name(s)

Chinese rose beetle, Chinese rose chafer

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Adoretus* **Species**: *Adoretus sinicus* Burmeister, 1855

Adult diagnosis

Total body length 10.0–12.0 mm (0.39–0.47 in). Body elongate oval. Color brownish with numerous distinctive, cream-white setae; setae sometimes missing in worn specimens. Front tibia with 3 teeth on external margin; male teeth pointed; female teeth comparatively rounded; teeth may be worn in older specimens. Front tarsomere with length of segments 2–4 (combined) more than 1.5 times that of segment 1 in male; front tarsomere with length of segments 2–4 (combined) less than 1.2 times that of segment 1 in female. Last sternite of female with apex rounded posteriorly; apex weakly quadrate in male.

Larval diagnosis

(Habeck, 1962): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused. Lacinia of maxilla with 3 well-developed terminal unci. Mandible with a ventral, elongate, oval, stridulatory area consisting of a numerous transverse, granular ridges; left mandible with outer scissorial tooth wider than inner tooth; right mandible with teeth equal in width but outer tooth projects farther than inner. Maxillary stridulatory teeth with apical points anteriorly projecting. Plegmatia present. Haptomerum of epipharynx with a dense, transverse row of 5–8 (usually 6) heli. Last antennal segment with single dorsal sensory spot. Respiratory plate C-shaped with numerous oval to round openings surrounding a prominent oval bulla. Raster with a subtriangular teges of hamate setae; palidia absent. Anal opening slightly curved, transverse. Lower anal lip with 8 stout setae, 10 long slender setae and 10 short slender setae.

Native range

Japan and Taiwan. Although this species is native to Japan and Taiwan (Mau and Kessing, 1991), it has spread widely and is now established in a great number of locations including Cambodia, the Caroline Islands, China, Guam, Hawaii, Indonesia, Singapore, Thailand, and Vietnam (McQuate and Jameson, 2011).

Plant host(s)

This species has been recorded feeding on over 500 species of plants (Hession et al., 1994), including such economically important species as broccoli (*Brassica oleracea*), cabbage (*Brassica oleracea*), cacao (*Theobroma cacao*), Chinese broccoli (*Brassica oleracea*), Chinese cabbage (*Brassica rapa*), chiso (*Perilla frutescens*), corn (*Zea mays*), cotton (*Gossypium barbadense*), cucumber (*Cucumis sativus*), eggplant (*Solanum melongena*), ginger (*Zingiber officinale*), grape (*Vitis labrusca*), green beans *(Phaseolus vulgaris*), jack fruit *(Artocarpus heterophyllus*), okra (*Hibiscus esculentus*), peanuts (*Arachis hypogaea*), Oriental persimmon (*Diospyros kaki*), raspberry (*Rubus niveus*), roses (*Rosa* spp.), salak palm (*Salacca zalacca*), soybean (*Glycine max*), star fruit (*Averrhoa carambola*), strawberry (*Fragaria chiloensis*), sweet potato (*Ipomoea batatas*), taro (*Colocasia esculenta*), and tea (*Camellia sinensis*) (McQuate and Jameson, 2011). In Hawaii, this species is also known to damage several endangered native plants including kauila (*Colubrina oppositifolia*), hau kuahiwi (*Hibiscadelphus distans*), and ko'oloa'ula (*Abutilon menziesii*) (Howarth, 1985).

Life history

Adults are active year-round and emerge after dusk to feed, with large numbers often congregating on the same plant (McQuate and Jameson, 2011). During the day, adults hide in soil at the base of their food plant (Williams, 1931). Host plants can easily be identified by the distinctive lace-like damage inflicted upon the leaves (Arrow, 1917). Developmental time was examined by Habeck (1964) in laboratory-reared specimens. He found that females deposited eggs 4 cm (1.6 in) in soil, with larvae emerging after 7–16 days. Warmer temperatures resulted in shorter emergence times. The first instar lasted 19.6–22.8 days, the second lasted 14.5–16.8 days, and the final lasted 34.3–44.4 days. The pupal stage lasts 11–17 days. Interestingly, larvae appear to develop more rapidly in the field, with the egg to adult cycle lasting 6–7 weeks (Mau and Kessing, 1991). Larvae are detritivores and do not appear to feed on living plant tissues (Mau and Kessing, 1991).

Pest potential

Severe. This species is a known biosecurity threat with a long history of biological invasion. It has spread continuously over the past 120 years with recent records coming from specimens intercepted in India (Bhawane et al., 2012) and Australia (Stanway et al., 2001). It is officially recognized by the USDA as a class B pest (USDA APHIS, 2012), and it is officially regarded as a pest with high risk of introduction in California (Cosner, 2013). It damages a great range of economically important plants, causing severe and economically significant damage (McQuate and Jameson, 2011).

Status in Hawaii

Established. This species is found on all the major islands of Hawaii (Nishida, 2002). It became established in the late 19th century, with the earliest record dating to 1891 (Riley and Howard, 1893). By 1893, it was “rapidly becoming a most serious pest” (Riley and Howard, 1893). Across its range, *Adoretus sinicus* may be found in many habitats including urban, agricultural, and wilderness areas (García-Moll, 2013).

Status in Guam

Established. This species has long been established in Guam, with the first report dating to 1949 (Pemberton, 1954).

Potential distribution and dispersal pathway

It is thought that *Adoretus sinicus* first arrived to Hawaii as larvae or eggs transported in soil associated with plants imported from Asia (Ohaus, 1935; Pemberton, 1964). Adults are attracted to dim lights at night (though oddly may be deterred by bright lights), and it is possible that they would be attracted to artificialy lit docks or airports and hitchhike aboard freight and cargo. Indeed, this species has been intercepted in Australia on maritime containers (Stanway et al., 2001). This beetle is very common in Hawaii (pers. observation), and it should be regarded as having a very high likelihood of spreading to the southern U.S. and U.S. territories, including Puerto Rico and the U.S. Virgin Islands.

Similar species

This species is extremely similar to the closely related *Adoretus compressus*. The two species cannot reliably be separated based on external morphology. Identification requires dissection and examination of the male genitalia.

Other names (synonyms)

Adoroleptus sinicus (Burmeister)

Anomala albopilosa

Common name(s)

green chafer, white-haired leaf chafer

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Anomala* **Species**: *Anomala albopilosa* (Hope, 1839)

Adult diagnosis

Total body length 15.0–26.0 mm (0.59–1.02 in). Body shape ovate. Color rich green, slightly shiny; rarely reddish or olive colored. Front tibia with two external teeth; apical tooth long and slightly decurved in female (may be worn in older specimens), often shorter in male; basal tooth evident in male and female. Front inner claw bifurcate; bifurcate claw weakly sinuate in male, simple in female. Hind tibia with inner margin simple, not greatly dilated at the middle.

Larval diagnosis

Undescribed. For *Anomala* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Lacinia of maxilla with 2 apical unci equal in size. Maxillary stridulatory area with 4–7 sharp, recurved teeth. Epipharynx with 2–4 prominent heli. Final antennal segment with single dorsal sensory spot. Spiracles on abdominal segments 7 and 8 similar in size and conspicuously larger than spiracles on abdominal segments 1–

6. Anal slit transverse, arcuate; bordered by several irregular rows of stout setae. Lower anal lip bearing patch of 13 hamate setae.

Native range

East Asia. This scarab is known from the four major islands of Japan (Kysushu, Shikoku, Honshu, and Hokkaido) (Kobayashi and Matsumoto, 2011), the Ryuku Islands, Korea, and Taiwan (Arakaki et al., 2015).

Plant host(s)

The larvae of this species feed on the roots of kenaf (*Hibiscus cannabinus*) (Hiramatsu et al., 2001), pines (*Pinus* spp.) (Nitto and Taohibana, 1955), sweet potatoes (*Ipomoea batatu*), and sugarcane (*Saccharum officinarum*) (Arakaki et al., 2015).

Life history

(Arakaki et al., 2015): This species has one generation per year, and adults emerge from May to late July. Eggs are deposited in soil by June. First instar larvae emerge by July and third instars by October. Overwintering occurs in the third instar, and pupation usually begins by May. Larvae live in soil and feed on the roots of several plant species.

Pest potential

Significant. In Japan, larvae of this scarab are known pests (Arakaki et al., 2015). In the Ryuku Islands, *Anomala albopilosa* is a particularly significant pest of sugarcane with periodic outbreaks causing severe damage to sugarcane production of Okinawa (Arakaki et al., 2015).

Status in Hawaii

Recorded, not established. This species has been recorded in Hawaii at least twice, with records from 1955-56 and 1971-72 (USDA, 1957; USDA, 1974). In both cases specimens were found on aircraft flying into Hawaii from Japan.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species is attracted to lights at night, and it is likely that it would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Indeed, this species has entered Hawaii at least twice aboard aircraft (USDA, 1957; USDA, 1974).

Similar species

Anomala albopilosa is one of five *Anomala* species recorded from Hawaii and Guam, along with *Anomala orientalis*, *Anomala sulcatula*, *Anomala viridana*, and *Anomala cuprea*. It can be separated from the other species by examination of the bifurcate male front claw (weakly sinuate in *A. albopilosa* versus strongly sinuate in *A. cuprea* and *A. viridana*, curved but non-sinuate in *A. orientalis* and *A. sulcatula*), male hind tibia (*A.*

albopilosa not greatly dilated at the middle on the inner margin versus inner margin greatly dilated at the middle in *A. sulcatula*), and total body length (*A. albopilosa* 15.0–26.0 mm [0.59–1.02 in] versus less than 13.0 mm [0.51 in] in *A. orientalis*).

Other names (synonyms)

Anomala immarginata Reitter

Anomala cuprea

Common name(s)

cupreus chafer

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Anomala* **Species**: *Anomala cuprea* (Hope, 1839)

Adult diagnosis

Total body length 17.0–26.0 mm (0.67–1.02 in). Body shape ovate. Color dark grey-green or brown-green, shining; rarely with red or green sheen. Front tibia with two external teeth; apical tooth long and decurved in both sexes; middle tooth small in female, lacking or very feeble in male. Front, inner claw bifurcate; strongly sinuate in male, simple in female. Hind tibia with inner margin simple, not greatly dilated at the middle.

Larval diagnosis

Undescribed in English. For *Anomala* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Lacinia of maxilla with 2 apical unci equal in size. Maxillary stridulatory area with 4–7 sharp, recurved teeth. Epipharynx with 2–4 prominent heli. Final antennal segment with single dorsal sensory spot. Spiracles on abdominal segments 7 and 8 similar in size and conspicuously larger than spiracles on abdominal segments 1–6. Anal slit transverse, arcuate; bordered by several irregular rows of stout setae. Lower anal lip bearing patch of 13 hamate setae.

Native range

Japan. This scarab is known from the four major islands of Japan: Kysushu, Shikoku, Honshu, and Hokkaido (Kobayashi and Matsumoto, 2011).

Plant host(s)

This species' hosts are poorly described in English language publications. Adults are folivores and are active at night (Fujiyama et al., 1979). Recorded larval hosts include sugarcane (*Saccharum officinarum*) (Mitsuhashi et al., 2014), beans (Bhuiyan and Nishigaki, 1996), turf grass (Suzuki et al., 1994), sweet potato (*Ipomoea batatas*) (Suzuki et al., 1994), and peanuts (*Arachis hypogaea*) (Kato et al., 1980).

Life history

(Fujiyama et al., 1979): Adults are active June through September (Kobayashi and Matsumoto, 2011), with a single generation per year. Eggs are laid in August and

September with larvae emerging shortly thereafter. Larvae require one or two years to develop, depending on soil temperature and larval densities. Larvae overwinter as first or second instars, but first instars suffer high winter mortality, despite burrowing deep into soil. Interestingly, some larvae that survive the winter estivate through the summer and emerge as adults two years after the egg stage. Larvae feed on the roots of a number of plant species, while adults are nocturnal folivores.

Pest potential

Significant. In Japan, larvae of this scarab are important insect pests (Bhuiyan and Nishigaki, 1996), feeding on the roots of a number of important agricultural and horticultural plant species.

Status in Hawaii

Recorded, not established. This species has been found on Oahu in quarantine, when a single dead specimen was found on a plane flying from Japan to Honolulu in 1953 (Maehler, 1953).

Status in Guam

Not established or recorded. This species has not been recorded from Guam.

Potential distribution and dispersal pathway

This species is attracted to lights at night, and it is likely that it would be attracted to well-lit ports and airports. Indeed, in 1967-68, a specimen was intercepted aboard an aircraft flying to California from Japan (USDA, 1969). Further, it is possible that larvae or eggs could be transported in shipments of commercial turf.

Similar species

Anomala cuprea is one of five *Anomala* species recorded from Hawaii and Guam along with *Anomala orientalis*, *Anomala sulcatula*, *Anomala viridana*, and *Anomala albopilosa*. It is separated from the other species by examination of the bifurcate male front claw (strongly sinuous in *A. cuprea* versus weakly sinuous in *A. albopilosa* and curved but non-sinuous in *A. orientalis* and *A. sulcatula*), male hind tibia (*A. cuprea* not greatly dilated at the middle on the inner margin versus inner margin greatly dilated at the middle in *A. sulcatula*), and total body length (*A. cuprea* is 17.0–26.0 mm [0.67–1.02 in] versus size less than 13.0 mm [0.51 in] in *A. orientalis*).

Other names (synonyms)

Euchlora cuprea Hope

Anomala orientalis

Common name(s)

oriental beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Anomala* **Species**: *Anomala orientalis* (Waterhouse, 1875)

Adult diagnosis

Total body length 8.0–13.0 mm (0.31–0.51 in). Body shape ovate; female often wider than male. Color tan to black; tan specimens often with black markings of variable size and position. Front tibia with two external teeth; apical tooth long and decurved, longer in female than male; basal tooth evident in male and female. Front claw bifurcate; bifurcate claw never sinuate; female claws less robust than in male. Hind tibia with inner margin simple, not greatly dilated at the middle.

Larval diagnosis

(Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia entirely fused. Lacinia of maxilla with 2 unci. Maxillary teeth anteriorly projecting. Dorsoexterior region of mandible bare. Crest of labrum not strongly rugose. Haptomerum of epipharynx with a transverse row of 3 prominent unci; never with a conspicuous, transverse, curved row of stout setae. Last antennal segment with a single sensory spot. Posterior frontal setae consisting of 2 single setae. Dorsa of abdominal segments 7–9 rather uniformly covered with many medium-sized setae; each bearing a caudal transverse row of 5 or 6 very long setae. Septula oblong; palidia monostichous, slightly diverging, each set with 11–15 pali. Anal slit slightly curved, transverse.

Native range

Uncertain. This species is probably native to either Japan or the Philippines (Reding and Klein, 2006). Because *Anomala orientalis* is an established, non-native pest in Korea

(Choo et al., 2002) and the U.S. (Maine west to Ohio and south to the Carolinas) (CABI, 2015), an origin in temperate Japan may be more likely, though this remains speculation.

Plant host(s)

This scarab feeds on plants as both larva and adult. Adults are minor pests, sometimes causing damage to horticultural species such as *Dahlia* spp., hollyhock (*Alcea* spp.), *Iris* spp., *Petunia* spp., *Phlox* spp., and roses (*Rosa hybrida*). Larvae are more serious pests, feeding on the roots of important crop and turf species including: corn (*Zea mays*), cranberry (*Vaccinium* spp.), creeping bentgrass (*Agrostis stolonifera*), Japanese chestnut (*Castanea crenata*), manila grass (*Zoysia matrella*), nandina (*Nandina domestica*), perennial ryegrass (*Lolium perenne*), pineapple (*Ananas comosus*), raspberry (*Rubus* spp.), reed fescue (*Festuca arundinacea*), smooth-stalked meadowgrass (*Poa pratensis*), strawberry (*Fragaria* × *ananassa*), and sugarcane (*Saccharum officinarum*).

Life history

(CABI, 2015): In New York, this species has a one year lifecycle. Adults emerge in late June and remain active until August. Adults are weak fliers and are active at night. Females deposit eggs in damp soil, with larvae emerging from the eggs after 17–25 days. First instars are encountered by August, second instars by September, and final instars begin appearing by early October. Overwintering occurs in the final instar. Feeding on plant roots, which occurs close to the surface, resumes in late March or early April.

Pest potential

Significant. This species is a known biosecurity threat, having a long history biological invasion. In California, *Anomala orientalis* is officially a species of biosecurity concern and is regarded as having a moderate risk of introduction (Cosner, 2013). Larvae are major turf pests and also attack a range of crop plants. In Hawaii, this species historically has been a major pest of sugarcane and pineapple (Pemberton, 1964.).

Status in Hawaii

Established. *Anomala orientalis* is known from Oahu, where it became established sometime before 1908 (Myers et al., 2003). Interestingly while this species was once a common pest (Pemberton, 1964) on the island, anecdotal evidence suggest its numbers on Oahu have declined significantly over the last several decades.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

Anomala orientalis has a long history as an invasive species, having become established in Hawaii before 1908 and Connecticut (and hence the rest of the northeastern U.S.) by 1920 (Alm, 1996). The species should be treated as having some potential of establishing on the other islands. While the means of its arrival in Hawaii are uncertain, it was noted that the Connecticut population appears to have arrived in balled nursery stock from Japan (Alm, 1996). Because adults feed on many plants of horticultural importance and are easily overlooked, hitchhiking on transported garden plants likely represents a major mode of invasion. Grass sod carrying larvae could also represent a potential pathway; adults attracted to lights at major shipping points such as ports and airports and subsequently stowing away on cargo could represent another.

Similar species

Anomala orientalis is one of five *Anomala* species known from Hawaii and Guam, along with *Anomala cuprea*, *Anomala sulcatula*, *Anomala viridana*, and *Anomala albopilosa*. It can be separated from the other species based upon by examination of the bifurcate male front claw (curved but non-sinuate in *A. orientalis* versus strongly sinuate in *A. cuprea* and *A. viridana*, weakly sinuate in *A. albopilosa*), the hind tibia of males (*A. orientalis* not greatly dilated at the middle on the inner margin versus inner margin greatly dilated at the middle in *A. sulcatula*), and body size (*A. orientalis* at 8.0–13.0 mm [0.31–0.51 in] versus 14.0 mm [0.55 in] or greater in the other recorded *Anomala* species).

Other names (synonyms)

Blitopertha orientalis (Waterhouse), *Exomala flavipennis* Reitter, *Exomala orientalis* (Waterhouse), *Exomala tanbaensis* Niijima and Kinoshita, *Exomala xanthrogasta* Harold, *Phyllopertha orientalis* Waterhouse

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Anomala sulcatula

Common name(s)

Philippine chafer

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Anomala* **Species**: *Anomala sulcatula* (Burmeister, 1844)

Adult diagnosis

Total body length 14.0–18.0 mm (0.55–0.71 in). Body shape ovate. Color brown to nearly black; somewhat metallic. Front tibia with two external teeth; apical tooth longer in female than male; basal tooth feeble in male and female. Front inner claw bifurcate; bifurcate claw curved but not sinuate in either sex. Hind tibia of male with inner margin greatly dilated at the middle (less so in female).

Larval diagnosis

Undescribed. For *Anomala* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Lacinia of maxilla with 2 apical unci equal in size. Maxillary stridulatory area with 4–7 sharp, recurved teeth. Epipharynx with 2–4 prominent heli. Final antennal segment with single dorsal sensory spot. Spiracles on abdominal segments 7 and 8 similar in size and conspicuously larger than spiracles on abdominal segments 1–6. Anal slit transverse, arcuate; bordered by several irregular rows of stout setae. Lower anal lip bearing patch of 13 hamate setae.

Native range

Philippines. This species is thought to have originated from the Philippine Islands (Suehiro, 1960).

Plant host(s)

Larvae are known to feed upon the roots of sugar cane (*Saccharum* spp.) (Pemberton, 1963), rice (*Oryza sativa*) (International Rice Research Institute, 1986), and corn (*Zea mays*) (Bryan, 1949).

Life history

Poorly known. Presumably, the life history of this species is similar to that of the closely related oriental beetle (*Anomala orientalis*). Larvae develop in soil where they feed upon the roots of a number of plant species. Adults are likely generalist folivores and active at night.

Pest potential

Moderate. This species is a USDA APHIS regulated pest (USDA APHIS, 2012) and is a species of concern in California (Cosner, 2013). Larvae attack the roots of several important grass crops and are minor pests in the Philippines, Guam, and the Northern Marianas (Pemberton, 1963).

Status in Hawaii

Recorded, not established. In 1955-56 this species was detected on a plane flying into Hawaii from Japan (USDA, 1957). Although not established on the main Hawaiian Islands, *Anomala sulcatula* was previously detected on Midway (Suehiro, 1960), but no recent records are known.

Status in Guam

Established. Anomala sulcatula has been established in Guam since at least 1948 (Krombein, 1949).

Potential distribution and dispersal pathway

Having already spread to Guam, this species has a high likelihood of reaching Hawaii in the near future. Florida and the U.S. Caribbean territories are also potentially at risk. It is unclear if *Anomala sulcatula* could survive the cool winters in California, Texas, and the southern U.S. This species is attracted to lights at night, and it is likely that it would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo, as occurred with the 1956-57 specimen. Further, it is possible that larvae or eggs could be transported in shipments of commercial turf.

Similar species

Anomala sulcatula is one of five *Anomala* species recorded from Hawaii and Guam along with *Anomala orientalis*, *Anomala cuprea*, *Anomala viridana*, and *Anomala albopilosa*. It is separated from the other species by examination of the bifurcate male front claw (which is curved but non-sinuate in *A. sulcatula* versus strongly sinuate in *A. cuprea* and *A. viridana*, weakly sinuate in *A. albopilosa*), male hind tibia (*A. sulcatula* with inner margin greatly dilated at the middle versus all other Hawaiian and Guamanian *Anomala* not greatly dilated at the middle), and total body length (*A. sulcatula* is 14.0–18.0 mm [0.55–0.71 in] versus less than 13.0 mm [0.51 in] in *A. orientalis*).

Other names (synonyms)

None known

Anomala viridana

Common name(s)

green chafer

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Anomala* **Species**: *Anomala viridana* (Kolbe, 1886)

Adult diagnosis

Total body length 18.0–24.0 mm (0.71–0.94 in). Body shape ovate. Color brownish-green with metallic sheen. Front tibia with two external teeth; apical tooth long, longer in female than male; basal tooth feeble in male, more evident in female. Front inner claw bifurcate; bifurcate claw strongly sinuate in male, simple in female. Hind tibia with inner margin simple, not greatly dilated at the middle.

Larval diagnosis

Undescribed. For *Anomala* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Lacinia of maxilla with 2 apical unci equal in size. Maxillary stridulatory area with 4–7 sharp, recurved teeth. Epipharynx with 2–4 prominent heli.

Final antennal segment with single dorsal sensory spot. Spiracles on abdominal segments 7 and 8 similar in size and conspicuously larger than spiracles on abdominal segments 1–6. Anal slit transverse, arcuate; bordered by several irregular rows of stout setae. Lower anal lip bearing patch of 13 hamate setae.

Native range

Northeast Asia. This species has been recorded from Japan (Kobayashi and Matsumoto, 2011), Korea (Park et al, 2014), and Sakhalin and the Kurile Islands in the Russian Far East (Bezborodov, 2014)

Plant host(s)

In the Kurile Islands, adults of this chafer have been recorded on the herb sea-watch or seacoast angelica (*Angelica lucida*) (Krivolutskaya, 1973) as well as northern water hemlock (*Cicuta virosa*), hemlock-parsley (*Conioselinum chinense*), and giant knotweed (*Fallopia sachalinensis*) (Bezborodov et al., 2011).

Life history

Poorly known. Presumably, the life history of this species is similar to that of the closely related oriental beetle (*Anomala orientalis*). Larvae develop in soil where they feed upon the roots of a number of plant species. Adults are likely nocturnal, generalist folivores.

Pest potential

Low. This species has been recorded on Wake Island in abundance (Hawaiian Entomological Society, 1953) and potentially could spread to Hawaii or Guam. It is not apparent that *Anomala viridana* causes significant damage to plants of horticultural or agricultural importance, but native plants could possibly be impacted.

Status in Hawaii

Recorded, not established. This species was recorded in 1952 as a hitchhiker on aircraft coming to Honolulu airport from Wake Island where it is, or was, established and abundant (Hawaiian Entomological Society, 1953).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

Although this species is temperate in origin, its establishment on Wake Island demonstrates its ability to survive in tropical climates. As such, it should be regarded as having the potential to spread to both Hawaii and Guam. Further, the possibility of the introduction of the *Anomala viridana* to the mainland U.S. must also be considered. As previously mentioned, this species is a known hitchhiker on aircraft, and it is reasonable to expect that marine cargo also represents a potential vehicle of introduction.

Similar species

Anomala viridana is one of five *Anomala* species recorded from Hawaii and Guam, along with *Anomala orientalis*, *Anomala sulcatula*, *Anomala cuprea*, and *Anomala albopilosa*. It can be separated from the other species by examination of the bifurcate male front claw (strongly sinuate in *A. viridana* versus weakly sinuate in *A. albopilosa* and curved but non-sinuate in *A. orientalis* and *A. sulcatula*), male hind tibia (*A. cuprea* with hind tibia not greatly dilated at the middle on the inner margin versus hind tibia dilated at the middle in *A. sulcatula*), and total body length (*A. cuprea* 17.0–26.0 mm [0.67–1.02 in] versus less than 13.0 mm [0.51 in] in *A. orientalis*).

Other names (synonyms)

Anomala borealis Arrow, *Anomala izuensis* Sawada, *Anomala japonica* Arrow, *Euchlora mongolica* Lewis, and *Euchlora viridana* Kolbe

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Aphodiinae

Common name(s)

aphodiine dung beetles

Taxonomy

Family: Scarabaeidae **Subfamily**: Aphodiinae

Adult diagnosis

The subfamily Aphodiinae is diverse in species, but fairly uniform in body shape. The subfamily is characterized by small body size and an elongate, cylindrical body form. Coloration is usually brown to black (Ratcliffe and Paulsen, 2008), though more colorful exceptions are known. In Hawaii and Guam, size range is 1.7–8.5 mm (.07–.33 in). Species known from the islands are dark brownish to black, with the exception of *Aphodius fimetarius* which has shiny reddish elytra. The antennae are 11-segmented, with 3 segments forming the antennal club.

Larval diagnosis

(Ritcher, 1966): Grub C-shaped, not usually hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia close together but distinctly separated. Epipharynx trilobed with tormae united mesally. Antennae with 4 or 5 apparent segments. Legs 4-segmented with well-developed claws. Anal lobes whitish or yellowish, lacking setae.

Native range

Worldwide. The Aphodiinae are among the most widespread of all scarab beetles, occurring on all continents except Antarctica. They occur in habitats varying from tropical rainforest to alpine tundra (Elias et al., 2000).

Plant host(s)

The majority of Aphodiinae are dung feeders and are not associated directly with plants. Most species recycle dung and are beneficial for ranching and farming, thus posing no threat to crops or ornamental plants. However, a few species are known to feed on the roots of grasses, particularly *Ataenius spretulus* and *Aphodius granarius* (Shetlar and Niemczyk, 1999). Neither species is known from Hawaii or Guam.

Life history

This diverse subfamily shows a wide range of life history traits. Most are dung "dwellers" that breed and feed within dung and do not usually tunnel under or roll fecal matter (Ritcher, 1966). A few species, however, are associated with ant or termite nests, are parasitic on other scarabs, or feed on grass roots (Ritcher, 1966).

Pest potential

Minor. The majority of aphodiine dung beetles are either harmless or beneficial to agriculture and horticulture. Indeed, several species were purposely brought to the islands to aid in control of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). A few exceptions, such as *Ataenius spretulus* and *Aphodius granarius,* are known to be minor pests of sod and turf (Shetlar and Niemczyk, 1999). Neither of these species is currently known from Hawaii or Guam.

Status in Hawaii

Established. Several species of aphodiines are established in Hawaii (Nishida, 2002). Members of the Aphodiinae are recorded from all the major Hawaiian islands except for Kahoʻolawe (Nishida, 2002). Species identification may be hampered by changes in classification and taxonomy (Gordon and Skelly, 2007).

Status in Guam

Established. Specimens examined at the University of Guam indicate that several species of Aphodiinae occur on the island, as do species checklists by Bourquin (2002) and Cartwright and Gordon (1971).

Potential distribution and dispersal pathway

Several species of aphodiines were intentionally released in Hawaii, as biocontrol agents (Markin and Yoshioka, 1998). Other species may have been unintentionally transported to the islands (Nishida, 2002).

Similar species

Aphodiine dung beetles can be separated from the true dung beetles (Scarabaeinae) by examination of antennae (Aphodiinae with 11 segments versus Scarabaeinae with 8 or 9 segments), small size (Aphodiinae at 1.7–8.5 mm [.07–.33 in] versus Scarabaeinae at 2.0–40.0 mm [0.07–1.57 in), and body shape (Aphodiinae are typically elongate and cylindrical versus Scarabaeinae that vary widely in form from rounded or oval to oblong or rarely cylindrical).

Special note

Species level fact sheets for the Aphodiinae will be released pending completion of a review of the Hawaiian and Guamanian fauna. Unfortunately, species level identifications for Hawaiian and Guamanian specimens are usually incorrect, and any non-authoritative identification should be regarded cautiously.

Apterocyclus honoluluensis

Common name(s)

Hawaiian stag beetle

Taxonomy

Family: Lucanidae **Subfamily**: Lucaninae **Genus**: *Apterocyclus* **Species**: *Apterocyclus honoluluensis* Waterhouse, 1871

Adult diagnosis

Total body length 14.0–21.0 mm (0.55–0.83 in). Body elongate-oval, thorax constricted anterior to elytra; flight wings lacking. Color dull black. Mandibles falcate; male with variable number of internal teeth; female lacking teeth; surface lacking small tubercles or granulosites in both sexes. Ocular canthus distinct. Front tibia moderately expanded toward apex; external margin with a single, apical tooth, variable number of small external teeth; apical spur projecting forward.

Larval diagnosis

Undescribed. For Lucaninae (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Mandible with a ventral process; left molar with inner margin distad of the molar areas with one or more teeth. Maxillary stridulatory teeth usually absent. Maxillary palpus 4-segmented. Thoracic spiracles with emarginations of respiratory plates facing anteriorly. Legs not reduced in size; stridulatory organs present on front and middle legs. Middle leg with trochanter with a stridulatory area consisting of a single longitudinal row of very short transverse ridges. Raster with 2 patches of spine-like setae.

Native range

Kauai. Despite the misleading name, this species is known only from the Kōke'e State Park (Paulsen and Hawks, 2014) area of Kauai.

Plant host(s)

Probably none. This species is not known to feed on living plant tissues. However, adults and larvae are known to be closely associated with dead logs of the native Hawaiian koa tree (*Acacia koa*) (Osborn, 1920; Paulsen and Hawks, 2014).

Life history

Poorly known. This species is associated with native Hawaiian koa (*Acacia koa*) forests at elevations above 1,200 meters. Here, flightless adults and larvae burrow amongst rotting koa logs (Van Dyke, 1922), with larvae presumably feeding upon the decaying wood and perhaps associated fungus.

Pest potential

None. *Apterocyclus* species are not known to feed on living plants. This, combined with their great rarity and dependence on undisturbed native habitat, greatly limits any pest potential.

Status in Hawaii

Native, rare, and local. Known only from Kauai. While the stag beetle is now rarely encountered, it appears that it was once much more abundant across its small range (Van Dyke, 1922; Hawaiian Entomological Society, 1915). The decline of the native Hawaiian stag beetles is likely due to a combination of habitat loss and heavy predation from non-native rodent species (Howden, 2008).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

All *Apterocyclus* species are flightless, rare, and dependent upon vanishing native Hawaiian habitat. As such, members of this genus are unlikely to spread beyond their small natural ranges.

Similar species

Apterocyclus honoluluensis is one of five *Apterocyclus* known from Kauai. It can be separated from other native stag beetles by examination of the male mandibles (*A.*

honoluluensis with short, falcate mandibles; surface lacking small tubercles or granulosites versus *A. palmatus* with tusk-like mandibles, *A. kawaii* with mandibles short, falcate; surface with numerous small tubercles or granulosites), ocular canthus (*A. honoluluensis* with distinct ocular canthus versus all other *Apterocyclus* species with canthus indistinct), and front tibia (*A. honoluluensis* tibia moderately expanded toward apex; external margin with a single, apical tooth, variable number of small external teeth; apical spur projecting forward versus *A. palmatus* with front tibia expanded toward apex with apical ¼ greatly produced; with 1 large apical tooth and 1 large external tooth; apical spur enlarged and projecting medially, *A. kawaii* with front tibia gradually expanded toward a greatly broadened apex; with 1 broad apical tooth and 1 weak external tooth; apical spur peg-like, *A. munroi* tibia moderately expanded toward apex; external margin with 2 teeth at apex (appearing somewhat bidentate); with 2-5 small external teeth; apical spur thin and projecting forward, *A. waterhousei* with front tibia enlarged from base; apical tooth small or lacking, numerous small external teeth; apical spur small and projecting forward).

