Quantifying the dominance of little fire ant (Wasmannia auropunctata) and its effect on crops in Solomon Islands

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ABSTRACT
We measured the impact of little fire ants on the ant fauna within gardens, and on a significant pest of one crop - taro and its natural predators. We surveyed the ant fauna in garden sites of four common subsistence crops; potato, cassava, taro and yam; a total of 24 gardens with three trials per garden, using baiting and hand collecting. The impact of W. auropunctata on Tarophagus sp (a pest on taro crops) and Cyrtotinus fulvus (a natural predator of Tarophagus) was measured in 56 taro gardens with half of the gardens infested with little fire ants. Twenty five taro plants were randomly selected in each taro garden where standardized visual identification and recording was conducted for Tarophagus sp and C. fulvus. Sites with W. auropunctata had significantly lower mean abundance of other ant species than gardens free of W. auropunctata. Significantly more Tarophagus were found on taro plants in the presence of W. auropunctata than in the absence of W. auropunctata. The presence of W. auropunctata appears to lead to a reduction in the ant fauna at a site, and could lead to ecological damage to other invertebrates and vertebrates. The presence and dominance of W. auropunctata on subsistence crops may provide an environment for insect pests to thrive. Little fire ants therefore could pose an economic as well as an ecological risk in subsistence gardens in the Solomon Islands.

Keywords: Pest, Wasmannia auropunctata, ecological risk, economical risk

INTRODUCTION
The little fire ant (Wasmannia auropunctata) was first reported in Solomon Islands in 1974.1 It is likely that it was first brought to the islands to serve as a biological control against nutfall bug (Amblypelta sp) in coconut and cocoa.2 Since introduction, it has spread and colonised a number of different environments across the country. To date, no studies have investigated the impact of these ants on the ecology and agricultural practices in the Solomon Islands.

Forest disturbance and agricultural activities are known to aid the spread and dominance of W. auropunctata.3 In sites around the islands to serve as a biological control against nutfall bug (Amblypelta sp) in coconut and cocoa.4 Since introduction, it has spread and colonised a number of different environments across the country. To date, no studies have investigated the impact of these ants on the ecology and agricultural practices in the Solomon Islands.

Forest disturbance and agricultural activities are known to aid the spread and dominance of W. auropunctata.5 In sites around the world where it has established, W. auropunctata is known to reach high population densities and cause major ecological havoc.6 On some Pacific islands W. auropunctata has invaded a range of habitats and caused disruption to the native ant fauna and even to vertebrate communities.5,6,7 W. auropunctata has been known to eradicate entire ant faunas.8

Taro (Colocasia esculenta) is an important food crop in the Solomon Islands. Tarophagus sp; are hemipteran pests of taro plants (Colocasia esculenta). Cyrtotinus fulvus is a mirid bug that is a predator of Tarophagus and thus is also almost exclusively found on taro plants. C. fulvus feeds on the egg of Tarophagus sp. and thereby acts as a natural control. Ants are known to tend hemipterans, and may influence the nature of the ecological relationship between C. fulvus and Tarophagus. Hence the presence of W. auropunctata could lead to an increase in abundance of Tarophagus individuals and a concomitant increase in damage to the crop plants. We will use the abundance of Tarophagus and C. fulvus in sites with and without W. auropunctata as a measure of the impact of the ants to agricultural systems.

Since introduction to the Solomon Islands over 30 years ago, W. auropunctata has continued to spread between islands and habitats. To date it is likely that no island in the Solomon Islands has been spared from the invasion of W. auropunctata (pers. Com.). In spite of evidence of the potential damage caused by W. auropunctata, Ministry of Agriculture in Solomon Islands still appears to promote the spread of W. auropunctata in the light of its benefit to coconut and cocoa.9

In this study, we determined the impact of W. auropunctata on native ant fauna of Solomon Islands and to important agricultural crops on the islands. We assess the abundance and diversity of ants in garden sites with and without W. auropunctata, and also measure the abundance of a significant taro pest (Tarophagus sp.) and its natural predator (Cyrtotinus fulvus) in gardens with and without the invasive ant.

