A New Record of the Fruit Piercing Moth Oraesia excavata (Butler) (Erebidae: Calpinae: Calpini) for Hawaii and the United States

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A NEW RECORD OF THE FRUIT PIERCING MOTH *ORAESIA EXCAVATA* (BUTLER) (EREBIDAE: CALPINAE: CALPINI) FOR HAWAII AND THE UNITED STATES

Additional key words: Asia, Pacific, peach, pear, orchard pest, Menispermaceae

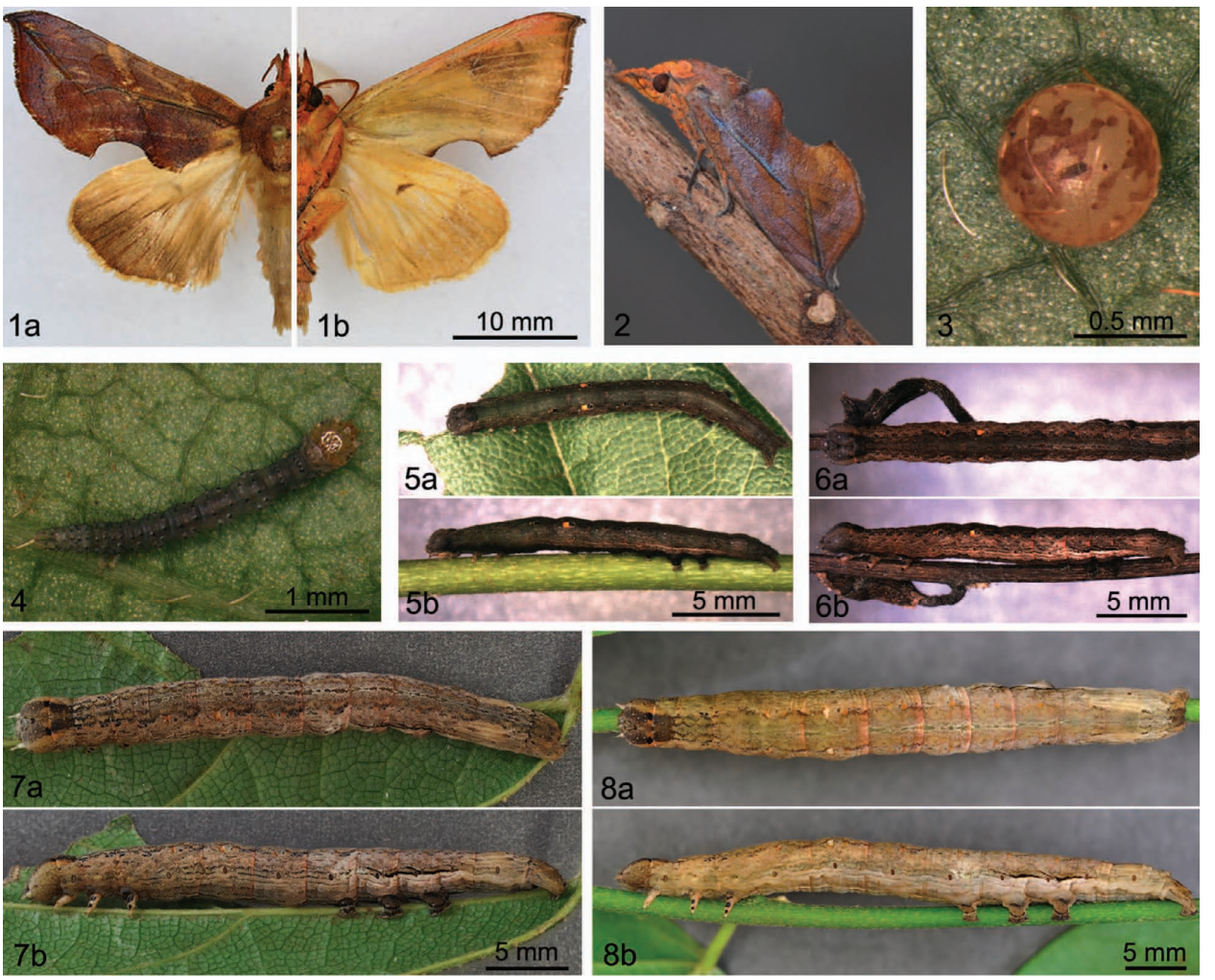
In November 2009, an exotic fruit piercing moth was collected at an elevation of 1125 m in Kula, Maui, Hawaii by W. G. King, and the specimen was submitted with his insect collection for an introductory entomology course at the University of Hawaii. Soon thereafter, the species was independently collected by the authors and others from other localities on the islands of Maui, Kauai, Oahu, and Hawaii (C. Campora, B. Kumashiro, C. Jacobsen pers. comm.), and tentatively identified as *Oraesia excavata* (Butler) (Erebidae: Calpinae: Calpini), which was confirmed by M. Pogue (2010). To our knowledge, this is the first record of establishment of *O. excavata* outside of Asia, and certainly the first record of establishment in the USA. Widespread surveys have not taken place, so the full extent of the invasion within Hawaii remains unknown. However, the species has been collected from widely dispersed sites on the islands of Kauai, Oahu, Maui, and Hawaii, and eradication is not considered a possibility.