Other names (synonyms)

Apterocyclus deceptor Sharp, *Apterocyclus feminalis* Sharp, *Apterocyclus varians* Sharp

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Apterocyclus kawaii

Common name(s)

Hawaiian stag beetle

Taxonomy

Family: Lucanidae **Subfamily**: Lucaninae **Genus**: *Apterocyclus* **Species**: *Apterocyclus kawaii* Paulsen and Hawks, 2014

Adult diagnosis

Only male specimens known (Paulsen and Hawks, 2014). Total body length 16.5–23.0 mm (0.64–0.91 in). Body somewhat oval-shaped, pronotum posterior base constricted; lacking flight wings. Color dull black. Mandibles falcate; lacking internal teeth; surface with small tubercles or granulosites. Ocular canthus indistinct. Front tibia gradually expanded toward a greatly broadened apex; with 1 broad apical tooth and 1 weak external tooth; apical spur peg-like.

Larval diagnosis

Undescribed. For Lucaninae (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Mandible with a ventral process; left molar with inner margin distad of the molar areas with one or more teeth. Maxillary stridulatory teeth usually absent. Maxillary palpus 4-segmented. Thoracic spiracles with emarginations of respiratory plates facing anteriorly. Legs not reduced in size; stridulatory organs present on front and middle legs. Middle leg with trochanter with a stridulatory area consisting of a single longitudinal row of very short transverse ridges. Raster with 2 patches of spine-like setae.

Native range

Kauai. Both known specimens of this rare beetle were collected near Kaumakani (formerly known as Makaweli) at about 1000 m (3,200 ft).

Plant host(s)

Probably none. This species is not known to feed on living plant tissues. However, larvae of related *Apterocyclus* are known to be closely associated with dead logs of the native Hawaiian koa tree (*Acacia koa*) (Osborn, 1920; Paulsen and Hawks, 2014).

Life history

Poorly known. Related *Apterocyclus* species are associated with native Hawaiian koa (*Acacia koa*) forests at high elevations. Flightless adults and larvae burrow amongst rotting koa logs (Van Dyke, 1922), with larvae presumably feeding upon the decaying wood and perhaps associated fungus.

Pest potential

None. *Apterocyclus* species are not known to feed on living plants. This, combined with their great rarity and dependence on undisturbed native habitat, greatly limits any pest potential.

Status in Hawaii

Native, very rare. Known only from Kauai. *Apterocyclus kawaii* is known from only two specimens (Paulsen and Hawks, 2014). Like the other native stag beetles, this species presumably has suffered from a combination of habitat loss and heavy predation from non-native rodent species (Howden, 2008).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

All *Apterocyclus* species are flightless, rare, and dependent upon vanishing native Hawaiian habitat. As such, members of this genus are unlikely to spread beyond their small natural ranges.

Similar species

Apterocyclus kawaii is one of five *Apterocyclus* known from Kauai. It can be separated from other native stag beetles by examination of the male mandibles (*A. kawaii* with mandibles short, falcate; surface with numerous small tubercles or granulosites versus *A. palmatus* with tusk-like mandibles, all other *Apterocyclus* with mandible surface lacking small tubercles or granulosites), ocular canthus (*A. kawaii* with canthus indistinct versus *A. honoluluensis* with distinct ocular canthus), and front tibia (*A. kawaii* with front tibia gradually expanded toward a greatly broadened apex; with 1 broad apical tooth and 1 weak external tooth; apical spur peg-like versus *A. munroi* tibia moderately expanded toward apex; external margin with 2 teeth at apex (appearing somewhat bidentate); with 2–5 small, basal external teeth; apical spur thin and projecting forward, *A. honoluluensis* tibia moderately expanded toward apex; external margin with a single, apical tooth, variable number of small external teeth; apical spur projecting forward, ***A. palmatus*** with front tibia expanded toward apex with apical ¼ greatly produced; with 1 large apical tooth and 1 large external tooth; apical spur enlarged and projecting medially, ***A. waterhousei*** with front tibia enlarged from base; apical tooth small or lacking, numerous small external teeth; apical spur small and projecting forward).

Other names (synonyms)

None known

Apterocyclus munroi

Common name(s)

Hawaiian stag beetle

Taxonomy

Family: Lucanidae **Subfamily**: Lucaninae **Genus**: *Apterocyclus* **Species**: *Apterocyclus munroi* Sharp, 1908

Adult diagnosis

Only male specimens known (Paulsen and Hawks, 2014). Total body length 18.0 mm (0.71 in). Body somewhat oval-shaped, pronotum posterior base constricted; lacking flight wings. Color dull black. Mandibles falcate; with single internal tooth; surface lacking small tubercles or granulosites. Ocular canthus indistinct. Front tibia moderately expanded toward apex; external margin with 2 teeth at apex (appearing somewhat bidentate); with 2-5 small, external basal teeth (smaller than apical teeth); apical spur thin and projecting forward.

Larval diagnosis

Undescribed. For Lucaninae (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Mandible with a ventral process; left molar with inner margin distad of the molar areas with one or more teeth. Maxillary stridulatory teeth usually absent. Maxillary palpus 4-segmented. Thoracic spiracles with emarginations of respiratory plates facing anteriorly. Legs not reduced in size; stridulatory organs present on front and middle legs. Middle leg with trochanter with a stridulatory area consisting of a single longitudinal row of very short transverse ridges. Raster with 2 patches of spine-like setae.

Native range

Kauai. Type specimens were collected at about 600–900 m (2,000–3,000 ft) on Kauai, one was recorded near Kaumakani (formerly Makaweli) (Paulsen and Hawks, 2014).

Plant host(s)

Probably none. This species is not known to feed on living plant tissues. However, adults and larvae of related species are known to be closely associated with dead logs of the native Hawaiian koa tree (*Acacia koa*) (Osborn, 1920; Paulsen and Hawks, 2014).

Life history

Poorly known. Related *Apterocyclus* species are associated with native Hawaiian koa (*Acacia koa*) forests at high elevations. Here, adults and larvae burrow amongst rotting koa logs (Van Dyke, 1922), and larvae presumably feed upon the decaying wood and perhaps associated fungus.

Pest potential

None. *Apterocyclus* species are not known to feed on living plants. This, combined with their great rarity and dependence on undisturbed native habitat, greatly limits any pest potential.

Status in Hawaii

Native (possibly extinct). Known only from Kauai. *Apterocyclus munroi* is known from only four specimens, and it has not been collected since 1908 (Paulsen and Hawks, 2014). Like the other native stag beetles, this species has presumably suffered from a combination of habitat loss and heavy predation from non-native rodent species (Howden, 2008).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

All *Apterocyclus* species are flightless, rare, and dependent upon vanishing native Hawaiian habitat. As such, members of this genus are unlikely to spread beyond their small natural ranges.

Similar species

Apterocyclus munroi is one of five *Apterocyclus* known from Kauai. It is separated from other native stage beetles by examination of the male mandibles (*A. munroi* with short, falcate mandibles; surface lacking small tubercles or granulosites versus *A. palmatus* with tusk-like mandibles, *A. kawaii* with mandibles short, falcate; surface with numerous small tubercles or granulosites), ocular canthus (*A. munroi* with canthus indistinct versus *A. honoluluensis* with distinct ocular canthus), and front tibia (*A. munroi* tibia moderately expanded toward apex; external margin with 2 teeth at apex (appearing somewhat bidentate); with 2-5 small, basal external teeth; apical spur thin and projecting forward versus *A. honoluluensis* tibia moderately expanded toward apex; external margin with a single, apical tooth, variable number of small external teeth; apical spur projecting forward, *A. palmatus* with front tibia expanded toward apex with apical ¼ greatly produced; with 1 large apical tooth and 1 large external tooth; apical spur enlarged and projecting medially, *A. kawaii* with front tibia gradually expanded toward a greatly broadened apex; with 1 broad apical tooth and 1 weak external tooth; apical spur peg-like, *A. waterhousei* with front tibia enlarged from base; apical tooth small or lacking, numerous small external teeth; apical spur small and projecting forward).

Other names (synonyms)

Apterocyclus adpropinquans Sharp

Apterocyclus palmatus

Common name(s)

Hawaiian stag beetle

Taxonomy

Family: Lucanidae **Subfamily**: Lucaninae **Genus**: *Apterocyclus* **Species**: *Apterocyclus palmatus* Van Dyke, 1921

Adult diagnosis

Only male specimens known (Paulsen and Hawks, 2014). Total body length 22.0–23.0 mm (0.86–0.90 in). Body elongate-oval, thorax constricted anterior to elytra; flight wings lacking. Color dull black. Mandibles elongate, tusk-like; lacking internal teeth; surface lacking small tubercles or granulosites. Ocular canthus indistinct. Front tibia greatly expanded at apex with 1 large apical tooth and 1 large external tooth; apical spur enlarged and projecting medially.

Larval diagnosis

Undescribed. For Lucaninae (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Mandible with a ventral process; left molar with inner margin distad of the molar areas with one or more teeth. Maxillary stridulatory teeth usually absent. Maxillary palpus 4-segmented. Thoracic spiracles with emarginations of respiratory plates facing anteriorly. Legs not reduced in size; stridulatory organs present on front and middle legs. Middle leg with trochanter with a stridulatory area consisting of a single longitudinal row of very short transverse ridges. Raster with 2 patches of spine-like setae.

Native range

Kauai. Distribution data for this species is particularly scarce. The limited information available from museum specimens indicates that it occurs only on Kauai above elevations of 1,200 m (4,000 ft) (Paulsen and Hawks, 2014).

Plant host(s)

Probably none. This species is not known to feed on living plant tissues. However, larvae of related *Apterocyclus* are known to be closely associated with dead logs of the native Hawaiian koa tree (*Acacia koa*) (Osborn, 1920; Paulsen and Hawks, 2014).

Life history

Poorly known. Related *Apterocyclus* species are associated with native Hawaiian koa (*Acacia koa*) forests at high elevations. Here, adults and larvae burrow amongst rotting koa logs (Van Dyke, 1922), and larvae presumably feed upon decaying wood and perhaps fungus associated with koa logs.

Pest potential

None. *Apterocyclus* species are not known to feed on living plants. This, combined with their great rarity and dependence on undisturbed native habitat, greatly limits any pest potential.

Status in Hawaii

Native (possibly extinct). Known only from Kauai. This species has not been collected or recorded in the last 50 years (Paulsen and Hawks, 2014). Like other native *Apterocylcus* stag beetles, this species has likely suffered from a combination of habitat loss and heavy predation from non-native rodent species (Howden, 2008).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

All *Apterocyclus* species are flightless, rare, and dependent upon vanishing native Hawaiian habitat. As such, members of this genus are unlikely to spread beyond their small natural ranges.

Similar species

Apterocyclus palmatus is one of five *Apterocyclus* known from Kauai. It is separated from other native stag beetles by examination of the male mandibles (*A. palmatus* male with tusk-like mandibles versus mandibles short and falcate in all other *Apterocyclus* species), ocular canthus (*A. palmatus* with ocular canthus indistinct versus *A. honoluluensis* with distinct ocular canthus), and front tibia (*A. palmatus* with front tibia expanded toward apex with apical ¼ greatly produced; with 1 large apical tooth and 1 large external tooth; apical spur enlarged and projecting medially versus *A. kawaii* with front tibia gradually expanded toward a greatly broadened apex; with 1 broad apical tooth and 1 weak external tooth; apical spur peg-like, *A. honoluluensis* with front tibia moderately expanded toward apex; external margin with a single, apical tooth, variable number of small external teeth; apical spur projecting forward, *A. munroi* tibia moderately expanded toward apex; external margin with 2 teeth at apex (appearing somewhat bidentate); with 2-5 small external teeth; apical spur thin and projecting forward, *A. waterhousei* with front tibia expanded from base; apical tooth small or lacking, numerous small external teeth; apical spur small and projecting forward).

Other names (synonyms)

Apterocyclus honoluluensis var. *palmatus* Van Dyke

Apterocyclus waterhousei

Common name(s)

Hawaiian stag beetle

Taxonomy

Family: Lucanidae **Subfamily**: Lucaninae **Genus**: *Apterocyclus* **Species**: *Apterocyclus waterhousei* Sharp, 1908

Adult diagnosis

Total body length 18.0–22.0 mm (0.71–0.87 in). Body elongate-oval, thorax constricted anterior to elytra; flight wings lacking. Color dull black. Mandibles falcate; with single internal tooth; surface lacking small tubercles or granulosites. Ocular canthus indistinct. Front tibia expanded from base; apical tooth small or lacking, numerous small external teeth; apical spur small and projecting forward.

Larval diagnosis

Undescribed. For Lucaninae (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Mandible with a ventral process; left molar with inner margin distad of the molar areas with one or more teeth. Maxillary stridulatory teeth usually absent. Maxillary palpus 4-segmented. Thoracic spiracles with emarginations of respiratory plates facing anteriorly. Legs not reduced in size; stridulatory organs present on front and middle legs. Middle leg with trochanter with a stridulatory area consisting of a single longitudinal row of very short transverse ridges. Raster with 2 patches of spine-like setae.

Native range

Kauai. Specimens have been collected from a small number of sites in northwestern Kauai including Kohua Stream, Kaholuamano, Waialae River, Po'omau Canyon, and Kohua Ridge (Paulsen and Hawks, 2014).

Plant host(s)

Probably none. This species is not known to feed on living plant tissues. However, adults and larvae are known to be closely associated with dead logs of the native Hawaiian koa tree (*Acacia koa*) (Osborn, 1920; Paulsen and Hawks, 2014).

Life history

Poorly known. Related *Apterocyclus* species are associated with native Hawaiian koa (*Acacia koa*) forests at high elevations. Here, flightless adults and larvae burrow amongst rotting koa logs (Van Dyke, 1922), with larvae presumably feeding upon the decaying wood and perhaps associated fungus.

Pest potential

None. *Apterocylus* species are not known to feed on living plants. This, combined with their great rarity and dependence on undisturbed native habitat, greatly limits any pest potential.

Status in Hawaii

Native and rare. Known only from Kauai. Like the other native stag beetles, this rare species has presumably suffered from a combination of habitat loss and heavy predation from non-native rodent species (Howden, 2008).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

All *Apterocyclus* species are flightless, rare, and dependent upon vanishing native Hawaiian habitat. As such, members of this genus are unlikely to spread beyond their small natural ranges.

Similar species

Apterocyclus waterhousei is one of five *Apterocyclus* known from Kauai. It can be separated from other native stage beetles by examination of the male mandibles (*A. waterhousei* male with mandibles falcate; with single internal tooth; surface lacking small tubercles or granulosites versus *A. palmatus* male with tusk-like mandibles, *A. kawaii* male without internal tooth*;* surface with many small tubercles or granulosites), ocular canthus (*A. waterhousei* with ocular canthus indistinct versus *A. honoluluensis* with distinct ocular canthus), and front tibia (*A. waterhousei* with front tibia expanded from base; apical tooth small or lacking, numerous small external teeth; apical spur small and projecting forward versus *A. palmatus* with front tibia expanded toward apex with apical ¼ greatly produced; with 1 large apical tooth and 1 large external tooth; apical spur enlarged and projecting medially, *A. kawaii* with front tibia gradually expanded toward a greatly broadened apex; with 1 broad apical tooth and 1 weak external tooth; apical spur peg-like, *A. honoluluensis* with front tibia moderately expanded toward apex; external margin with a single, apical tooth, variable number of small external teeth; apical spur projecting forward, *A. munroi* tibia moderately expanded toward apex; external margin with 2 teeth at apex (appearing somewhat bidentate); with 2-5 small external teeth; apical spur thin and projecting forward).

Other names (synonyms)

None known

Ateuchus lecontei

Common name(s)

Leconte's dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Ateuchus* **Species**: *Ateuchus lecontei* (Harold, 1868)

Adult diagnosis

Total body length 4.0–7.0 mm (0.16–0.28 in). Body shape round (dorsal view); may be caked in dung. Color shiny black. Eye shape semicircular when viewed from above. Mandibles not visible when viewed from above. Clypeal apex bidentate. Front tibia with apical spur bifurcate in male; spur pointed in female; often worn or missing in older individuals. Middle and hind legs not greatly elongate.

Larval diagnosis

Undescribed. For *Ateuchus* species (Ritcher, 1966): Grub C-shaped, with projecting hump, cylindrical, whitish. Maxilla with galea and lacinia distinctly separated. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented;

distal segment of antenna greatly reduced in size. Prothoracic shield without anteriorly projecting processes. Third abdominal segment without a prominent, conical, dorsal gibbosity. Venter of last abdominal segment with 2 monostichous, longitudinal palidia. Legs 2-segmented; claws absent.

Native range

Southeastern U.S.. In the U.S., this species is known from the Atlantic coastal plain from New Jersey south through Florida and east to Alabama (Woodruff, 1973).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this dung beetle feeding on live plant tissues, although adults have been recorded on rotten, fallen fruit (Woodruff, 1973).

Life history

(Woodruff, 1973): Although the life history of this species is poorly known, related *Ateuchus* species are dung burrowers, with adults creating a burrow 25.4–30.5 cm (10.0–12.0 in) beneath a fecal source. A burrow is provisioned with dung, and a single egg is laid near the entrance of the burrow. The nocturnal adults have been observed on cattle, dog, and human feces. Additional food sources include fungi, carrion, and rotting fruit.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. This species was intentionally released at Ewa on Oahu in August of 1963 (Davis and Krauss, 1964). Similar dung beetle introductions were undertaken to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). It is known only from Oahu (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released.

Similar species

This scarab could be confused with small, similarly colored Hawaiian *Onthophagus* spp. or *Hybosorus roei*. It is easily separated from these, however, by examination of the clypeal apex (*Ateuchus lecontei* with apex bidentate versus *Onthophagus* with the apex entire or sinuate) and mandibles (*Ateuchus lecontei* with mandibles hidden under clypeus when viewed from above versus mandibles clearly visible from above in *Hybosorus roei*).

Other names (synonyms)

Choeridium lecontei Harold

Canthon humectus

Common name(s)

tumblebug

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Canthon* **Species**: *Canthon humectus* (Say, 1831)

Adult diagnosis

Total body length 10.0–17.0 mm (0.39–0.67 in). Body shape round (dorsal view); may be caked in dried dung. Color dark blue-black; weakly metallic. Eyes crescent shaped; longer than wide. Clypeus bidentate; surface smooth, never coarsely granulate. Pronotum and elytra smooth, never coarsely granulate. Front tibia with apical spur bifurcate in male and spine-like in female (spur may be worn down in older individuals). Middle and hind legs elongate. Pygidium width more than twice height.

Larval diagnosis

Undescribed. For *Canthon* spp. (Ritcher, 1966): Grub C-shaped,hump-backed, cylindrical, whitish. Prothoracic shield with anterior projecting, angular process on each side. Legs each with a single long, terminal seta surrounded by numerous short setae; 2-segmented; without stridulatory structures; claws absent. Anal slit transverse.

Native range

Central Mexico to Guatemala. This species is known primarily from the high plateau of central Mexico, though it has been recorded south to the highlands of Guatemala (Halffter et al., 2011) and north to the Mexican state of Sonora (Navarrete-Heredia, 2012).

Plant host(s)

None. This species feeds on dung as both an adult and larva (Ortega-Martínez et al., 2014).

Life history

Similar to other *Canthon* spp., this diurnal scarab is a dung roller (Ortega-Martínez et al., 2014). It is known primarily from elevations between 1,200–2,000 meters (3,900–6,500 ft) where it occurs in pastures, shrubland, and rarely in open forests (Halffter et al., 2011). In central Mexico, it is amongst the most common dung beetle species found in cattle pastures and shows a strong affinity for cattle droppings (Ortega-Martínez et al., 2014). Males arrive at droppings and shape a portion of dung into a ball. The dung ball is then rolled, or "tumbled", away from the initial dung source. Females do not roll dung but may passively ride atop the ball. Adults may consume the dung ball, or a single egg may be deposited in it and then buried in the soil by the male for larval consumption (Ortega-Martínez et al., 2014).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. This species was intentionally introduced to Big Island twice (once in 1923 and again in 1952) to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). It is also known from Maui (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released.

Similar species

This scarab is one of four *Canthon* species recorded from Hawaii (none are known from Guam). It is distinguished from the other *Canthon* species recorded in Hawaii by examination of the pronotal texture (texture smooth in *Canthon humectus* versus coarsely granulate in *C. pilularius*), color (dark blue-black in *C. humectus,* versus dark metallic green in *C. indigaceus,* velvety black to green in *C. pilularius*, shining green or red in *C. viridis*), size (10.0–17.0 mm [0.39–0.67 in] in *C. humectus* versus 2.0–4.0 mm [0.08–0.16 in] in *C. viridis*), and pygidium shape (pygidium width more than twice the height in *C. humectus* versus width less than twice the height in *C. viridis*, *C. pilularius* and *C. indigaceus)*.

Other names (synonyms)

Canthon amythestinus Harold**,** *Canthon gagatinus* Harold

Canthon indigaceus

Common name(s)

tumblebug

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Canthon* **Species**: *Canthon indigaceus* Leconte, 1866

Adult diagnosis

Total body length 8.5–12.0 mm (0.33–0.47 in). Body shape round (dorsal view); may be caked in dried dung. Color dark metallic green. Eyes crescent shaped; longer than wide. Clypeus bidentate; surface smooth, never coarsely granulate. Pronotum and elytra smooth, never coarsely granulate. Front tibia with apical spur bifurcate in male and spine-like in female (spur may be worn down in older individuals). Middle and hind legs elongate. Pygidium width less than twice height.

Larval diagnosis

Undescribed. For *Canthon* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, whitish. Anal slit transverse. Prothoracic shield with anterior projecting, angular process on each side. Legs each with a single long, terminal seta surrounded by numerous short setae; 2-segmented; without stridulatory structures; claws absent.

Native range

Southwestern U.S., Mexico, Central America. In the U.S., this species is known only from Arizona and Texas (Robinson, 1948). It occurs through much of Mexico, with its distribution extending south to Costa Rica (Solis-Blanco, 2002).

Plant host(s)

None. This species is primarily a dung feeder and has not been recorded feeding on live plants. However it has been observed tumbling the rinds of prickly pear (*Opuntia* spp.) fruit (Novelo et al., 2007), suggesting opportunistic feeding on fallen fruit.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded attacking crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. *Canthon indigaceus* was intentionally introduced to Hawaii. Specimens were released in 1954 at Weima on Kauai, Molokai Ranch on Molokai, and the University of Hawaii Dairy on Oahu (Weber, 1955). Similar dung beetle introductions were undertaken to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released.

Similar species

This scarab is one of four *Canthon* species recorded from Hawaii (none are known from Guam). It is distinguished from the other *Canthon* species recorded in Hawaii by examination of the pronotal texture (texture smooth in *C. indigaceus* versus coarsely granulate in *C. pilularius*), color (metallic dark green in *C. indigaceus* versus dark blue-black in *C. humectus,* shining green or red in *C. viridis,* velvety black to green in *C. pilularius*), size (C. *indigaceus* 8.5–12.0 mm [0.33–0.47 in] versus 2.0–4.0 mm [0.08–0.16 in] in *C. viridis*, 12.0–19.0 mm [0.39–0.59 in] in *C. pilularius*), and pygidium shape (pygidium width less than twice the height in *C. indigaceus* versus width more than twice the height in *C. humectus*).

Other names (synonyms)

Canthon chevrolati Harold*, Canthon chiapas* Robinson

Canthon pilularius

Common name(s)

dull tumblebug

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Canthon* **Species**: *Canthon pilularius* (Linnaeus, 1758)

Adult diagnosis

Total body length 12.0–19.0 mm (0.39–0.59 in). Body shape round (dorsal view); may be caked in dried dung. Color variable; dull, velvety black to dull, bronze or green. Eyes crescent shaped, longer than wide. Clypeus bidentate; surface coarsely granulate. Pronotum and elytra coarsely granulate. Front tibia with apical spur bifurcate in male and spine-like in female (spur may be worn down in older individuals). Middle and hind legs elongate. Pygidium width less than twice the height.

Larval diagnosis

(Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, whitish. Anal slit transverse. Chaetoparia each with 7–9 setae. Maxillary stridulatory area with 12–17 teeth. Prothoracic shield with anterior projecting, angular process on each side. Legs each with a single long, terminal seta surrounded by 8–9 short setae; 2-segmented; without stridulatory structures; claws absent. Venter of last abdominal segment with single, broad, caudal, median lobe flanked by 2 smaller fleshy lobes; median lobe with 2 inconspicuous patches of very short setae.

Native range

Eastern North America. This species is common and widespread across the eastern U.S., occupying much of the area east of the Rocky Mountains and south of the boreal forest (Woodruff, 1973).

Plant host(s)

None. This species feeds on dung as both an adult and larva (Woodruff, 1973).

Life history

Canthon pilularius favors open habitats where it feeds preferentially on horse and cattle dung (Woodruff, 1973). On fresh dung, several hundred individuals may congregate to feed and mate (Ratcliffe and Paulsen, 2008). Dung balls are created and rolled only by the males with females often riding passively atop the balls (Woodruff, 1973). Dung balls may be either eaten by the adults or buried and used for rearing larvae. Dung balls used for larvae each hold a single egg and are buried 7.6–12.7 cm (3.0–5.0 in) deep in firm soils (Ritcher, 1966). In the laboratory, development from egg to adult ranged between 29 and 44 days (Ratcliffe and Paulsen, 2008).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being an obligate dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Established. This species was intentionally released on Oahu in August of 1963 (Hawaiian Entomological Society, 1964). Similar dung beetle introductions were undertaken to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). It is established on Oahu (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released.

Similar species

This scarab is one of four *Canthon* species recorded from Hawaii (none are known from Guam). It is distinguished from the other *Canthon* species recorded in Hawaii by examination of the pronotal texture (texture coarsely granulate in *Canthon pilularius* versus smooth in *C. viridis*, *C. indicageus* and *C. humectus*), color (velvety black, bronze or green in *Canthon pilularius* versus shining green or red in *Canthon viridis*, dark blue-black in *C. humectus*), size (12.0–19.0 mm [0.39–0.59 in] in *C. pilularius* versus 2.0–4.0 mm [0.08–0.16 in] in *C. viridis*), and shape of the pygidium (pygidium width less than twice the height in *Canthon pilularius* versus width more than twice the height in *C. humectus*).

Other names (synonyms)

Scarabaeus pilularius Catesby, *Scarabaeus laevis* Drury, *Scarabaeus hudsonias* Forster, *Scarabaeus volvens* Fabricius, *Coprobius obtusidens* Ziegler, *Canthon laevis* Horn

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Canthon viridis

Common name(s)

tumblebug

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Canthon* **Species**: *Canthon viridis* (Beauvois, 1805)

Adult diagnosis

Total body length 2.0–4.0 mm (0.08–0.16 in). Body shape round (dorsal view); may be caked in dried dung. Color metallic shining green, sometimes metallic coppery red. Eyes crescent shaped, longer than wide. Clypeus bidentate; surface smooth. Pronotum and elytra smooth, lacking coarse granular texture. Front tibia with apical spur bifurcate in male and spine-like in female (spur may be worn down in older individuals). Middle and hind legs elongate. Pygidium width less than twice the height.

Larval diagnosis

(Blume, 1981): Grub C-shaped, hump-backed, cylindrical, whitish. Anal slit transverse. Chaetoparia with 4–5 setae. Maxillary stridulatory area with 8–10 teeth. Prothoracic shield without anterior projecting, angular process on each side. Legs each with a single long, terminal seta surrounded by 5–6 short setae; 2-segmented; without stridulatory structures; claws absent. Venter of last abdominal segment with single, broad, caudal, median lobe; median lobe with 2 inconspicuous patches of very short setae.

Native range

Eastern North America. This species is widespread across much of eastern North America, occupying nearly all of the area east of the Rocky Mountains and south of the boreal forest (Woodruff, 1973).

Plant host(s)

None. This species feeds on dung as both an adult and larva (Woodruff, 1973).

Life history

(Blume, 1981): In Texas, adults of this species are active April through June. Adults are dung rollers, laying an egg within an ovate-shaped piece of dung. The formed dung is rolled away from the fecal pile before being buried in soil 3–6 cm (1.1–2.5 in) below the surface. Larvae emerge from eggs 24–36 hours after being laid, and the larva feeds upon the dung. An average of five days is spent in the combined first and second instars, with the final instar lasting 9–10 days. The pupal stage lasts an average of 3 days. *Canthon viridis* is diurnal and is largely confined to woodland areas where it has been recorded feeding on the dung of rabbits, humans, swine, cattle, and birds (Ratcliffe and Paulsen, 2008).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. As an obligate dung feeder, this species poses no threat to crop or ornamental plants.

Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Not established. This species was intentionally released in 1954 at Parker Ranch on Big Island (Weber, 1955). Similar dung beetle introductions were undertaken to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). Despite this effort, *Canthon viridis* failed to establish populations in the state (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released but it did not establish.

Similar species

This scarab is one of four *Canthon* species recorded from Hawaii (none are known from Guam). It is distinguished from the other *Canthon* species recorded in Hawaii by examination of the pronotal texture (texture smooth in *C. viridis* versus coarsely granulate in *C. pilularius*), color (shining green or red in *C. viridis* versus dark blue-black in *C. humectus,* dark metallic green in *C. indigaceus,* velvety black to green in *C. pilularius*), size (2.0–4.0 mm [0.08–0.16 in] in *C. viridis* versus from 8.0-17.0 mm [0.31-

0.67 in] in the other *Canthon* species), and pygidium shape (pygidium width less than twice the height in *C. viridis* versus width more than twice the height in *C. humectus)*.

Other names (synonyms)

Ateuchus obsoletus Say, *Canthon metallicus* Sturm, *Canthon viride* Beauvois, *Canthon viridulus* Dejean, *Copris viridis* Beauvois, *Glaphyrocanthon viridis* (Beauvois), *Onthophagus viridicatus* Say

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Catharsius molossus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Catharsius* **Species**: *Catharsius molossus* (Linnaeus, 1789)

Adult diagnosis

Total body length 25.0–45.0 mm (0.98–1.80 in). Body shape elongate-oval; may be caked with dung. Color dull black. Clypeus broadly rounded. Head of male with clypeal horn; female lacking clypeal horn. Frons lacking horns or tubercles in both sexes. Pronotum with well-developed tumosity and distinct horizontal ridge in both sexes; lateral margins with distinct horns in major male (reduced or lacking in minor males, lacking in female). Elytra with indistinct striae.

Larval diagnosis

Undescribed. For Scarabaeinae (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia distinctly separate. Antennae with 4 or 5 apparent segments. Distal segment of antenna much reduced in size. Epipharynx with tormae united mesally, anterior phoba present. Anal opening surrounded by fleshy lobes. Legs 2-segmented.

Native range

Southeastern Asia. This species is distributed widely through southeastern Asia, including India, southern China, Thailand, Vietnam, and Indonesia (Xu et al., 2002). Recently, this species was rediscovered in Singapore after nearly 40 years of searching (Ong et al. 2013).

Plant host(s)

None. This species feeds on dung as both an adult and larva (Ong et al. 2013).

Life history

Unlike many of the more familiar dung beetles that can occur in livestock pastures, this species is dependent upon primary and late-stage secondary rain forests (Ong et al. 2013). In Borneo, this species has declined in concert with the loss of primary forests (Davis, 2001). *Catharsius molossus* prefers the dung of large herbivores, constructing a brood burrow near fresh dung at night. Dung is then deposited in the burrow and impregnated with an egg (Ong et al. 2013).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Recorded, *not established*. This species was imported into Hawaii in 1921 for evaluation as a biocontrol agent to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock. However imported specimens failed to thrive, and none were released (Fullaway, 1921).

Status in Guam

Not established or recorded. This species has not been recorded in Guam.

Potential distribution and dispersal pathway

This species was intentionally imported into Hawaii.

Similar species

This species is somewhat like the similarly colored and sized *Dichotomius carolinus*. These two species are separated by examining the head (*C. molossus* with a single clypeal horn in males with females lacking a horn versus *D. carolinus* with paired clypeal tubercles in males and females with a tubercle on the frons), pronotum (*C. molossus* major males with pronotal horns with minor males and females lacking horns versus *D. carolinus* always lacking pronotal horns), and elytra (*C. molossus* with indistinct striae versus *D. carolinus* with distinct striae).

Other names (synonyms)

Sacrabaeus molossus Linnaeus, *Catharsius abbrevatius* Herbst in Jablonsky, *Catharsius berbicaeus* Herbst in Jablonsky, *Catharsius janus* Olivier, *Catharsius ursus* Fabricius

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Copris incertus

Common name(s)

black dung beetle, uncertain dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Copris* **Species**: *Copris incertus* Say,1835

Adult diagnosis

Total body length 12.0–20.0 mm (0.47–0.78 in). Body shape oval; may be caked in dung. Color shiny black. Head of major male with long, thin, well-developed horn; reduced in minor male; horn truncate to lacking in female. Pronotum with four horn-like protuberances in major male; protuberances much reduced in minor male and female. Elytra with 9 striae; 8th stria incomplete, never reaching posterior margin of elytra.

