Parasitism of the leafhopper Sophonia rufofascia (Kuoh and Kuoh), a recent immigrant that has become a widespread pest in Hawaii, was examined in a 1-year survey in Hawaii Volcanoes National Park. Samples of young leaves of four plant species infested with eggs of S. rufofascia were collected at five sites ranging from 880 to 1190 m in elevation. Leafhopper eggs were parasitized principally by three species of Mymaridae (Hymenoptera): Polynema sp., Schizophragma sp. probably bicolor (Dozier), and Chaetomymar sp. Although parasitism by each species fluctuated at levels usually below 10%, all three were detected consistently across most host plants, sites, and sample periods. Total parasitism differed at a marginally significant level among host plants and sites, but not among sample periods. Total parasitism averaged 14.3% (maximum: 26.3%) on Dodonaea viscosa Jacquin, 10.6% (maximum: 17.5%) on Myrica faya Aiton, 8.7% (maximum: 29.5%) on Metrosideros polymorpha Gaudich-Beaupre, and 1.6% (maximum: 4.3%) on Vaccinium reticulatum Smith. Parasitism was generally higher at sites lower in elevation. Further monitoring is recommended to determine whether parasitism will increase to levels that can effectively suppress S. rufofascia populations. The efficacy of natural enemies already present in Hawaii is important because concern over nontarget impacts on endemic leafhoppers makes introduction of new biological control agents difficult.
caused widespread uluhe dieoff is lacking. Uluhe dieoff
leads to problems with erosion on the steep slopes of
forest watersheds (Scott, 1969) and permits invasion
by alien weeds (P. Follett, unpublished data). Fortu-
nately, in the past few years the rate of uluhe dieoff
appears to have slowed, and in some cases dead
patches are being recolonized by surrounding live
uluhe (P. Follett, unpublished data).

High populations of *S. rufofascia* have been detected
in Hawaii Volcanoes National Park on the island of
Hawaii since 1994 in association with the weed
*Myrica faya* Aiton (P. Yang and D. Foote, unpublished data).
In some areas of the park invaded by *M. faya*, there has
been extensive dieback of ohia-lehua, *Metrosideros
polymorpha* Gaudich-Beaupre, a dominant tree of na-
tive Hawaiian forests. Although cases of widespread
ohia-lehua dieoff precede the arrival of *S. rufofascia*
(Mueller-Dombois, 1993), the role of leafhoppers in ar-
eas of recent ohia-lehua decline is being investigated
(L. Lenz, personal communication).

The ability of *S. rufofascia* to invade Hawaiian forest
habitats, where conventional insecticidal control is un-
feasible, makes this pest a prime candidate for classi-
cal biological control. However, control of leafhoppers
by natural enemies already present in Hawaii may render a costly program of foreign exploration and host
screening unnecessary. In the course of previous stud-
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(L. Lenz, personal communication).

**TABLE 1**

<table>
<thead>
<tr>
<th>Site</th>
<th>Elevation (m)</th>
<th>Dodonaea viscosa</th>
<th>Metrosideros polymorpha</th>
<th>Myrica faya</th>
<th>Vaccinium reticulatum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kipuka Kahalii</td>
<td>880</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Puhimau Crater</td>
<td>1100</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Devastation Trail</td>
<td>1130</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crater Rim</td>
<td>1160</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kipuka Puuulu</td>
<td>1190</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MATERIALS AND METHODS**

**Sampling**

Leaves of four plant species commonly attacked by *S.
rufofascia* were collected at five sites ranging from 880
to 1190 m in elevation in HAVO. Because all plant
species could not be found in sufficient abundance at
any single site, two to three species were sampled at
each site (Table 1). Three of the host plants are com-
mon Hawaiian natives: ohia-lehua, *M. polymorpha*;
a‘ali‘i, *Dodonaea viscosa* Jacquin; and ohelo, *Vac-
cinium reticulatum* Smith. The fourth host plant, fire-
tree, *Myrica faya*, is an invasive weed that has been
spreading in HAVO since 1961 (Vitousek et al., 1987).