The large moth is quite distinctive, with a scalloped trailing edge of the forewings, unusual porrect palpi, and orange head and ventral surface of the body and legs (Fig. 1), which easily distinguish it from other species present in Hawaii. Antennae of males are pectinate, while those of females are simple. When resting with folded wings, the moth somewhat resembles a dead leaf with a scalloped dorsal edge, and the beaklike palpi are noticeable (Fig. 2).

Because we observed only a few eggs and larvae, and none were successfully reared completely from egg to adult, we are unsure of the number of instars, duration of life cycle, and extent of color variation. We successfully reared one field-caught caterpillar to adulthood (Fig. 2), confirming the association between caterpillars and adults. Six eggs were laid in the laboratory by a female caught by S. Montgomery *et al*. at Kokee, Kauai. These were roughly spherical (diameter about 0.80 mm), light brown with dark brown splotches, and loosely adhered to a substrate within the collecting container (Fig. 3). Newly hatched larvae (Fig. 4, body length 3.2 mm, head capsule width 0.45 mm) are uniformly grey with black tubercules and setae. Intermediate instars (Figs. 5 and 6) are very dark

brown, with an orange dorso-lateral spot on the second abdominal segment. Late instars (Figs. 7 and 8) are light brown or grey, with or without a lighter dorso-lateral spot on the second abdominal segment. The head capsule width of the penultimate instar (Fig. 8) is approximately 3.6 mm. Caterpillars of *O. excavata* are loopers, and can move quite quickly, but the caterpillars we observed in the field generally remained quite still, oriented cryptically along a stem or petiole. Caterpillars were found on vines both during the daytime and at night, and often dropped from foliage when disturbed. When feeding, early instars leave the leaf epidermis intact, creating "windowpane" damage, while older caterpillars chew through the entire leaf, usually starting from the edge.

Originally described from Japan (Butler 1878), *O. excavata* is a major pest there as well as in other Asian regions, including China (Chen *et al*. 1992; Liu 2002), Korea (Lee *et al*. 1970), Taiwan (Taiwan Forestry Research Institute 2010), and Thailand (Pholboon 1965). It has been recorded as a pest on many soft fruit crops, including peaches, plums, pears, apples, grapes, citrus, mango, loquat and papaya (Liu 2002; Zhang 1994; H. Tsumuki pers. comm.). The adult uses its



FIGS. 1–8: **1)** *Oraesia excavata*, ♂. USA: HI, Oahu, Koolau Mtns. Waahila Ridge. 360m. 21.308N, 157.796W. UV light trap. 9 Jan 2010. W. Haines. **a,** Dorsal surface. **b,** Ventral surface. **2)** *O. excavata*, ♀, live moth showing resting position. USA, HI, Maui, Olinda, Hawea Pl., 890 m. 20.822N, 156.297W. reared ex: *Cocculus orbiculatus*. collected: 12 Feb 2010, pupated: 18 Mar 2010, emerged: 9 Apr 2010. F. and K. Starr. **3)** *O. excavata*, egg laid by female collected at Kokee, Kauai. **4)** *O. excavata*, first instar larva, newly hatched from egg laid by female collected at Kokee, Kauai. **5)** *O. excavata*, intermediate instar larva, USA, HI, Maui, Olinda, Hawea Pl., 890 m. 20.822N, 156.297W. ex: *Cocculus orbiculatus*. F. and K. Starr. Collected: 7 Mar 2010. Photographed: 17 Mar 2010. **a,** dorsal view. **b,** lateral view. **6)** *O. excavata*, intermediate instar larva, same individual as Fig. 5. Photographed: 22 Mar 2010. **a,** dorsal view. **b,** lateral view. **7)** *O. excavata*, late instar larva, same individual as Fig. 5. Photographed: 30 Mar 2010. **a,** dorsal view. **b,** lateral view. **8)** *O. excavata*, penultimate instar larva, from same locality as Fig. 5. Collected: 12 Feb 2010. Photographed: 17 Mar 2010. **a,** dorsal view. **b,** lateral view.