Larval diagnosis

Undescribed. For *Copris* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, whitish. Maxilla with galea and lacinia distinctly separated. Epipharynx with tormae united mesally, anterior phoba present. Antenna 4-segmented, distal segment much reduced in size. Legs with small, blunt claws each bearing a terminal seta. Prothoracic shield with an anteriorly projecting, angular process on each side. Venter of last abdominal segment with paired, median, caudal lobes or a cleft median lobe.

Native range

Mexico, Central and South America. This species is distributed in the New World tropics from Veracruz, Mexico south through Central America and into Colombia and Ecuador (Palestrini et al., 1990).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of *Copris incertus* feeding on live plant tissues.

Life history

(Halffter et al., 1994): The female creates a burrow that terminates in a brood chamber under or near a dung pat. With the aid of the male, dung is relocated into the brood chamber, brood balls are created, and the burrow is sealed. On average, five brood balls are created and an egg is laid within each. The larvae grow and feed within the dung balls, and the maternal female remains in the brood chamber and continues to apply dung to the surface of the ball. She also repairs damaged brood balls and drives away parasites. Loss of the maternal female results in greatly increased larval mortality.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. In Hawaii, this species was imported in to combat the horn fly (*Haematobia irritans*), a biting pest of livestock. It was released in 1922-1923 (Hawaii Division of Forestry, 1923) on all the major islands of Hawaii and is now widely established (Nishida, 2002).

Status in Guam

Recorded, not established. This species was released on Guam in 1953 to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Peterson, 1956). Peterson (1956) stated that it was likely established on the island. Yet, neither Cartwright and Gordon (1971) nor Bourquin (2002) reported it from Guam, and no specimens are present in the University of Guam insect collection (pers. obs. 2015).

Potential distribution and dispersal pathway

In both Hawaii and Guam, this species was intentionally imported.

Similar species

This scarab is extremely similar to the closely related *Copris remotus*. These *Copris* species are separated by examining the elytra (*C. incertus* with the outer 8th stria incomplete, not reaching the posterior elytral margin versus *Copris remotus* with the 8th stria complete, reaching the posterior elytral margin).

Other names (synonyms)

Copris denticornis Gemminger and Harold, *Copris exadius* Gemminger and Harold, *Copris prociduus* Say

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Copris remotus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Copris* **Species**: *Copris remotus* Leconte, 1866

Adult diagnosis

Total body length 10.0–16.0 mm (0.39–0.63 in). Body shape oval; may be caked in dung. Color shiny black. Clypeal apex notched. Frons of major male with long, thin, well-developed horn; horn reduced in minor males; horn truncate to lacking in females. Pronotum with four horn-like protuberances in males; protuberances much reduced in females. Elytra with 9 striae; 8th stria complete, reaching rear margin of elytra.

Larval diagnosis

Undescribed. For *Copris* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, whitish. Maxilla with galea and lacinia distinctly separated. Epipharynx with tormae united mesally, anterior phoba present. Antenna 4-segmented; distal segment much reduced in size. Legs with small, blunt claws each bearing a terminal seta. Prothoracic shield with an anteriorly projecting, angular process on each side. Venter of last abdominal segment with paired, median, caudal lobes or a cleft median lobe.

Native range

Southwestern U.S., northern Mexico. In the U.S., this species is known from Texas and Oklahoma. In Mexico, the species is recorded from Coahuila, Nuevo León, and Tamaulipas (Kohlmann et al., 2003).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of *Copris remotus* feeding on live plant tissues.

Life history

(Woodruff, 1973): Although the life history of this species is poorly known, related *Copris* species are dung tunnelers, with a male and female creating a burrow under a dung source. The burrow is provisioned with dung, which is formed into pear-shaped brood balls. An egg is deposited within each brood ball. Brood balls are attended by the female during development of the larva (Ratcliffe and Paulsen, 2008).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Recorded, not established. In Hawaii, this species was imported in 1921 to combat the horn fly (*Haematobia irritans*), a biting pest of livestock (Fullaway, 1921). Specimens were released on all major islands except Kauai (Hawaii Division of Forestry, 1923). Despite these efforts the species failed to establish in Hawaii (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This scarab is extremely similar to the closely related *Copris incertus.* These species are separated by examination of the elytra (*Copris remotus* with the 8th stria complete, reaching the posterior elytral margin versus *C. incertus* with 8th stria incomplete, not reaching the posterior elytral margin).

Other names (synonyms)

Copris remotus dicyrtus Matthews and Halffter

Cotinis mutabilis

Common name(s)

green June bug, green June beetle, figeater beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Cetoniinae **Genus**: *Cotinis* **Species**: *Cotinis mutabilis* (Gory and Percheron, 1833)

Adult diagnosis

Total body length 17.0–34.0 mm (0.67–1.34 in). Body shape vaguely pentagonal, somewhat dorsoventrally flattened. Color above velvety green, rarely black or plum; ventral color metallic green, rarely black or brownish; elytral margins or mid-disc often tan. Head with short process at apex of clypeus and short, anteriorly produced, horn-like process on frons. Scutellum hidden by pronotum. Sternum with strongly produced metasternal keel.

Larval diagnosis

(Ritcher, 1966): Live larvae crawl on their backs, legs up, and feel distinctly "squishy". Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Labrum symmetrical, trilobed. Lacinia with fewer than 3 well-developed, terminal unci. Last antennal segment with sensory spots. Claws cylindrical; bearing 7 or more setae. Abdominal segments 9 and 10 fused. Anal opening transverse, straight or slightly curved. Raster with 2 or more irregular rows of pali; inner row of each palidium having 7–10 pali each much larger than those pali in the outer row.

Native range

Southwestern U.S. to northern South America. This species occurs from the southwestern U.S. (California, Nevada, Utah, Arizona, New Mexico, and Texas) south through Mexico and Central America into northern South America (Goodrich, 1966).

Plant host(s)

Adults have been reported on a number of plants, most of which are thin-skinned fruits: apple (*Malus* spp.), apricot (*Prunus armeniaca*), blackberry (*Rubus* spp.), grape (*Vitis* spp.), fig (*Ficus carica*), nectarine (*Prunus persica*), peach (*Prunus persica*), pear (*Pyrus* spp.), pineapple (*Ananas comosus*), plum (*Prunus domestica*), raspberry (*Rubus* spp.), and tomato (*Solanum lycopersicum)* (Davis, 2014). There are also reports of larvae damaging pineapple roots (Joy et al., 2013).

Life history

Adults of this species are diurnal, flying actively and noisily while searching for feeding or oviposition sites (Chapell, 1984). In Utah, adults are active in July and August (Davis, 2014**)**, while in California adults are seen May through early October (Chapell, 1984). Eggs are laid in compost, manure, or organic rich soils, where larvae feed on organic debris and detritus (Davis, 2014).

Pest potential

Minor. Unlike the very similar looking *Cotinis nitida*, *C. mutabilis* is not a significant pest (Davis, 2014). Adults do not damage developing fruit, but they may actively seek out ripe fruit (Chapell, 1984) and can cause minor damage, particularly to thin-skinned fruits (Davis, 2014). There are few reports of larvae damaging roots (Camino-Lavín et al., 1996), although it is not clear that this is a common occurrence.

Status in Hawaii

Recorded, not established. In Hawaii, this species has been intercepted in quarantine at Hilo on Big Island. The specimen was collected in 2014 in an automobile that originated from San Diego, California. A 1964 record for *Cotinis*, also intercepted arriving from California, probably refers to this species (Look, 1974).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This diurnal species is both widespread and a powerful flier (Chapell, 1984). It is possible that the frugivorous adults could be transported in commercial shipments of fruits, as may have occurred with the 2014 specimen.

Similar species

Though distinctive amongst recorded Hawaiian and Guamanian species, it is possible this beetle could be confused with *Protaetia orientalis* (Asian flower beetle) or *Protaetia pryeri* (Midway emerald beetle). A number of characters are useful in separating *Cotinis* and *Protaetia*, including: scutellum (*Cotinis mutabilis* with scutellum hidden under pronotum versus scutellum clearly visible in *Protaetia* spp.), color (*Cotinis mutabilis* usually velvety green versus dark brown or black with white maculations in *Protaetia orientalis*, shining bright green in *Protaetia pryeri*), head armature (*Cotinis mutabilis* with short, horn-like process on the frons and produced clypeal apex versus head armature absent in *Protaetia* spp.), and metasternal keel (*Cotinis mutabilis* with metasternal keel strongly produced, versus metasternal keel reduced in *Protaetia* spp.).

Other names (synonyms)

Cotinis abdominalis Casey, *Cotinis arizonica* Casey, *Cotinis atrata* (Gory and Percheron), *Cotinis capito* Casey, *Cotinis malinus* Janson, *Cotinis mexicana* (Gory and Percheron), *Cotinis nigrorubra* (Gory and Percheron), *Cotinis obliqua* Casey, *Cotinis palliata* (Gory and Percheron), *Cotinis sobrina* (Gory and Percheron), *Cotinis texana* Casey, *Gymnetis mutabilis* Gory and Percheron

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Cyclocephala pasadenae

Common name(s)

Pasadena masked chafer, southwestern masked chafer

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Cyclocephala* **Species**: *Cyclocephala pasadenae* (Casey, 1915)

Adult diagnosis

Total body length 12.0–14.0 mm (0.47–0.55 in). Body elongate oval. Elytra and pronotum tan to golden-brown in color; clypeus and frons black to dark brown. Head lacking horns or tubercles. Pronotum lacking horns or tubercles. Elytral lacking obvious striae. Lateral margin of front tibia with 3 teeth. Claws of front tibia noticeably more robust in males than females.

Larval diagnosis

(Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well developed unci. Maxillary stridulatory teeth truncate. Inner, concave surface of mandible, distad of the molar area, smooth. Head yellow-brown to light reddish-brown, lacking coarse punctures. Dorsal surface of last antennal segment with 2–5 sensory spots. Legs 4-segmented. Spiracles of first 6 abdominal segments similar in size. Scutella of front and middle sections of thorax each with 2 setae. Anal opening transverse, straight or slightly curved. Plegmatia absent.

Native range

Southern U.S., northern Mexico. This species is known from the southern half of the U.S. (Hardy, 1991). It is most common in the southwestern states (Ratcliffe and Paulsen, 2008) and is also known from northern Mexico (Ratcliffe et al., 2013).

Plant host(s)

Larvae are associated with turf grasses (Jameson et al., 2009).

Life history

In Nebraska, this species has a single generation per year, with adults active from June to October. Adult abundance peaks strongly in July (Ratcliffe and Paulsen, 2008). Females lay eggs in the soil, with larvae feeding on both grass roots and organic soil debris. Adults do not appear to feed (Ritcher, 1966).

Pest potential

Moderate. The pest potential of this species is somewhat unclear. Some sources state that larvae rarely occur in sufficient density to cause serious turf damage (Ratcliffe and Paulsen, 2008). Other sources describe it as among the most destructive turf pests in its range (Jameson et al., 2009). In its small Hawaiian range, this species has been associated with visible turf damage, some caused indirectly when birds dig for grubs (Jameson et al., 2009).

Status in Hawaii

Established. *Cyclocephala pasadenae* is known only from a Waikaloa golf course on Big Island, where it was first recorded 2007 (Jameson et al., 2009). Anecdotal evidence from the golf course staff suggest it may have established as early as the mid 1990's (Jameson et al., 2009).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species is attracted to lights at night (Ratcliffe and Paulsen, 2008) and could be attracted to well lit ports and airports. This would allow for hitchhiking on marine or air cargo. Because eggs are laid in turf grasses, it is possible that eggs or larvae could be transported in shipments of commercial sod. *Cyclocephala pasadenae* should be regarded as a potential invasive threat to the other U.S. Pacific territories and the Caribbean.

Similar species

Cyclocephala pasadenae is the only member of its genus known from Hawaii. It is superficially most similar to another turf pest, *Anomala orientalis* (oriental beetle). These species are easily separated by size (*C. pasadenae* at 12.0–14.0 mm [0.47–0.55 in] versus 7.0–11.0 mm [0.28–0.43 in] in *A. orientalis*) and examination of the front tarsi (*C. pasadenae* with 3 teeth along the lateral margin of the front tibia versus 2 teeth along the lateral margin in *A. orientalis*).

Other names (synonyms)

Cyclocephala mexica Martínez, *Ochrosidia arizonica* Casey, *Ochrosidia facilis* Casey, *Ochrosidia melina* Casey, *Ochrosidia ovulata* Casey, *Ochrosidia pasadenae* Casey, *Ochrosidia pusilla* Casey, *Ochrosidia validiceps* Casey

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Dichotomius carolinus

Common name(s)

Carolina dung beetle, Carolina copris

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Dichotomius* **Species**: *Dichotomius carolinus* (Linnaeus, 1767)

Adult diagnosis

Total body length 20.0–30.0 mm (0.78–1.18 in). Body shape distinctly round when viewed from above; may be caked with dung. Color dull black. Clypeus broadly rounded. Head of major male with paired tubercles on clypeus; clypeal tubercles reduced in minor male; lacking clypeal tubercles in female. Head of female with single tubercle on frons; tubercle on frons lacking in male. Pronotum with well-developed tumosity (male and female); lacking horns. Elytra with distinct striae.

Larval diagnosis

(Ritcher, 1966): Grub C-shaped and hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia distinctly separate. Antennae with 4 or 5 apparent segments. Distal segment of antenna much reduced in size. Epipharynx with tormae united mesally, tormae symmetrical; anterior phoba present. Chaetopariae each consisting of 15–20 setae. Prothoracic shield with an anteriorly projecting, angular process on each side. Venter of last abdominal segment with polystichous palidia. Anal opening surrounded by fleshy lobes. Legs 2-segmented; with paired terminal setae; claws lacking.

Native range

Eastern United States. This is a common dung beetle species in many pastures of the eastern U.S., where it is known from southeastern South Dakota southward to eastern Texas and east to southern Florida and New England (Woodruff, 1973).

Plant host(s)

None. This species feeds on dung as both an adult and larva (Woodruff, 1973).

Life history

Dichotomius carolinus is a nocturnal species and often is attracted to lights (Woodruff, 1973). Male-female pairs excavate a brood burrow near dung, often leaving a large mound of dirt near the entrance. Such burrows can contain multiple tunnels and are constructed at night near fresh dung in meadows and grasslands. A mass of dung is placed at the end of a tunnel, and an egg is laid within. In Nebraska, adults have been found in June and August (Ratcliffe and Paulsen, 2008). In Florida, however, adults are found throughout the year (Woodruff, 1973).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants.

Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Recorded, not established. This species was intentionally released from Florida to the Big Island at Parker Ranch in 1954 (Weber, 1955) to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock. Despite this effort *Dichotomius carolinus* failed to establish populations in the state (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released but did not establish.

Similar species

The only dung beetle recorded from Hawaii that reaches the size of *Dichotomius carolinus* is the similarly colored *Catharsius molossus*. These species are separated by examining the head (*D. carolinus* with paired clypeal tubercles in males and females with a tubercle on the frons versus *C. molossus* with a single clypeal horn in males and females lacking a horn), pronotum (*D. carolinus* always lacking pronotal horns versus *C. molossus* major males with pronotal horns), and elytra (*D. carolinus* with distinct striae versus *C. molossus* with indistinct striae).

Other names (synonyms)

Copris carolinus Linnaeus, *Copris colonicus* Say, *Dichotomius colonicus* Say, *Pinotus bituberculatus* Harold, *Pinotus carolinus* Linnaeus

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Digitonthophagus gazella

Common name(s)

brown dung beetle, gazelle scarab, gazelle dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Digitonthophagus* **Species**: *Digitonthophagus gazella* (Fabricius, 1787)

DNA barcode

DNA barcode available: specimen information

Adult diagnosis

Total body length 10.0–13.0 mm (0.39–0.51 in). Body shape oval; may be caked in dung. Color brown to dark-brown; margin of pronotum tan. Medium-sized *Onthophagus*-like dung beetle, more than 10 mm. Clypeal apex weakly sinuate; not strongly produced in either sex. Head of male with 2 short, upward curving horns at base; minor male with horns reduced or absent; female lacking horns, instead with transverse ridge. Ocular canthus completely dividing eye. Pronotum with anterior angle rounded. Pronotum lacking horns; male with weak hump-like process; minor male and female with weak bi-lobed process. Tibia of male elongated, gracile; female tibia comparatively stout. Scutellum absent.

Larval diagnosis

(Huerta et al., 2010): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Lacinia with 2–6 dorsobasal setae. Labium hypopharynx glossa with 9–15 latero-posterior setae; 13–32 setae on lateral lobe. Epipharynx with tormae united mesally, anterior phoba present. Chaetoparia with 10 setae. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Africa. This dung beetle is native to hot, arid, and semi-arid areas of sub-Saharan Africa (Tyndale-Biscoe, 1990). This species was introduced to Texas in 1970 and has spread (sometimes with deliberate human intervention) throughout much of the southern half of the U.S., southward to Uruguay and Argentina (Noriega et al., 2010). It was introduced to Australia (Tyndale-Biscoe, 1990).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

(Tyndale-Biscoe, 1990): Adults of this species live about 2 months, flying from sunrise to sunset in search of dung. In areas of moist, loose soil, females construct a burrow 20–25 cm (7.87–9.84 in) under or near a dung source. The burrow is provisioned with dung formed into oval-shaped brood balls. Each brood ball is impregnated with a single egg. Development from egg to adult can take as little as 3–5 weeks under optimal conditions. Development often takes much longer when the conditions are less favorable. There are multiple generations per year.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. In Hawaii, this species was introduced to Oahu in 1957 (Davis, 1960) and on Big Island in 1973 at Parker Ranch (Nakao et al., 1975). Further introductions occurred on Kauai and Maui, though it is unclear if those introductions took place in 1957 or 1973 (Markin and Yoshioka, 1998). In much of Hawaii, this species is usually most abundant at lower elevations. It is one of the most common dung beetles on Oahu (Harris et al., 1982), Kauai, and Maui (Markin and Yoshioka, 1998).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This species could be confused with the similarly colored, medium-sized (more than 10 mm) species: *Onthophagus nigriventris* and *Onthophagus sagittarius*.

Major males are readily separated by examining the head armature (*D. gazella* with 2 short, upward curving horns versus *O. nigriventris* lacking horns, *O. sagittarius* with 2 tusk-like horns).

Minor males and females are separated by examining the base of the head (*D. gazella* with straight, transverse ridge versus *O. nigriventris* with a sinuate ridge, *O. sagittarius* with single horn).

Other names (synonyms)

Scarabaeus gazella Fabricius, *Onthophagus antelope* Fabricius, *Onthophagus catta* Fabricius, *Onthophagus dorcas* Olivier, *Onthophagus gazella* Fabricius, *Onthophagus intermedius* Reiche, *Onthophagus metallicus* Fabricius

Euoniticellus africanus

Common name(s)

greater sandy dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Euoniticellus* **Species**: *Euoniticellus africanus* (Harold, 1873)

Adult diagnosis

Total body length 7.0–13.0 cm (0.26–0.51 in). Body oblong, somewhat dorsoventrally compressed; may be caked in dung. Color tan to grayish-brown with dark brown markings. Clypeus with distinct ridge at anterior margin in male; anterior ridge lacking in female. Frontoclypeal suture with inverted V-shaped ridge in male; female lacking ridge. Ocular canthus quadrately produced. Pronotum of male somewhat hump-like when viewed laterally. Tibia of female robust; male tibia comparatively gracile.

Larval diagnosis

Undescribed: For Scarabaeinae (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Antennae with 4 or 5 apparent segments. Distal segment of antenna much reduced in size. Epipharynx with tormae united mesally, anterior phoba present. Legs 2-segmented. Anal opening surrounded by fleshy lobes.

Native range

Southern Africa. This species is native to southern Africa where it is known from Lesotho, Mozambique, and South Africa (Tyndale-Biscoe, 1990). It has been introduced to Australia (Tyndale-Biscoe, 1990).

Plant host(s)

None. *Euoniticellus* spp. feed on dung as both adults and larvae (Hull et al., 2013).

Life history

Poorly known. Adults of this species prefer a slightly cooler climate than the related intermediate sandy dung beetle (*Euoniticellus intermedius*) (Edwards, 2007). In related species of *Euoniticellus,* adults are diurnal dung tunnelers (Blume, 1984). Working together, a male and female dig a burrow beneath a dung source. Dung is used to line the burrow and create a brood mass. The brood mass is created at the end of the burrow and impregnated with a single egg. Multiple brood masses, each with its own egg, can occupy the same burrow. Larvae develop within the mass where they feed on the dung (Blume, 1984).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Established. This dung beetle was intentionally released in 1974 at Parker Ranch on Big Island to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Nakao and Funasaki, 1976). Nishida (2002) reported it as being established on the Big Island.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally introduced.

Similar species

The greater sandy dung beetle (*Euoniticellus africanus*) is one of two *Euoniticellus* species known from Hawaii, the other recorded species being the very similar intermediate sandy dung beetle (*Euoniticellus intermedius*). The two scarabs can be separated by examination of the frons (*E. africanus* male lacking a horn and female with a V-shaped anterior ridge versus *E. intermedius* male with a horn on frons and female with slightly curved transverse ridge on the frons).

Other names (synonyms)

Oniticellus africanus Harold

Euoniticellus intermedius

Common name(s)

intermediate sandy dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Euoniticellus* **Species**: *Euoniticellus intermedius* (Reiche, 1849)

Adult diagnosis

Total body length 6.5–9.5 cm (0.26–0.37 in). Body oblong, somewhat dorsoventrally compressed; make be caked in dung. Color tan to grayish-brown with dark brown markings. Clypeus of male with distinct anterior ridge; female lacking ridge. Frontoclypeal suture of female quadrate, male suture indistinct. Frons of male with peg-like horn; female lacking horn. Canthus quadrately produced. Pronotum of male somewhat hump-like when viewed laterally. Tibia of female robust; male tibia comparatively gracile.

Larval diagnosis

(Blume, 1984): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Lacinia with uncus lacking proximal teeth. Frons with both sides bearing single posterior frontal seta. Chaetoparia composed of 12 or 13 setae. Tormae symmetrical. Mesophoba monostichous. Haptolachus with 4 macrosensillae at center. Mandible with 2 lateral setae; left mandible with 3 scissorial teeth, right mandible with 2 scissorial teeth. Maxillary stridulatory area with 11 or 12 anteriorly pointing teeth. Glossa with transverse row of setae anterior to the oncyli. Legs 2-segmented; with terminal papilla bearing a single seta. Prothoracic shield lacking anterior projections. Raster with tenth sternum bearing a central undivided patch of short, stout setae.

Native range

Africa and Arabia. This species is native to Africa from South Africa north to the Sahel. It is also known from the Arabian peninsula (Tyndale-Biscoe, 1990). In the mainland U.S., this species was intentionally released in California, Texas, and Florida (Wood and Kaufman, 2008). It was also released in Australia (Tyndale-Biscoe, 1990).

Plant host(s)

None. *Euoniticellus* spp. feed on dung as both adults and larvae (Hull et al., 2013).

Life history

Adults are found in variety of moist and semi-arid habitat types (Edwards, 2007), although they show some preference for open areas with clay-loam soils (Blume, 1984). Adults are diurnal with flight activity peaking between 2–5 pm. Adults are readily attracted to cattle dung but avoid pig feces (Blume, 1984). Working together, a male and female dig a 7–15 cm (2.7–5.9 in) deep burrow beneath a dung source. Dung is used to line the burrow and create a 3.0–3.5 gram brood ball. The brood ball is created at the end of the burrow and impregnated with a single egg. Multiple brood masses, each with its own egg, can occupy the same burrow. The number of masses is dependent upon food availability, soil moisture, and temperature. Development from egg to adult takes five or six weeks. Adults live up to two months (Hull et al., 2013).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Established. This dung beetle was intentionally released in 1974 at Parker Ranch on Big Island to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Nakao and Funasaki, 1976).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally introduced.

Similar species

Euoniticellus intermedius is one of two *Euoniticellus* species known from Hawaii, the other recorded species being the very similar *Euoniticellus africanus*. The two scarabs can be separated by examination of the frons (*E. intermedius* male with horn on the frons versus *E. africanus* male lacking a horn, instead with a v-shaped ridge) and frontoclypeal suture (*E. intermedius* female with suture quadrate and male suture indistinct versus *E. africanus* female suture triangulate and male suture crescent shaped).

Other names (synonyms)

Oniticellus intermedius Reiche, *Euoniticellus clavatus* Roth, *Euoniticellus nasicornis* Peringuey, *Euoniticellus pallens* Laporte (Comte de Castelau), *Euoniticellus speciosus* Costa

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Figulus integricollis

Common name(s)

none known

Taxonomy

Family: Lucanidae **Subfamily**: Lucaninae **Genus**: *Figulus* **Species**: *Figulus integricollis* Thomson, 1862

Adult diagnosis

Total body length 11.0–22.0 mm (0.43–0.87 in) including mandibles. Body shape elongate oval; dorsoventrally flattened. Color shiny black. Ocular canthus completely dividing eye. Mandibles prominent; not sexually dimorphic. Pronotum smooth; often with tubercle at anterior border at middle. Elytra with prominent striae.

Larval diagnosis

Undescribed. For *Lucanidae* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Antenna 3 or 4 segmented. Last antennal segment much reduced in size. Maxilla with galea and lacinia distinctly separated; maxillary stridulatory teeth absent. Epipharynx with united tormae. Anal opening Y-shaped.

Native range

Guam and the Marianas: This species is recorded from Guam and the Northern Marianas Islands of Farallon de Medinilla, Rota, and Alamagan (Bourquin, 2002).

Life history

Poorly known. Larvae and adults of the related Australian species *Figulus regularis* are known to tunnel in dead tree trunks. Dispersing adults may exhibit some host preferences when selecting new logs to colonize, and they have been recorded from trunks of *Angophora bakeri* (Hawkeswood, 2014) and *Xanthorrhoea johnsonii* (Hawkeswood, 1985). Larvae likely feed on rotting wood. Adults are probably predacious, feeding on small invertebrates similar to the related *Figulus binodulus* (Mori and Chiba, 2009).

Limited parental care (observed in *F. binodulis*) may occur in this species, and significant larval mortality may be due to filial cannibalism (Mori and Chiba, 2009).

Pest potential

None. Adult *Figulus* spp. are predators and larvae feed upon dead wood. No associations with living plants are known (Mori and Chiba, 2009).

Status in Hawaii

Not established or recorded. There are no records of this species from Hawaii.

Status in Guam

Native. This species is a native species in Guam, and it is endemic to the Marianas Archipelago (Bourquin, 2002).

Potential distribution and dispersal pathway

This uncommon species does not appear likely to spread beyond its natural range.

Similar species

This species is unlikely to be confused with other scarab beetles of Guam or Hawaii. The possibility exists that this species might be confused with exotic bess beetles (Passalidae). They are separated based on head armature (*Figulus integricollis* lacking horns versus passalids with horn or tubercle on the central, anterior portion of the head).

Other names (synonyms)

None known

Holotrichia bipunctata

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Melolonthinae **Genus**: *Holotrichia* **Species**: *Holotrichia bipunctata* Brenske, 1892

Adult diagnosis

Total body length 13.8–18.1 mm (0.54–0.71 in). Body shape cylindrical, somewhat elongate. Color yellowish-brown. Antennae 10-segmented; club 3-segmented; male club slightly shorter than segments 2-7; female club half the length of segments 2-7. Clypeus reflexed; sinuate. Head with weak ridge at base of frons. Pronotum with obvious constriction posterior to apical angle; female with distinct fovea at each side of anterior margin; male lacking fovea. Elytra smooth; lacking prominent setae.

Larval diagnosis

(Boving, 1945): Grub C-shaped, not hump-backed, cylindrical, whitish, numerous dark spots on body. Maxilla with galea and lacinia fused. Mandible with basolateral region with 7 setae; dorsoexterior region lacking setae and punctures. Epipharynx haptomerum with 9 heli. Proplegmatium absent. Last antennal segment with single large, oblong, dorsal sensory spot. Respiratory plates of spiracles cribriform, not constricted. Raster with closely set palidia. Pali short, pointed, slightly curved. Anal opening V-shaped.

Native range

Philippines. This species is native to the island of Mindanao, the southernmost of the major Philippine Islands (Cartwright and Gordon, 1971). This beetle is also known from the Philippine island of Luzon (Oakley, 1945).

Plant host(s)

This species feeds on a variety of cultivated and wild plants. Amongst plants of economic interest, adults have been found on: avocado (*Persea* spp.), banana (*Musa* spp.), breadfruit (*Artocarpus altilis*), cassava (*Manihot esculenta*), coconut (*Cocos nucifera*), coffee (*Coffea* spp.), corn (*Zea mays*), and kapok (*Ceiba pentandra*) (Oakley, 1945). Larvae also attack plants, feeding on the roots of beans (*Phaseolus* spp.), citrus (*Citrus* spp.), coconut (*Cocos nucifera*), corn (*Zea mays*) (Oakley, 1945), and rice (*Oryza sativa*) (Litsinger et al., 2002).

Life history

(Oakley, 1945): Adults of this beetle are generalist herbivores, feeding at night on the foliage of a variety of plant species. At daybreak, adults fly to the ground and burrow into the soil, re-emerging at dusk. In Guam, there appears to be one generation per year with adult activity peaking in March and April. Females deposit eggs 10–15 cm (4–6 in) under loose soils. Larvae emerge from their eggs after 11–15 days. The larval stage lasts 290–309 days and is followed by a 14–15 day pupal stage.

Pest potential

Significant. This species is a pest as both a larva and adult. The larvae are significant pest in upland rice fields in their native range (Litsinger et al., 2002). Larvae are also known to feed on corn roots resulting in major (Oakley, 1945) to minor (Anonymous, 1984) crop loss. Adults damage above-ground plant parts, feeding on the leaves of important crops such as coconut, coffee, and breadfruit (Oakley, 1945). Due to the negative economic potential of this species, it is regarded as a Class B pest by the USDA (USDA APHIS, 2012).

Status in Hawaii

Not established or recorded. There are no records of this species from Hawaii.

Status in Guam

Established. This now common species was first detected in 1936 (misidentified as *H. mindanaona*) by Swezey, with a more ambiguous record that dates to 1931 (Oakley, 1945). It is now established across the island.

Potential distribution and dispersal pathway

This species comes to lights at night and could be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Cartwright and Gordon (1971) suggested that the beetle reached Guam by hitchhiking aboard military aircraft flying between Guam and U.S. bases in the Philippines. As such, *Holotrichia bipunctata* has a high likelihood of arriving to Hawaii from Guam in the future.

Similar species

This species is quite similar to the closely related ephilida may beetle (*Phyllophaga ephilida*). They are differentiated by examination of the head (*H. bipunctata* with a weak ridge at base of the frons versus *P. ephilida* which lacks the ridge) and pronotum (*H. bipunctata* with obvious constriction posterior to apical angle; female with distinct fovea at each side of anterior margin versus *P. ephilida* without constriction or fovea in either sex).

Other names (synonyms)

Phyllophaga bipunctata (Brenske)

Special note

In Guamanian literature, there is considerable confusion between this species and the very similar *H. mindanaona*. Early reports of *Ancylonycha* (=*Holotrichia*) from Guam refer to *H. mindanaona.* This is also the case for Boving's (1945) larval description. However, later checklists make no mention of *H. mindanaona,* instead referring to *H.*

bipunctata (Cartwright and Gordon, 1971; Bourquin, 2002). To resolve this discrepancy, Guamanian specimens were compared with the type specimens of both *H. mindanaona* and *H. bipunctata* (both being valid species). Based on careful examination of type specimens, the Guamanian specimens were identified as *H. bipunctata*. It is likely then that reports *H. mindanaona* were misidentifications. It is still possible that both *Holotrichia* species occur (or occured) on Guam, though all *Holotrichia* specimens from Guam we examined were identified as *H. bipunctata*.

Hybosorus roei

Common name(s)

none known

Taxonomy

Family: Hybosoridae **Subfamily**: Hybosorinae **Genus**: *Hybosorus* **Species**: *Hybosorus roei* Westwood, 1845

Adult diagnosis

Total body length 5.0–7.0 mm (0.19–0.28 in). Color above shiny black. Body vaguely egg-shaped in dorsal view; dorsal surface convex. Elytra with numerous distinct, punctate striae. Antennae with 3-segmented club; first segment of club enlarged, hollowed to hold second segment. Mandibles prominent, visible in dorsal view. Clypeus narrow, not widely broadened.

Larval diagnosis

Undescribed. For *Hybosorus* spp. (Grebennikov et al., 2004): Grub C-shaped, cylindrical, not hump-backed, whitish. Maxilla with galea and lacinia distinctly separated. Frontoclypeal suture distinct. Labrum at apex with 3 truncate lobes. Antennomeres 2 and 3 separate. Combined apical antennomere with markedly narrowed base and widened apex; two combined apical antennomeres with 10 long setae; tormae united. Short and flattened setae of palidia pointed towards apex.

Native range

Old World. The native range of this species includes vast regions of the Old World, ranging from temperate areas in Europe and China to tropical and subtropical regions of the Middle East, India, Vietnam, and all of Africa except the Sahara (Ocampo, 2002).

