those initially observed in October 2011 (Fig. 4). It seems more likely that 3 Points had and continues to have, higher numbers of slugs than either Palikea or Ekahanui but that this was not detected initially. These high numbers may explain why only the bimonthly application of Sluggo effectively suppressed slugs at 3 Points, while the monthly rate provided equally good suppression of slugs at Palikea and Ekahanui. This explanation is unsatisfactory however, because in addition to having the highest slug density, 3 Points also had the smallest treatment area (only 144 m$^2$ vs. Palikea’s 625 m$^2$ or Ekahanui’s 930 m$^2$). A small treatment area meant greater incursion of slugs from untreated areas. Thus, the effect of density and treatment area are confounded in the case of 3 Points. The effect of consecutive treatments (bimonthly followed by monthly) may also have inflated the efficacy of the monthly application. It is possible that lingering suppression of slugs from the bimonthly treatment was responsible for the perceived efficacy of the monthly treatment. Figure 5 suggests this is not the case however. If the bimonthly application was responsible for the success of the monthly application, we would expect slug numbers to gradually rise in Palikea and Ekahanui as the monthly application progressed. This did not happen. Alternatively the dramatic dips in slug numbers directly following each monthly treatment at 3 Points shows that slugs are responding but recovering before the next Sluggo application.

7.2 **Future research**

Starting in October 2012, we have resumed treatment of all rare plants in these three MUs with one difference. We increased the treatment area at 3 Points so that it now measures 250 m$^2$. We may expand this area to be more comparable to the Palikea site where monthly application was successful (~500 m$^2$). Also of interest would be to reduce the size of the treatment areas at Palikea and Ekahanui to see whether slug incursion becomes a problem, as we suspect happened at 3 Points. Alternately, we could increase the treatment area at Palikea or Ekahanui to examine whether Sluggo could be just as affective when applied less frequently than once per month (say once every six weeks for example).

Presently, however, slugs are only being counted in the treatment and control sites at 3 Points while applying Sluggo once per month. If slug numbers are significantly depressed in the treatment site relative to the control after 4 months, we will have evidence that Sluggo applied over a greater area reduces the need for repeat visits despite high pest density. As this work demonstrated, Sluggo applied once a month in Ekahanui and Palikea is as effective as bimonthly application thereby reducing the cost of labor and materials associated with slug control.

Further research is needed to determine the resource response to different slug densities. Missing from this particular study was any regeneration or survival data for the rare plant species treated. We do not know the level of slug suppression needed to create the greatest benefit for rare plant taxa. This is expected to differ for different species of plants in different areas at different times of year. We will focus on tackling these complex questions in future studies.

7.3 **Survey of invasive ant species**

In Hawaii, ants are most likely to become established around disturbed areas frequented by humans such as bathrooms, campgrounds, fence lines, helipads, and roads (See Appendix 7-2 of the 2010 YER). As stated in previous reports (see section 5.4 of the 2011 YER) OANRP conducts annual surveys of invasive ants in high-risk areas using a standard protocol developed by University of Hawaii entomologists (see appendix 7-1 of the 2010 YER). These areas include trailheads, cabins and landing zones, where accidental introductions of ants are more likely to occur as well as in areas where rare resources (plants, snails or endangered *Drosophila*) may prove vulnerable to ant attack. Careful monitoring will increase our chances of early detection and eradication.
Table 3. List of ant species found in each MU. New records for 2012 are indicated with an asterisk. Risk (low, medium and high) is taken from species factsheets (Sarnat 2008).