barbed proboscis to pierce ripe fruit and feed on juice, often causing rot to develop around the injury, and causing some fruits to fall prematurely (Hattori 1969). In some regions of Asia, this species is considered the most important moth pest of fruit crops (Lee *et al.* 1970; Chen *et al*. 1992). It is on quarantine lists for India (Plant Quarantine Organization of India 2003), Australia (Biosecurity Australia 2008), and New Zealand (Ministry of Agriculture and Forestry 1999) as an importation threat from countries where it occurs.

The genus *Oraesia* Gueneé is mostly pantropical, and includes about 25 species of fruit piercing moths (Zaspel & Branham 2008). Although there are many exceptions, calpine moths, including the genus *Oraesia*, predominantly specialize on the plant family Menispermaceae for oviposition (Fay 1996). Based on published records, menispermaceous plants are certainly preferred hosts for *O. excavata* (Pholboon 1965; Fujimura 1972; Ohmasa *et al*. 1991), but there are also some records of caterpillars feeding on other plant families, for instance *Lepisanthes rubiginosa* (Sapindaceae) (Pholboon 1965). In Japan, caterpillars of *O. excavata* feed primarily on *Cocculus orbiculatus* (L.) (Menispermaceae), a creeping vine that occurs outside of orchards (Ohmasa *et al*. 1991). This plant is also native to Hawaii, and is a local host for *O. excavata*. However, because *C. orbiculatus* is not a particularly common or abundant plant in Hawaii, it is possible that *O. excavata* may utilize other hosts as well. We collected *O. excavata* caterpillars on *C. orbiculatus* at two sites in Hawaii: upland mesic forest at Olinda, Maui (890 m), and dry coastal shrubland at Kaena Point on Oahu (73 m), suggesting that *O. excavata* tolerates a wide range of moisture, elevation, and temperature.

Many fruits grown in Hawaii, including papaya, mango, banana, orange, and guava, will likely be fed upon by adult *O. excavata*, but it remains to be seen whether damage will be economically significant. At this time, excessive fruit-piercing damage has not been reported by fruit growers in Hawaii. Another fruit piercing moth *Eucodima phalonia* (Clerck), has been established in Hawaii for 25 years (Heu *et al*. 1985), but is not considered a major pest there, despite being very problematic elsewhere in the Pacific (Fay 1996; Reddy *et al*. 2005). Its relative innocuousness in Hawaii may be due to high levels of attack by *Trichogramma* and other parasitoids (Heu *et al*. 1985). This may prove to be the case with *O. excavata* as well.

There has been considerable research towards the control and monitoring of *O. excavata* in Asia, including sex pheromones (Ohmasa *et al*. 1991), plant kairomone attractants (Miyazaki *et al*. 1972; Tian *et al*. 2008), chemical deterrents (Fujimura 1972; Tian *et al*. 2007), bagging of fruits (Fujimura 1972; Liu 2002), pesticides (Fujimura 1972; Liu *et al*. 2001), and light traps (Hattori 1969; Fujimura 1972; Liu *et al*. 2001; Liu 2002), but these have had only limited success. A female sex pheromone of *O. excavata* was identified and found to be very attractive to males (Ohmasa *et al*. 1991), but is not commercially available or currently used for monitoring or control in Japan (H. Tsumuki pers. comm.). The odor of ripe fruit is also attractive to the moths, and traps may be baited either with the fruit themselves, or a chemical mixture that simulates fruit odor (Tian *et al*. 2008).