Plant host(s)

Possibly turf grasses. Larvae of this species are reportedly pests of turf in the mainland U.S. (Barden, 2011). Adults are not known to feed on plants (Ocampo, 2002).

Life history

(Ocampo, 2002): Adults of this species appear to be carnivorous, feeding on both carrion and other invertebrates. Adults are attracted to dung where they feed on small dung beetles and other coprophagous insects. In the U.S., adults have been collected from February to October and are most active in the months of May and June. Eggs are laid in the soil. Larvae may feed upon plant roots and/or detritus, similar to other hybosorid species.

Pest potential

Moderate. Although it is not clear that larvae feed on grass roots, this species is reported as a destructive turf pest (Barden, 2011). Because adults feed on dung beetles, this species could be problematic for ranching. *Hybosorus roei* also has a well-recorded history of rapid invasion into new areas (Ocampo, 2002) where it can reach high population densities (Buss, 2006). This species arrived to the mainland U.S. (probably South Carolina) sometime in the 1840's, possibly on an incoming slave ship from Africa (Woodruff, 1973). Though its range expanded slowly at first, the second half of the 20th century saw a rapid expansion of the species' range in the Americas. *Hybosorus roei* is now known from much of the southern half of the U.S., Mexico, Caribbean Islands, Central America, and Colombia (Ocampo, 2002).

Status in Hawaii

Not established or recorded. There are no records of this species from Hawaii, although it should be regarded as likely to arrive in the future.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species is strongly attracted to lights at night and is a capable flier (Ocampo, 2002). Thus, it is likely that this beetle would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Further, it is possible that larvae or eggs could be transported in shipments of commercial turf. It should be regarded as having a significant chance of arriving to Hawaii or Guam in the future.

Similar species

While the egg-shaped body of this species is distinctive, it might be confused with similar-sized dung beetles. It is separated from the dung beetles based upon the clypeal shape (*Hybosorus roei* with narrowed clypeus versus comparably broad clypeus in most dung beetles) and mandibles (*Hybosorus roei* with mandibles visible when viewed dorsally versus mandibles never visible dorsally in dung beetles).

Other names (synonyms)

Hybosorus carolinus LeConte, *Hybosorus illigeri* Reiche, *Hybosorus nitidus* Lansbergel, *Hybosorus oblongus* Dahlbom, *Hybosorus pinguis* Westwood, *Hybosorus thoracicus* Westwood

Special note

This species was long known as *Hybosorus illigeri*, and it remains widely known and reported under that name.

Lepidiota carolinensis

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Melolonthinae **Genus**: *Lepidiota* **Species**: *Lepidiota carolinensis* Arrow, 1939

Adult diagnosis

Total body length 19.0–21.9 mm (0.74–0.86 in). Body shape oblong, cylindrical, tapering slightly posteriorly. Color yellowish-brown; head, pronotum, and scutellum brownish-red. Antennae 10-segmented; club 3-segmented; club subequal in length to scape (male) or half the length of scape (female). Elytra with numerous small white scales; weakly striated.

Larval diagnosis

Undescribed. For *Lepidiota* (Ahrens et al., 2007): Grub C-shaped, not hump-backed, cylindrical, whitish. Galea and lacinia fused proximally but separated distally or tightly fitted together. Frons rugose. Claws of hind legs reduced. Raster with 2 parallel rows of setae. Anal opening Y-shaped.

Native range

Western Micronesia. This species is endemic to the Marianas (including Guam) and Palau (Cartwright and Gordon, 1971).

Plant host(s)

Not recorded. In many related *Lepidiota* species, adults are generalist folivores and larvae feed upon grass roots (Kuniata and Young, 1992).

Life history

Poorly known. Cartwright and Gordon (1971) noted that this species comes to lights, suggesting nocturnal habits. It is likely that adults are folivores and that the larvae develop within soil where they feed on grass roots. Such habits are seen in related *Lepidiota* species (Kuniata and Young, 1992). There are likely one or two generations per year.

Pest potential

Probably none. There are no records of this poorly known species feeding on commercially important plants. However, a considerable number of related species are significant larval pests of grasses including (but not limited to) *Lepidiota frenchi*, *L. squamulata*, and *L. stigma* (all of which all feed on sugarcane) (Britton, 1962; Kuniata and Young, 1992), *L. reuleauxi* (a pest of sugarcane and corn) (Kuniata and Young, 1992), and *L. vogeli* (a pest of pasture grasses) (Barrett, 1966).

Status in Hawaii

Not established or recorded. There are no records of this species from Hawaii.

Status in Guam

Native. Cartwright and Gordon (1971) reported this species as endemic to Micronesia, occurring in the Marianas and Palau.

Potential distribution and dispersal pathway

It appears unlikely that this rare, native species would spread beyond its small, natural range. However, because this scarab is attracted to lights at night (Cartwright and Gordon, 1971), it is possible this species could be attracted to well-lit ports and airports where it could be transported to new regions.

Similar species

This scarab is somewhat similar to *Holotrichia bipunctata*, a common species on Guam. The species are separated by size (19.0–21.9 mm [0.74–0.86 in] in *Lepidiota carolinensis* versus 13.8–18.1 mm [0.54–0.71 in] in *H. bipunctata*) and elytra (*L. carolinensis* elytral surface with numerous, small, white scales versus scales lacking in *H. bipunctata*).

Other names (synonyms)

none known

Ligyrus gibbosus

Common name(s)

carrot beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Ligyrus* **Species**: *Ligyrus gibbosus* (DeGeer, 1774)

Adult diagnosis

Total body length 11.6–16.5 mm (0.46–0.65 in). Body oblong. Color reddish-brown, rarely shiny black. Clypeus strongly constricted towards acute apex; apex with 2 close-set, apical teeth. Head with weak, transverse ridge on disc; without horns or tubercles. Pronotum with small tubercle near anterior margin; distinct fovea present behind apical tubercle. Apex of last sternite weakly emarginate in male, quadrate in female.

Larval diagnosis

For *Ligyrus* spp. (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well developed unci. Maxillary stridulatory teeth truncate. Inner concave surface of mandible, distad of molar area, toothed. Dorsal surface of the last antennal segment with 2–5 sensory spots. Legs 4-segmented. Anal opening transverse, straight or slightly curved. Plegmatia absent.

Native range

North America, southern Canada to Mexico. *Ligyrus gibbosus* is broadly distributed across North America from the Pacific to Atlantic coasts (Ratcliffe and Paulsen, 2008). It has been recorded in Canada (Bousquet, 1991), throughout the U.S., and as far south as central Mexico (Ratcliffe et al., 2013).

Plant host(s)

This species damages a broad range of plants as both larva and adult. Hayes (1917) recorded larvae feeding on the roots of *Amaranthus* spp., domestic sunflower (*Helianthus annuus*), oats (*Avena sativa*), "pigweed" (Amaranthaceae), and wheat (*Triticum* spp.). Adults exhibit an even wider dietary range, including carrot (*Daucus carota*), celery (*Apium graveolens)*, corn (*Zea mays*), cotton (*Gossypium* spp.), *Dahlia* spp., elm (*Ulmus* spp.), oak (*Quercus* spp.), sugar beet (*Beta vulgaris*), and sweet potato (*Ipomoea batatas*).

Life history

(Hayes, 1917): Eggs are laid in soil, 12.7–15.2 cm deep (5.0–6.0 in), at the base of a host plant. Plants in organic rich soils are preferred. In Kansas, eggs were laid May to July, larvae emerging after an average of 10 days. The larval stage lasts an average of 52 days. The pre-pupal and pupal stages last an average of 7 and 19 days, respectively. Adults are most active May to June, and then again in August, suggesting that there may be multiple generations per season. Adults are nocturnal, hiding in soil during the day. Overwintering adults burrow into the soil to escape freezing.

Pest potential

Significant. Larvae and adults of this species damage a wide range of commercially important plants. Celery, potatoes, sugar beets, and sunflowers may be economically impacted. Sunflowers appear particularly susceptible, with both wild (Ratcliffe and Paulsen, 2008) and domestic (Hayes, 1917) species suffering heavy infestations.

Status in Hawaii

New record, not established. We recorded a single specimen of *Ligyrus gibbosus* from Oahu (deposited at The Bernice Pauahi Bishop Museum). The specimen label indicates it was discovered dead in a package of dates shipped from Coachella Valley in California in 1934.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species is strongly attracted to lights at night and is a strong flier (Ratcliffe and Paulsen, 2008). Thus, it is likely that this beetle would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo, as likely occurred with the new record of this species in Oahu.

Similar species

Although *Ligyrus gibbosus* is the only member of its genus recorded from Hawaii, it is similar to potential future invasive species such as the sugarcane beetle (*Tomarus subtropicus*) and taro beetles (*Papuana* spp.). It can be separated from those scarabs by examination of the head that lacks horns or tubercles in *L. gibbosus* (*Papuana* spp. often possess horns or tubercles), central disc of the head that has a weak, transverse ridge in *L. gibbosus* (lacking in *T. subtropicus*), clypeal apex (*L. gibbosus* with clypeus constricted with 2 close-set apical teeth versus clypeus broad, never with 2 close-set apical teeth as in *Papuana* spp.), color (*T. gibbosus* reddish-brown, rarely black versus *Papuana* spp. and *T. subtropicus* always shiny black), and size (*T. gibbosus* 11.6–16.5 mm [0.46–0.65 in] versus 15.0–25.0 mm [0.59–0.98 in] in *Papuana* spp. and 20.0–26.0 mm [0.79–1.02 in] in *T. subtropicus*).

Other names (synonyms)

Bothynus morio (LeConte), *Ligyrus californicus* (Casey), *Ligyrus spissipes* (Casey), *Ligyrus arizonensis* (Casey), *Ligyrus bicorniculatus* (Casey), *Ligyrus brevipes* (Casey), *Ligyrus breviusculus* (Casey), *Ligyrus curtipennis* (Casey), *Ligyrus effetus* (Casey), *Ligyrus farctus* (Casey), *Ligyrus lacustris* (Casey), *Ligyrus laetulus* (Casey), *Ligyrus laevicauda* (Casey), *Ligyrus laticollis* (Casey), *Ligyrus longulus* (Casey), *Ligyrus lucublandus* (Casey), *Ligyrus parallelus* (Casey), *Ligyrus puncticauda* (Casey), *Ligyrus remotus* (Casey), *Ligyrus rubidus* (Casey), *Ligyrus scitulus* (Casey), *Ligyrus texanus* (Casey), *Ligyrus virginicus* (Casey), *Ligyrus laticauda* (Casey), *Podalgus variolosus*

Burmeister, *Scarabaeus juvencus* Fabricius, *Scarabaeus gibbosus* DeGeer**,** *Tomarus gibbosus* (DeGeer)

Special note

The scientific name of this species has undergone considerable change over the last several years. The genera *Ligyrus* and *Tomarus* were synonymized in 2002 (Ratcliffe, 2002) but this was challenged in a 2015 publication (Morón and Grossi, 2015).

Maladera castanea

Common name(s)

Asian garden beetle, Asiatic garden beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Melolonthinae **Genus**: *Maladera* **Species**: *Maladera castanea* (Arrow, 1913)

Adult diagnosis

Total body length 7.0–11.0 mm (0.28–0.43). Body shape oblong-oval, widest posteriorly; convex when viewed laterally. Color rusty-brown to orange-brown with iridescent sheen. Clypeus with anterior margin strongly reflexed. Antennae 10-segmented; club 3-segmented. Pronotum with indistinct, shallow punctation. Elytra lacking obvious setae. Front tibia of female more robust than in male.

Larval diagnosis

(Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Cardo, maxillary articulating membrane, and many other body parts with numerous black dots. Galea and lacinia fused proximally, but separated distally or tightly fitted together. Maxilla with dramatically swollen, bulbous stipes. Maxillary stridulatory area with row of 17–20 peg-like teeth. Last antennal segment always with a single, large, oblong, dorsal, sensory spot. Haptomerum with 3 or 4 heli. Dorsal anal lobe much smaller than the ventral anal lobes. Anal lobes densely setose. Raster with a curved, transverse row of prominent setae anterior to the ventral anal lobes. Anal opening Y-shaped with base of the Y much more elongate than the arms.

Native range

Northeastern Asia. This species is known from temperate northeastern Asia, occurring in Korea, China, and the Russian Far East (Ahrens, 2007). In the mainland U.S., this species is known from Maine west to Kansas and south to northernmost Florida (Skelley, 2012).

Plant host(s)

The adults of this scarab have been recorded feeding on the foliage, stems, and flowers of over 100 plant species (Skelley, 2012). Economically important host plants damaged by adults include *Aster* spp., basil (*Ocimum basilicum*), beans (*Phaseolus* spp.), beet (*Beta vulgaris), Begonia* spp., blackberry (*Rubus* spp.), blueberry (*Vaccinium* spp.), broccoli (*Brassica oleracea*), cabbage (*Brassica oleracea)*, carrot (*Daucus carota*), cherry (*Prunus* spp.), *Chrysanthemum* spp., currant (*Ribes* spp.), *Dahlia* spp., eggplant (*Solanum* *melongena),* foxglove (*Digitalis* spp.), *Geranium* spp., hemp (*Cannabis* spp.), lettuce (*Lactuca sativa*), morning-glory (*Ipomoea* spp.), pea (*Pisum sativum*), peach (*Prunus persica*), plum (*Prunus* spp.), bell pepper (*Capsicum annuum*), rose (*Rosa* spp.), spinach (*Spinacia oleracea*), strawberry (*Fragaria* × *ananassa*), sunflower (*Helianthus annuus*), turnip (*Brassica rapa*), *Viburnum* spp., and willow (*Salix* spp.) (Eckman, 2015). Larvae, too, are generalist herbivores and have been recorded feeding on the roots of such economically important plants as blueberries (*Vaccinium* spp.), corn (*Zea mays*), soy beans (*Glycine max*), sweet potato (*Ipomoea batatas*), and turf grasses (Skelley, 2012).

Life history

(Eckman, 2015): In New York, females of this species deposit eggs in soil between July and October, showing a preference for shady, moist, overgrown, and weedy areas. After emerging, the larvae burrow to a depth of 15–30 cm (5.9-11.8 in) and begin feeding of plant roots. Winter is passed in the second or third larval instar and feeding usually resumes by mid-April. Roughly ten months are spent in the larval stage, with pupation lasting 14 days. Adult emergence begins in July, but likely begins earlier in warmer climates. Adults can live for more than 100 days, although the average lifespan is closer to 30 days. Adults are nocturnal and fly only when temperatures exceed 16°C (70°F). During the day, adults are inactive and remain near or on host plants.

Pest potential

Major. This species is a known biosecurity threat with a history of biological invasion (Ahrens, 2007). Invasive populations have become established in Canada (Cutler and

Rogers, 1990), Turkey, the Republic of Georgia, and the US (Ahrens, 2007). In the US, the range of this species has expanded slowly but steadily since its 1921 introduction (Skelly, 2012). Adults cause severe leaf damage to a wide range of plant species important for agriculture, horticulture, and forestry (Eckman, 2015). Larvae feed on plant roots and can cause significant damage, particularly to turf grass (Held and Ray, 2009). The pest potential of larvae is reduced somewhat by their tendency to burrow deep into soils, and their preference for weedy, unkempt habitats (Skelley, 2012).

Status in Hawaii

New record, not established. We recorded a single specimen of *Maladera castanea* from Oahu (deposited at the Bernice Pauahi Bishop Museum). The specimen label indicates it was discovered at Hickham Air Force Base in a spider's web in 1977.

Status in Guam

Not established or recorded. This species has not been recorded from Guam.

Potential distribution and dispersal pathway

This species is strongly attracted to lights at night (Held and Ray, 2009), and it is likely attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Indeed, the Oahu record may represent an individual that hitchhiked aboard military aircraft. Adults hide on or near food plants by day (Eckman, 2015) and could be moved during transportation of nursery plants. Further, it is possible that larvae or eggs could be transported in shipments of commercial turf or potted plants.

Similar species

This species is very similar to the closely related *Maladera japonica*. These species can be separated by comparison of the male genitalia, examination of pronotal punctation (punctures shallow and indistinct in *M. castanea* versus moderately deep and distinct in *M. japonica*), and more superficially by color (color rusty-brown to orange-brown with iridescent sheen in *M. castanea* versus dark brown without iridescent sheen in M. *japonica*).

Other names (synonyms)

Aserica castanea (Hallock), *Autoserica castanea* (Hallock), *Maladera verticalis* (Fairmaire), *Serica korgei* Petrovitz, *Serica verticalis* Fairmaire

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Maladera japonica

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Melolonthinae **Genus**: *Maladera* **Species**: *Maladera japonica* (Motschulsky, 1860)

Adult diagnosis

Total body length 7.0–10.0 mm (0.28–0.39 in). Body shape oblong-oval, widest posteriorly; convex when viewed laterally. Color dark-brown without iridescent sheen. Clypeus with anterior margin strongly reflexed. Antennae 10-segmented; club 3-segmented. Pronotum with distinct, moderately deep punctation. Elytra lacking obvious setae. Male and female lacking obvious characters for separation.

Larval diagnosis

Undescribed in English. For *Maladera* spp. (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Cardo, maxillary articulating membrane, and many other body parts with numerous black dots. Galea and lacinia fused proximally, but separated distally or tightly fitted together. Last antennal segment always with a single, large, oblong, dorsal, sensory spot. Haptomerum with 3 or 4 heli. Dorsal anal lobe much smaller than the ventral anal lobes. Anal lobes densely setose. Raster with a curved, transverse row of prominent setae anterior to the ventral anal lobes. Anal opening Y-shaped with base of the Y much more elongate than the arms.

Native range

Japan. This species is known from Japan (Ahrens, 2007). Past records from Korea are likely the result of confusion with *Maladera orientalis* (Kim and Lee, 1997).

Plant host(s)

Host plants for this scarab are poorly recorded. There are records of larvae damaging rice (*Oryza sativa*) (Litsinger et al., 1987) and sweet potato (*Ipomoea batatas*) (Yokoyama et al., 1998). Adults are recorded causing damage to the tung tree (*Vernicia fordii*) (Sikharulidze, 1975).

Life history

Poorly known. The life history of this species is probably similar to that of the closely related Asiatic garden beetle (*Maladera castanea*). The Asiatic garden beetle (*Maladera castanea*) is a generalist herbivore both as adult and larva. Larvae develop deep in the soil where they feed on plant roots in moist, shaded, weedy areas (Woodruff and Beck, 1989). Adults are nocturnal, hiding on or near host plants by day (Eckman, 2015).

Pest potential

Probably minor. There are relatively few records of this scarab causing damage to crop or ornamental plants. However, both adults and larvae are likely generalist herbivores and could potentially cause some degree of damage to a wide range of plant species. Both rice (Litsinger et al., 1987) and sweet potato (Yokoyama et al., 1998) are recorded hosts.

Status in Hawaii

Recorded, not established. Nishida (2002) recorded this species being intercepted in quarantine. Details of the interception, however, could not be located.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species probably comes to lights at night, and it is likely that it would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Further, it is possible that larvae or eggs could be transported in shipments of commercial turf or potted plants.

Similar species

This species is very similar to the closely related *Maladera castanea*. These species can be separated by comparison of the male genitalia, examination of pronotal punctation (*M. japonica* with punctation moderately deep and distinct versus *M. castanea* with punctures shallow and indistinct), and more superficially by color *(M. japonica* dark brown without an iridescent sheen versus *M. castanea* a rusty-brown to orange-brown with an iridescent sheen).

Other names (synonyms)

Aserica japonica Motschulsky

Microserica guamensis

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Melolonthinae **Genus**: *Microserica* **Species**: *Microserica guamensis* Gordon, 1971

Adult diagnosis

Total body length 4.2 mm (0.17 in). Body shape short, stout, broadly oval; widest posteriorly. Color reddish-brown. Antennae 11-segmented; club 4-segmented; club more than twice the length of segments 1–7. Elytra weakly striated; lacking obvious setae. Females of this species are not known.

Larval diagnosis

Undescribed. For Sericini (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Cardo, maxillary articulating membrane, and many other body parts with numerous black dots. Galea and lacinia fused proximally but separated distally or tightly fitted together. Last antennal segment always with a single, large, oblong, dorsal, sensory spot. Haptomerum with 3 or 4 heli. Dorsal anal lobe much smaller than the ventral anal lobes. Anal lobes densely setose. Raster with a curved, transverse row of prominent setae anterior to the ventral anal lobes. Anal opening Y-shaped.

Native range

Uncertain. Although this scarab was described from Guam, Cartwright and Gordon (1971) suggested that it was not native. Instead, they proposed a potential Bornean origin for the species.

Plant host(s)

Undescribed. In many related Melolonthine genera, adults are generalist folivores and larvae feed upon plant roots (Ratcliffe and Paulsen, 2008).

Life history

Poorly known. Cartwright and Gordon (1971) noted that this species does not come to lights, thus suggesting a diurnal habit. It is likely that adults are folivores and that the larvae develop within soil where they feed on plant roots. Such habits are seen in related genera including *Serica* (Ratcliffe and Paulsen, 2008) and *Maladera* (Skelley, 2013).

Pest potential

Probably none. There are no records of this poorly known species acting as a plant pest.

Status in Hawaii

Not established or recorded. There are no records of this scarab from Hawaii.

Status in Guam

Recorded, not established. This scarab was described from Guam (Cartwright and Gordon, 1971) and is included on the Bourquin, 2002 checklist. However, it appears that the species is known only from the type specimen, and no further specimens have been taken on Guam. This suggests the species is not established.

Potential distribution and dispersal pathway

If this species was introduced to Guam, it is likely that it arrived to the island by hitchhiking on marine or air cargo. Potentially, adults also could have arrived on incoming nursery plants, and larvae or eggs could have been transported in soil or sod.

Similar species

This species is somewhat similar to the *Maladera* species recorded from Hawaii. *Microserica guamensis* can be separated from the *Maladera* species based on its much smaller size (3.7–4.7 mm [0.15–0.19 in] in *M. guamensis* versus 7.0–10.0 mm [0.28–0.39 in] in *Maladera*) and the form of its antennae (11-segmented antennae with 4-segmented club in *M. guamensis* versus 10-segmented antennae with 3-segment club in *Maladera*).

Other names (synonyms)

none known

Neosisyphus spinipes

Common name(s)

grey dungball roller

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Neosisyphus* **Species**: *Neosisyphus spinipes* (Thunberg, 1818)

Adult diagnosis

Total body length 7.5–12.0 mm (0.30–0.47 in). Body shape round, somewhat spherical. Color dark grey-brown. Clypeus broadly emarginate. Pronotum with short, fine setae (may be missing in worn specimens). Hind and middle legs slender, greatly elongated. Hind trochanter of male elongate, spine-like (lacking in female). Antennae 8-segmented. Pygidium with height greater than width.

Larval diagnosis

Undescribed. For Scarabaeinae (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Antennae with 4 or 5 apparent segments. Distal segment of antenna much reduced in size. Epipharynx with tormae united mesally, anterior phoba present. Legs 2-segmented. Anal opening surrounded by fleshy lobes.

Native range

Africa. This species is native to Africa, occurring from South Africa northward through East Africa to Ethiopia (Tyndale-Biscoe, 1990). It was intentionally introduced to Australia (Bailey, 2007).

Plant host(s)

None. This species feeds on dung as both an adult and larva.

Life history

(Tyndale-Biscoe, 1990): During the day, females search for fresh dung. Upon discovery, the female, with aid of the male, shapes a portion of the dung into a ball. Using the elongated hind legs, the pair rolls the dung ball from the original site before attaching it to the stem of nearby surface vegetation. A single egg is laid on the dung ball, with the egg taking 6–11 weeks to develop into an adult. Females rarely lay more than a single egg each day. In Australia, adults are most active between December and May, with several generations occurring each year (Bailey, 2007).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming. As an obligate dung feeder, *Neosisyphus spinipes* poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii.

Status in Hawaii

Recorded, not established. This species was intentionally released on Big Island in 1967 to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). Despite this effort, *Neosisyphus spinipes* failed to establish on the island (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released but did not establish.

Similar species

With its greatly elongate hind and middle legs, *Neosisyphus spinipes* is distinctive amongst dung beetles recorded from Hawaii. It is possible that this scarab might be confused with similar-shaped species of *Canthon*. *N. spinipes* is separated from the *Canthon* species by examining the legs (*N. spinipes* with middle and hind legs greatly elongated and with the hind trochanter of the male long and spine-like versus *Canthon* dung beetles that possess less elongate legs and lack the elongated trochanter) and antennae (*N. spinipes* with 8 segments versus *Canthon* species with 9 segments).

Other names (synonyms)

Sisyphus spinipes Thunberg

Omorgus procerus

Common name(s)

none known

Taxonomy

Family: Trogidae **Subfamily**: Troginae **Genus**: *Omorgus* **Species**: *Omorgus procerus* (Harold, 1872)

Adult diagnosis

Total body length 10.0–15.0 mm (0.39–0.59 in). Body shape strongly convex dorsally, flattened ventrally; appearance warty; often encrusted with debris. Color dark gray to reddish-brown. Abdomen extremely flat when viewed laterally. Pronotum with base scalloped and basal angle obtuse. Scutellum hastate. Elytra with patches of short, reddish-brown hairs. Middle tibia with numerous fine teeth at outer margin.

Larval diagnosis

Undescribed. For *Omorgus* spp. (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia distinctly separated. Antennae with 3 segments, lacking distal sensory cone on second segment. Distal segment of antennae much reduced in size. Epipharynx with tormae united mesally. Legs 4-segmented, never with stridulatory organ. Spiracles cribriform.

Native range

Northeastern Africa, western Asia. This species is broadly distributed across arid and semi-arid regions of Africa and western Asia, occurring from India through the Middle East, Egypt, and into the Horn of Africa and across the Sahel (Zidek, 2013).

Plant host(s)

None. Larvae of this species appear to be specialized egg predators of the desert locust (*Schistocerca nitens* [formerly *S. gregaria*]) (Roffey, 1958). The adult diet is unclear, but the related bark-like hide beetle (*Omorgus suberosus*) feeds upon late stage carrion and other animal debris as adults (Ratcliffe and Paulsen, 2008).

Life history

(Roffey, 1958): Eggs are deposited in loose soil near egg cases of the desert locust (*Schistocerca nitens)* and emerge after 2–3 days. Larvae grow rapidly with the final instar reached in an average of 14 days. During this time, grubs move through the soil feeding on the locust eggs, often leaving behind small mounds of dirt. The final adult form is reached after an average of 60 days.

Pest potential

None. This species feeds upon the eggs of the desert locust (*Schistocerca nitens*), a destructive pest in the Hawaiian Islands (Latchininsky, 2008).

Status in Hawaii

Recorded, not established. This species was intentionally released in Hawaii as a biocontrol agent. In 1966, specimens were released on Sand Island in Honolulu to combat the invasive desert locust (*Schistocerca nitens*) (Davis and Krauss, 1967), a generalist herbivore with periodic outbreaks that can cause serious ecological damage (Latchininsky, 2008). *Omorgus procerus* failed to establish in Hawaii (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released but did not establish (Nishida, 2002).

Similar species

Omorgus procerus is one of three hide beetles (Trogidae) known from Hawaii and Guam. The other two species are *Trox scaber* and *Omorgus suberosus*. These species are separated based on examination of the scutellum (hastate in *O. procerus* versus parabolic in *T. scaber*), the pronotum (pronotal base scalloped and the basal angle obtuse in *O. procerus* versus pronotal base weakly sinuate and basal angle quadrate *T. scaber*), and the middle tibia (*O. procerus* with a row of fine teeth along outer margin versus teeth lacking in *O. suberosus*).

Other names (synonyms)

Afromorgus procerus (Harold), *Trox procerus* Harold

Oniticellus cinctus

Common name(s)

bordered dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Oniticellus* **Species**: *Oniticellus cinctus* (Fabricius, 1775)

Adult diagnosis

Total body length 9.0–13.0 cm (0.35–0.51 in). Body ovate, oblong, somewhat dorsoventrally compressed; make be caked in dung. Color shiny black; outer margins of elytra bordered with tan. Head smooth, lacking distinct transverse ridge or horn in both sexes. Pronotum with distinct, impressed, medio-longitudinal line at posterior margin; anterior margin smooth, lacking excisions or tubercles. Front tibia of male gracile, apex with inner spur; female tibia more robust, apex with a broad, downward curving, inner tooth (spur lacking).

Larval diagnosis

Undescribed in English. For *Oniticellus* spp. (Ritcher, 1966): Grub C-shaped, with projecting hump, cylindrical, whitish. Maxilla with galea and lacinia distinctly separated. Epipharynx with tormae united mesally, anterior phoba present. Antennae with 4 segments; distal segment of antenna much reduced in size. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment without a prominent, conical, dorsal gibbosity. Venter of last abdominal segment with 2 patches of short, spine-like setae.

Native range

Tropical Asia. This species is found across a broad area of southern and eastern Asia with records from Burma, southern China, India, Indonesia, Malaysia, Thailand, and Vietnam (Karimbumkara, 2013).

Plant host(s)

None. This species feeds on dung as both adult and larva (Klemperer, 1983).

Life history

(Klemperer, 1983): Adults of this diurnal scarab are active throughout the year (Venugopal et al., 2012), and may show some preference for forested habitat. Females create a brood chamber within a dung pat and create brood balls from the surrounding feces. An egg is implanted within each brood ball, with approximately 20 brood balls created in total. While the larvae grow and feed within the dung balls, the maternal female remains in the brood chamber and continues to apply dung to the surface of the ball. She will drive other female dung beetles from her chamber (though males may be tolerated) and will kill larvae of other dung beetle species. As the larvae develop, their brood balls become both more hollowed and more dry. By the time pupation occurs, the brood ball is a dry, hollow chamber. The maternal female remains in the brood chamber until the larvae emerge as adults.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Established. There is conflicting information regarding the arrival of this species to Hawaii. Markin and Yoshioka (1998) reported that this species was intentionally introduced to Big Island in 1956 and Oahu in 1957-1958 to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock. However, it has also been reported that specimens collected on Oahu in 1965 represent the first record of this species in Hawaii (Hawaiian Entomological Society, 1967), and that the species is adventive to the state (Harris et al., 1982). It does appear that this beetle is established on both islands, though it is rare on Oahu (Toyama and Ikeda, 1976).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

It is unclear how this species arrived to Hawaii. It was probably intentionally introduced. It is possible that adults or larvae were transported on farm or ranching supplies or in natural, manure-based fertilizers.

Similar species

Oniticellus cinctus is one of two *Oniticellus* species known from Hawaii, the other being *Oniticellus militaris*. These two scarabs are separated by examining the head armature (*O. cinctus* lacking horns or distinct ridges in both males and females versus *O. militaris* with a short horn in males and a transverse ridge in females), elytral color (*O. cinctus* with elytra black bordered with tan versus *O. militaris* which is dark brown with broken, tan stripes), and the form of the pronotum (*O. cinctus* lacking sinuate excisions versus anterior margin with sinuate excisions in *O. militaris*).

Other names (synonyms)

Oniticellus diadema Wiedemann, *Oniticellus serratipes* Drury, *Scarabaeus cinctus* Fabricius

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Onitcellus militaris

Common name(s)

yellow shouldered dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Oniticellus* **Species**: *Oniticellus militaris* (Laporte [Comte de Castelnau], 1840)

Adult diagnosis

Total body length 7.0–11.0 cm (0.27–0.43 in). Body oblong oval, somewhat dorsoventrally compressed; may be caked in dung. Color dark brown; pronotum bordered with tan; elytra with longitudinal tan stripes (some broken). Head of male with short horn, female with distinct transverse ridge near base. Pronotum with weak longitudinal median line; anterior margin with excisions paired at middle, excision reduced in female. Front tibia of female slightly more robust than in male.

Larval diagnosis

Undescribed. For *Oniticellus* spp. (Ritcher, 1966): Grub C-shaped, with projecting hump, cylindrical, whitish. Maxilla with galea and lacinia distinctly separated. Epipharynx with tormae united mesally, anterior phoba present. Antennae with 4 segments; distal segment of antenna much reduced in size. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment without a prominent, conical, dorsal gibbosity. Venter of last abdominal segment with 2 patches of short, spine-like setae.

Native range

Africa. This species is native to eastern Africa, ranging from Ethiopia southward to South Africa. It has been introduced to Australia (Tyndale-Biscoe, 1990).

Plant host(s)

None. *Oniticellus* spp. feed on dung as both adults and larvae.

Life history

(Tyndale-Biscoe, 1990): This diurnal species is a dung tunneler, with females constructing a burrow 0–15 cm (0–5.9 in) beneath a dung source. The burrow is stocked with dung to form a brood ball in which one egg is laid. The larva develops within its brood ball and will remain within the burrow until emerging as an adult.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Established. This species was intentionally released in 1957-1958 on Big Island and Oahu (Markin and Yoshioka, 1998). It is also found on Kauai and Maui (Nishida, 2002), although it is unclear when the beetle arrived to those islands.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released.