Young, fully expanded leaves were collected from five
separate plants of each species at each site. Collections
were repeated at intervals of 6 weeks, approximately
twice per leafhopper generation (Duan and Messing,
2000), from September, 1997 to August 1998. *S. rufo-
fascia*-infested leaves of guava, *Psidium guajava* L.,
were collected in Hilo, Hawaii, 40 km north of the park,
on two occasions during the survey period.

Samples were returned to the Kilauea Field Station
laboratory at HAVO, where each leaf was examined
using backlighting. Leaves without visible *S. rufofas-
cia* oviposition scars were discarded, leaving a sample
of 20–60 leafhopper-infested leaves from each plant.
Each sample was held separately in a plastic Ziploc bag
(8 × 16 cm; DowBrands, Indianapolis, IN). Samples
were checked every 2–3 days; emerged *S. rufofascia*
and parasitoids were removed and placed in 70% eth-
anol.

After 3 weeks, leaves were dissected under magnifi-
cation. Leaves of *D. viscosa* were usually dissected
after 2 weeks due to problems with mold. Some scars
initially identified as oviposition sites were found to
lack eggs. Such scars, apparently formed in response to
leafhoppers probing without laying eggs, were deleted
from our sample total. The remaining oviposition scars
were classed into two main categories: (1) scars from
which *S. rufofascia* emerged, and (2) scars from which
parasitoids emerged. Emergence of *S. rufofascia* was
distinguished by a narrow, elongate opening with re-
mains of the egg chorion protruding at one end (Cul-
liney, 1998). Parasitoid emergence holes were round
and lacked remains of chorion. Occasionally, partially
developed leafhoppers or parasitoids were dissected.
These were totaled with unparasitized and parasitized
eggs, respectively.

Parasitoids were grouped initially into morphospee-
cies. Midway through our survey, and again at the end,
representatives of all morphospecies were mounted
and identified. Voucher specimens have been deposited in the insect museum of the Department of Entomology, University of Hawaii, Honolulu.

**Analysis**

Parasitism was calculated from numbers of emerged and dissected parasitoids as a percentage of oviposition scars for each plant sampled. Samples with fewer than 15 oviposition scars (<3% of all samples) were excluded as too small. Variables calculated included total parasitism, parasitism by individual species of parasitoids, and parasitism by unknown species. Total parasitism was based on counts of parasitoid emergence holes plus dissected parasitoids. Parasitism by each species was based on emerged parasitoids plus dissected parasitoids, which typically could be identified to morphospecies. Unknown parasitism (i.e., by parasitoids that emerged before sampling) was calculated from the difference between number of parasitoid emergence holes and totals of all morphospecies. Parasitism by each species was based on emerged parasitoids plus dissected parasitoids, which typically could be identified to morphospecies. Unknown parasitism (i.e., by parasitoids that emerged before sampling) was calculated from the difference between number of parasitoid emergence holes and totals of all morphospecies. Because samples were collected on different dates at different sites, data were grouped for analysis into nine sampling periods with durations of approximately 6 weeks each.

Effects of host plant, site, and sampling period on total percentage parasitism were examined using repeated-measures ANOVA (Littell et al., 1996). Some data were excluded from analysis to resolve problems with unbalance: data from the host V. reticulatum, because it was sampled at only one site; and data from M. polymorpha at the Crater Rim site, where adequate samples of this host were obtained on only three dates. Data were first averaged across plants sampled at each site/host plant/period to reduce problems with zero values. Sample means were transformed by the square-root method before ANOVA to improve normality and homogeneity of variance. Effects found to be significant in ANOVA were examined further using Tukey HSD (SAS Institute, 1994).

Effects of host plant and site on percentage parasitism by each parasitoid species were examined using the Kruskal-Wallis test (SAS Institute, 1994). A non-parametric analysis was chosen because the data (means across plant samples) were strongly skewed toward zeros and very small values.