<table>
<thead>
<tr>
<th>Management Unit</th>
<th>Ants recorded prior to 2012</th>
<th>Ants recorded 2012</th>
<th>Action needed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pahole</td>
<td>Solenopsis geminata, S. papuana, Paratrechina bourbonica, Leptogenys falcigera</td>
<td>S. papuana</td>
<td>S. geminata remains absent following treatment in 2011</td>
</tr>
<tr>
<td>Kaluakauila</td>
<td>Anoplolepis gracilipes, Cardiocondyla emeryi, Ochetellus glaber, Paratrechina bourbonica, Plagiolepis alludi, S. papuana</td>
<td>Paratrechina bourbonica, Plagiolepis alludi</td>
<td>Anoplolepis gracilipes is an aggressive species; however, it was not detected in 2012</td>
</tr>
<tr>
<td>Kaala</td>
<td>Solenopsis papuana, Ochetellus glaber, Tetramorium simillimum, Cardiocondyla venustula, C. wroughtoni, C. minutior</td>
<td>Ochetellus glaber</td>
<td>No ants detected in 2012</td>
</tr>
<tr>
<td>Kahanahaiki</td>
<td>Cardiocondyla emeryi, C. wroughtoni, C. venustula, Leptogenys falcigera, Ochetellus glaber, Plagiolepis alludi, S. geminata, S. papuana, Technomyrmex albipes, Tetramorium simillimum</td>
<td>Ochetellus glaber</td>
<td>Solenopsis geminata remains absent following treatment in 2011. Ochetellus glaber is a low risk species</td>
</tr>
<tr>
<td>Pahole mid-elevation nursery (Nike site)</td>
<td>Solenopsis papuana, S. geminata, Ochetellus glaber, Anoplolepis gracilipes</td>
<td>Anoplolepis gracilipes, Solenopsis papuana, Ochetellus glaber, Cardiocondyla obscurior*, Tetramorium bicarinatum*</td>
<td>S. geminata not detected this year following treatment in 2011. Research into A. gracilipes control is ongoing. New species detected this year not considered high risk species</td>
</tr>
<tr>
<td>Kaena East of Alau</td>
<td>Tetramorium simillimum, Solenopsis papuana, Ochetellus glaber</td>
<td>T. caldarium*, Ochetellus glaber, Monomorium floricola*</td>
<td>Ants found are low risk species</td>
</tr>
<tr>
<td>Lower Ohikilolo</td>
<td>Ochetellus glaber, Pheidole megacephala</td>
<td>Ochetellus glaber, Pheidole megacephala, Monomorium destructor*</td>
<td>Ants found are too widespread at low elevations for control</td>
</tr>
<tr>
<td>Honouliuli</td>
<td>Solenopsis papuana, Pheidole megacephala</td>
<td>Solenopsis papuana, Pheidole megacephala</td>
<td>Solenopsis papuana detected at high elevation sites, but is not considered a threat. Pheidole megacephala was only found on the road at the trailhead</td>
</tr>
</tbody>
</table>
Makaha | *Anoplolepis gracilipes, S. papuana* | *Anoplolepis gracilipes, S. papuana* | These two species were only found in the parking lot, they were not detected at the outplanting sites at higher elevation. Only *A. gracilipes* is a species of concern

Ekahanui | *Solenopsis papuana, Plagiolepis alludi* | *Solenopsis papuana, Technomyrmex albipes* | Species present are not considered a high threat

Palikea | *Cardiocondyla venustula, Pheidole megacephala, Solenopsis papuana* | *Solenopsis papuana* | *Pheidole megacephala* doesn’t appear established, not detected in 2012.

### 7.3.1 Ant Control Actions

Three infestations of the *Solenopsis geminata* (tropical fire ant or TPA) were identified and treated in 2011 by State and OANRP staff (infestations were at Pahole Mid Elevation Nursery, Puu 2210 and Peacock Flats). Follow up monitoring in 2012 failed to detect continued persistence of TPA. Further monitoring in 2013 is recommended to assure successful eradication.

### 7.3.2 Yellow Crazy Ant Control

*Anoplolepis gracilipes* or yellow crazy ant (YCA) continues to be a problem at the Pahole Mid Elevation Nursery where it occupies an area of approximately 1 acre. Since its initial discovery at that site in 2008, OANRP has attempted control using various insecticides with no success (see section 5.4.1.1 in 2011 YER).

USFWS recently developed a bait mixture containing 25% cat food, 25% Karo syrup and 50% water with the active ingredient dinotefuran (the pesticide Safari™ 20 SG, Valent U.S.A. Co.) which successfully controlled YCA on a small atoll. Following their protocol, we tested this mixture at our Wahiawa baseyard where YCA is well established and present in high numbers. Treatment took place on 30 August 2012 at the recommended rate (6 g a.i./0.5 ha). Numbers of foragers at cards with non-toxic bait (SPAM, peanut butter and honey mixture) were counted before and after treatment to determine treatment efficacy (*n = 20 cards*). Initial results showed a dramatic knockdown within 1 week but full recovery occurred after about 1 month (Fig. 10). A one-way ANOVA was used to test for differences in YCA visitors to bait cards pre and post-treatment across the four time periods sampled (Fig. 11). A significant decline due to treatment was found (*F* _3, 79_ = 10.87, *p* = 0.000).
Figure 10. Proportion of bait cards with at least 1 YCA forager before and after treatment. Following treatment the number of baits with ants drops, but recovers in about 18 days.
Figure 11. Ant counts over time at bait cards (bars are ± 1 SEM) following treatment with Safari 20 SG. Letters denote groups that differ significantly from one another according to post hoc comparisons using Tukey’s HSD. Though ants 10 days after treatment remained significantly lower than pre-treatment, recovery is noticeable.

Though ants were able to recover fully in one month’s time, incursion from surrounding areas is high and eradication at the Wahiawa baseyard was not expected. This is the first time we have found YCA to respond to any insecticide. We remain hopeful that with further testing, including multiple treatments, Safari 20 SG might be used to eradicate the isolated population of YCA from Pahole Mid Elevation Nursery.

References