Similar species

Oniticellus militaris is one of two *Oniticellus* species known from Hawaii, the other being *Oniticellus cinctus*. The two scarabs are separated by examining the head armature (the male of *O. militaris* possesses a short horn and the female has a distinct transverse ridge versus *O. cinctus* that lacks horns or distinct ridges in both sexes), color of the pronotum (*O. militaris* possesses a dark brown pronotum bordered in tan, whereas *O. cinctus* has a shiny black pronotum), and pronotal form (*O. militaris* has anterior margin with paired excisions versus *O. cinctus* with anterior margin smooth, without excisions).

Other names (synonyms)

Liatongus militaris Laporte (Comte de Castelau), *Oniticellus quadrituberculatus* Lansberge

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Onitis alexis

Common name(s)

Alexis dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onitis* **Species**: *Onitis alexis* Klug, 1835

Adult diagnosis

Total body length 15.0–22.0 cm (0.59–0.86 in). Body shape subquadrate posteriorly; may be caked in dried dung. Color of head and pronotum dark green to blackish-green. Clypeus weakly sinuate or rounded. Frons with weakly developed central tubercle; female tubercle comparatively larger than in male. Front tibia of male elongate, curving ventrally and inward at apex; female tibia less elongate and curved than male; tarsi lacking in both sexes. Tibia of middle leg gradually expanded to a triangulate apex. Hind trochanter lacking spine on posterior margin in both sexes. Hind femur of male with well-developed, curved spine on posterior margin; female lacking spine.

Larval diagnosis

Undescribed. For Scarabaeinae (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharnyx with tormae united mesally, anterior phoba present. Antennae with 4 or 5 apparent segments. Distal segment of antenna reduced in size. Legs 2-segmented. Anal opening surrounded by fleshy lobes.

Native range

Africa and the Mediterranean. *Onitis alexis* is broadly distributed from Spain and Syria, southward to South Africa. It is, however, largely absent from the heavily forested areas of western Africa (Krikken, 1977).

Plant host(s)

None. *Onitis* spp. feed on dung as both adults and larvae (Edwards and Aschenborn, 1987).

Life history

This species inhabits savannahs, grasslands, and pastures where they are most active at dusk and dawn. Adults show a preference for the dung of large herbivorous mammals. The species is recorded feeding on elephant, cattle, and buffalo droppings (Krikken, 1977). Male-female pairs dig a dung-lined tunnel under a dung source to an average depth of 17 cm (6.7 in). The burrow is then stocked with 150–200 grams of dung, which is made into multiple sausage-like shapes. One to four eggs are deposited into each dung-sausage (Edwards and Aschenborn, 1987). The egg to adult lifecycle can be completed in as little as two months in the summer, but it may require over a year if conditions are poor. In good habitat, there can be several generations per year (Tyndale-Biscoe, 1990). Larvae cannot survive cool, wet winters (Tyndale-Biscoe, 2006).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Established. This scarab was released in 1976 at Parker Ranch on Big Island where it is now established (Nakao and Funasaki, 1979). Like most of Hawaii's dung beetles this species was introduced to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally introduced.

Similar species

Three species of *Onitis* are recorded from Hawaii (none are known from Guam). *Onitis alexis* is separated from the other *Onitis* species by examination of the middle tibia (*O. alexis* with middle tibia gradually expanded to triangulate apex versus abruptly expanded to a trapezoidal apex in *O. phartopus*), the hind trochanter (*O. alexis* lacking a spine on the posterior margin versus *O. phartopus* with well-developed spine in male), hind femur of the male (*O. alexis* with a curved femoral spine versus *O. vanderkelleni* with straight spine, *O. phartopus* lacking a spine) and color (*O. alexis* dark green to blackish-green with brown elytra versus color entirely dull black in *O. vanderkelleni* and *O. phartopus*).

Other names (synonyms)

Onitis africanus Gillet, *Onitis aygulus* Latreille, *Onitis inuus* Klug, "*Onitis sphinx*" of authors, *Onitis tuberculatus* Balthasar

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Onitis phartopus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onitis* **Species**: *Onitis phartopus* Lansberge, 1875

Adult diagnosis

Total body length 18.0–26.0 cm (0.71–1.02 in). Body shape subquadrate posteriorly; may be caked in dried dung. Color dull black. Clypeus rounded to weakly sinuate. Frons with weak, central tubercle. Front tibia of male elongate, curving ventrally and inward at apex; female tibia less elongate and less curved than male; tarsi lacking in both sexes. Middle leg with tibia of male abruptly expanded to a trapezoidal apex, female tibia less clearly trapezoidal. Hind trochanter with spine on posterior margin in male (lacking in female). Hind femur lacking spine-like process on posterior margin in both sexes.

Larval diagnosis

Undescribed. For Scarabaeinae (Ritcher, 1966): Grub C-shaped and hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia distinctly separate. Antennae with 4 or 5 apparent segments. Distal segment of antenna much reduced in size. Epipharynx with tormae united mesally, anterior phoba present. Anal opening surrounded by fleshy lobes. Legs 2-segmented.

Native range

Philippines. This species is known from the islands of the Philippines (Fullaway, 1921).

Plant host(s)

None. *Onitis* spp. feed on dung as both adults and larvae (Edwards and Aschenborn, 1987).

Life history

Poorly known. (Edwards and Aschenborn, 1987): Related species of *Onitis* burrow under fresh dung and create a vertical tunnel lined with dung. Male and female beetles cooperate to transport dung pieces down the burrow where they are shaped into sausage-like masses. An egg (or eggs) is deposited into each of the dung sausages, and larval development occurs within the brood mass.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Recorded, not established. This species was brought to Hawaii for evaluation of its potential for biocontrol of the horn fly (*Haematobia irritans*), a biting pest of livestock. However, imported specimens failed to thrive and were not released (Fullaway, 1921).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

Three species of *Onitis* are recorded from Hawaii (none are known from Guam). *Onitis phartopus* can be separated from the other *Onitis* species by examination of the middle tibia (*O. phartopus* male with an abruptly expanded, trapezoidal apex versus a gradually expanded, triangulate apex in *O. alexis* and *O. vanderkelleni*), hind trochanter (with a spine in *Onitis phartopus* versus *O. alexis* and *O. vanderkelleni* that lack a spine), hind femur (*O. phartopus* lacking femoral spine versus *O. alexis* and *O. vanderkelleni* males with spine on the posterior margin), and color (*O. phartopus* is dull black versus dark greenish with brown elytra in *O. alexis*).

Other names (synonyms)

Onitis sphinx Illiger

Onitis vanderkelleni

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onitis* **Species**: *Onitis vanderkelleni* Lansberge, 1886

Adult diagnosis

Total body length 18.0–26.0 cm (0.71–1.02 in). Body shape subquadrate posteriorly; may be caked in dried dung. Color dull black. Clypeal apex rounded to weakly sinuate. Frons with weak, central tubercle. Front tibia of male elongate, curving ventrally and inward at apex; female tibia somewhat shorter; tarsi lacking in both sexes. Tibia of middle leg gradually expanded to a triangulate apex. Hind trochanter lacking spine on posterior margin in both sexes. Hind femur of male with well-developed, posteriorly produced, straight spine; female lacking spine.

Larval diagnosis

Undescribed. For Scarabaeinae (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia distinctly separate. Antennae with 4 or 5 apparent segments. Distal segment of antenna much reduced in size. Epipharnyx with tormae united mesally, anterior phoba present. Anal opening surrounded by fleshy lobes. Legs 2-segmented.

Native range

Africa. This species occurs in the tropical highlands of sub-Saharan Africa, with records from Angola, Burundi, Cameroon, Kenya, Rwanda, Tanzania, Uganda, and the Democratic Republic of the Congo (formerly Zaire) (Krikken, 1977). It usually occurs at elevations over 1,800 meters (5,900 ft) where rainfall ranges from 800–2,000 mm (31–79 in) per year (Edwards, 2007).

Plant host(s)

None. *Onitis* spp. feed on dung as both adults and larvae (Edwards and Aschenborn, 1987).

Life history

Poorly known. Related species of *Onitis* are dung burrowers. A vertical tunnel lined with dung is created under the initial dung source. Adult male and female beetles cooperate to transport dung pieces down the burrow where the dung is shaped into sausage-like masses. An egg (or eggs) is deposited into each of the dung sausages, and larval development occurs within the dung mass.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none are known from Hawaii or Guam.

Status in Hawaii

Established. *Onitis vanderkelleni* was released in 1976 at Parker Ranch on Big Island (Nakao and Funasaki, 1979) where it is now established (Nishida, 2002). Like most of Hawaii's dung beetles, this species was introduced to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally introduced.

Similar species

Three species of *Onitis* are recorded from Hawaii (none are known from Guam). *Onitis vanderkelleni* can be separated from the other *Onitis* species by examination of the middle tibia (*O. vanderkelleni* with gradually expanded middle tibia with a triangulate apex versus *O. phartopus* with an abruptly expanded tibia with trapezoidal apex), the hind trochanter (*O. vanderkelleni* hind trochanter lacking spine-like process *versus* trochanter with a well-developed spine in male *O. phartopus*), hind femur of male (*O. vanderkelleni* with a posteriorly produced, straight spine versus *O. alexis* with a curved spine and *O. phartopus* that lacks a spine), and color (*O. vanderkelleni* dull black versus greenish-black with brown elytra in *O. alexis*).

Other names (synonyms)

none known

Onthophagus armatus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus armatus* Blanchard, 1853

Adult diagnosis

Total body length 6.0–10.0 mm (0.24–0.39 in). Body shape oval; may be caked in dung. Color shiny black. Small or medium-sized *Onthophagus*, over 6 mm. Clypeal apex of major male bisinuate, not strongly reflexed; minor male and female with clypeal apex rounded to feebly sinuate. Head of major male with 2 sinuate, vertically oriented horns, that are connected by a broad ridge; female and minor male with feebly sinuate ridge near base. Ocular canthus not completely dividing eye. Pronotum of male with hump-like process; female lacking process. Pronotum with anterior angles rounded. Front tibia of male slightly slender and elongate, female tibia comparatively stout. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Eastern Asia. This species is recorded from much of eastern Asia including India, Burma (Myanmar), Taiwan (Chandra and Gupta, 2013), Indochina, Malaysia, Indonesia, and the Philippines (Cartwright and Gordon, 1971).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

Poorly known: Adults of this nocturnal species are dung tunnelers (Chandra and Gupta, 2013). Females locate dung and create a burrow near or under a dung source. The burrow is provisioned with dung that is formed into brood balls. An egg is deposited within each brood ball, and larval development occurs within.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Not established or recorded. There are no records of this species from Hawaii.

Status in Guam

Established. This species is established on Guam (Bourquin, 2002). Based on in-field observations and specimens examined at the University of Guam, this species is common on the island.

Potential distribution and dispersal pathway

It is unclear when or how this scarab first arrived to Guam, although Cartwright and Gordon (1971) proposed that it may have arrived from the Philippines. It is possible that the species arrived on military ships or aircraft during or after World War 2, though this is speculation.

Similar species

This scarab could be confused with similar small to medium-sized *Onthophagus* (more than 6 mm) including *Onthophagus binodis*, *Onthophagus incensus*, *Onthophagus comperei*, *Onthophagus cuniculus* and *Onthophagus laminatus*.

Major males of these species can readily be distinguished by examining the head armature (*O. armatus* with vertical, bisinuate horns versus *O. cuniculus* with paired tubercles, *O. binodis* lacking horns or tubercles, *O. comperei* with sinuate, vertically-oriented, weakly bifurcate horns, *O. incensus* and *O. laminatus* both with slightly curved, vertically-oriented, undivided horns).

Females are separated by examining the base of the head (*O. armatus* with feebly bisinuate ridge versus *O. laminatus* and *O. incensus* with a straight, transverse ridge, *O.*

comperei with 2 tubercles, *O. binodis* and *O. cuniculus* with a slightly curved ridge), pronotum (*O. armatus* lacking process versus *O. binodis* with small lobe-like process, *O. cuniculus* with bi-lobed process) and anterior pronotal angle (*O. armatus* with anterior angle rounded versus *O. cuniculus and O. laminatus* with anterior angle curved outward).

Other names (synonyms)

Onthophagus luzonicus Lansberge

Onthophagus binodis

Common name(s)

humpbacked dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus binodis* Thunberg, 1818

Adult diagnosis

Total body length 10.0–15.0 mm (0.39–0.59 in). Body shape oval; may be caked in dung. Color dull black. Small to medium-sized *Onthophagus*, over 6 mm. Clypeal apex of major male weakly produced and reflexed; minor male and female apex rounded, not reflexed. Head lacking horns in both sexes; female and male with curved ridge at base of head. Ocular canthus not completely dividing eye. Pronotum of major male with a quadrate, hump-like process; process reduced in minor male and female. Pronotum with anterior angles rounded in both sexes. Front tibia not gracile and elongate; male and female not noticeably dimorphic. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Africa. This species is known from regions of South Africa where annual rainfall exceeds 500 mm (19.7 in). It was introduced to Australia to control cattle dung and dung flies (Tyndale-Biscoe, 1990).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

This diurnal species is a dung tunneler (Houston et al., 1982). After locating suitable (often very wet) dung, adults construct a tunnel 3.0–17.5 cm (1.1–6.9 in) (Barkhouse and Ridsill-Smith, 1986) beneath the fecal source in sandy soils (Tyndale-Biscoe, 1990). Larvae are particularly sensitive to desiccation, and adults will dig deeper tunnels to avoid dry soil (Barkhouse and Ridsill-Smith, 1986). Tunnels are provisioned with dung in the form of brood balls. Each brood ball is impregnated with an egg, and larval development occurs within. Development from egg to larvae takes 4–6 weeks, though poor conditions will increase development time (Tyndale-Biscoe, 1990). This species is quite sensitive to low moisture environments and is rarely found in areas with prolonged dry seasons (Barkhouse and Ridsill-Smith, 1986).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. This species was introduced to Big Island in 1973 to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). It is now established on Big Island where it occurs at higher elevations (Markin and Yoshioka, 1998).

Status in Guam

Not established or recorded. This species has not been recorded from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This species could be confused with similarly colored small to medium-sized dung beetles (6+ mm) including *Onthophagus* species such as *Onthophagus laminatus*, *Onthophagus cuniculus*, *Onthophagus incensus*, *Onthophagus armatus*, and *Onthophagus comperei*.

Major males can be separated by examining the head armature (*O. binodis* lacking horns or tubercles versus *O. laminatus, O. incensus, O. armatus,* and *O. comperei* with horns versus *O. cuniculus* with two tubercles).

Females are separated by examining the base of the head (*O. binodis* with a slightly curved ridge versus *O. cuniculus, O. laminatus,* and *O. incensus* with a transverse ridge versus *O. armatus* with feebly bisinuate ridge versus *O. comperei* with 2 tubercles), pronotum (*O. binodis* with a lobe-like process versus *O. cuniculus* with a bi-lobed process versus *O. incensus*, *O. armatus,* and *O. comperei* without a process), and anterior pronotal angle (*O. binodis* with anterior angle rounded versus *O. laminatus* and *O. cuniculus* with angle curving outward).

Other names (synonyms)

Onthophagus columella Fahreus in Boheman

Onthophagus comperei

Common name(s)

Compere's dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus comperei* Blackburn, 1903

Adult diagnosis

Total body length 7.0–9.0 mm (0.27–0.35 in). Body shape oval; may be caked in dung. Color shiny black. Small to medium-sized *Onthophagus*, over 6 mm. Clypeal apex of major male produced and strongly recurved; not produced or recurved in minor male and female. Head of major male with 2 sinuate, vertically-oriented horns, apex of horns weakly bifurcate, no ridge between horns, horns variable in size; minor male and female with 2 tubercles near base of head. Ocular canthus not completely dividing eye. Pronotum with anterior angles curved weakly outward; surface lacking distinct process in either sex. Front tibia of male somewhat slender, female tibia comparatively more stout. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Australia. This species is native to Queensland, Australia. It has been recorded from the Townsville area southward to the Stewart River (Matthews, 1972).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

This nocturnal species is recorded from tropical savannahs and open woodlands (Matthews, 1972). Life history is poorly known, but related *Onthophagus* species are dung tunnelers, with females creating a burrow under or near dung (Woodruff, 1973). The burrow is then provisioned with dung in the form of brood balls. Each ball is impregnated with an egg; larval development occurs within the brood ball.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this scarab is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Recorded, not established. This species was intentionally brought to Hawaii in 1921, though it is appears no specimens were released (Hawaii Division of Forestry, 1923).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This scarab could be confused with other *Onthophagus* species of similar coloration and small to medium-size (more than 6 mm): *Onthophagus binodis*, *Onthophagus incensus*, *Onthophagus armatus*, *Onthophagus cuniculus* and *Onthophagus laminatus*.

Major males of these species can most readily be distinguished by examining the head armature (*O. comperei* with two sinuate, vertically-oriented, weakly bifurcate horns versus *O. binodis* lacking horns, *O. cuniculus* lacking horns but with paired tubercles at base of head, and *O. incensus, O. armatus* and *O. laminatus* with non-bifurcate horns).

Females are somewhat more difficult to distinguish, but can nonetheless be separated by examining the base of the head (*O. comperei* with two tubercles versus *O. binodis and O. cuniculus* with a slightly curved ridge, *O. laminatus* and *O. incensus* with a transverse ridge, and *O. armatus* with a feebly bisinuate ridge), the pronotal process (*O. comperei* female without a process versus *O. binodis* with a small lobe-like process, *O. cuniculus* with a bi-lobed process) and the pronotal anterior angles (*O. comperei* with the anterior angles rounded versus *O. cuniculus* and *O. laminatus* with the anterior angles curved outward).

Other names (synonyms)

None known

Onthophagus cuniculus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus cuniculus* MacLeay, 1864

Adult diagnosis

Total body length 7.0–12.0 mm (0.28–0.47 in). Body shape oval; may be covered in dung. Color of head and thorax bright metallic red-green; abdomen black. Small to medium-sized dung beetle, over 6 mm. Clypeal apex of major male produced, strongly recurved; minor male and female with apex rounded or feebly sinuate, not strongly recurved. Head of both sexes lacking horns; major male with paired tubercles near base; minor male and female with slightly curved ridge near base. Ocular canthus completely dividing eye. Pronotum of major male with horn-like process; minor male and female with bi-lobed process. Pronotum with anterior angles curved outward in both sexes. Front tibia of male slightly slender and elongate, female tibia somewhat more robust. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Australia. This species is known from Queensland Australia, where it occurs between the Atherton Tablelands and the Tropic of Capricorn (Matthews, 1972).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

This diurnal species has been found on cattle and human dung, it is also known to feed on carrion (Matthews, 1972). It can be found in savannahs and open woodlands where annual rainfall exceedes 127 cm (50 in). Life history of the species is poorly known, but related *Onthophagus* species are dung tunnelers, with females creating a burrow under or near dung (Woodruff, 1973). The burrow is then provisioned with dung in the form of brood balls. Each ball is impregnated with an egg; larval development occurs within the brood ball.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Recorded, not established. This species was intentionally brought to Hawaii in 1921, though it is unclear if any individuals were released (Hawaii Division of Forestry, 1923). Similar dung beetle introductions were undertaken to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). If this species was released, it failed to establish populations in the state (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This dung beetle could be confused with similarly colored, small to medium-sized (more than 6 mm) *Onthophagus* species such as *Onthophagus binodis*, *Onthophagus incensus*, *Onthophagus laminatus*, *Onthophagus armatus*, and *Onthophagus comperei*.

Major males of these species can be distinguished by examining the head armature (*O. cuniculus* has paired tubercles versus *O. incensus, O. laminatus, O. armatus,* and *O. comperei* all with head horns versus *O. binodis* lacking horns).

Females are somewhat more difficult to distinguish, but nonetheless can be separated by examining the base of the head (*O. cuniculus* with a slightly curved ridge versus *O. armatus* with a feebly bisinuate ridge and *O. comperei* with 2 tubercles), pronotal process (*O. cuniculus* with a bi-lobed process versus *O. binodis* and *O. laminatus* with a small lobe-like process versus *O. incensus*, *O. armatus,* and *O. comperei* lacking a pronotal process) and anterior angle of the pronotum (*O. cuniculus* with anterior angles curved outward versus *O. binodis*, *O. incensus, O. armatus,* and *O. comperei* with anterior angles rounded).

Other names (synonyms)

none known

Onthophagus foliaceus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus foliaceus* Lansberge, 1886

Adult diagnosis

Total body length 8.0–10.0 mm (0.31–0.39 in). Body shape oval; may be caked in dung. Color black; elytra dark brownish striped with tan. Small-sized *Onthophagus*, 6-10 mm (rarely, slightly over 10 mm). Clypeus not strongly produced or reflexed in either sex. Head of major male with single long, curved horn; minor male and female with transverse ridge near base. Ocular canthus not completely dividing eye. Pronotum with anterior angle rounded. Pronotum of major male with broad, hump-like process; minor male and female lacking distinct process. Front tibia of male slender, female tibia comparatively more robust. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Africa. This species is native to Africa, where it has been recorded from Angola (Lansberge, 1886).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

Poorly known. Related *Onthophagus* species are dung tunnelers, with females creating a burrow under or near a dung source (Woodruff, 1973). The burrow is then provisioned with dung in the form of brood balls. Each ball is impregnated with an egg; larval development occurs within the brood ball.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this scarab is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Recorded, not established. In Hawaii, this species was intentionally released in 1975 at Kahua Ranch on Big Island to combat the horn fly (*Haematobia irritans*), a biting pest of livestock (Nakao and Funasaki, 1979).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This scarab could be confused with the similarly colored, small-sized (6–10 mm) *Onthophagus* species: *Onthophagus granulatus* and *Onthophagus nuchicornis*.

Major males of these species can quickly be distinguished by examining the head armature (*O. foliaceus* with a single long curving horn versus *O. granulatus* lacking horns but with a recurved, produced clypeal apex, *O. nuchicornis* with a single small, spine-like horn).

Minor males and females are somewhat more difficult to distinguish but can be separated by examining the pronotum (*O. foliaceus* without a distinct process versus *O. granulatus* with 4 tubercle-like processes, *O. nuchicornis* with a rounded peg-like process).

Other names (synonyms)

Onthophaghus alterneater D'Orbigny

Onthophagus granulatus

Common name(s)

granulose dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus granulatus* Boheman, 1858

Adult diagnosis

Total body length 6.0–8.0 mm (0.23–0.31 in). Body shape oval; may be caked in dung. Color dull brownish. Small-sized *Onthophagus*, 6-10 mm. Clypeal apex of major male produced, strongly recurved; not produced and recurved in minor male or female. Head of male lacking horns; minor male and female with transverse ridge near base. Ocular canthus not completely dividing eye. Pronotum with anterior angle rounded or weakly acute. Pronotum of major male with single lobe-like process; minor male and female with 4 weak, tubercle-like processes. Front tibia of male slender, female tibia comparatively more robust. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Australia. This species is native to eastern Australia. It has been recorded occurring from the province of Victoria northward to Mackay in Queensland (Matthews, 1972). It is also known from New Zealand, where it established in the 1870's (Forgie, 2009).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

This diurnal scarab is known from pastures and other open areas, particularly where soils are sandy (Matthews, 1972). Adults live up to 46 weeks (Forgie, 2009) and have been recorded from carrion as well as dung (human, cattle, sheep, and wallaby) (Matthews, 1972). After locating suitable feces, females create a burrow under or near the dung source (Forgie, 2009). The burrow is then provisioned with dung in the form of brood balls. Each ball is impregnated with an egg; larval development occurs within the brood ball. There is a single generation per year (Forgie, 2009). Duration from egg to adult is 6–10 weeks, with adult numbers peaking in early summer (Forgie, 2009).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this scarab is not a threat to native dung beetles because none occur in Hawaii or Guam. An odd record of this species killing a horse through perforation of the horse's stomach (Matthews, 1972) should be regarded with skepticism.

Status in Hawaii

Recorded, not established. This species was intentionally brought to Hawaii in 1921, though it is unclear if any individuals were released (Hawaii Division of Forestry, 1923). Similar dung beetle introductions were undertaken to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). If this species was released, it failed to establish populations in the state (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This scarab could be confused with *Onthophagus* of similar color and small-size (6–10 mm): *Onthophagus foliaceus* and *Onthophagus nuchicornis*.

Major males of these species can quickly be distinguished by examination of the head (*O. granulatus* lacking horns, instead with strongly recurved, produced clypeal apex versus *O. nuchicornis* with single spine-like horn, *O. foliaceus* with a single, long forward curving horn).

Minor males and females are somewhat more difficult to distinguish but can be separated by examination of the pronotum (*O. granulatus* with four tubercle-like processes versus *O. nuchicornis* with a rounded peg-like process, *O. foliaceus* without a process).

Other names (synonyms)

None known

Onthophagus incensus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus incensus* Say, 1835

Adult diagnosis

Total body length 6.5–12.0 mm (0.25–0.47 in). Body shape oval; may be caked in dung. Color shiny black, with bluish or greenish hues under bright light. Small to medium-sized dung beetle, over 6 mm. Clypeal apex of major male produced, quadrate or trapezoidal; comparatively rounded in minor male and female. Head of major male with 2 slightly curved, vertically-oriented horns that are not connected by a ridge and with apices that are not bifurcate; minor male with horns reduced or replaced by straight, transverse ridge; female with transverse ridge near base. Ocular canthus completely dividing eye. Pronotum of major male with hump-like process; minor male with hump reduced to small bi-lobed process; female lacking process. Pronotum with anterior angles rounded in both sexes. Front tibia of male slightly slender and elongate, female tibia comparatively stout. Scutellum absent.

Larval diagnosis

(Huerta et al., 2010): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Labium hypopharynx glossa with 4 or 5 setae of the lateral lobe; 9–12 setae and 4 macrosensilla on the central lobe. Lacinia with 2 or 3 dorso-basal setae. Maxillary palps with single setae. Maxillary stridulatory area with a row of 8 short, conical teeth. Cardo with 3 external setae. Epipharynx with tormae united mesally. Epipharyngeal phoba with teeth small and conical; chaetoparia with 2 or 3 setae. Epicranial stem shallowly forked basally on frons. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes.

Native range

United States to Ecuador. This species is recorded from Texas through Mexico and Central America southward to Venezuela and Ecuador (Huerta and García-Hernández, 2013).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

(Huerta and García-Hernández, 2013; Huerta et al., 2010): This diurnal species is associated with pasture land near tropical forests. After locating suitable dung, adults construct a gallery of tunnels 5–15 cm (1.9–5.9 in) beneath the fecal source. Tunnels are provisioned with dung in the form of brood balls. Each brood ball is impregnated with an egg and larval development occurs within. The number of brood balls appears to be seasonally dependent, increasing with onset of the rainy season. Development from egg to adult is about 38 days. There are multiple generations per year.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Being a dung feeder, this species has never been recorded damaging crops or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. This species was introduced to Big Island and Oahu in 1923 to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and

Yoshioka, 1998). It is fairly common on Oahu (mostly above 500 m) but less abundant on Big Island (Markin and Yoshioka, 1998).

Status in Guam

Recorded, not established. This species was released on Guam in 1953 to help control populations of the horn fly (*Haematobia irritans*), a biting pest of livestock (Peterson, 1956). However, it failed to establish on the island (Cartwright and Gordon, 1971; Bourquin, 2002).

Potential distribution and dispersal pathway

In both Hawaii and Guam, this species was intentionally imported.

Similar species

This dung beetle could be confused with similarly colored, small to medium-sized (more than 6 mm) *Onthophagus* species such as *Onthophagus binodis*, *Onthophagus cuniculus*, *Onthophagus laminatus*, *Onthophagus armatus*, and *Onthophagus comperei*.

Major males of *O. incensus* are most readily distinguished by examining the head armature (*O. incensus* with two slightly curved, vertically-oriented horns that are not connected by a ridge, with apices not bifurcate versus *O. binodis,* and *O. cuniculus* that both lack horns, *O. comperei* with sinuate horns that are weakly bifurcate, *O. laminatus* that has a distinct ridge between the horns, *O. armatus* with bisinuate horns connected by a distinct ridge).

Females can be separated by examining the base of the head (*O. incensus* with transverse ridge versus *O. binodis* and *O. cuniculus* with a slightly curved ridge, *O. armatus* with feebly bisinuate ridge, *O. comperei* with two tubercles), the pronotal process (*O. incensus* without a process versus *O. binodis* and *O. laminatus* with a small lobe-like process, *O. cuniculus* with a bi-lobed process), and the anterior pronotal angle (*O. incensus* with anterior angle rounded versus *O. cuniculus* and *O. laminatus* with the anterior angle curved outward).

Other names (synonyms)

none known

Onthophagus laminatus

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus laminatus* MacLeay, 1864

Adult diagnosis

Total body length 11.0–22.0 mm (0.43–0.86 in). Body shape oval; may be caked in dung. Color shiny black. Small to medium-sized *Onthophagus*, over 6 mm. Clypeal apex weakly produced in major male; apex not produced in minor male or female. Head of major male with two upward curving horns, apex of horns not bifurcate, distinct transverse ridge between horns; horns lacking in minor male and female; female and minor male with transverse (straight) ridge at base of head. Ocular canthus completely dividing eye. Pronotum with lobe-like process in major male, process reduced in minor male and female. Anterior angles of pronotum curved outward in both sexes. Front tibia of male slightly slender and elongate; female tibia somewhat more robust. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Australia and New Guinea. This species is native to New Guinea and tropical northern Australia. In Australia, it is found from Derby in Western Australia eastward to Gladstone in Queensland (Matthews, 1972).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this scarab feeding on live plant tissues.

Life history

This nocturnal species is associated with pastures and open woodland in areas with annual rainfall that exceeds 76 cm (30 in) (Matthews, 1972). Adults are recorded from cattle and horse dung. Life history of the species is poorly known, but related *Onthophagus* species are dung tunnelers, with females creating a burrow under or near dung (Woodruff, 1973). The burrow is then provisioned with dung in the form of brood balls. Each ball is impregnated with an egg; larval development occurs within the brood ball.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Recorded, not established. This species was intentionally brought to Hawaii in 1921, though it is appears no specimens were released (Hawaii Division of Forestry, 1923).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This dung beetle could easily be confused with similarly colored and small to medium-sized (more than 6 mm) *Onthophagus* species such as *Onthophagus binodis*, *Onthophagus cuniculus*, *Onthophagus incensus*, *Onthophagus armatus*, and *Onthophagus comperei*.

Size can be used to distinguish both sexes of *Onthophagus laminatus* from *O. armatus* and *O. comperei* (*O. laminatus* is 11.0–22.0 mm [0.43–0.86 in] versus *O. armatus* and *O. comperei* that are both under 11.0 mm [0.43 in]).

Major males of these species can be separated by examining the head armature (*O. laminatus* has two upward curving, non-bifurcate horns connected by a distinct ridge versus *O. binodis* and *O. cuniculus* that lack horns or tubercles, *O. incensus* and *O.*

comperei that lack a ridge between the horns, *O. armatus* that has a distinctly bisinuate ridge connecting the horns).

Minor males and females can be differentiated by examining the rear of the head (*O. laminatus* with transverse (straight) ridge versus *O. binodis* with slightly curved ridge, *O. armatus* with feebly bisinuate ridge, *O. comperei* with two tubercles), pronotum (*O. laminatus* with lobe-like process versus *O. cuniculus* with bi-lobed process, and *O. incensus, O. armatus* and *O. comperei* all lacking a distinct process), and the anterior angles of the pronotum (*O. laminatus* with anterior angles curved outward versus *O. binodis, O. armatus, O. comperei* and *O. incensus* all with the anterior angles rounded or quadrate).

Other names (synonyms)

Onthophagus cowleyi Blackburn, *Onthophagus palmerstoni* Blackburn

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Onthophagus nigriventris

Common name(s)

coastal dung beetle, black-bottom dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus nigriventris* D'Orbigny, 1902

Adult diagnosis

Total body length 10.0–17.0 mm (0.39–0.67 in). Body shape oval; may be caked in dung. Color black with greenish cast; elytra brown. Medium-sized *Onthophagus*, more than 10 mm. Clypeal apex not strongly produced or reflexed in either sex. Major male lacking horns, tubercles, or ridges on head; head of minor male and female with sinuate ridge near base. Ocular canthus not completely dividing eye. Pronotum of major male produced into long, straight horn with smaller bi-lobed process above horn; minor male and female with lobe-like process. Pronotum with anterior angles rounded. Front tibia of males somewhat slender and elongate; female tibia comparatively stout. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

East Africa. This species is native to moist highlands in eastern Africa. It also was introduced to Australia (Tyndale-Biscoe, 1990).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

(Tyndale-Biscoe, 1990): Adults of this diurnal species live 2–4 months. During that time, adults actively fly in search of fresh dung. Females create oval-shaped brood balls in burrows constructed under or near dung. Development from egg to adult requires 4–7 weeks. There are multiple generations per year.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. In Hawaii, this species was imported in 1975 to Big Island and Maui to combat the horn fly (*Haematobia irritans*), a biting pest of livestock (Markin and Yoshioka, 1998). It is established in the highlands of both islands, being rare on Maui (Krushelnycky et al., 2007) but more common on Big Island (Markin and Yoshioka, 1998).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This species could be confused with the similarly colored and medum-sized (more than 10 mm) *Digitonthophagus gazella* and *Onthophagus sagittarius*.