**RESULTS**

Parasitoid Species

In total, 1055 parasitoids were recovered from our samples and grouped into morphospecies. Of these specimens, 169 were formally identified. Only 3 specimens were found misclassified as morphospecies, an error rate of less than 2%. A total of 3888 leafhopper nymphs were recovered, and all except 4 were identified as S. rufofascia. (Four leafhopper nymphs, probably of a single native species, emerged from M. polymorpha leaves collected 29 May, 1998, at Kipuka Kahalii.)

Over 95% of the parasitoids collected in this survey belong to three genera of mymarids: Polynema (39%), Schizophragma (26%), and Chaetomymar (30%) (Table 2).

**TABLE 2**

Parasitoids Emerged from Leaves Bearing S. rufofascia Oviposition Scars, Collected on Hawaii September 1997–August 1998

<table>
<thead>
<tr>
<th>Sample totals</th>
<th>Family</th>
<th>Species</th>
<th>Dodonaea viscosa</th>
<th>Metrostegos polymorpha</th>
<th>Myrica faya</th>
<th>Vaccinium reticulatum</th>
<th>Psidium guajava</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. plants</td>
<td></td>
<td></td>
<td>141</td>
<td>142</td>
<td>118</td>
<td>58</td>
<td>11</td>
</tr>
<tr>
<td>No. leaves</td>
<td></td>
<td></td>
<td>3659</td>
<td>3578</td>
<td>3355</td>
<td>1191</td>
<td>65</td>
</tr>
<tr>
<td>No. S. rufofascia oviposition scars</td>
<td></td>
<td></td>
<td>3720</td>
<td>4282</td>
<td>3432</td>
<td>1522</td>
<td>85</td>
</tr>
<tr>
<td>No. parasitoids emerged</td>
<td>Mymaridae</td>
<td>Polynema spp.</td>
<td>282</td>
<td>72</td>
<td>32</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Schizophragma sp. prob. bicolor</td>
<td>63</td>
<td>90</td>
<td>115</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chaetomymar sp.</td>
<td>53</td>
<td>135</td>
<td>93</td>
<td>—</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alaptus sp.</td>
<td>22</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stethynium spp.</td>
<td>1</td>
<td>—</td>
<td>7</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anagrus sp.</td>
<td>1</td>
<td>—</td>
<td>2</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Trichogrammatidae</td>
<td>Oligosia sp.</td>
<td>3</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Encyrtidae</td>
<td>?</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>?</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Unknown*</td>
<td>Unknown*</td>
<td>132</td>
<td>85</td>
<td>105</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

* Parasitoids emerged in the field before samples were collected.
2). The majority of Polynema (49 out of 63 specimens formally identified) appear to belong to a single species. The remaining specimens represent 2–4 other species of Polynema. This genus is in need of revision, and consequently its members are not currently identifiable to species (Beardsley and Huber, 2000). The Schizophragma sp. is probably Schizophragma bicolor (Dozier), and the Chaetomyrmex sp. appears to be an undescribed species new to Hawaii.

The Alaptus sp., recovered in low numbers primarily from D. viscosa, is probably a result of contamination of our samples with mites, which are the usual hosts of Alaptus (Huber, 1986) and which are common on D. viscosa (M. T. Johnson, unpublished data). Stethynium spp. (probably two species in our samples) and Anagrus sp. are known to parasitize leafhopper eggs (Huber, 1986), but their association with S. rufofascia appears to be weak, given the small numbers recovered (Table 2). Similarly, the association between S. rufofascia and the few non-nymphaids recovered may be only incidental.

A substantial number of parasitoids emerged from oviposition scars before our samples were collected, and therefore their identities remain unknown (Table 2).

Variation in Total Parasitism

Total parasitism was low at all HAVO sites throughout our sampling effort, never exceeding 30% (Fig. 1). Differences in total parasitism were marginally significant among host plant species (F = 3.83; df = 2, 5; P = 0.098) and among sites (F = 4.08; df = 3, 5; P = 0.082), but not among sample periods (linear component: F = 0.06; df = 1, 64; P = 0.81; quadratic component: F = 0.23; df = 1, 64; P = 0.63). Total parasitism was highest on D. viscosa, followed by M. faya and M. polymorpha (Table 3). Parasitism of S. rufofascia on V. reticulatum was very low at the one site where this host plant was sampled (Table 3, Fig. 1). In general, total parasitism decreased with increasing elevation of sample site (Table 3), with the exception of the 1190 m site, where parasitism on D. viscosa in particular was relatively high (Fig. 1).

