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IDENTITY, RELEASE AND ESTABLISHMENT OF
CALOPTILIA NR. *SCHINELLA* (WALSINGHAM) (GRACILLARIIDAE)
ON THE ISLAND OF HAWAII FOR CONTROL OF *MYRICA FAYA*
AITON (MYRICACEAE)

Additional key words: *Phyllonorycter myricae*, leaf miner.

In 1956, *Strepsicrates smithiana* Walsingham (Tortricidae) was introduced to Hawaii for the biological control of *Myrica faya* Aiton (Myricaceae), commonly known as faya or fayatree. This new association failed because *S. smithiana* established on *Myrica cerifera* L. (Julien 1992) solely at low elevations (150 m) in Hawaii. *Myrica cerifera* is the host of *S. smithiana* in its native range of Florida and Georgia. Although *S. smithiana* was capable of growth and reproduction on potted *M. faya* and *M. cerifera* at higher elevations (1200 m), it did not become established on *M. faya*.

In 1991, *Caloptilia* nr. *schinella* (Walsingham) (Gracillariidae) was first released on the island of Hawaii for the biological control of *M. faya*. This is the first agent to become established on *M. faya*, although faya has been the target of a biological control program in Hawaii since the 1950s (Davis & Krauss 1962). *Caloptilia* nr. *schinella* is a leaf miner in early instars but feeds externally on the tips of the youngest leaves in the later instars and produces silk, causing the tips of the leaves to roll. Pupation occurs on yet another leaf where an elliptical cocoon is formed on the lower surface. Adults have a plain forewing of about 7 mm in length. Problems with the insect's identity and the details of its release are discussed in this note.

Previous reports (Gardner et al. 1988, Markin 1991, Markin et al. 1991, Taylor & Markin 1992) and the release permit for *C. nr. schinella* refer to *Phyllonorycter myricae* Deschka (Gracillariidae). Confusion about the identification of *C. nr. schinella* was resolved with determinations by Gaden Robinson at the Natural History Museum, London, where voucher specimens have been retained. The released agent is presently referred to as *C. nr. schinella* because there are morphological and host differences from *C. schinella*. Our specimens are slightly larger and darker than the type specimens for *C. schinella*, which were collected on the island of Tenerife, Canary Islands, from *Schinus molle* L. (Anacardiaceae) (Walsingham 1907). *Schinus molle* is native to Brazil and is introduced to the Canaries. True *C. schinella* probably expanded its host range from *Pistacia atlantica* Desf. (Anacardiaceae), a native Canary Island species to the introduced *S. molle*. *Pistacia atlantica* is a recorded host of *C. schinella* in the Canary Islands, and other species of *Caloptilia* Hübner are also known to use *Pistacia* L. (Klimesch 1970). The agent introduced to Hawaii, *C. nr. schinella*, originates from Madeira and the Azore Islands and was collected from *M. faya* in Madeira. Although *S. molle* is also present in Madeira and the Azores, *C. nr. schinella* was never collected from *S. molle*. Moreover, *C. nr. schinella* was not found on the *M. faya* in the Canary Islands during four exploratory trips.

Host specificity tests also suggest the presence of two separate species of *Caloptilia* in the Atlantic Islands. In no-choice tests, *C. nr. schinella* laid 251 eggs on *S. terebinthifolius* Raddi (Anacardiaceae), but none developed beyond the larval stage, and when tested on *S. molle*, insects developed through the last larval instar and one completed development to the adult stage (Markin, unpubl. data). Unlike *C. schinella*, *Schinus* spp. do not appear to be suitable hosts for *C. nr. schinella*. In addition, *C. nr. schinella*'s host, *M. faya*, is classified in the Myricaceae which is quite distantly related to the Anacardiaceae (Takhtajan 1980). Although both families are dicotyledons (Class Magnoliopsida), Myricaceae is classified in the Subclass Hamamelididae (Order Myrtales) and Anacardiaceae is classified in the Subclass Rosidae (Order Rutales).

