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Site of Oviposition and Description of Eggs of *Sophonia rufofascia* (Homoptera: Cicadellidae: Nirvaninae), a Polyphagous Pest in Hawai'i

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Abstract. Eggs and ovipositional site on the fern *Dicranopteris linearis* (Burman) Underwood (common name: uluhe) and the woody angiosperm *Aleurites moluccana* (L.) Willdenow (kukui) are described for *Sophonia rufofascia* (Kuoh & Kuoh), a polyphagous leafhopper pest of agriculture and forestry in Hawai'i. Extremely little information is available on the bioecology of any *Sophonia* species; almost nothing is known of *S. rufofascia*. Acquisition of such basic biological information as the site of oviposition and egg characteristics of a pest species is a necessary prerequisite to further study of other aspects of its biology and to the search for potential biological control agents. Ovipositional scars were found on the abaxial surface of host plant foliage, usually at the juncture of the midrib vein and lamina. Many of the scars contained remains of the egg chorion. Eggs were hyaline to milky white, elongate and slightly curved, with a whitish operculum. They averaged 1.41 ± 0.01 mm in length, 0.30 mm at greatest width. Eggs were deposited at shallow depth in the pith of the vein with the long axis aligned with that of the vein. The predominance of unhatched eggs in the smaller uluhe fronds and kukui leaves suggests that females oviposit preferentially in younger foliage. The major veins presumably are the only sites available affording adequate protection for the large eggs produced by this species. Observations reported here suggest that the eggs of *S. rufofascia* deposited in certain hosts, such as *D. linearis* and *A. moluccana*, may be vulnerable to attack by egg parasitoids, and the leafhopper thus subject to potentially effective biological control by these agents.

Sophonia rufofascia (Kuoh & Kuoh), a polyphagous nirvanine leafhopper, was first detected in Hawai'i on O'ahu Island in June 1987 (Heu & Kumashiro 1990), subsequently spreading to the other major islands over the next five years (Hawai'i Dept. of Agric. records). Originally described from tea (*Camellia sinensis* [L.] O. Kuntze) and rice (*Oryza sativa* L.) in Zhejiang and Guizhou Provinces, China (Kuoh & Kuoh 1983), to date, *S. rufofascia* has been recorded from more than 300 host plants in Hawai'i, including several commercially important food and ornamental crops (M. Fukada and V. Jones, Univ. of Hawai'i; V. Tanimoto, Hawai'i Dept. of Land & Natural Resources; TWC, R. Heu, and S. Matayoshi, Hawai'i Dept. of Agric.; unpubl. data). In Hawai'i, it is regarded as a major pest of guava (*Psidium guajava* L.) (J. Frazier and K. Borman, Kilauea Agronomics, Inc., pers. comm.), is a suspected vector of plant pathogens, and has been implicated in the decline of forest plants important in maintaining watersheds (Markin 1993; TWC, unpubl. observations). Feeding typically produces chlorosis in the foliage of hosts. The species ranks high on the State of Hawai'i's priority list of insects targeted for biological control.

Extremely little published information is available on the bioecology of any species of *Sophonia*, a genus originally distributed throughout the subtropics and tropics of the Oriental and Australian regions, and parts of Melanesia (Walker 1870, Evans 1973, Viraktamath & Wesley 1988, Huang 1989, Li & Wang 1991a,b, Viraktamath 1992). Almost nothing is known of *S. rufofascia*, a critical lack that has hampered control efforts in Hawai'i. The acquisition of such basic biological information as the site of oviposition and egg characteristics of a pest species is a necessary prerequisite to further study of

other aspects of its biology and to the search for potential biological control agents, particularly egg parasitoids. This paper reports the first description of the ovipositional site and eggs of *S. rufofascia* on two of its favored host plants in Hawai'i, false staghorn fern (*Dicranopteris linearis* [Burman] Underwood), also known locally as uluhe, a plant of considerable importance in holding soil on steep hillsides, and kukui (*Aleurites moluccana* [L.] Willdenow), the state tree.