Fluctuation in total parasitism across sample periods tended to decrease from M. polymorpha (mean coefficient of variation ± SE: 53.3% ± 6.0) and D. viscosa (41.6% ± 6.8) to M. faya (28.0% ± 7.8) (Fig. 1), but overall differences among these host plants were only marginally significant (F = 3.32; df = 2, 9; P = 0.083).

Variation among Parasitoid Species

Host plant species significantly affected percentage parasitism by Polynema spp., Schizophragma sp., and unknown parasitoids (Table 4). Parasitism by Polynema spp. was highest on D. viscosa. Parasitism by Schizophragma sp. was highest on M. faya. Parasitism by Chaetomyrmex sp. did not differ significantly among host plants in HAVO. This Chaetomyrmex sp. was the only parasitoid species collected from guava near sea level in Hilo (Table 2).

Parasitism differed significantly among sites for Schizophragma sp., Chaetomyrmex sp., and unknown parasitoids, and in every case was higher at low elevation sites (Table 4). Parasitism by Polynema spp. did not differ significantly among sites.

DISCUSSION

In this survey, S. rufofascia eggs in HAVO were attacked principally by three species of parasitoids: Polynema sp., Schizophragma sp., and Chaetomyrmex sp.
sp. Although parasitism by each species fluctuated at levels usually below 10%, all three were detected consistently across host plants and sample sites (Table 4). A notable exception to the ubiquity of these species was the absence of Chaetomymar sp. from samples of V. reticulatum. The major peaks in parasitism on D. viscosa were due to activity of Polynema spp., the most common parasitoids on this host plant (Fig. 1, Table 4). In contrast, total parasitism on M. faya fluctuated little over the year at three sites (Fig. 1) and appeared to consist mainly of Schizophragma and Chaetomymar (Table 4). However, a substantial proportion of parasitism (23% overall) was by unknown parasitoids that emerged in the field before samples were collected (Tables 2 and 4), which caution against concluding too much about the relative abundance of each species.

Because S. rufofascia prefers to oviposit in young foliage (Jones et al., 2000), seasonal variation in plant growth is likely to result in shifting abundance on the various host plants. Seasonality in phenology of D. viscosa (M. T. Johnson, unpublished data) and M. polymorpha (Porter, 1973) may explain why parasitism on these hosts was so variable over our 1-year survey (Fig. 1). In contrast, M. faya may provide a steadier supply of host eggs due to its more uniform production of

### TABLE 3
Effects of Host Plant and Site on Total Parasitism of S. rufofascia Eggs

<table>
<thead>
<tr>
<th>Effect</th>
<th>Level</th>
<th>% parasitism</th>
<th>Range</th>
<th>% of plant samples</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host plant</td>
<td>Dodonaea viscosa</td>
<td>14.3 ± 3.4 a</td>
<td>3.9-26.3</td>
<td>3.7</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>Myrica faya</td>
<td>10.6 ± 3.5 ab</td>
<td>4.3-17.5</td>
<td>4.4</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Metrosideros polymorpha</td>
<td>8.7 ± 3.5 b</td>
<td>1.3-29.5</td>
<td>22.1</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>Vaccinium reticulatum</td>
<td>1.6 ± 4.4 c</td>
<td>0-4.3</td>
<td>68.2</td>
<td>44</td>
</tr>
<tr>
<td>Site</td>
<td>Kipuka Kahalii (880 m)</td>
<td>15.9 ± 3.6 a</td>
<td>4.0-29.5</td>
<td>2.0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Puhimau Crater (1100 m)</td>
<td>11.3 ± 3.3 ab</td>
<td>2.5-23.0</td>
<td>6.3</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>Kipuka Puauulu (1190 m)</td>
<td>11.2 ± 3.7 ab</td>
<td>1.3-25.4</td>
<td>13.2</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Devastation Trail (1130 m)</td>
<td>7.9 ± 3.6 b</td>
<td>1.3-17.8</td>
<td>18.2</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Crater Rim (1160 m)</td>
<td>2.1 ± 4.1 c</td>
<td>0-4.9</td>
<td>61.4</td>
<td>57</td>
</tr>
</tbody>
</table>

* Means (based on plant sample means averaged across sample periods) in the same column followed by the same letter are not significantly different (Tukey HSD test; P < 0.05). Effects of host plant and site were tested separately.