Major males are readily separated by examining the head armature (*O. nigriventris* lacking horns on head versus *D. gazella* with 2 short, upward curving horns and *O. sagittarius* with 2 tusk-like horns).

Minor males and females can be separated by examining base of the head (*O. nigriventris* with a sinuate ridge versus *D. gazella* with straight, transverse ridge versus *O. sagittarius* with single horn).

Other names (synonyms)

none known

Onthophagus nuchicornis

Common name(s)

small black and brown dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus nuchicornis* (Linnaeus, 1758)

Adult diagnosis

Total body length 6.7–9.5 mm (0.26–0.37 in). Body shape oval; may be caked in dung. Color black; elytra brown, mottled with black. Small-sized dung beetle, 6-10 mm. Clypeal apex weakly sinuate; not strongly produced or reflexed in either sex. Head of major male with single spine-like horn; minor male horn greatly reduced; female with transverse ridge at base of head. Ocular canthus completely dividing eye. Pronotum with anterior angles rounded. Pronotum of major male with slight hump-like process; process reduced in minor male; female with rounded peg-like process. Front tibia of male somewhat slender, female tibia comparatively more stout. Scutellum absent.

Larval diagnosis

Undescribed in English (see Perris, 1877): For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present.

Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Temperate Eurasia. This species is native to a broad area of temperate Eurasia, occurring from Europe and Turkey eastward to Siberia and Mongolia (Global Biodiversity Information Facility, 2015). This species was also introduced to North America in the 1840's and occurs coast to coast, from southern Canada south to Missouri (MacRae and Penn, 2001).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

Adults of this species have been recorded on cattle and horse dung (Howden and Cartwright, 1963). Like many related *Onthophagus* species, *O. nuchicornis* is a dung tunneler (MacQueen and Beirne, 1975), creating a burrow near or under a fecal source. The burrow is then provisioned with feces in the form of brood balls. An egg is deposited in each brood ball, within which larval development occurs.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this scarab is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Recorded, not established. In Hawaii, this species was imported in 1910 to combat the horn fly (*Haematobia irritans*), a biting pest of livestock. However, imported specimens did not thrive and none were released (Division of Forestry, 1910).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This species could be confused with *Onthophagus* of similar small size (6–10 mm) and color: *Onthophagus foliaceus* and *Onthophagus granulatus*.

Males of these species can quickly be distinguished by examining the head armature (*O. nuchicornis* with single spine-like horn versus *O. foliaceus* with a single, long, forward curving horn; *O. granulatus* lacking horn, but with an almost vertically produced clypeal apex).

Females are somewhat more difficult to distinguish, but they can be separated by examining the pronotum (*O. nuchicornis* with rounded peg-like process versus *O. foliaceus* without process, and *O. granulatus* with four tubercle-like processes).

Other names (synonyms)

Onthophagus acornis Geoffrey in Fourcoy, *Onthophagus alpinus* Kolenati, *Onthophagus dilwyni* Stephens *Onthophagus immaculatus* Mulsant, *Onthophagus indistinctus* Mulsant, *Onthophagus planicornis* Herbst in Fuessly, *Onthophagus rhinoceros* Melsheimer, *Onthophagus rubripes* Mulsant, *Onthophagus submarginalis* Sahlberg, *Onthophagus trituberculatus* Schrank, *Onthophagus vulneratus* Mulsant, *Onthophagus xiphias* Fabricius

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Onthophagus oklahomensis

Common name(s)

Oklahoma dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus oklahomensis* Brown, 1927

Adult diagnosis

Total body length 2.0–4.1 mm (0.07–0.16 in). Body shape oval; may be caked in dung. Color shiny black. Size tiny, under 6 mm. Clypeal apex rounded, never emarginate; female with frontoclypeal suture very feeble, male suture indistinct. Head without horns or tubercles. Ocular canthus not completely dividing eye. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Southeastern U.S. This species is native to the U.S., where it is found from western Texas and central Kansas eastward to Virginia and southern Florida (Woodruff, 1973).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this scarab feeding on live plant tissues, although adults will feed on rotting fruit (Woodruff, 1973).

Life history

(Woodruff, 1973): This species is often associated with sandy habitats where adults feed on dung, rotting fruit, and fungus. Specimens have been collected on human, dog, and cattle feces. Females dig a shallow burrow 2.50–7.6. cm (1.0–3.0 in) near or under dung. Within the burrow, dung is formed into brood balls in which larval development occurs. Developmental time from egg to adult is about three weeks.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. In Hawaii, this species was imported in 1963 to combat the horn fly (*Haematobia irritans*), a biting pest of livestock. Specimens were released at Ewa on Oahu (Davis and Krauss, 1964).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This tiny scarab is extremely similar to the closely related *Onthophagus tuberculifrons* and superficially similar to small specimens of Leconte's dung beetle (*Ateuchus lecontei*). These three species are separated by examining the clypeus (*O. oklahomensis* with clypeus entirely round versus *O. tuberculifrons* with an emarginate or bidentate clypeus, and *A. lecontei* with a bidentate clypeus) and tubercles of the head (*O. oklahomensis* lacking tubercles versus *O. tuberculifrons* with paired tubercles).

Other names (synonyms)

none known

Onthophagus sagittarius

Common name(s)

Sri Lankan dung beetle, Sagittarius dung beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus sagittarius* (Fabricius, 1775)

Adult diagnosis

Total body length 10.0–13.0 mm (0.39–0.52 in). Body shape oval; may be caked in dung. Color dark brown; elytra pale brown. Medium-sized *Onthophagus*, more than 10 mm. Clypeal apex rounded to sinuate; not strongly produced or reflexed in either sex. Head of male with paired tusk-like horns on the clypeus; female with single horn on the frons. Ocular canthus not completely dividing eye. Pronotum with anterior angle rounded. Pronotum of male with broad, hump-like process; female with spine-like process. Front tibia of male and female similar. Scutellum absent.

Larval diagnosis

Undescribed. For *Onthophagus* spp. (Ritcher, 1966): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Epipharynx with tormae united mesally, anterior phoba present. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity covered with numerous short, stout setae.

Native range

Southeastern Asia. This species is native to southeastern Asia, where it has been recorded from Malaysia, Indochina (Hawaiian Entomological Society, 1964), India (Chandra, 2000), and Sri Lanka (Edwards, 2007). This species was introduced to Australia (Edwards, 2007).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this beetle feeding on live plant tissues.

Life history

Like related *Onthophagus* species, this nocturnal scarab is a dung tunneler, with the female creating a burrow under or near a fresh dung source (Simmons and Emlen, 2008). The burrow is then provisioned with dung in the form of brood balls. Each ball is impregnated with an egg; larval development occurs within the brood ball. This species is confined to tropical areas that experience warm, wet summers, and annual rainfall over 800 mm (31.5 in) (Edwards, 2007).

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this scarab is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. There is conflicting information regarding the arrival of this species to Hawaii. Markin and Yoshioka (1998) reported that *Onthophagus sagittarius* was purposely released on Oahu in 1957 and 1958. However, Harris et al. (1982) stated that the species was accidentally introduced. Regardless, this scarab is now established on both Molokai and Oahu, where it is one of the most commonly encountered dung beetles (Nishida, 2002; Harris et al., 1982).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was probably intentionally imported.

Similar species

This scarab could be confused with *Onthophagus* of similar color and medium size (more than 10 mm): *Onthophagus nigriventris* and *Digitonthophagus gazella*.

Major males of these species can quickly be distinguished by examination of the head armature (*O. sagittarius* with two tusk-like horns on the clypeus versus *O. nigriventris* without horns or ridges, *D. gazella* with two short, upward curving horns at the base of the head).

Females and can be separated by examining the base of the head (*O. sagittarius* with a single horn *O. nigriventris* with a sinuate ridge, *D. gazella* with a straight, transverse ridge).

Other names (synonyms)

Onthophagus erectus Wiedemann, *Onthophagus javanus* Fabricius, *Onthophagus obtusus* Wiedemann, *Onthophagus oryx* Fabricius, *Scarabaeus sagittarius* Fabricius

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Onthophagus tuberculifrons

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Onthophagus* **Species**: *Onthophagus tuberculifrons* Harold, 1873

Adult diagnosis

Total body length 3.5–5.0 mm (0.13–0.20 in). Body shape oval; may be caked in dung. Color dull black, sometimes with orange spots on abdomen. Size tiny, under 6 mm. Sexes noticeably dimorphic. Clypeal apex broadly emarginate in male; bifurcate in female. Head with 2 weak tubercles in both sexes. Ocular canthus not completely dividing eye. Scutellum absent.

Larval diagnosis

(Brach, 1977): Grub C-shaped, hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia distinctly separate. Mandible maxillary stridulatory area with a row of 5–7 short, conical teeth. Epicranial stem deeply forked basally on frons. Epipharynx with tormae united mesally. Epipharyngeal phoba with teeth small and conical. Antennae 4-segmented, distal segment much reduced. Legs 2-segmented. Prothoracic shield without anteriorly projecting processes. Third abdominal segment bearing a prominent conical, dorsal gibbosity with two patches of 45–52 weakly curved to straight, finely-pointed setae. Venter of last abdominal segment with two sparsely-set, irregular patches of 30–39 caudally oriented setae.

Native range

Eastern U.S. This species is native to the U.S. where it is found from eastern Texas and Kansas north to Wisconsin and eastward to Connecticut and southern Florida (Woodruff, 1973).

Plant host(s)

None. This species feeds on dung as both an adult and larva. There are no records of this scarab feeding on live plant tissues, although adults will consume rotting vegetation (Woodruff, 1973).

Life history

(Woodruff, 1973): This species is often associated with sandy habitats where adults feed on dung, rotting vegetation, carrion, and fungus. In South Carolina, adults are active throughout the year (Bertone, 2004). Life history is poorly known, but related *Onthophagus* species are dung tunnelers, and females create burrows under or near a dung source. The burrow is then provisioned with dung in the form of brood balls. Each ball is impregnated with an egg; larval development occurs within the brood ball.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. Primarily being a dung feeder, this species has never been recorded damaging crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Established. In Hawaii, this species was imported to combat the horn fly (*Haematobia irritans*), a biting pest of livestock. Specimens were released in 1963 at Ewa and Kailua on Oahu (Davis and Krauss, 1964).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally imported.

Similar species

This tiny scarab is extremely similar to the closely related *Onthophagus oklahomensis* and superficially similar to small specimens of Leconte's dung beetle (*Ateuchus lecontei*). These three species are separated by examining the clypeal apex (*O. tuberculifrons* with an emarginate or bidentate clypeus versus *O. oklahomensis* with an entirely rounded clypeus) and tubercles of the head (*O. tuberculifrons* with paired tubercles versus *O. oklahomensis* and *A. lecontei* lacking tubercles).

Other names (synonyms)

Onthophagus tuberculifrons Sturm (*nomen nudum*), *Onthophagus tuberculatus* Gemminger and Harold (*nomen nudum*)

Oryctes

Common name(s)

coconut rhinoceros beetles

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Oryctes*

Adult diagnosis

Scarabs of the genus *Oryctes* are somewhat uniform in color and armature, but more variable in body shape. Body length ranges between 22.0–77.0 mm (0.86–3.03 in). The body form of these beetles is usually convex dorsally, but varies from elongate and somewhat cylindrical to oblong and weakly flattened dorsoventrally. Color is more uniform, ranging from dark brown to black. While the size of the cephalic horn varies considerably between species, horn shape is similar with all males (and females in many species) having a single, unbranched (ending in one point), curved horn. In many species, sexes can be differentiated based upon the cephalic horn, with females either lacking horns or with a reduced horn. The form of the ocular canthus is variable, being simple in some species or quadrately produced in others. Both males and females of most species possess a broad, sculpted depression on the pronotum.

Larval diagnosis

Undescribed at the generic level. For *Dynastinae* (Ritcher, 1966): When alive, larvae are firm to the touch (not distinctly "squishy" as in *Protaetia* spp. with which they may be confused), and they are not able to crawl on their back (a characteristic of *Protaetia* spp.). Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well-developed unci. Maxillary stridulatory teeth truncate. Legs 4-segmented. Anal opening transverse, straight to slightly curved. Plegmatia absent.

Native range

Old World. *Oryctes* spp. are distributed widely across the Old World. Species are distributed from western Europe and Scandinavia southward to the African Cape region and eastward across Asia to the Pacific islands (Dechambre and Lachaume, 2001).

Plant host(s)

Many members of this genus are associated with palms (Dechambre and Lachaume, 2001) including economically important species such as African oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera*) (Molet, 2013). Both *Oryctes rhinoceros* and *Oryctes monocerus* damage a range of palm and non-palm plant species (Bedford, 2015; Dechambre and Lachaume, 2001). *Oryctes rhinoceros* in particular, is known to attack non-palms such as the Alexandria laurel (*Calophyllum inophyllum*), banana (*Musa* spp.), breadfruit (*Artocarpus* spp.), mango (*Mangifera* spp.), pineapple (*Ananas comosus*), and sugarcane (*Saccharum* spp.) (Molet, 2013).

Life history

While details vary between species, members of this genus are fairly uniform in terms of general life history (Dechambre and Lachaume, 2001). Females deposit eggs in burrows dug into mulch, decaying vegetation, manure-rich soils, or soft, rotten wood. Standing, dead palms may be used as breeding sites, as well as rotten plant matter caught in the petioles of living palms. Larvae feed on organic debris within the nesting medium. Development of the pest species, *Oryctes rhinoceros*,takes 101–170 days from egg to adult emergence (Molet, 2013).

Pest potential

Severe. Though most of the 43 described species (Dechambre and Lachaume, 2001) of this genus are not considered pests, both *Oryctes rhinoceros* (Molet, 2013) and *Oryctes monocerus* (Allou et al., 2006) cause severe damage to palms and other host plants. Damage is caused when adults bore into the crowns of the host plant, burrowing as deep as 50 cm (19.7 in) into the hosts tissue (Molet, 2013). This results in destruction of unopened leaves and often the leaf midrib (Molet, 2013). After feeding on the juices produced by damaged host tissue, the beetle bores out of the host plant, often through the base of a frond (Molet, 2013). Plants, particularly young plants, can be killed either when the scarab damages the apical meristem or via secondary infection in the feeding burrow (Hinckley, 1973). In Palau, Gressitt (1953) attributed coconut mortality rates of 50% to damage caused by *Oryctes rhinoceros*. In Zanzibar, Mansfield-Aders (1920) reported that at some palm plantations, *Oryctes monocerus* killed over 50% of all young coconut palms.

Status in Hawaii

Established. In Hawaii, *Oryctes rhinoceros* is currently established on Oahu where it was first detected in December 2013 on Pearl Harbor-Hickam Joint Base (Hawaii Department of Agriculture, 2014). Efforts are underway to eradicate the scarab and prevent its spread from Oahu. It is likely that this destructive beetle reached Hawaii by hitchhiking on military aircraft flying to Oahu from military bases on Guam, a known transportation pathway for several other invasive scarabs (Moore, 2012).

Status in Guam

Established. In Guam, *Oryctes rhinoceros* has been established since approximately 2007, when specimens were found in the Tumon Bay area (Moore, 2007). The species has since spread to the remainder of the island.

Potential distribution and dispersal pathway

The best known and probably most destructive member of the genus is the highly invasive *Oryctes rhinoceros* (the coconut rhinoceros beetle). *Oryctes rhinoceros* has been intercepted in quarantine on multiple occasions, with at least five U.S. interceptions known (Molet, 2013). Adults have been recorded on military equipment, air cargo, coconut "material", and potted plants (Molet, 2013; Bedford, 2015). It has also been reported that larvae are able to survive in floating logs out at sea (Molet, 2013). Any location where palms grow should be considered at risk for invasion by *Oryctes* species.

Similar species

These large scarabs could be confused with the similarly sized and colored Japanese rhinoceros beetle (*Trypoxylus dichotomus*) and *Xylotrupes* species. Males of these scarabs can readily be separated by examining of the head horn (*Oryctes* with single, unbranched horn [ending in single point] versus *Xylotrupes* with the horn bifurcate [ending in two points] versus *T. dichotomus* with the horn doubly bifurcate [ending in four points]). Females are separated by examining the pronotum (*Oryctes rhinoceros* with a broad, sculpted depression versus *Xylotrupes* without a depression or fovea and *T. dichotomus* with a distinct, vertical fovea).

Other names (synonyms)

Ryanoryctes

Oryctes rhinoceros

Common name(s)

coconut rhinoceros beetle, coconut beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Oryctes* **Species**: *Oryctes rhinoceros* (Linnaeus, 1758)

Adult diagnosis

Total body length 40.0–60.0 mm (1.57–2.36 in). Body shape elongate, slightly cylindrical. Color dark brown to black. Ocular canthus not produced. Head of male with long, slightly curved horn ending in single point; female with horn present but usually reduced. Pronotum of both sexes without horns, but with broad, sculpted depression. Pygidium of female with dense red-brown setae, setae much more sparse in male.

Larval diagnosis

(Bedford, 1974): When alive, larvae are firm to the touch and crawl on their venter. Similar-sized *Protaetia* larvae feel distinctly "squishy" and crawl on their backs with their legs up. Grub C-shaped, not hump-backed, cylindrical, and cream-colored. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well-developed unci. Maxillary stridulatory teeth truncate. Head with numerous rounded pits, most with a tiny seta. Respiratory plate with 40–80 (sometimes more) round or oblong punctures. Legs 4-segmented. First thoracic segment with single, long seta and 3–8 shorter setae; shorter than width of sclerite. Thoracic spiracles larger than abdominal spiracles. Distinct anal ring on terminal segment. Plegmatia absent.

Native range

Southeastern Asia. This species has a wide distribution across tropical and subtropical southeastern Asia, ranging from India and Pakistan, through Indochina, east to Okinawa, the Philippines, and Indonesia. The species has spread widely beyond its native range and can now be found in the Bismarck Archipelago, Palau, Reunion, Samoa, Tonga, Fiji, Micronesia, Mauritius, Guam, and Hawaii (Bedford, 2015).

Plant host(s)

Adults of this species are best known as pests of the coconut palm (*Cocos nucifera*). A great many other palms are damaged by adults, including the African oil palm (*Elaeis guineensis*), betel nut or areca nut palm (*Areca catechu*), Chinese fan palm (*Livistona chinensis*), date palm (*Phoenix dactylifera*), ivory nut palm (*Metroxylon amicarum*), Fiji fan palm (*Pritchardia pacifica),* Palmyra palm (*Borassus flabellifer*), *Pandanus* spp., ruffle palm (*Aiphanes horrida*), royal palm (*Roystonea regia*), sugar palm (*Arenga pinnata*), and talipot palm (*Corypha umbraculifera*). Non-palm species recorded as hosts include the Alexandria laurel (*Calophyllum inophyllum*), banana (*Musa* spp.), breadfruit (*Artocarpus* spp.), mango (*Mangifera* spp.), pineapple (*Ananas comosus*), and sugarcane (*Saccharum* spp.) (Molet, 2013).

Life history

(Molet, 2013): Females deposit eggs in burrows dug into mulch, decaying vegetation, manure-rich soils, or soft rotten wood. Standing, dead palms are used as breeding sites, as is rotten plant matter caught in the petioles of living palms. Adults burrow as deep as 50 cm (19.7 in) into the crowns of host plants. Adults prepare the burrow for larvae by covering eggs with chewed nesting medium. Females lay three or four clutches of about 30 eggs each. With favorable conditions, there may be up to three overlapping generations per year. The larval stage is 72–130 days, followed by a pre-pupal stage, and then a pupal stage that lasts 31–40 days before adult emergence. Adults are nocturnal.

Pest potential

Severe. *Oryctes rhinoceros* is a severe and known biosecurity threat with a history of invasive spread. Damage is caused when young adults bore into the crowns of host plants, burrowing as deep as 50 cm into the host tissue (Molet, 2013). This often results in destruction of unopened leaves and damage of the leaf midrib (Molet, 2013). After feeding on the juices produced by damaged host tissue, the beetle bores out of the host, often through the base of the frond (Molet, 2013). Plants, particularly young plants, can be killed when the scarab damages the apical meristem or via secondary infection in the feeding burrow (Hinckley, 1973). In Palau, Gressitt (1953) attributed coconut palm mortality rates of 50% to damage caused by this beetle. Even when coconut palms are not killed in this manner, fruit production is adversely impacted. Estimates of fruit set reduction range from 5 to 25% (Bedford, 2015). Larvae of this species are not reported as pests.

Status in Hawaii

Established. This species is currently established on Oahu where it was first detected in December 2013 on Pearl Harbor-Hickam Joint Base (Hawaii Department of Agriculture, 2014). Efforts are underway to eradicate the scarab and prevent its spread from Oahu. It is very likely that this destructive scarab reached Hawaii by hitchhiking on aircraft flying to Oahu from Guam, a known dispersal pattern for several other invasive scarabs (Moore, 2012).

Status in Guam

Established. *Oryctes rhinoceros* was first recorded in Guam in 2007 in the Tumon Bay area and has spread to the remainder of the island since that time (Moore, 2007). It has been suggested that the current infestation originated from the Phillipines (DeNitto et al., 2015).

Potential distribution and dispersal pathway

This species has been intercepted in quarantine on multiple occasions, with at least five U.S. interceptions known (Molet, 2013). Adults have been recorded on coconut "materials", military equipment and air cargo, and in potted plants (Molet, 2013; Bedford, 2015). It has been reported that larvae are able to survive in floating logs in the ocean (Molet, 2013). The distribution of the species correlates with its primary host, the coconut palm. As such, it should be regarded as a serious potential threat to territories where coconut palms occur: Florida, Puerto Rico, and the U.S. Virgin Islands. Because *Oryctes rhinoceros* also damages other palms, it should also be regarded as a potential threat to states such as California, Arizona, Texas, Louisiana, Mississippi, Alabama, Georgia, and the Carolinas.

Similar species

This large scarab could be confused with the similarly sized and colored Japanese rhinoceros beetle (*Trypoxylus dichotomus*) and *Xylotrupes* species.

Males of these species can readily be separated by examining the male head horn (*Oryctes rhinoceros* with a single unbranched horn that ends in single point versus *Xylotrupes* with a bifurcate horn that ends in two points versus *T. dichotomus* with a horn that is doubly bifurcate and ends in four points).

Females can be separated by examining the ocular canthus (*O. rhinoceros* lacks a produced canthus versus *Xylotrupes* species that have a quadrately produced canthus, *T. dichotomus* with an acutely produced canthus) and the form of the pronotal depression (*O. rhinoceros* with broad, sculpted depression versus *Xylotrupes* without an anterior depression or fovea and *T. dichotomus* with a distinct fovea).

Other names (synonyms)

Oryctes stentor Laporte (Comte de Castelau), *Scarabaeus rhinoceros* Linnaeus

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Papuana

Common name(s)

taro beetles

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Papuana*

Adult diagnosis

Papuana is a genus of medium-sized scarab beetles that are armed with horns or tubercles. All species are shiny black and have an elongated, oval body shape. Total body length ranges between 15.0–30.0 mm (0.59–1.18 in). The apex of the clypeus is broad and never has 2 teeth close together. Both males and females have either tubercles or horns on the clypeus. Males of many species also have horns or tubercles on the pronotum. Horns, if present, are often reduced in females. The apex of the last sternite is emarginate in male and rounded in the female.

Larval diagnosis

Undescribed. For *Dynastinae* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well-developed unci. Maxillary stridulatory teeth truncate. Legs 4-segmented. Anal opening transverse, straight or slightly curved. Plegmatia absent.

Native range

*Indo-Pacific***.** All 19 described species (Aloalii et al., 1993) are native to the Indo-Pacific area. Two species are known from the Philippines, one from the Moluccas, one from northern Australia, 14 from New Guinea, four from the Solomon Islands, and two from Vanuatu (Aloalii et al., 1993).

Plant host(s)

While the best known plant host of the taro beetles (*Papuana*) is taro (*Colocasia esculenta*), other plants in the aroid family (Araceae) are also acceptable hosts including *Alocasias* spp., *Cyrtosperma* spp., and elephant ear ***(Xanthosoma sagittifolium).*** A number of non-aroids are also recorded as hosts: *Angiopteris* spp., banana (*Musa* spp.), cabbage (*Brassica oleracea*), cocoa (*Theobroma cacao),* coconut (*Cocos nucifera),* coffee (*Coffea arabica), Crinium* spp., *Marattia* spp., nut palm (*Areca catechu*), oil palm (*Elaeis guineensis*), peanuts (*Arachis hypogea),* pineapple (*Ananas comosus)*, potato (*Solanum tuberosum*), purple yam (*Dioscorea alata*), sugarcane (*Saccharum officinarum*), sweet potato (*Ipomoea batatas*), tea (*Camellia chinensis*), and white yam (*Dioscorea rotundata*) (Aloalii et al., 1993; Lal et al., 2008).

Life history

(Lal et al., 2008): Eggs are laid in moist, organic, rich soils. For *Papuana uninodis,* larvae emerge after an average of two weeks. The first instar lasts an average of two weeks, the second instar 4–5 weeks, and the final instar 3–4 months. The entire pre-adult lifecycle lasts 17–28 weeks, varying with temperature and humidity. Adults can live as long as 22 months, during which time females lay about 140 eggs. Adults feed by boring into the corm of a variety of aroids. Larvae do not appear to cause direct plant damage. Instead, they feed on detritus and other organic soil debris.

Pest potential

Significant. Of the 19 species of taro beetles (*Papuana*), eight are major taro pests (Aloalii, 1993). In Fiji and Papua New Guinea, these beetles reduce yields by up to one third, and this has led to the abandonment of many taro farms (Lal et al., 2008). Damage is caused by adults that bore into the taro corm (or root) and cause serious damage. Further, *Papuana* spp. have a history of invasive establishment beyond their native range. *Papuana hubneri,* a species native to New Guinea, spread to Kiribati in 1934 and to Fiji by 1984 (Aloalii et al., 1993).

Status in Hawaii

Not established or recorded. There are no records of this genus from Hawaii.

Status in Guam

Not established or recorded. There are no records of this genus from Guam.

Potential distribution and dispersal pathway

While it is unclear how *Papuana hubneri* first arrived to Fiji and Kiribati, it is not difficult to imagine these scarabs hitchhiking on commercial shipments of taro or other host plants. Similar to other dynastine scarabs that are attracted to lights at night (Ratcliffe and Paulsen, 2008), it is likely that this beetle would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine and air cargo. Because taro is cultivated throughout the Pacific, and beetles damage a broad range of economically important plants, *Papuana* spp. should be regarded as a significant potential biosecurity hazard in both Hawaii and Guam.

Similar species

Scarabs most likely to be confused with this genus are members of the genera *Ligyrus* and *Tomarus*. While not recorded on Guam, the carrot beetle (*Ligyrus gibbosus*) has been found on Oahu, and other species such as the sugarcane beetle (*Tomarus subtropicus*) may arrive in the future. *Papuana* spp. may be distinguished from *Tomarus* by examination of the head (*Papuana* spp. usually with horns or tubercles on head versus *L. gibbosus* and *T. subtropicus* never with horns or tubercles) and clypeal apex (*Papuana* spp. never with 2 close-set apical teeth versus clypeus constricted with 2 close-set apical teeth in *L. gibbosus* and *T. subtropicus*).

Other names (synonyms)

none known

Phanaeus daphnis

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Scarabaeinae **Genus**: *Phanaeus* **Species**: *Phanaeus daphnis* Harold, 1863

Adult diagnosis

Total body length 13.0–19.0 mm (0.51–0.74 in). Color metallic green, rarely blue or yellow-green. Head of major male with single large horn; horn reduced in minor males, lacking in female. Clypeus usually rounded, sometimes triangular or trapezoidal; never strongly emarginated. Pronotum of major male with 3 elevated ridges; ridges reduced in minor males, absent in females. Pronotal surface at lateral margins granulate. Elytra with distinct striae. Middle and hind legs without claws.

Larval diagnosis

Undescribed. For *Phanaeus* species (Ritcher, 1966): Maxilla with galea and lacinia distinctly separated. Epipharynx with tormae united mesally, anterior phoba present. Antenna 4- segmented; distal segment of antenna much reduced in size. Prothoracic shield with an anteriorly projecting, angular process on each side. Legs 2-segmented;

lacking claws, instead with a single terminal seta. Last abdominal segment with median portion of venter covered with a large quadrate patch of stout, caudally directed, spine-like setae; venter with a single, broad, caudal, median lobe.

Native range

Mexico. This species is known from the transvolcanic belt of central Mexico where it occurs at elevations between 1,000 and 1,600 meters (Edmunds, 1994).

Plant host(s)

None. This species feeds on dung as both an adult and larva (Price and May, 2009). There are no records of this scarab feeding on live plant tissues.

Life history

(Price and May, 2009): Like the majority of *Phanaeus* species, *P. daphnis* feeds on mammalian dung. The droppings of omnivores such as swine and humans are preferred, but the dung of herbivores such as cattle is readily accepted. Carnivore dung is the least preferred. Females locate dung by flying low over the ground, then land near (but rarely on) the feces. Using their front legs, females move a portion of the dung up to 18 m (59 ft) from the original site. Unlike most other *Phanaeus* species, the *P. daphnis* beetle does not aid in moving the dung. Dung is deposited in a burrow and formed into a pear-shaped brood ball. The brood ball is impregnated with an egg and then enclosed in clay (perhaps to prevent dessication). No further parental care takes place, though adults may continue to inhabit the burrow. In the native range, breeding takes place between June and November. Adult females lay approximately 12 eggs over 180 days. Adults are diurnal.

Pest potential

None. This species recycles dung and is beneficial for ranching and farming in Hawaii. As an obligate dung feeder, this species poses no threat to crop or ornamental plants. Additionally, this species is not a threat to native dung beetles because none occur in Hawaii or Guam.

Status in Hawaii

Recorded, not established. This species was intentionally released in Hawaii with the goal of controlling populations of the horn fly (*Haematobia irritans*). Introductions were made in 1954 at Parker Ranch on Big Island (Weber, 1954). In 1955, further introduction attempts were made at Molokai Ranch on Molokai and Waimea on Kauai (Weber, 1955). Despite these release attempts, the beetle apparently never established self-sustaining populations (Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species was intentionally released but did not establish.

Similar species

With their distinctive shape and coloration, major males of the *Phanaeus daphnis* are unmistakable. However females and minor males could be confused with the green form of *Canthon pilularius*. *P. daphnis* can be separated from *C. pilularius* by examination of the rear tarsi (*P. daphnis* lacking rear tarsal claws versus *C. pilularius* with rear tarsal claws) and the apex of clypeus (*P. daphnis* clypeal apex rounded versus *C. pilularius* with clypeus distinctly emarginated).

Other names (synonyms)

Phanaeus coerulus Bates, *Phanaeus herbeus* Bates, *Phanaeus substriolatus* Balthasar, *Phanaeus tricornis* Olsoufieff

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Phyllophaga ephilida

Common name(s)

May beetle, June bug

Taxonomy

Family: Scarabaeidae **Subfamily**: Melolonthinae **Genus**: *Phyllophaga* **Species**: *Phyllophaga ephilida* (Say, 1825)

Adult diagnosis

Total body length 13.0–17.8 mm (0.51–0.70 in). Body shape cylindrical, somewhat elongate. Color reddish-brown. Antennae 10-segmented; club 3-segmented; male club subequal in size to segments 1-7; female club noticeably shorter than segments 1-7. Clypeus reflexed; sinuate. Head lacking ridge at base of frons. Pronotum lacking constriction near apical angle; lacking distinct fovea at each side of anterior margin in male and female. Elytra smooth; lacking prominent setae.

Larval diagnosis

(Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused. Mandible with basolateral region with 9 setae; dorsoexterior region with fewer than 3 setae. Epipharynx haptomerum with 11 heli. Proplegmatia with 7–10 proplegmata. Last antennal segment with single large, oblong, dorsal sensory spot. Respiratory plates of spiracles not constricted. Raster with closely set palidia. Pali short, somewhat hooked, less than 3 times as long as the widths of their bases. Anal opening Y-shaped.

Native range

Eastern North America. This species is widely distributed across eastern North America, occurring from Nebraska east to New York and south to northeast Texas and Florida (Woodruff and Beck, 1989).

Plant host(s)

Adults of *Phyllophaga ephilida* feed at night on the foliage of a variety of plants: alder (*Alnus* spp.), apple (*Malus* spp.), ash (*Fraxinus* spp.), black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), pear (*Pyrus* spp.), pecan (*Carya illinoinensis*), persimmon (*Diospyros* spp.), plum (*Prunus* spp.), red oak (*Quercus rubra*), river birch (*Betula nigra*), rose (*Rosa* spp.), strawberry (*Fragaria* spp.), water oak (*Quercus fastigiata*), wild cherry (*Prunus avium*), willow (*Salix* spp.), and winged elm (*Ulmus alata*) (Woodruff and Beck, 1989). Larvae are known to damage roots of turf grasses (Watschke et al., 1994) and sweet potato (*Ipomoea batatas*) (Diagne et al., 2006).

Life history

(Woodruff and Beck, 1989): Adults of this species feed on foliage at night. Adults are active through summer, and females deposit eggs in loose soil near potential host plants. The larvae live in the soil where they feed on the roots of nearby plants, particularly grasses. Overwintering occurs in the larval stage. Larvae take between one to three years to develop into adults (dependent upon location).