MATERIALS AND METHODS

Samples of green, fully-expanded uluhe fronds and kukui leaves were taken during 1993 from sites in the upper Manoa Valley and Kaneohe, O'ahu, respectively. Preliminary examinations of these hosts failed to reveal signs of oviposition on any parts other than foliage.

In the laboratory, foliage containing ovipositional scars was placed under a stereomicroscope and dissected at 25–50x. Eggs (n = 20) were carefully exposed and removed from foliage using insect pins (of sizes 1, 00, and minuten, depending on the toughness of the tissue) to tease away surrounding plant tissue. Egg measurements were made at 50x employing a calibrated ocular micrometer (1 unit = 0.0125 mm). After they were measured, eggs were preserved in 70% ethanol (specimens have been placed in the insect collection of the Plant Pest Control Branch, Hawai'i Department of Agriculture).

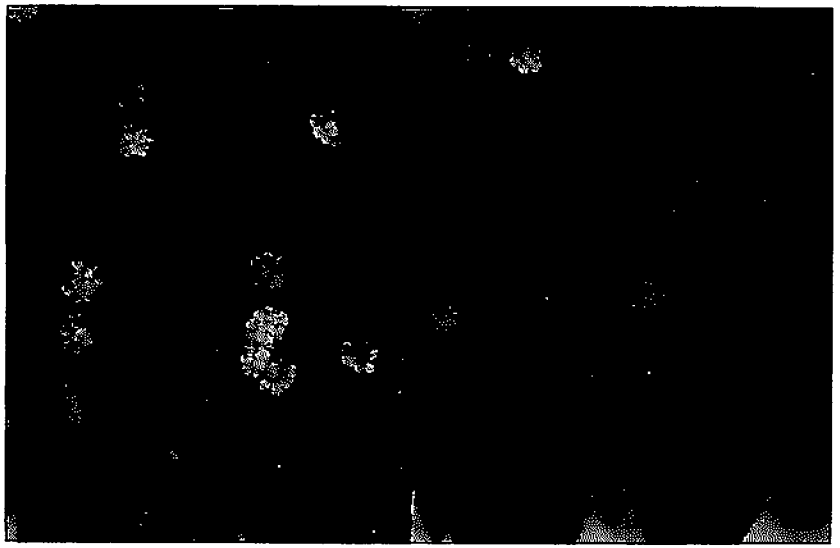
To confirm identity of the insect, sections of young, fully-expanded fronds and leaves with oviposition scars containing eggs (i.e., with an operculum visible) were held for eclosion in 65-ml plastic snap-cap vials, each containing paper tissue moistened with water to maintain high humidity and delay foliage desiccation. A careful examination ensured that no leafhoppers were present on the material prior to its placement in the vials. Vials were examined twice a day for presence of neonates.

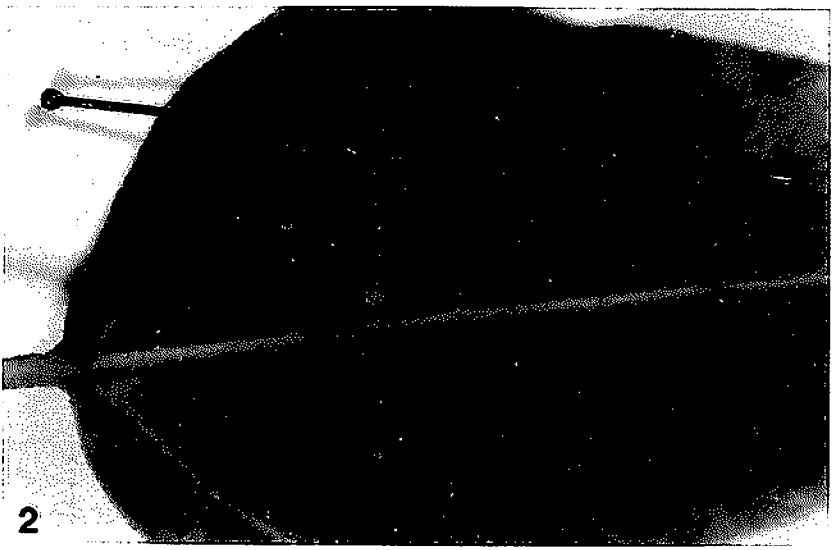
RESULTS

Small numbers of mites, a coccid scale (probably *Coccus viridis* [Green]), and *S. rufofascia* were the only arthropods found on collected foliage.