### TABLE 4
Effects of Host Plant and Site on Parasitism of S. rufofascia Eggs by Three Mymarid Species and Unknown Parasitoids

<table>
<thead>
<tr>
<th>Effect</th>
<th>Level</th>
<th>Polynema spp.</th>
<th>Schizophragma spp.</th>
<th>Chaetomymar spp.</th>
<th>Unknown parasitoids</th>
<th>% parasitism (mean across sample periods ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host plant</td>
<td>Dodonaea viscosa</td>
<td>6.1 ± 1.0</td>
<td>1.7 ± 0.5</td>
<td>1.5 ± 0.5</td>
<td>4.3 ± 0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Myrica faya</td>
<td>0.7 ± 0.2</td>
<td>3.5 ± 0.6</td>
<td>2.8 ± 0.9</td>
<td>3.3 ± 0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metrosideros polymorpha</td>
<td>1.5 ± 0.4</td>
<td>2.0 ± 0.6</td>
<td>3.3 ± 1.3</td>
<td>1.9 ± 0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vaccinium reticulatum</td>
<td>1.4 ± 0.6</td>
<td>0.2 ± 0.1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kruskal-Wallis test</td>
<td>χ² = 27.72</td>
<td>df = 3</td>
<td>P &lt; 0.0001</td>
<td>0.0019</td>
<td>0.0776</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.86</td>
<td>3</td>
<td>0.0002</td>
<td>0.0002</td>
<td>19.38</td>
</tr>
<tr>
<td>Site</td>
<td>Kipuka Kahalii (880 m)</td>
<td>2.9 ± 0.9</td>
<td>2.6 ± 0.9</td>
<td>6.4 ± 1.5</td>
<td>3.8 ± 0.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Puhimau Crater (1100 m)</td>
<td>1.9 ± 0.7</td>
<td>3.4 ± 0.7</td>
<td>2.3 ± 1.3</td>
<td>3.6 ± 0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Devastation Trail (1130 m)</td>
<td>1.5 ± 0.4</td>
<td>2.4 ± 0.5</td>
<td>0.2 ± 0.1</td>
<td>3.5 ± 0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crater Rim (1160 m)</td>
<td>1.2 ± 0.5</td>
<td>0.6 ± 0.3</td>
<td>0.3 ± 0.2</td>
<td>0.1 ± 0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kipuka Puauulu (1190 m)</td>
<td>6.8 ± 1.8</td>
<td>0.3 ± 0.2</td>
<td>1.5 ± 0.6</td>
<td>1.7 ± 0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kruskal-Wallis test</td>
<td>χ² = 7.63</td>
<td>df = 4</td>
<td>P &lt; 0.0001</td>
<td>0.0007</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19.33</td>
<td>4</td>
<td>0.0001</td>
<td>0.0013</td>
<td>17.82</td>
</tr>
</tbody>
</table>
leaves (Whiteaker and Gardner, 1987). Our survey method did not allow direct comparison of parasitism and leafhopper density; however, recent surveys in HAVO show that S. rufofascia densities are 3–10 times higher on M. faya than on adjacent M. polymorpha, and that densities on M. polymorpha are reduced up to 10-fold in areas where M. faya has been removed compared to nearby unmanaged areas (Lenz, 2000). These data indicate the importance of M. faya as a source of high populations of S. rufofascia as well as its parasitoids.