Pest potential

Significant. Both adults and larvae of this species are pests. Larvae are destructive turf pests in their native range causing significant damage to grass roots (Watschke et al., 1994). Larvae damage sweet potatoes and are a major pest of that crop in the southern United States (Diagne et al., 2006). Adults are pests, damaging and sometimes defoliating a number of important horticultural and agricultural species including apples, pears, pecans, and plums (Woodruff and Beck, 1989).

Status in Hawaii

Recorded, not established. Nishida (2002) recorded this species being intercepted in quarantine. Details of the interception could not be located.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species comes to lights at night, and it is likely that it would be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Further, it is possible that larvae or eggs could be transported in shipments of commercial turf. *Phyllophaga* species are common and widespread in the mainland U.S. and have a high likelihood of reaching the islands in the future.

Similar species

This species is quite similar to the related *Holotrichia bipunctata*. They are differentiated by examination of the head (*P. ephilida* lacking ridge at the base of the frons versus *H. bipunctata* with a distinct ridge) and the female pronotum (*P. ephilida* lacking fovea at anterior margin of the pronotum versus *H. bipunctata* with distinct fovea at each side of pronotal anterior margin).

Other names (synonyms)

Lachnosterna burmeisteri LeConte, *Lachnosterna ephilidia* Horn, *Melolontha ephilida* Say

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Popillia japonica

Common name(s)

Japanese beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Popillia* **Species**: *Popillia japonica* Newman, 1838

DNA barcode

DNA barcode available: specimen record; sequence file

Adult diagnosis

Total body length 9.0–13.7 mm (0.35–0.54 in). Body oval-shaped. Color shining green, sometimes with reddish sheen; elytra shiny brownish. Clypeus slightly narrowed toward strongly recurved apex. Front claw toothed; male with toothed claw more robust than in female. Pronotum with dense punctation near anterior border; punctures distinct.

Pygidium with 2 vaguely oval-shaped patches formed by dense whitish hairs (sometimes absent in worn specimens).

Larval diagnosis

(Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Frons lacking numerous punctures. Labrum asymmetrical. Claws sharply pointed. Dorsa of 9th and 10th abdominal segments not fused. Spiracles on 7th and 8th abdominal segments nearly equal in size. Segments 7–9 with dorsa with most of setae confined to 2 transverse bands. Palidia present, each palidium with 5-8 pali. Pali depressed or conical, never compressed. Venter of last abdominal segment with 14 or more preseptular hooked setae. Septula triangularly-shaped. Preseptular, hamate setae 35–57 in number. Lower anal lip with 19–29 long and short, straight setae.

Native range

Japan. This species is native to Japan, occurring on the four main islands of Honshu, Hokkaido, Kyushu, and Shikoku, but not the subtropical Ryuku Islands. This species is also known from the Russian Far East, specifically the islands of Sakhalin and Kunashir (Klein, 2008). Records from Korea and China are misidentifications of the similar four spotted beetle (*Popillia quadriguttata*) (Lee et al., 2007).

Plant host(s)

Popillia japonica feeds on a broad array of flowering plants. Over 300 plant species are recorded as hosts (Vittum et al., 1999). Amongst economically important plants, major hosts include maples (*Acer* spp.), asparagus (*Asparagus officinalis*), soybean (*Glycine max*), apples (*Malus* spp.), stone fruit including plums, peaches, etc. (*Prunus* spp.), rhubarb (*Rheum* x *hybridum*), roses (*Rosa* spp.), blackberry and raspberry (*Rubus* spp.), basswood (also known as linden or lime trees) (*Tilia* spp.), elms (*Ulmus* spp.), grapes (*Vitis* spp.), and corn (*Zea mays*) (Gyeltshen and Hodges, 2005). Secondary hosts include buckeyes (*Aesculus* spp.), hollyhocks (*Althaea* spp.), birches (*Betula* spp.), chestnuts *Castanea* spp.), rosemallows (*Hibiscus* spp.), American walnut (*Juglans nigra*), plane trees and sycamores (*Platanus* spp.), poplars (*Populus* spp.), willow (*Salix* spp.), common sassafras (*Sassafras albidum*), and American mountain ash (*Sorbus americana*) (Gyeltshen and Hodges, 2005). Larvae feed on the roots of many of the same plants that adults defoliate and also damage the roots of many turf grass species (Klein, 2008).

Life history

Because of its pest status, the lifecycle of the *Popillia japonica* is well known. In the eastern U.S., adults first emerge from pupation between May and July, and females begin laying eggs soon thereafter (Gyeltshen and Hodges, 2005). Females lay as many as 60 eggs (Klein, 2008) that are deposited 5.0–7.6 cm (2.0–3.0 in) deep in the soil, often under turf. Most larvae reach their final instar by September, burrowing as deep as 25.0 cm (10.0 in) to escape falling soil temperatures. Once temperatures fall below 10° C (50° F), grubs cease activity and overwintering occurs. Grubs resume feeding in the spring, and pupation takes place 4 to 6 weeks after feeding resumes. Pupation, which occurs near the soil surface, takes between 1 and 3 weeks. Males often emerge a few days before females (Gyeltshen and Hodges, 2005). Adult lifespan and activity are highly dependent upon local weather conditions. In the southern part of their range in the U.S., *P. japonica* adults often emerge in May (Gyeltshen and Hodges, 2005), while in Minnesota, adults usually emerge in mid-July (Krischik, 2011). Adults live between 30–45 days (Klein, 2008). Adults are most active during warm sunny weather, particularly around midday when they may be found feeding on exposed foliage (Gyeltshen and Hodges, 2005).

Pest potential

Severe. Though not a significant pest in its native Japan, this species is regarded as the single most destructive insect pest of lawns, gardens, and golf courses in the eastern U.S. (Klein, 2008). In 2000, the USDA estimated that $450 million were spent annually in the U.S. on *Popillia japonica* control (Potter and Held, 2002). Adults and larvae are both destructive pests. Adults defoliate a vast variety of plants, often congregating on a single plant, attracted by aggregating pheromones. Once a host plant is chosen, the beetles feed on foliage, stems, and flowers. Larvae feed upon grass roots and are serious turf pests (Krischik, 2011). In California, this species has established populations at least three times. Fortunately, subsequent eradication was successful (Potter and Held, 2002). In California, the beetle is regarded as a class A regulated pest, with a high likelihood of future introduction (Cosner, 2013). It is also listed as a quarantine pest in six other states, the Canadian province of British Columbia, and by the European and Mediterranean Plant Protection Organization (Potter and Held, 2002).

Status in Hawaii

Recorded, not established. While not established in Hawaii, this species has been intercepted repeatedly in quarantine on Oahu (Nishida, 2002). The earliest of numerous records dates to 1925, when a single male was found on air cargo coming into Honolulu from Japan (Rainwater, 1963). Further interceptions took place in 1954, when 18 live adults were found over the course of a month on aircraft flying into Honolulu from East Asia. In 1955, eight specimens were intercepted on five different aircraft flying into Hickham Airforce Base from Tokyo, Japan (Hawaiian Entomological Society, 1954). In fact, between 1951 and 1959, 153 specimens were found by USDA inspectors (Hawaiian Entomological Society, 1961).

Status in Guam

Not established or recorded. No records of this species on Guam exist (this may reflect a lack of documentation), though the closely related *Popillia lewisi* is established on the island (Marler and Moore, 2011).

Potential distribution and dispersal pathway

Popillia japonica has been recorded hitchhiking on both air and marine cargo. The original introduction to the U.S. took place in the 1910's (Ritcher, 1966). It is believed that the initial introduction occured when an iris bulb shipment that hosted eggs or larvae was imported via a ship from Japan (Klein, 2008). Records in Hawaii indicate that this species has been intercepted in air cargo on multiple occasions (Rainwater, 1963). While parts of the western U.S. are suitable habitat, as illustrated by California introductions, it is unclear if Hawaii and Guam have optimal climates for *P. japonica* proliferation. Indeed, despite clear evidence that *P. japonica* has reached the islands, it has never established a self-sustaining population. In the eastern U.S., this species has never spread further south than Georgia, and it is absent from Florida (Gyeltshen and Hodges, 2005). In Japan, this beetle is most common on the colder, northern islands of Honshu and Hokkaido (Klein, 2008). This may be due to the seasonal lifecycle of *P. japonica*. Perhaps the larval overwintering period is required for successful pupation.

Similar species

Popillia japonica is very similar to both *Popillia lewisi*, established on Guam, as well as the potential invader *Popillia quadriguttata*. These three species can be separated by examination of of the pronotal punctation (*P. japonica* with dense, distinct punctures near anterior border versus *P. lewisi* with sparse, small and indistinct punctures), pygidium (*P. japonica* with two vaguely oval-shaped patches of setae versus *P. lewisi* with crescent-shaped patches), clypeus (*P. japonica* with clypeus barely narrowing at apex, strongly recurved versus *P. quadriguttata* and *P. lewisi* with clypeus rounded, narrowing at apex, somewhat recurved), and often size (*P. japonica* at 9.0–13.7 mm [0.35–0.54 in] versus 11.0 mm [0.43 in] or less in *P. quadriguttata* and *P. lewisi*).

Other names (synonyms)

Popillia placatipennis Burmeister

Popillia lewisi

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Popillia* **Species**: *Popillia lewisi* Arrow, 1913

Adult diagnosis

Total body length 8.4–10.3 mm (0.33–0.41 in). Body oval-shaped. Color shining green, sometimes with reddish sheen; elytra shiny tan to brown. Clypeus rounded with apex somewhat recurved; narrowed toward apex. Front claw toothed, male with toothed claw more robust than in female. Pronotum with sparse punctation near anterior border; punctures small, indistinct. Pygidium with 2 crescent-shaped patches formed by dense, whitish setae (setae often lost in older specimens).

Larval diagnosis

Undescribed. For *Popillia* spp. (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Frons sparsely punctate. Labrum asymmetrical. Claws sharply pointed. Spiracles on 7th and 8th abdominal segments nearly equal in size. Dorsa of 9th and 10th abdominal segments not fused. Septula shaped like an equilateral triangle, palidia strongly diverging posteriorly; each palidium with 5–7 (rarely 8) long, ensiform pali. Venter of last abdominal segment with 14 or more preseptular, hooked setae.

Native range

Japan. In Japan, this species is known from Okinawa and the Ryuku Islands (Schreiner and Nafus, 1986).

Plant host(s)

Though little information is available regarding the feeding habits of this species, it is likely that preferences are similar to the well-known Japanese beetle (*Popillia japonica*). Adult Japanese beetles (*P. japonica*) are generalists, feeding on the foliage and flowers of a broad range of plants, while larvae feed on grass roots (Krischik, 2011).

Life history

Adults may be found during the day feeding on plant foliage. Based on specimens examined at the University of Guam, it appears that the adults are active throughout the year. Natural history and larvae are undescribed.

Pest potential

Significant. In Guam, this species is a significant pest of "ornamental plants" (Marler and Moore, 2011), although details are scarce. The related *Popillia japonica* damages plants as both an adult and larva. Adults of *P. japonica* damage plants in mass, attracted to aggregating pheromones and feed on both foliage and flowers. Larvae feed upon grass roots and can be serious turf pests (Krischik, 2011). In California, *P. lewisi* is regarded as a class A regulated pest, with a high likelihood of introduction (Cosner, 2013).

Status in Hawaii

Recorded, not established. While not established in Hawaii, this species has been intercepted in quarantine on Oahu (Nishida, 2002). Intercepted specimens were found in 1991 aboard U.S. Air Force aircraft flying in from Andersen Air Force Base on Guam (Moore, 2012).

Status in Guam

Established. This species is established on Guam, having first arrived in 1985 (Schreiner and Nafus, 1986). It seems likely that this early population came in on U.S. Air Force aircraft, flying from bases on Okinawa (Marler and Moore, 2011). Indeed, for many years *P. lewisi* was confined to the vicinity of the docking bay of Andersen Air Force Base, persisting there despite some early eradication efforts (Schreiner and Nafus, 1986). Since then, this beetle has spread to the remainder of Guam, becoming a serious pest (Marler and Moore, 2011).

Potential distribution and dispersal pathway

In both Hawaii and Guam, it appears that military air cargo was the primary mode of transportation for this species (Moore, 2012). It is possible that this species could spread to California or Florida via similar means. Further, it is reasonable to expect that adult beetles could hitchhike on nursery plants, or larvae could be transported in commercial turf. This species should be regarded as having a high likelihood of spreading to Hawaii.

Similar species

This species is easily confused with two very similar potential invaders: *Popillia quadriguttata* and *Popillia japonica*. These species are separated by examination of pronotal punctation (*P. lewisi* with sparse, small and indistinct punctures near anterior border versus *P. japonica* and *P. quadriguttata* with dense, distinct punctures near anterior border), clypeus (*P. lewisi* with clypeus narrowing at apex and somewhat recurved versus *P. japonica* with the clypeus barely narrowing at the apex and strongly recurved), the pygidium (*P. lewisi* with 2 crescent-shaped patches of white setae versus *P. japonica* and *P. quadriguttata* with patches vaguely oval-shaped), and often by size (*P. lewisi* at 8.4–10.3 mm [0.3–0.4 in] versus *P. japonica* at 9.0–13.7 mm [0.35–0.54 in]).

Other names (synonyms)

none known

Popillia quadriguttata

Common name(s)

none known

Taxonomy

Family: Scarabaeidae **Subfamily**: Rutelinae **Genus**: *Popillia* **Species**: *Popillia quadriguttata* (Fabricius, 1787)

Adult diagnosis

Total body length 8.0–11.0 mm (0.31–0.43 in). Body oval-shaped. Color shining green, sometimes with reddish sheen; elytra shiny brownish. Clypeus rounded; apex somewhat recurved; narrowing toward apex. Front claw toothed, male with toothed claw more robust than in female. Pronotum with dense punctation near anterior border; punctures distinct. Pygidium with 2 vaguely oval-shaped patches formed by dense whitish hairs (sometimes absent in worn specimens).

Larval diagnosis

Undescribed. For *Popillia* spp. (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Frons sparsely punctate. Labrum asymmetrical. Claws sharply pointed. Spiracles on 7th and 8th abdominal segments nearly equal in size. Dorsa of 9th and 10th abdominal segments not fused. Septula shaped like an equilateral triangle, palidia strongly diverging posteriorly; each palidium with 5–7 (rarely 8) long, ensiform pali. Venter of last abdominal segment with 14 or more preseptular, hooked setae.

Native range

East Asia. This species is known from a wide area of East Asia, ranging from North Vietnam, China, Taiwan, to Korea (Lee et al., 2007). Records from the Russian Far East are also known (Chen et al., 2014).

Plant host(s)

(Lee et al., 2002): Like the related Japanese Beetle (*Popillia japonica*), this species is known to feed on a broad range of host plants from a broad range of plant families. Recorded hosts of adult beetles include: *Acalypha australis,* indigo bush (*Amorpha fruticosa*)*, Artesmia princeps,* feather fingergrass (*Chloris virgata*)*,* Asian hazel (*Corylus heterophylla*)*, Dioscorea septembola,* soybean (*Glycine max*)*,* bush clover (*Lespedeza cyrtobotrya*)*,* Amur privet (*Ligustrum obtusifolium*)*,* spicebush (*Lindera erythrocarpa*)*, Lysimachia burystachys, Herlicteres angustifolia,* paradise apple (*Malus pumila*)*, Persicaria senticosa,* bracken (*Pteridium aquilinum*)*, Pyrus* spp.*,* sargent cherry (*Prunus sargentii*)*, Rhapontica uniflora,* Asian raspberry (*Rubus parvifolius*)*,* bao li (*Quercus serrata*)*,* Korean willow (*Salix koreansis*)*,* lyreleaf nightshade (*Solanum lyratum*)*,* Siberan elm (*Ulmus pumila*)*,* Japanese wisteria (*Wistaria floribunda*)*, Zanthoxylum* spp., and corn (*Zea mays*). Larvae mostly feed on grass roots, though soybeans are also known as hosts (Chen et al., 2014).

Life history

(Lee et al., 2002): In Korea, this species was found to fly most actively between noon and 2 p.m., with particularly vigorous activity occurring on sunny days after a rain. Adults are strictly diurnal and do not come to lights at night. Adults were encountered from late June to late July with abundance peaking in early July. Notably, the appearance of adults corresponded with the onset of the Korean rainy season.

Pest potential

Significant. This species is known to damage a variety of commercially valuable plants, both as adults (Chen et al., 2014) and as larvae (Lee et al., 2002). In China, this species is considered a major pest of soybean (*Glycine max*). Adults cause significant damage to foliage, buds, and stems, while larvae destroy roots (Chen et al., 2014). In Korea, *Popillia quadriguttata* is a pest of corn (*Zea mays*) and fruit trees. Larvae are recognized as important turf-grass pests, particularly on golf courses. The larvae cause direct damage by feeding on the roots of turf-grass, and further harm is inflicted when wildlife dig up turf in search of grubs (Lee et al., 2002).

Status in Hawaii

Not established or recorded. This species has not been recorded in Hawaii, but because it is a widespread pest in East Asia, it has a high potential for introduction.

Status in Guam

Not established or recorded. This species has not been recorded in Guam, but because it is a widespread pest in East Asia, it has a high potential for introduction.

Potential distribution and dispersal pathway

With a native range that spans from tropical Vietnam to the cold temperate forests of the Russian Far East, this beetle is a biosecurity threat not only to Hawaii and Guam, but also to the contiguous U.S. If established, *Popillia quadriguttata* could become a pest of corn and soybeans in the midwestern U.S., a region similar in climate to northeastern China and Korea. Because adults of this species congregate on foliage, they could be transported on nursery stock. It is also plausible that larvae or eggs could be transported in turf grass or plant roots, the probable manner of the U.S. introduction of the related *Popillia japonica* (Krischik, 2011).

Similar species

Two *Popillia* species are recorded from Hawaii and Guam: the well-known *Popillia japonica* and *Popillia lewisi*. *Popillia quadriguttata* is quite similar to both. These species can be separated by examination of the pronotal punctation (*P. quadriguttata* with dense, distinct punctures near the anterior border versus *P. lewisi* with sparse, indistinct punctures near the anterior border), pygidium (*P. quadriguttata* with two vaguely oval-shaped patches of white setae versus *P. lewisi* with crescent-shaped patches), clypeus (*P. quadriguttata* with clypeus narrowing at apex, somewhat recurved versus *P. japonica* with clypeus barely narrowed at apex, strongly recurved), and often size (*P. quadriguttata* at 8.0–11.0 mm [0.31–0.43 in] versus *P. japonica* at 9.0–13.7 mm [0.35–0.54 in]).

Other names (synonyms)

Trichius biguttatus Fabricius, *Popillia bogdanowi* Ballion, *Popillia castanoptera* Hope, *Popillia chinensis* Frivaldszky, *Popillia dichroa* Blanchard, *Popillia frivaldszkyi* Kraatz, *Popillia purpurarescens* Kraatz, *Popillia ruficollis* Kraatz, *Popillia sordida* Kraatz, *Popillia straminipennis* Kraatz, *Popillia uchidai* Niijima and Kinoshita

Protaetia fusca

Common name(s)

mango flower beetle, Asian mango flower beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Cetoniinae **Genus**: *Protaetia* **Species**: *Protaetia fusca* (Herbst, 1790)

Adult diagnosis

Total body length 12.0–17.0 mm (0.47–0.67 in). Body broad oval; dorsoventrally flattened. Color dull, dark grey-brown to black, rarely metallic/shiny greenish; elytra with distinct pale markings (may be lost in worn specimens). Clypeus broad, anterior margin entire or sinuate. Front tibia of male with 2 external teeth (rarely with small basal tooth); female with 3 distinct external teeth. Hind tibia with single lateral ridge. Elytra of male with apical spines, female lacking spines.

Larval diagnosis

(Simpson, 1990): Like other *Protaetia* species, when alive, larvae crawl on their backs with their legs up, and they feel distinctly "squishy" rather than firm (a characteristic of coconut rhinoceros beetle [*Oryctes rhinoceros*] larvae). Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused, or nearly so. Clypeus with posterior row of 4 setae, 1 seta anteriorly at each margin. Labrum symmetrical; 1 large lateral seta posteriorly, 2 pairs of smaller setae centrally, 1 large anterolateral seta, apex with 8 setae, group of 3 smaller setae either side of apex. Terminal segment of antenna with 2 dorsal and 3 ventral spots. Claws of third leg large and cylindrical, with 5–8 hairs. 9th and 10th abdominal segments fused. Anal opening transverse, straight to slightly curved, palidium present.

Native range

Southeastern Asia. This beetle occurs across a vast stretch of the Indo-pacific region, occurring from India through China and southern Japan, into Indochina, the East Indies, and northern Australia (Woodruff, 2006). It is adventive in Florida, parts of the West Indies, Fiji, and Mauritius (Woodruff, 2006).

Plant host(s)

Like other *Protaetia* species, *P. fusca* is a generalist, with adults feeding upon the nectar, pollen, fruit, and sap of a number of plant species. Avocados (*Persea americana*), domestic roses (*Rosa* spp.), and peaches (*Prunus persica*) are attacked in Australia (Simpson, 1990). Elsewhere, African rattlebox (*Crotalaria saltiana),* bean tree (*Cassia brewsteri),* candle flower (*Cassia alata*), citrus (*Citrus spp*.), coconut palm *(Cocos nucifera),* corn (*Zea mays*), guava (*Psidium guajava*), longan (Dimocarpus *longan)*, lychee (*Litchi chinensis),* mango (*Mangifera indica*), orange jasmine (*Murraya paniculata),* pigeon pea (*Cajanus cajan),* poinciana tree (*Delonix regia),* solitaire palm (*Ptychosperma elegans),* and yellow ginger (*Hedychium flavescens)* are all recorded as hosts (Woodruff, 2006), though almost any nectar producing or commercial fruit bearing plant is likely at risk. Larvae are compost feeders and not known as plant pests (Simpson, 1990).

Life history

In Australia, both adults and larvae are found throughout the year. Females deposit as many as 147 eggs in humus during their 6–7 month adult lifespans. Larvae feed on organic materials within the soil rather than live plant roots and reached maturity in roughly 50 days. Natural enemies include wasps (*Scolia* spp.) that attack larvae, a variety of birds, and *Aspergillus fIavus* (a fungus that sometimes infects adults).

Pest potential

Significant. This species is a known and widespread pest. Beyond its native range, *Protaetia fusca* has spread widely and is known from the Bahamas, Barbados, Fiji, Florida, Guam, Hawaii, and Mauritius (Woodruff, 2006). Specimens are recorded from the Cook Islands (McCormack, 2007). Throughout its distribution, the beetle damages a wide range of plants, feeding on foliage, petals, nectar, pollen, and fruit. Beetles often damage flowers when foraging for nectar and pollen, sometimes completely severing the blossom (Woodruff, 2006). Destruction of the flower can reduce the abundance of fruits that the plant will later bear. Although this species prefers already damaged or overripe fruits, fruits may be damaged (as is case in some related *Protaetia* species) (LeBlanc et al., 2013). Interestingly, there are records of this beetle invading commercial bee hives for honey (Woodruff, 2006).

Status in Hawaii

Established. *Protaetia fusca* is found on all the major islands of Hawaii (Nishida, 2002). It occurs in both urban and rural areas where it can be common. It first arrived in the state in 1949 (Woodruff, 2006).

Status in Guam

Established. This species is established on Guam, with the earliest published record dating from 1954 (Pemberton, 1954).

Potential distribution and dispersal pathway

Protaetia fusca has already spread from Hawaii to the U.S. mainland. The beetle was first recorded in Florida in 1982 when it was found in moss around the roots of a Madagascar dragon tree (*Dracaena marginata*) imported from a nursery in Hawaii. A number of specimens were found in South Florida in the following years, often on or near citrus plants (Woodruff, 2006), and the species is now regarded as established (Thomas, 1998). There are reliable reports of this species from the Caribbean nations of Barbados and the Bahamas (Woodruff, 2006). Further, a number of specimens have been intercepted in the state of California (Gaimari, 2005). These specimens were found in cargo from Hawaii (Woodruff, 2006). While it is not clear if this beetle can survive winters in most of the contiguous U.S., it appears likely that this species will reach Puerto Rico and the U.S. Virgin Islands in the future. In addition to cargo and nursery stock, it is possible that this species might be transported in commercially exported fruit, given its frugivorous habits.

Similar species

This beetle is one of the three members of the genus *Protaetia* known from Hawaii and Guam. The remaining two species are *Protaetia orientalis* and *Protaetia pryeri*. These three species are separated by size (*P. fusca* 12.0–17.0 mm [0.47–0.67 in] versus *P. orientalis* and *P. pryeri* that are both over 19.0 mm [0.75 in]), examination of the elytral apices (*P. fusca* with apical spines in the male versus *P. orientalis* and *P. pryeri* always without apical spines), and hind tibia (*P. fusca* with single lateral ridge versus *P. orientalis* with two ridges).

Other names (synonyms)

Cetonia atomaria Fabricius, *Cetonia fictilis* Newman, *Cetonia fusca* Herbst, *Cetonia mandarina* Weber, *Heteroprotaetia fusca* Miksic, *Protaetia bourgoini* Paulian, *Protaetia mandarinea* Burmeister, *Protaetia taiwana* Niijima and Kinoshita

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Protaetia orientalis

Common name(s)

oriental flower beetle, Asian flower beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Cetoniinae **Genus**: *Protaetia* **Species**: *Protaetia orientalis* (Gory and Percheron, 1833)

Adult diagnosis

Total body length 19.9–26.8 mm (0.78–1.1 in). Body broadly oval; dorsoventrally flattened. Color shiny black, rarely shiny greenish; elytra with prominent to indistinct pale markings. Clypeus broad, anterior margin entire to sinuate. Front tibia of male with 2 or 3 external teeth (third tooth weak); female with 3 external teeth. Hind tibia with 2 lateral ridges. Elytra lacking apical spine in both sexes.

Larval diagnosis

Undescribed in English. For Cetoniinae (Ritcher, 1966): Like other *Protaetia* species, when alive, larvae crawl on their backs with their legs up, and they feel distinctly "squishy" rather than firm (a characteristic of coconut rhinoceros beetle [*Oryctes rhinoceros*] larvae). Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused, or nearly so. Labrum symmetrical. Claws of hind leg large, cylindrical, and hairy. Abdominal segments 9 and 10 fused. Anal opening transverse, straight to slightly curved.

Native range

East Asia. *Protaetia orientalis* is a native of East Asia (LeBlanc et al., 2013), ranging from China to Korea and Japan (Marler and Muniappan, 2006).

Plant host(s)

Adults of this species are generalist frugivores and are associated with the flowers and overripe or damaged fruit of 42 recorded plant species in 25 families (Ijima and Takeuchi, 2007). Commercially important among these are papaya (*Carica papaya*), coconut (*Cocos nucifera*), mango (*Mangifera indica*), banana (*Musa* spp.), sorghum (*Sorghum bicolor*), and corn (*Zea mays*). Additionally, the Asian flower beetle is known to opportunistically feed from sap flows (Ijima and Takeuchi, 2007). In Guam, this species is a minor pest of the endangered Micronesian cycad (*Cycas micronesica*) (Marler and Muniappan, 2006). Larvae are not plant pests and subsist on organic soil debris and compost (Kim et al., 2002), as is typical of many cetoniine scarab larvae (Ritcher, 1966).

Life history

(Kim et al., 2002): In Korea, adults are active from April until October, with peak abundance occurring in July and August. Larvae overwinter in the final instar, with pupation occurring in the following spring. The first larval instar lasts an average of 10.6 days, the second instar 18.7 days, the final instar 38.1 days, and pupation averaged 35.5 days. Female adults live an average of 135.2 days, during which an average of 82.8 eggs were laid. Larvae feed on organic soil debris. Adults of this species are diurnal and may be found feeding or actively flying at midday, particularly on warm, sunny days. It is not clear that Hawaiian or Guamanian populations of the Asian flower beetle show the same strong seasonal patterns that are observed in Korea. In Guam, museum specimens provide evidence that adults are found throughout the year.

Pest potential

Moderate. Like the Midway emerald beetle (*Protaetia pryeri*), this species can often be found in large feeding aggregations on fruit. While the sight of these aggregations may be alarming for plant owners, they rarely cause significant damage to healthy fruit; instead, beetles prefer overripe or already damaged fruits, perhaps attracted to the odors of fermentation (LeBlanc et al., 2013). Beetles are, however, capable of causing a degree of mechanical damage to surrounding healthy fruits or flowers with their sharp tarsal claws when they clamber towards fruit (LeBlanc et al., 2013).

Status in Hawaii

Established. The first record of this species dates to 1952, when a live specimen was found on an aircraft flying into Hickam Air Force Base from Japan (Hawaiian Entomological Society, 1952A). USDA APHIS records show further quarantine interceptions from Air Force aircraft arriving from Andersen Air Force Base in Guam in the 1980's and 90's (Moore, 2012). However, populations did not become established on Oahu until 2002. The species reached Maui in 2010 and Big Island in 2013 (LeBlanc et al., 2013).

Status in Guam

Established. This species has been present in Guam since the 1970's (LeBlanc et al., 2013) and is now one of the more common and visible scarabs on the island.

Potential distribution and dispersal pathway

Adults of this species have an established history of hitchhiking aboard military aircraft (Moore, 2012). As such, United States Air Force bases in California and Florida should be regarded as very likely sites of future introductions. Indeed, in California this species was intercepted in quarantine at San Mateo in 2003 (Gaimari, 2005) and is now regarded as a class A pest species (Cosner, 2013). Further, because adults are attracted to fermenting fruits and nectar-bearing flowers, it is possible that the *Protaetia orientalis* could hitchhike on nursery plants. Adults could also be accidentally spread in shipments of commercially grown fruits.

Similar species

This beetle is one of the three species in the genus *Protaetia* known from Hawaii and Guam. The remaining two species are *Protaetia pryeri* and *Protaetia fusca*. These three species are separated by size (*P. orientalis* at 19.9–26.8 mm [0.78–1.1 in] versus *P. fusca* at 12.0–17.0 mm [0.47–0.67 in]), examination of the elytral apices (*P. orientalis* and *P. pryeri* always without apical spines versus *P. fusca* with apical spines in the male), and hind tibia (*P. orientalis* with 2 lateral ridges versus *P. fusca* and *P. pryeri* with a single lateral ridge).

Other names (synonyms)

Cetonia orientalis Gory and Percheron, *Calopotosia orientalis* (Gory and Percheron), *Protaetia aereta* Erichson, *Protaetia speculifera* Schauman

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Protaetia pryeri

Common name(s)

Midway emerald beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Cetoniinae **Genus**: *Protaetia* **Species**: *Protaetia pryeri* (Janson, 1888)

Adult diagnosis

Total body length 19.0–28.0 mm (0.75–1.1 in). Body broad oval; dorsoventrally flattened. Color shiny bright green, rarely shiny olive-green, lacking pale markings. Clypeus broad, anterior margin entire to sinuate. Front tibia of male with 2 or 3 external teeth (third tooth weak); female with 3 external teeth. Hind tibia with single lateral ridge. Elytra lacking apical spine in both sexes.

Larval diagnosis

Undescribed. For Cetoniinae (Ritcher, 1966): Like other *Protaetia* species, when alive, larvae crawl on their backs with their legs up, and they feel distinctly "squishy" rather than firm (a characteristic of coconut rhinoceros beetle (*Oryctes rhinoceros*) larvae). Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused, or nearly so. Labrum symmetrical. Claws of hind legs large, cylindrical and hairy.

9th and 10th abdominal segments fused. Anal opening transverse, straight to slightly curved.

Native range

Japan. In Japan this species is found on Okinawa and the Ryuku Islands (Arakaki, et al. 2009).

Plant host(s)

Adults of this species are associated with the overripe or damaged fruit of a number of plant species. These plants include papaya (*Carica papaya*), guava (*Psidium guajava*), and wax apple (*Syzygium samarangense*) (Arakaki, et al. 2009). While only a handful of plants have been formally described as hosts, it is likely that this beetle, like the related *Protaetia orientalis*, is a generalist frugivore capable of damaging a wide range of fruit species (Ijima and Takeuchi, 2007). *Protaetia pryeri* is also known to visit flowers for nectar and pollen (Nishida and Beardsley, 2002) and may visit sap flows like *Protaetia orientalis* (Ijima and Takeuchi, 2007). While it has been suggested that larvae of this beetle may attack plant roots (Nishida and Beardsley, 2002), this is not typical of cetoniine scarabs (Ritcher, 1966), and related species are known to subsist entirely on organic soil debris and compost (Gujarathi and Pejaver, 2014).

Life history

On Midway Island, larvae were found in organic-rich soils, particularly near ironwood (*Casuarina* species) or occasionally naupa-ka (*Scaevola* species) (Nishida and Beardsley, 2002). Adults emerged beginning in April, with numbers declining until December.