Although *O. excavata* and *O. emarginata* are major pests in Asia, a risk assessment conducted by the New Zealand Ministry of Agriculture and Forestry (Tyson *et al*. 2009) concluded that the risk of importation of these species along with fruit was negligible, because larvae and eggs are not associated with fruit trees, while adults are nocturnal, highly mobile, and unlikely to remain on produce during the daytime when fruit is harvested. It is unknown from which country or by what pathway *O. excavata* was introduced to Hawaii, but it appears to have spread rapidly upon arrival, being independently collected or photographed on four islands within months of initial detection. It is possible that adults actively flew or were carried by winds among the different islands, but considering the apparently rapid spread between distant islands (greater than 115 km of open ocean between Oahu and Kauai), human-mediated transport seems likely. Since adult noctuiod moths often seek shelter in dark places during the day, it is possible that they could be transported in packing crates or containers, even if not associated with a specific product. The lack of a known invasion pathway may complicate inspection efforts for this pest.

Because of the importance of orchard and vine crops in the continental US, *O. excavata* could potentially become a pest if established there, and its geographic range in Asia is similar in climate to regions of North America, especially the Eastern US. One major factor which might limit establishment or population growth in North America is the occurrence of suitable larval host plants. There are only six species of Menispermaceae (5 native, 1 exotic) established in the continental US, and most of these are confined to the southeastern part of the country. (Rhodes 1997). West of the Rocky Mountains, there are no native or naturalized menispermaceous species in the continental US, other than *Cocculus diversifolius* de Candolle in the very southern parts of Arizona and Texas. However, east of the Rocky Mountains there are five species of Menispermaceae, including the widespread natives *Cocculus carolinus* (L.) and *Menispermum canadense* L.

(Rhodes 1997). Of course, it is also possible that *O. excavata* could establish or even thrive on a different plant family, since its degree of host-specificity has not been evaluated.

Given the potential threat of this species to fruit crops in the mainland United States, it would be worthwhile to study the biology and distribution of *O. excavata* in Hawaii. Monitoring methods could be developed in Hawaii and used for early detection or interception of *O. excavata* in the mainland United States.

Material examined (deposited at University of Hawaii Insect Museum, UHIM):

Adult moths: 1 ♂ , USA: HI, Maui, Kula, Upper Kimo Dr. 1125 m. 20.775N, 156.298W. 24 Nov 2009. G. King; 2 ♂, USA: HI, Maui, Kokomo, 2955 Kailiili Rd. 477m. 20.867N, 156.305W. At UV light. 17 – 19 Dec 2009. W. Haines; 2 ♂, USA: HI, Oahu, Koolau Mtns. Waahila Ridge. 360 m. 21.308N, 157.796W. UV light trap. 9 Jan 2010. W. Haines; 1 ♀, USA: HI, Oahu, Ewa, Aloun Farms citrus grove. Unbaited fruit fly trap. 58 m. 21.374N, 158.045W. 25 Jan 2010. L. Leblanc; 1 ♀, USA: HI, Kauai, Koke'e State Park. S. Montgomery, C. Campora, S. Lee; 1 ♀, USA, HI, Maui, Olinda, Hawea Pl., 890 m. 20.822N, 156.297W. reared ex: *Cocculus orbiculatus*. collected: 12 Feb 2010, pupated: 18 Mar 2010, emerged: 9 Apr 2010. F. and K. Starr; 1 ♂, USA: HI, Hawaii Island, Ka'u, Kahuku, Ocean View Estates, 550 m. 19.073N, 155.750W. 6 Dec 2010. S. Montgomery., 2 ♀, USA: HI, Hawaii Island, Ka'u, Kahuku, near Ocean View Estates, 550 m. 19.07N, 155.74W. 5 Jan 2011. S. Montgomery.

Larvae: 5 larvae, USA, HI, Maui, Olinda, Hawea Pl., 890 m. 20.822N, 156.297W. ex: *Cocculus orbiculatus*. 12 Feb – 16 Mar 2010. F. and K. Starr.; 5 larvae, USA, HI, North Oahu, Kaena Point, 73 m. 21.575N, 158.258W. ex: *Cocculus orbiculatus*. 15 May 2010. W. Haines.

Other existing material (photographs examined): 1 unknown sex, USA: HI, Oahu, Lualualei, Halona Valley, 500 m. 21.424N, 158.098W. 8 Dec 2009. C. Campora, S. Montgomery, S. Lee (specimen kept by S. Montgomery).; 1♂, USA: HI, Oahu, Nuuanu, on eaves of roof, 21 Dec 2009. G. Uchida. (Specimen at Hawaii Department of Agriculture); 1 unknown sex, USA: HI, Hawaii Island, Kawaihae, Honouli St., 20.062N, 155.839W, 95m, at residence, 7 Jul 2010 (photographed but not collected).

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