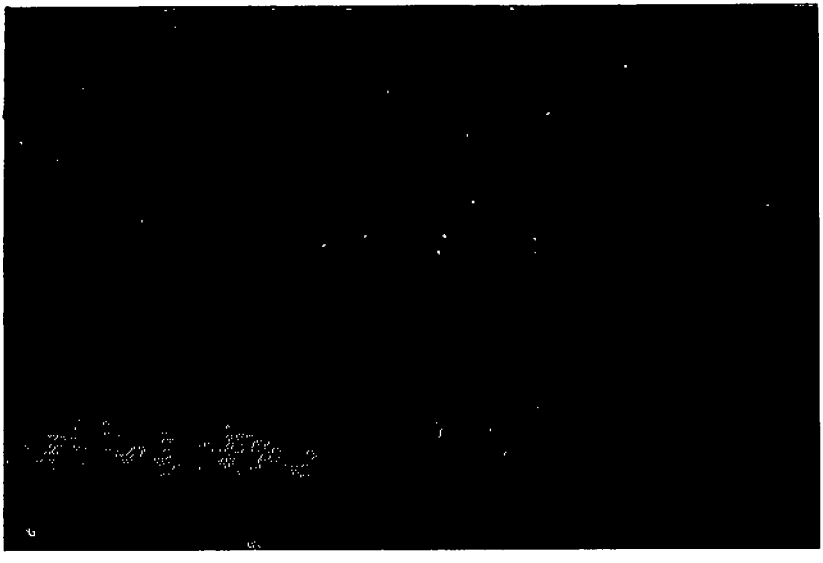
On both uluhe and kukui, ovipositional scars were plainly visible to the unaided eye, and were situated on the underside (abaxial surface) of foliage, usually at the juncture of the midrib vein and lamina, rarely directly on the midrib, and often near the intersection of the midrib and a cross-vein (Figs. 1 and 2). Viewed under the microscope, they were scab-like in appearance, roughly oval in shape, 0.50–0.80 mm in length, and of a purple-black or dark brown color (Fig. 3). Many of the scars contained a breach, and from some of these protruded whitish material, apparently remains of the chorionic membrane after eclosion of the insect (Fig. 4). (By contrast, on guava, another favored host, detection of ovipositional scars is much more difficult, perhaps because the leaf tissue reacts less severely to the mechanical and chemical wounding of oviposition. Scars are, again, found in the same situations as on uluhe and kukui, but are not readily visible. The guava leaf lamina must be folded down and away from the midrib to permit scars to be viewed under a microscope [unpublished observations].)

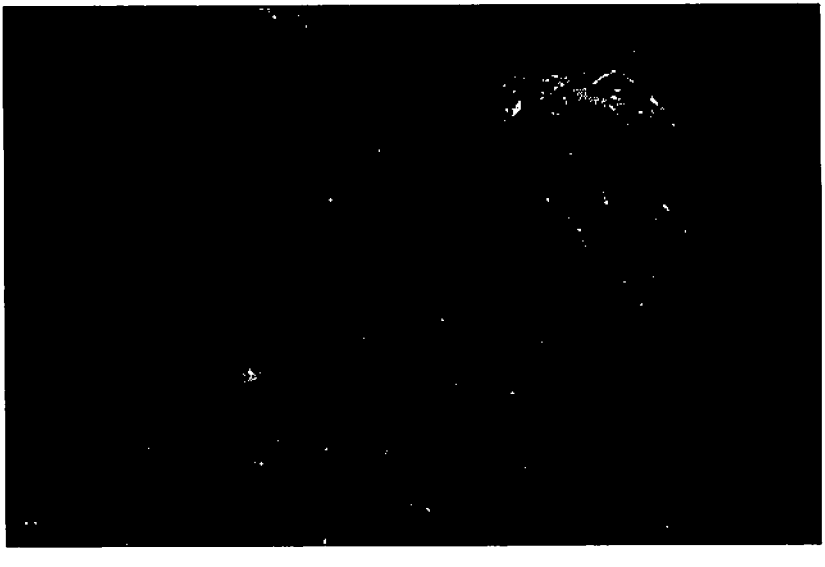
Many of the dissections revealed only subsurface necrotic lesions of the plant tissue, which may have represented aborted oviposition probes, or lesions and the chorionic remnants. Eggs were found either with the operculum protruding slightly from the oviposition scar or entirely concealed just below the scar surface, situated in the pith of the midrib with their long axis aligned with that of the vein. They were hyaline to somewhat milky white, elongate and slightly curved, with a whitish operculum (Figs. 5, 6), resembling those of other leafhopper species (e.g., Bakkendorf 1934). Mean length was 1.41 ± 0.01 mm (range: 1.34–1.48 mm); greatest width averaged 0.30 mm (SE < 0.01) (range:





Figs. 1–2. ***Sophonia rufofascia*** ovipositional scars. **1.** Along midrib vein of uluhe (***Dicranopteris linearis***) frond (magnification: 6x). **2.** Along midrib vein of kukui (***Aleurites moluccana***) leaf (2.4x).





Figs. 3–4. *Sophonia rufofascia* ovipositional scars. 3. Scar with egg operculum visible (50x). 4. Scar with remains of egg chorion protruding (nymphal exuviae at upper right) (15x).

Figs. 5–6. *Sophonia rufofascia* eggs. **5.** Egg exposed in pith of midrib (operculum at right) (40x). **6.** Excised egg showing developing embryo (eyespot visible on right) (45x).

0.26–0.34 mm). Developing embryos were seen in a number of eggs (Fig. 6). Whereas ovipositional scars were visible on fully-expanded fronds and leaves of all sizes, most of the eggs were found in the smaller ones, suggesting that females oviposit preferentially in younger foliage. The egg chorion was found to be quite delicate and susceptible to injury, and, in many cases, it was impossible to remove eggs from leaf tissue without damaging them to some degree. Many were disrupted and had to be discarded.

DISCUSSION

Oviposition by *S. rufofascia* on uluhe and kukui contrasts with that by *S. linealis* (= *S. greeni*) (Distant) on coconut palm (*Cocos nucifera* L.) (Rajan & Mathen 1984). The latter species inserts its eggs not into a vein, but through punctures distributed on the abaxial surface of the relatively thinner lamina.

Although there are no data on the sizes of eggs deposited by other species of *Sophonia*, and thus no means of correlating egg size in particular species with ovipositional site, egg size in *S. rufofascia* is proportionately larger than that recorded for other leafhopper species, in which the females are of similar size (e.g., Raine 1960, Nielson & Toles 1968, McKenzie & Beirne 1972, Valley & Wheeler 1985). The large egg produced by *S. rufofascia*, in relation to the size of the female (5.31 ± 0.05 mm in length; n = 10), suggests that fecundity in this species may be rather low. Female *S. rufofascia* oviposit into the midrib vein of host foliage presumably because only that site affords adequate protection for the large eggs. During the act of egg deposition, the area of softer lamina tissue adjacent to the midrib, rather than the midrib itself, is selected probably because it is easier to pierce with the ovipositor than is the hard outside surface of the midrib. (The relative hardness of the midrib surface was indicated by its resistance to probes by an insect pin, whereas adjacent lamina tissue yielded easily to such probes.) The ovipositor apparently is angled through the lamina toward the midrib, and the egg then inserted into the midrib, which is easily penetrated from below the leaf surface.

Eggs of *S. rufofascia* were placed near the surface in foliage of the host plants examined. If this pattern of ovipositional behavior is consistent among all hosts, it suggests that the eggs may be readily vulnerable to attack by egg parasitoids, and populations of the leafhopper thus amenable to biological control by these agents. However, few host plants of *S. rufofascia* have been examined closely. The ovipositional site in the many other hosts of this leafhopper may not be the same as, or similar to, that in uluhe, kukui, or guava, and therefore may not be as easy to attack by insect enemies (or to detect by human observers). Examination of additional host plants thus will be necessary to shed further light on the ovipositional behavior of *S. rufofascia* and on prospects for its biological control.

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