Pest potential

Moderate. Like the Asian flower beetle (*Protaetia orientalis*), this species is often noticed in large feeding aggregations on fruit. While the sight of these aggregations may be alarming for plant owners, beetles rarely cause significant damage to healthy fruit (LeBlanc et al., 2013). Instead, beetles prefer overripe or already damaged fruit, perhaps attracted to the odors of fermentation (LeBlanc et al., 2013). Beetles are, however, capable of causing minor damage to surrounding healthy fruits or flowers with their sharp tarsal claws when they clamber towards target fruit (LeBlanc et al., 2013).

Status in Hawaii

Recorded, not established. Although not yet known from the main Hawaiian Islands, this species is established on Midway (Nishida and Beardsley, 2002), where it is sometimes abundant.

Status in Guam

Established. This beetle was first recorded on Guam in 1990 and has since become one of the island's most conspicuous scarab species (Moore, 2010).

Potential distribution and dispersal pathway

In Japan, this species has been found aboard marine vessels (National Institute for Environmental Studies, 2014). Further, because adults are attracted to fermenting fruits and nectar-bearing flowers, it is possible that *Protaetia pryeri* could hitchhike on nursery plants. Adults could also be accidentally spread in shipments of commercially grown fruits.

Similar species

This beetle is one of the three species in the genus *Protaetia* known from Hawaii and Guam. The remaining two species are the *Protaetia pryeri* and *Protaetia fusca*. These three species are separated by size (*P. orientalis* at 19.9–26.8 mm [0.78–1.1 in] versus *P. fusca* at 12.0–17.0 mm [0.47–0.67 in]), examination of the elytral apices (*P. orientalis* and *P. pryeri* always without apical spines versus *P. fusca* with apical spines in the male), and hind tibia (*P. orientalis* with 2 lateral ridges versus *P. fusca* and *P. pryeri* with a single lateral ridge).

Other names (synonyms)

Cetonia pryeri Janson, *Protaetia nitidicosta* Yawata, *Protaetia okinavana* Miksic, *Pyropotosia pryeri* Reitter

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Temnorhynchus retusus

Common name(s)

plate-faced beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Temnorhynchus* **Species**: *Temnorhynchus retusus* (Fabricius, 1781)

Adult diagnosis

Total body length 16.0–20.0 mm (0.63–0.79 in). Body wide, oval-shaped. Color black. Head lacking horns or tubercles; with distinctive cranial "face" plate; cranial plate notched medially, more deeply notched in males than females. Pronotum with anteromedial concavity in male; female pronotum lacking concavity; pronotum lacking horns or tubercles. Elytra weakly striated.

Larval diagnosis

Undescribed. For *Dynastinae* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well developed unci. Maxillary stridulatory teeth truncate. Legs 4-segmented. Anal opening transverse, straight or slightly curved. Plegmatia absent.

Native range

Africa. This species is best known from southern Africa, where it has been recorded in South Africa, Namibia, and Lesotho. Isolated records also exist from Sudan, Eritrea, and Tanzania (Krell, 1993).

Plant host(s)

Adults and larvae of *Temnorhynchus retusus* are associated with grasses (Krell and Hangay, 1998). In Hawaii, adults have been found on the saline-tolerant turf species, seashore paspalum (*Paspalum vaginatum*) (Jameson et al., 2009). In South Africa, this species has been recorded damaging potatoes (Visser and Stals, 2012).

Life history

Poorly known. In Australia, adults of *Temnorhynchus retusus* are most abundant in September (Jameson et al., 2009) and are often found in or near watered, grassy areas in suburban and urban settings (Krell and Hangay, 1998). Both larvae and adults of this species appear to feed upon grasses (Krell and Hangay, 1998). It is likely that this species, like other Dynastinae, lays eggs in soil where larvae then feed on plant roots (Visser and Stals, 2012).

Pest potential

Minor. Though this species is closely associated with grasses (Krell and Hangay, 1998), it is not a significant grass pest in either horticultural or agricultural systems. The only record of this species causing appreciable damage comes from South Africa, where it has been associated with damage to potato tubers (Visser and Stals, 2012). This species does have a history of establishment beyond its native range, having spread to Australia in the 1980's (Krell and Hangay, 1998).

Status in Hawaii

Possibly established. In Hawaii, this species is known only from Big Island where it was found at Mauna Lani in Waikoloa in 2007 (Jameson et al., 2009).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

Adults of this species rarely come to lights (Krell and Hangay, 1998). It is likely that transportation occurs in the egg or larval stage, with immatures being moved with pallets of soil, in commercial turf, or around the roots of potted plants (Jameson et al., 2009).

Similar species

This scarab is superficially similar to the *Tomarus* species and the taro beetles (*Papuana* spp.) in color and size. However, the presence of the cranial plate is unique to *Temnorhynchus retusus* and easily separates it from all other scarabs recorded from Hawaii or Guam.

Other names (synonyms)

Scarabaeus retusus Fabricius

Tomarus subtropicus

Common name(s)

sugarcane beetle, sugarcane grub

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Tomarus* **Species**: *Tomarus subtropicus* (Blatchley, 1922)

Adult diagnosis

Total body length 20.0–26.0 mm (0.79–1.02 in). Body oblong. Color shiny black. Clypeus constricted towards parabolic apex; apex with 2 close-set, apical teeth. Head lacking weak, transverse ridge on disc; without horns or tubercles. Pronotum with small tubercle near anterior margin; distinct fovea present behind apical tubercle. Apex of last sternite emarginated in male, quadrate in female.

Larval diagnosis

For Tomarus (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well developed unci. Maxillary stridulatory teeth truncate. Inner, concave surface of mandible, distad of molar area, toothed. Dorsal surface of the last antennal segment with 2–5 sensory spots. Legs 4-segmented. Anal opening straight or slightly curved. Plegmatia absent.

Native range

Southeastern U.S. This species is found from North Carolina south through Florida and east to Alabama (Buss, 2003).

Plant host(s)

In its native range, larvae of this species are well-documented pests of sugarcane and turf grasses (Buss, 2003). Kostromytska and Buss (2011) investigated the suitability of different turf grasses as larval host plants. They found that the warm season turf grasses including palmetto saint augustine grass (*Stentaphrum secundatum*), 'tifway' bermuda grass (*C. dactylon* x *transvaalensis*), 'empire' zoysia grass (*Zoysia japonica*), common centipede grass (*Erimochloa ophiuroides*),'pensacola' bahia grass (*Paspalum notatum*), and 'sea dwarf' seashore paspalum (*Paspalum vaginatum*) were all suitable hosts. However, larvae failed to thrive on the cool season turf grasses including 'gulf' annual ryegrass (*Lolium multiflorum*).

Life history

In Florida, there is a single generation each year. Adults are active April through June, with numbers peaking in May and June when eggs are laid (Buss, 2003). The final instar is found from October to April. Pupation takes place in a subterranean pupal cell (Buss, 2003). Females of this species strongly prefer to lay eggs in "mucky" organic rich soils. Larvae are rarely found in sandy sites (Cherry and Coale, 1994).

Pest potential

Significant. Larvae of this species are serious and destructive pests of grasses (Buss, 2003). In Florida, *Tomarus subtropicus* is the single most important scarab pest of sugarcane and is able to reduce yields by more than a third (Cherry and Coale, 1994). The species also damages a variety of turf grasses (Kostromytska and Buss, 2011).

Status in Hawaii

Not established or recorded. There are no records of this species from Hawaii.

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

Because larvae feed on turf roots, it is possible that larvae or eggs could be transported in shipments of commercial turf. Other *Tomarus* species are known to fly to lights at night (Ratcliffe and Paulsen, 2008), and it is likely that this beetle is attracted to well-lit ports and airports. This would allow for hitchhiking on marine and air cargo.

Similar species

This species is similar to the carrot beetle (*Ligyrus gibbosus*) recorded on Oahu and the potential future invaders, the taro beetles (*Papuana* spp.). It can be separated from those scarabs by examination of the head (*T. subtropicus* without horns or tubercles versus *Papuana* spp. that often possess horns or tubercles), central disc of the head (*T. subtropicus* lacking a transverse ridge versus a weak, transverse ridge in *L. gibbosus*), clypeal apex (*T. subtropicus* clypeus constricted with 2 close-set apical teeth versus clypeus broad, never with 2 close-set apical teeth in *Papuana* spp.), color (*T. subtropicus* is shiny black versus reddish-brown in *L. gibbosus*), and size (*T. subtropicus* is 20.0–26.0 mm [0.79–1.02 in] versus *L.. gibbosus* at 11.6–16.5 mm [0.46–0.65 in]).

Other names (synonyms)

Ligyrus subtropicus Blatchley

Trox scaber

Common name(s)

hide beetle

Taxonomy

Family: Trogidae **Subfamily**: Troginae **Genus**: *Trox* **Species**: *Trox scaber* (Linnaeus, 1767)

DNA barcode

DNA barcode available: specimen information; sequence data

Adult diagnosis

Total body length 5.0–7.0 mm (0.19–0.28 in). Body shape oval (dorsal view), surface rough and warty, often dirt encrusted. Venter flat, dorsum convex (lateral view). Color dark grey-brown. Pronotum with base weakly sinuate, basal angle quadrate. Scutellum rounded, never hastate. Elytra with patches of short, reddish-brown hairs. Middle tibia lacking numerous fine teeth along outer margin.

Larval diagnosis

Undescribed. For *Trox* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, whitish. Maxilla with galea and lacinia distinctly separated. Antennae with 3 segments, with distal sensory cone on second segment. Distal segment of antennae much reduced in size. Epipharynx with tormae united mesally. Legs 4-segmented, never with stridulatory organ. Spiracles of thorax and abdomen biforous.

Native range

Holarctic, Australia, southern South America. *Trox scaber* is widely distributed across the temperate Northern and Southern Hemispheres (Zidek, 2013). It is widely distributed in the Palearctic, from the Canary Islands and North Africa eastward to Siberia. In North America, this species occurs from southern Canada through the northern half of the contiguous U.S. (Ratcliffe and Paulsen, 2008). In the Southern Hemisphere, the species is known from Australia and Argentina, and recorded (but not thought established) in Chile (Zidek, 2013).

Plant host(s)

None. Both adults and larvae of this species feed on late stage carrion and other dry animal remains, thus posing no threat to crops or ornamental plants.

Life history

Both adults and larvae of this species feed on feathers, hair, and other dry animal remains. These remains may consist of debris in mammal burrows, bird nest debris, dry carrion, or regurgitated owl pellets (Ratcliffe and Paulsen, 2008). Females lay eggs in batches of 3 or 4, burying them 1–3 mm (0.4–1.2 in) beneath an animal carcass. Larvae emerge from eggs after 8 or 9 days and begin feeding. Pupation occurs in a cell beneath the feeding site. It appears that only a single generation is produced per year, with overwintering occurring in the adult stage (Baker, 1966), though it is unclear that this is true of Hawaiian populations. In Nebraska, adults of this species have been found from April through September (Ratcliffe and Paulsen, 2008). This species is known to be attracted to lights at night (Hawaiian Entomological Society, 1977) and is likely nocturnal.

Pest potential

None. This species recycles carrion and poses no threat to crop or ornamental plants.

Status in Hawaii

Established. *Trox scaber* first arrived to Hawaii around 1900, first being recorded near Hilo on Big Island. To date, this species appears confined to Big Island, with most specimens found at lights (Hawaiian Entomological Society, 1977; Nishida, 2002).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

In Hawaii, this species may have first arrived in marine cargo, though this is speculation This species is native to the U.S. (Ratcliffe and Paulsen, 2008), thus it does not pose a threat in the contiguous U.S.

Similar species

Trox scaber is one of three hide beetles (Trogidae) known from Hawaii and Guam. The other two species are *Omorgus procerus* and *O. suberosus*. These species are separated by size (*T. scaber* at 5.0–7.0 mm [0.19–0.28 in] versus *O. suberosus* and *O. procerus* both over 10.0 mm [0.39 in]) and by examining the pronotum (*T. scaber* with the pronotal base weakly sinuate and basal angle quadrate versus *O. suberosus* and *O. procerus* with pronotal base scalloped and the basal angle obtuse), scutellum (*T. scaber* with scutellum rounded versus *O. suberosus* and *O. procerus* both with scutellum hastate), and middle tibia (*T. scaber* without middle tibia lacking numerous fine teeth along lateral margin versus *O. procerus* with numerous, fine teeth).

Other names (synonyms)

Silpha scabra Linnaeus, *Trox barbosus* von Laicharting, *Trox arenarius* Fabricius, *Trox hispidus* von Paykull, *Trox trisulcatus* Curtis, *Trox niponensis* Lewis

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Trypoxylus dichotomus

Common name(s)

Japanese rhinoceros beetle, Japanese horned beetle, Japanese elephant beetle

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Trypoxylus* **Species**: *Trypoxylus dichotomus* (Linnaeus, 1771)

Adult diagnosis

Total body length 40.0–80.0 mm (1.57–3.15 in) including horns. Body shape oblong. Color dull, dark brown to near black. Head of major male with large doubly bifurcate horn (ending in 4 points); minor male with horns reduced; female with 3 tubercles, but lacking horn. Ocular canthus acutely produced in both sexes. Pronotum of male with bifurcate horn; female with distinct fovea, lacking horn.

Larval diagnosis

Undescribed in English. For *Dynastinae* (Ritcher, 1966): Grub C-shaped, not hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well-developed unci. Maxillary stridulatory teeth truncate. Legs 4-segmented. Anal opening transverse, straight or slightly curved. Plegmatia absent.

Native range

East Asia. This species is found in Japan, Korea, Taiwan, and China (Bouchard, 2014).

Plant host(s)

Adults of this species feed on the sap of a number of tree species including bao li (*Quercus serrata*), evergreen ash (*Fraxinus griffithii*), Mongolian oak (*Quercus mongolica*), and sawtooth oak (*Quercus acutissima*) (Hongo, 2006).

Life history

In Japan, adults are active in June and July (Hongo, 2003). Adults congregate at sap flows at night to mate and feed, but if pre-existing flows are not available, then adults may strip bark to create a temporary sap flow (Hongo, 2006). Male competitions for females are well documented, with major males using their horns to attempt to physically pry and flip one another from tree trunk feeding and breeding sites (Hongo, 2003). Eggs are laid in humus, and larvae feed on soil detritus after emerging. Larval development continues until temperatures drop in autumn; winter diapause usually occurs in the final instar. In spring, larvae resume feeding and pupate before emerging as adults (Hongo, 2003).

Pest potential

Minor. Adults preferentially feed upon pre-existing sap flows but may strip bark from trees to create temporary sap flows (Hongo, 2006) causing minor damage. Larvae of this species are not associated with living plants, instead feeding upon soil detritus (Hongo, 2003).

Status in Hawaii

Recorded, not established. This species has been recorded from Oahu (Nishida, 2002) where a single adult male was found alive at Waikiki in 1973 (USDA, 1973). It was suggested that the specimen may have been intentionally brought into Hawaii as a pet (USDA, 1973).

Status in Guam

Not established or recorded. There are no records of this species from Guam.

Potential distribution and dispersal pathway

This species is attracted to lights at night and could be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. It is worth noting these beetles are popular pets in East Asia (Bouchard, 2014), and intentional transportation may be the most likely means of this species reaching Hawaii or Guam.

Similar species

This massive scarab could be confused with the related elephant (or rhinoceros) beetles of the genus *Xylotrupes*. *Trypoxylus dichotomus* is separated from *Xylotrupes* by examining the male head horn (*T. dichotomus* with horn doubly bifurcate [ending in four points] versus *Xylotrupes* with horn bifurcate [ending in two points]), ocular canthus in male and female (*T. dichotomus* with canthus rounded or quadrate, not acutely produced versus *Xylotrupes* with acutely produced canthus), and female pronotum (*T. dichotomus* with a distinct fovea versus *Xylotrupes* lacking a fovea).

Other names (synonyms)

Allomyrina dichotomus (Linnaeus), *Scarabaeus dichotomus* Linnaeus, *Xylotrupes dichotomus* (Linnaeus)

Xylotrupes

Common name(s)

rhinoceros beetles, elephant beetles

Taxonomy

Family: Scarabaeidae **Subfamily**: Dynastinae **Genus**: *Xylotrupes*

Adult diagnosis

The elephant (or rhinoceros) beetles of the genus *Xylotrupes* are large scarabs ranging in body length between 30.0–80.0 mm (1.18–3.15 in). Members of the genus are uniformly shiny black in color. Males have large bifurcate horns projecting from both the head and pronotum. Females lack the horns of the male (though sometimes have a weak tubercle) and have a rough, rugose pronotal surface without an anterior fovea. Both sexes lack the acutely produced ocular canthus observed in the related *Trypoxylus* scarabs; instead, the ocular canthus is rounded or quadrate.

Larval diagnosis

For *Xylotrupes ulysses* (Bedford, 1974): Grub C-shaped, not hump-backed, cylindrical, cream-colored. Maxilla with galea and lacinia fused or nearly so. Lacinia of maxilla with 3 well-developed unci. Maxillary stridulatory area with 11 or 12 blunt teeth. Left mandible with prominent tooth between molar and scissorial regions. Anterior frontal angle with 3–6 setae. Last antennal segment with 11–18 dorsal sensory spots. Thoracic spiracles pyriform. Legs 4-segmented. Claws each with 3 or four long setae. Raster with teges of 40–80 short, sharp setae, surrounded by longer setae. Lower anal lip with 80–130 short, sharp setae with caudal border of 100–130 longer setae. Anal opening transverse, straight to slightly curved. Plegmatia absent.

Native range

Asia and Australia. Species in the genus *Xylotrupes* have been recorded from Sri Lanka, India, Nepal, Bhutan, Burma, Indochina, China, the Philippines, Malaysia, Indonesia, Australia, Papua New Guinea, the Solomon Islands, and Vanuatu (Rowland, 2003).

Plant host(s)

Members of this genus feed upon the bark, sap, and flowers of crops such as coconut (*Cocos nucifera*), cacao (*Theobroma cacao*) (Bedford, 1975), guava (*Psidium guajava*) (Firake et al, 2013), and okra (*Abelmoschus esculentus*) (Nair et al., 2001). They also have been reported feeding upon ornamental plants including hoop pine (*Araucaria cunninghamii*), rudraksha (*Elaeocarpus sphaericus*), rainbow eucalyptus (*Eucalyptus deglupta*), flame tree (*Delonix regia*), ash (*Fraxinus* spp.), jacaranda (*Jacaranda mimosifolia*), raintree (*Samanea* spp.), and mahogany (*Toona australis*) (Bedford, 1975).

Life history

Elephant beetle larvae develop in moist humus, rotten wood, or compost. In New Guinea, larvae frequently occur under logs and rotting wood, particularly coconut (Bedford, 1974). In captivity, the egg stage lasted an average of 21 days before larval emergence, the first instar lasted 20 days, the second instar lasted 24 days, and the third instar lasted 144 days (Bedford, 1975). The pre-pupal stage lasted 14 days, with adults emerging from the true pupa after 32 days. Adult females lived 102 days, slightly longer than the 90-day adult lifespan of males. Adults are attracted to lights (Firake et al., 2013) and are likely nocturnal (Bedford, 1975). Adults often congregate at feeding locations where competition for mates takes place (Monteith, 2011).

Pest potential

Minor. While members of this genus are known to feed on commercially important plants, damage is rarely significant (Monteith, 2011). Guava fruits (Firake et al, 2013) and okra pods (Nair et al., 2001) are both recorded as being damaged by *Xylotrupes* species. These scarabs also cause occasional damage to palms, but reports of elephant beetles severely damaging palm fronds are likely due to misidentification with somewhat similar looking palm pests, the coconut rhinoceros beetle (*Oryctes rhinoceros*) and *Scapanes australis,* the Melanesian rhinoceros beetle (Bedford, 1975).

Status in Hawaii

Recorded, not established. This genus has been recorded once in Hawaii. In 1951, a single specimen was collected by a flight attendant in the cabin of a commercial aircraft flying to Honolulu from the Philippines (Hawaiian Entomological Society, 1952B).

Status in Guam

Not established or recorded. There are no records of this genus from Guam.

Potential distribution and dispersal pathway

Species of *Xylotrupes* are attracted to lights at night (Firake et al., 2013) and could be attracted to well-lit ports and airports. This would allow for hitchhiking on marine or air cargo. Indeed, the specimen recorded in 1951 was found aboard an aircraft. It is worth noting these beetles are popular pets in East Asia (Bouchard, 2014), and intentional transportation may be the most likely means of this species reaching Hawaii or Guam.

Similar species

These massive scarabs are unlikely to be confused with any other beetle recorded from Hawaii or Guam with the exception of the related Japanese rhinoceros beetle (*Trypoxylus dichotomus*). These scarab beetles may be separated by examining the male head horn (*Xylotrupes* with horn bifurcate [ending in two points] versus *T. dichotomus* with horn doubly bifurcate [ending in four points]), ocular canthus in male and female (*Xylotrupes* with the canthus rounded or quadrate versus *T. dichotomus* with an acutely produced canthus), and female pronotum (*Xylotrupes* lacking a fovea versus *T. dichotomus* with distinct pronotal fovea).

Other names (synonyms)

Scarabaeus gideon (Linnaeus)

Special note

The 1951 specimen was originaly identified as *Xylotrupes gideon.* However *X. gideon* has since been split into a number of species, with more than one occuring in the Phillipines. As such it is impossible to make a species level identification for the Hawaiian record without examining the original specimen.

Chapter 4

CONCLUSIONS

Successfully screening for diverse groups such as the Scarabaeoidea requires both a degree of familiarity with insect taxonomy and access to usable identification tools. The "Scarab and Stag Beetles of Hawaii and the Pacific" identification tool offers identifiers and screeners from USDA PPQ, the Hawaii Department of Agriculture, and other end users a means of efficiently and accurately identifying scarabaeoid beetles. It provides a single resource where Hawaiian and Guamanian scarabs are treated as a discrete fauna despite their worldwide origins. This eliminates the time wasting necessity of looking for various keys and taxonomic resources (in many languages) that cover only a small number Hawaiian scarab species. It also aids end users by providing succinct, up-to-date supporting information that is useful for species-level identification. Further, because the tool is easily edited, it can be up-dated as new species inevitably continue to arrive to the American Pacific and could potentially be scaled to include other US or world regions.

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APPENDIX

APPENDIX

CHECKLISTS TO SCARABAEOIDEA OF HAWAII AND GUAM

TABLE 1

CHECKLIST TO SCARABAEOIDEA OF HAWAII

	Family	Subfamily	Tribe	Species	Author	Status
1	Lucanidae	Lucaninae		*Apterocyclus honoluluensis*	Waterhouse, 1871	native
2	Lucanidae	Lucaninae		*Apterocyclus kawaii*	Paulson & Hawks, 2014	native
3	Lucanidae	Lucaninae		*Apterocyclus munroi*	Sharp, 1908	native, possibly
4	Lucanidae	Lucaninae		*Apterocyclus palmatus*	Van Dyke, 1921	native, possibly
5	Lucanidae	Lucaninae		*Apterocyclus waterhousei*	Sharp, 1908	native
6	Scarabaeidae	Aphodiinae	Aphodiini	*Aphodius fimetariu*	(Linnaeus, 1758)	intentionally imported
7	Scarabaeidae	Aphodiinae	Aphodiini	*Aphodius lividus*	(Olivier, 1789)	adventive
8	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius cognatus*	(Le Conte, 1859)	adventive
9	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius pacificus*	(Sharp, 1879)	adventive
10	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius peregrinato*	Harold, 1877	adventive
11	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius puncticolli*	(Le Conte, 1859)	adventive
12	Scarabaeidae	Aphodiinae	Eupariini	*Saprosites pygmaeus*	Harold, 1877	adventive
13	Scarabaeidae	Aphodiinae	Psammodiini	*Platytomus hawaiiensis*	(Rakovic 1981)	adventive
14	Scarabaeidae	Aphodiinae	Psammodiini	*Pleurophorus micros*	(Bates, 1887)	adventive
15	Scarabaeidae	Aphodiinae	Psammodiini	*Pleurophorus parvulus*	(Chevrolat, 1864)	adventive
16	Scarabaeidae	Cetoniinae	Cetoniini	*Protaetia fusca*	(Herbst, 1790)	adventive
17	Scarabaeidae	Cetoniinae	Cetoniini	*Protaetia orientalis*	(Gory & Percheron, 1833)	adventive
18	Scarabaeidae	Cetoniinae	Cetoniini	*Protaetia pryeri*	(Janson, 1888)	adventive
19	Scarabaeidae	Cetoniinae	Gymnetini	*Cotinis mutabilis*	(Gory and Percheron, 1833)	quarantine
20	Scarabaeidae	Dynastinae	Cyclocephalini	*Cyclocephala pasadenae*	Casey, 1915	adventive
21	Scarabaeidae	Dynastinae	Dynastini	*Trypoxylus dichotomus*	(Linnaeus, 1767)	intentionally imported?
22	Scarabaeidae	Dynastinae	Dynastini	*Xylotrupes gideon?*	(Linnaeus, 1771)	quarantine
23	Scarabaeidae	Dynastinae	Oryctini	*Oryctes rhinoceros*	(Linnaeus, 1758)	adventive
24	Scarabaeidae	Dynastinae	Pentodontini	*Ligyrus gibbosus*	(De Geer, 1774)	quarantine

25	Scarabaeidae	Dynastinae	Pentodontini	*Temnorhynchus retusus*	Fabricius, 1781	adventive
26	Scarabaeidae	Melolonthinae	Melolonthini	*Phyllophaga ephilida*	(Say, 1825)	quarantine
27	Scarabaeidae	Melolonthinae	Sericini	*Maladera castanea*	(Arrow, 1913)	adventive (not
28	Scarabaeidae	Melolonthinae	Sericini	*Maladera japonica*	(Motschulsky, 1860)	quarantine
29	Scarabaeidae	Rutelinae	Adoretini	*Adoretus compressus*	(Weber, 1801)	adventive
30	Scarabaeidae	Rutelinae	Adoretini	*Adoretus sinicus*	Burmeister, 1855	adventive
31	Scarabaeidae	Rutelinae	Anomalini	*Anomala albopilosa*	(Hope, 1839)	quarantine
32	Scarabaeidae	Rutelinae	Anomalini	*Anomala cuprea*	(Hope, 1839)	quarantine
33	Scarabaeidae	Rutelinae	Anomalini	*Anomala orientalis*	(Waterhouse, 1875)	adventive
34	Scarabaeidae	Rutelinae	Anomalini	*Anomala sulcatula*	Burmeister, 1844	adventive, extirpated?
35	Scarabaeidae	Rutelinae	Anomalini	*Anomala viridana*	(Kolbe, 1886)	quarantine
36	Scarabaeidae	Rutelinae	Anomalini	*Popillia japonica*	Newman, 1838	quarantine
37	Scarabaeidae	Rutelinae	Anomalini	*Popillia lewisi*	Arrow, 1913	quarantine
38	Scarabaeidae	Scarabaeinae	Ateuchini	*Ateuchus lecontei*	(Harold, 1874)	intentionally imported
39	Scarabaeidae	Scarabaeinae	Canthonini	*Canthon humectus*	(Say, 1832)	intentionally imported
40	Scarabaeidae	Scarabaeinae	Canthonini	*Canthon indigaceus*	Harold, 1868	intentionally imported, not established
41	Scarabaeidae	Scarabaeinae	Canthonini	*Canthon pilularius*	(Linnaeus, 1758)	intentionally imported
42	Scarabaeidae	Scarabaeinae	Canthonini	*Canthon viridis*	(Palisot de Beauvois, 1805)	intentionally imported, not established
43	Scarabaeidae	Scarabaeinae	Coprini	*Catharsius molossus*	(Linnaeus, 1758)	intentionally imported, not established
44	Scarabaeidae	Scarabaeinae	Coprini	*Copris incertus*	Say, 1835	intentionally imported
45	Scarabaeidae	Scarabaeinae	Coprini	*Copris remotus*	Le Conte, 1866	intentionally imported, not established
46	Scarabaeidae	Scarabaeinae	Coprini	*Dichotomius carolinus*	(Linnaeus, 1767)	intentionally imported, not established
47	Scarabaeidae	Scarabaeinae	Coprini	*Euoniticellus africanus*	(Harold, 1873)	intentionally imported
48	Scarabaeidae	Scarabaeinae	Coprini	*Euoniticellus intermedius*	(Reiche, 1847)	intentionally imported
49	Scarabaeidae	Scarabaeinae	Oniticellini	*Oniticellus cinctus*	(Fabricius, 1775)	intentionally imported?
50	Scarabaeidae	Scarabaeinae	Oniticellini	*Oniticellus militaris*	(Laporte Comte de Castelau, 1840)	intentionally imported
51	Scarabaeidae	Scarabaeinae	Onitini	*Onitis alexis*	Klug, 1835	intentionally imported
52	Scarabaeidae	Scarabaeinae	Onitini	*Onitis phartopus*	Lansberge, 1875	intentionally imported, not established
53	Scarabaeidae	Scarabaeinae	Onitini	*Onitis vanderkelleni*	Lansberge, 1886	intentionally imported

54	Scarabaeidae	Scarabaeinae	Onthophagini	*Digitonthophagus gazella*	(Fabricius, 1787)	intentionally imported
55	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus binodis*	(Thunberg, 1818)	intentionally imported
56	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus comperei*	Blackburn, 1903	intentionally imported, not established
57	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus cuniculus*	MacLeay, 1866	intentionally imported, not established
58	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus foliaceus*	Lansberge, 1886	intentionally imported, not established
59	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus granulatus*	Boheman, 1858	intentionally imported, not established
60	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus incensus*	Say, 1835	intentionally imported
61	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus laminatus*	MacLeay, 1866	intentionally imported, not established
62	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus nigriventris*	D'Orbigny, 1905	intentionally imported
63	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus nuchicornis*	(Linnaeus, 1758)	intentionally imported, not established
64	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus oklahomesis*	Brown, 1927	intentionally imported
65	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus sagittarius*	(Fabricius, 1775)	intentionally imported
66	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus tuberculifrons*	Harold, 1871	intentionally imported
67	Scarabaeidae	Scarabaeinae	Phanaeini	*Phanaeus daphnis*	Harold, 1863	intentionally imported, not established
68	Scarabaeidae	Scarabaeinae	Sisyphini	*Neosisyphus*	Thunberg, 1818	intentionally imported, not established
69	Trogidae			*Omorgus procerus*	(Harold, 1872)	adventive
70	Trogidae			*Omorgus suberosus*	(Fabricius, 1775)	intentionally imported, not established
71	Trogidae			*Trox scaber*	(Linnaeus, 1767)	adventive

TABLE 2

CHECKLIST TO SCARABAEOIDEA OF GUAM

	Family	Subfamily	Tribe	Species	Author	Status
1	Lucanidae	Lucaninae	Figulini	*Figulus integricollis*	Thomson, 1862	native
2	Lucanidae	Lucaninae	Figulini	*Figulus lilliputanus*	Westwood, 1855	quarantine?
3	Scarabaeidae	Aphodiinae	Aphodiini	*Aphodius lividus*	(Olivier, 1789)	adventive
4	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius cognatus*	(Le Conte, 1859)	adventive
5	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius nocturnus*	(Nomura, 1943)	adventive
6	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius orbicularis*	Schmidt, 1914	adventive
7	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius pacificus*	(Sharp, 1879)	adventive

8	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius peregrinator*	Harold, 1877	adventive
9	Scarabaeidae	Aphodiinae	Eupariini	*Ataenius yasumatsui*	Nomura, 1943	native
10	Scarabaeidae	Aphodiinae	Eupariini	*Saprosites pygmaeus*	Harold, 1877	adventive
11	Scarabaeidae	Cetoniinae	Cetoniini	*Protaetia fusca*	(Herbst, 1790)	adventive
12	Scarabaeidae	Cetoniinae	Cetoniini	*Protaetia orientalis*	(Gory & Percheron, 1833)	adventive
13	Scarabaeidae	Cetoniinae	Cetoniini	*Protaetia pryeri*	(Janson, 1888)	adventive
14	Scarabaeidae	Dynastinae	Oryctini	*Oryctes rhinoceros*	(Linnaeus, 1758)	adventive
15	Scarabaeidae	Melolonthinae	Melolonthini	*Holotrichia bipunctata*	(Brenske, 1892)	adventive
16	Scarabaeidae	Melolonthinae	Melolonthini	*Lepidiota carolinensis*	(Arrow, 1939)	native
17	Scarabaeidae	Melolonthinae	Melolonthini	*Microserica guamensis*	(Gordon, 1971)	adventive?
18	Scarabaeidae	Rutelinae	Adoretini	*Adoretus sinicus*	Burmeister, 1855	adventive
19	Scarabaeidae	Rutelinae	Anomalini	*Anomala sulcatula*	Burmeister, 1844	adventive
20	Scarabaeidae	Rutelinae	Anomalini	*Popillia lewisi*	Arrow, 1913	quarantine
21	Scarabaeidae	Scarabaeinae	Coprini	*Copris incertus*	Say, 1835	intentionally imported, not established
22	Scarabaeidae	Scarabaeinae	Onthophagini	*Onthophagus armatus*	Blanchard, 1853	adventive?
23	Trogidae			*Omorgus suberosus*	(Fabricius, 1775)	adventive?