Caloptilia nr. *schinella* was released in 1991 and 1992 at three sites in the Volcano Golf Course Subdivision and at one site in Volcano Village on the island of Hawaii, County of Hawaii. Sites in the subdivision were located at Dick Ashbaker's home at 98–2034 Popohau Place, an empty lot next to the home of Bud Doty at 99–1909 East Kaohelo Way, and

TABLE 1. Distribution of releases of 775 adult *Caloptilia* nr. *schinella* in the vicinity of the Volcano Golf Course Subdivision and Volcano Village, Hawaii, during 1991.

Site	Date	Number	Method
Bud Doty's	24 Jul	50	open
	14 Aug	60	open
	21 Aug	50	open
	26 Aug	50	open
	4 Sep	75	open
Volcano Winery	10 Sep	60	10 per sack
	12 Sep	25	open
	13 Sep	25	open
	17 Sep	50	open
	2 Oct	40	10 per sack
Dick Ashbaker's	7 May	20	tent
	20 Sep	40	tent
	16 Oct	35	open
	18 Oct	40	open
	21 Oct	40	10 per sack
Volcano Village	2 Nov	30	tent
	29 Oct	50	open

near the Volcano Winery at the intersection of Piimauna Drive and Pukiawe Circle. All three sites are located within 0.85 km of each other. The Volcano Village site was located where Road A intersects Wright Road and is approximately 3.3 km from the subdivision.

Adults were released by one of three methods: (a) into a 0.9 m × 1.2 m × 1.5 m tent enclosing a faya tree and containing a source of sugar water; (b) into sacks that enclosed one to six branches of *M. faya* and that held a supply of sugar water or lemon drops (the lemon drops were hygroscopic, dissolved slowly, and thus served as a supply of sugar and water for a week or longer; usually 10 adults were released and held in each sack for one week before the sack was removed); and (c) directly into the field. Multiple field releases of *C. nr. schinella* were made during 1991 on the island of Hawaii (Table 1). On 7 May, 20 adults were released into a tent at Dick Ashbaker's home. Generation time averages two months throughout the year (Markin, unpubl. data). On 24 July, 50 adults were removed from the tent and released at the lot next to Bud Doty's. This first field release also included more than 50 mature pupae and more than 300 larvae. Between 7 May and 2 November 1991, a total of 775 adults was released at the four locations with 685 released outside of the tent. An additional 30, 100, and 50 adults were added to the tent on 14 May, 21 May, and 1 June 1992, respectively. The final release was made in late June 1992 when the tent was removed and an unknown number of adults released.

Surveys of the Volcano Golf Course Subdivision between November 1991 and September 1992 located only a few larval mines and rolled tips in the field, and all were attacked by unknown natural enemies. Approximately 20 faya trees were surveyed in December 1992 near Dick Ashbaker's home and each had one or more live larvae per plant. Nearly all fayatrees located among the three release sites in the subdivision were also attacked by at least one larva. By November 1994, *C. nr. schinella* had established at locations up to 3 km from the release sites. As of November 1995, insects were present and reproducing in the field although their impact on faya trees appeared to be negligible.

We are conducting host specificity tests on the true *P. myricae*, described by Deschka (1976), within our quarantine facility in Hawaii Volcanoes National Park. So far, studies indicate that it is specific to *M. faya* and thus is a probable candidate for release. In contrast to *C. nr. schinella*, *P. myricae* is a leaf miner throughout its entire larval stage, and pupates within the mines of a leaf. Adults of *P. myricae* have forewings with white trans-

verse bars outlined in black and are only 4 mm in length. Neither agent is expected to effect complete control of *M. faya* because of faya's exceptionally invasive traits such as its ability to fix nitrogen, rapid growth rate, and high rate of seed production (Vitousek & Walker 1989).

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SEXUAL DIMORPHISM IN THE COCOON COLOR OF
BOMBYX MORI (BOMBYCIDAE)

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The mulberry silkworm, *Bombyx mori* L., is one of the most commercially exploited lepidopteran species. Hybrids between commercial silkworm strains are reared to produce