Of the three most common parasitoid species, Chaetomymar sp. is probably the most recent immigrant in Hawaii, and may have arrived simultaneously with S. rufofascia. The first record of this genus in Hawaii was in 1995 from S. rufofascia infesting guava on Kauai and Cibotium splendens Gaudichaud on Oahu (P. Yang, unpublished data). This parasitoid was not detected in 1995 samples of S. rufofascia-infested leaves from six host plants in HAVO, including the four plant species in the current survey (Yang et al., 2000), which suggests that it has only recently moved into the park. The high level of parasitism by Chaetomymar sp. near sea level in Hilo (49%; Table 2) and the fact that parasitism by Chaetomymar sp. was highest at the lowest elevation in HAVO (Table 4) suggest that this species is spreading from low elevation habitats.

Yang et al. (2000) collected Schizophragma sp. probably bicolor in HAVO in 1995 from S. rufofascia-infested M. faya. This parasitoid was collected as early as 1963 in Honolulu and was probably introduced from North America (Huber, 1987). Its original host in Hawaii, prior to the introduction of S. rufofascia, is unknown.

In Hawaii, the cosmopolitan genus Polynema includes 14 described endemic species, perhaps 20 or more undescribed species (Beardsley and Huber, 2000), and 2 known introduced species (Nishida, 1994). The several morphospecies of Polynema collected in our survey are probably all endemic. Their native hosts are unknown, but presumably include some of the many endemic leafhoppers (Zimmerman, 1948). Our single most commonly collected morphospecies of Polynema also was collected in 1995 by Yang et al. (2000), along with two additional morphospecies that do not match specimens identified from the current survey. Thus a total of 5 to 7 endemic species appear to have adopted S. rufofascia as a new host, although one species is much more common than the rest. Parasitism by Polynema spp. was significantly higher on one host plant, D. viscosa, than others (Table 4), which suggests that the native host of one of these parasitoids may be associated with this plant. Further systematic and ecological studies of this genus should emphasize determining host associations. Although difficult to obtain, this information will be of great assistance in assessing potential impacts of accidental and intentional insect introductions.

It remains to be seen whether natural enemies already present in Hawaii can suppress S. rufofascia populations to economically and ecologically acceptable levels. Parasitism rates observed in HAVO during this survey seem rather low, and indeed, sticky trap catches on M. faya show that leafhopper numbers have not declined in HAVO from 1994 (P. Yang and D. Foote, unpublished data) to 1999 (Lenz, 2000). However, the high rate of parasitism by Chaetomymar sp. in Hilo and its recent appearance in HAVO suggest that this species may become an important source of mortality in the future. We recommend continued monitoring in HAVO to determine if rates of parasitism increase with time.

Although Hawaii has a long tradition of biological control, with approximately 700 biological control agents introduced since 1900, the pace of introductions has slowed dramatically in the past two decades (Follett et al., 2000). This slowdown is in part a result of increased concerns regarding the nontarget impacts of biological control agents, particularly on the large native Hawaiian flora and fauna (Howarth, 1991). Any introduction targeting control of S. rufofascia would therefore have to address the risk to native leafhoppers, such as the many species (> 62) in the endemic leafhopper genus Nesophrosyne Kirkaldy (Zimmerman, 1948). This task is extremely difficult because so little is known of the biology of native Hawaiian leafhoppers and of S. rufofascia in its native range. Thus, it appears fortunate that parasitoid species already present in Hawaii are able to attack eggs of S. rufofascia.

These parasitoids may obviate the need for a new introduction; however they themselves, in particular the nonnative Chaetomymar sp. and Schizophragma sp., have potential for negative impact on native leafhoppers. In addition to aiding movement of alien parasitoids into new areas, a successful invader such as S. rufofascia could elevate population levels of native as well as nonnative mymarids, shifting the balance to the detriment of already rare native leafhoppers (Settle and Wilson, 1990). The data from HAVO suggest that the threat to native leafhoppers may be particularly high in areas where parasitoids are dispersing from high populations of S. rufofascia on the weed M. faya.
REFERENCES


Lenz, L. 2000. The dieback of an invasive tree in Hawaii: Interactions between the two-spotted leafhopper (Sophonia rufofascia) and faya tree (Myrica faya). M.S. thesis, University of Hawaii at Manoa, Honolulu, HI.