METHODS

Sampling area
This study was carried on Bauro area in Makira Island, Solomon Islands. Makira Island is located at 11º0’0 E and 162º 30’0 S. Makira Island is the fourth biggest of the six major islands of the Solomon Islands archipelago,10 with a land area of 3,100 sq km. With a tropical climate characterized by high humidity and uniform hot temperatures and an annual mean rainfall which ranges from 3000 mm to 5000 mm with a general higher occurrence of rainfall from May to October and November to April.11 Makira Island is typical of major islands in the Solomon Islands in the environmental conditions and the topography, with plains towards the coastal area and steeply dissected mountainous interiors rising to over 1000m. Agricultural activity occurs on the more favourable topography primarily along the coast where climate is hot and wet with lowland rainforest. Two areas selected for the study are in the Bauro lowland and in Bauro highland. Bauro highland is said to be among the few places within the Bauro area that is still free of W. auropunctata. The survey was conducted between January and February and repeated between April and May, 2008.

Impact of W. auropunctata on native ant fauna
We sampled 24 subsistence gardens of 4 subsistence crops (potato, cassava, taro and yam) in two areas; Bauro lowland and Bauro highland to measure the abundance and diversity of the native ant fauna. Gardens sampled were all approximately the same size. We used baiting and timed hand collecting to trap ants. Parallel transects were used along the garden sites. Transects were set 1.5m apart with a total of 30 baited (tuna and peanut butter) 60ml containers in each gardens. Baited containers were left in place for 45 minutes before collecting. Timed hand collecting involved dividing each garden into four quarters and spending 15 minutes in each quarter collecting ants from the soil, dead leaves, litter, stem and leaves of the crops. Collecting was undertaken using forceps or direct hand picking and a small manually operated aspirator. Ants collected were stored in 75% ethanol for identification and sorting.

**Effect of W. auropunctata on Tarophagus sp and C. fulvus**

To assess the impact of *W. auropunctata* on *Tarophagus* sp and *C. fulvus* on taro plants, 25 taro plants were randomly selected from each garden out of a total of 56 taro gardens with half of the gardens in each area (lowland and highland). The survey involved determining the population of *C. fulvus* and *Tarophagus* sp. by standardised visual identification and recording of *C. fulvus* and *Tarophagus* sp. on each of the 25 taro plants on the 26 taro gardens in Bauro lowland and 26 taro gardens in Bauro highland.

**Statistical analysis**

We compared the abundance of all native ants to *W. auropunctata* and also each of the same ant specie found on Bauro lowland (where *W. auropunctata* is present) to ones found on Bauro highland (where *W. auropunctata* is absent) using simple *t* test. The impact of *W. auropunctata* on the taro pest (*Tarophagus* sp) and its predator (*C. fulvus*) was tested using a *t* test to determine the significances of the difference between the population of the taro pest and its predator in the taro plants infested and free of *W. auropunctata*. The statistical test was carried out using SPSS version 16.

**RESULTS**

A total of 13 different ant species were found in both lowland and highland areas (Table 1). Highland sites however, showed 12 ant species compared to only 5 species in the lowland sites where *W. auropunctata* present (Table 1). Except for *W. auropunctata* and *Anoplolepis gracilipes*, all other ants are native to Makira Island.

### Table 1. Ant species composition found in the study areas.

Lowland Sites are infested with *W. auropunctata* and Highland Sites are free of *W. auropunctata*. Plus (+) indicates that ant species was found, minus (-) indicates not ant species found during the sampling period.

<table>
<thead>
<tr>
<th>Ants species</th>
<th>Lowland Sites</th>
<th>Highland Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Wasmannia auropunctata</em></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><em>Paratrechina stigmatica</em></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Paratrechina vaga</em></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Paratrechina consuta</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Paratrechina oceanica</em></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Pheidole oceanica</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Pheidole sp. 2</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Polyrachis sp.1</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Rhytidoponera sp.1</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Odontomachus sp.1</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Camponotus sp.1</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Anoplolepis gracilipes</em></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Oecophylla smaragdina</em></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

A significant difference was observed (*t*<sub>22</sub> = -2.21, *p* = 0.04) between the overall abundance of non-*W. auropunctata* ant species on lowland sites and highland sites (Fig. 1). Correspondingly, when comparing the mean abundance of single species of ants found in lowland sites and highland sites, a marked difference was observed (Fig. 2). Except for *P. oceanica* and *O. smaragdina*, the mean abundance of the individual ant species was significantly different in both areas (Fig.2).

![Fig. 1. The mean abundance of non-*W. auropunctata* ants found during the sampling period at both lowland and highland sites.](image-url)
Fig. 2. A comparison between the mean numbers of different ant species collected in the two sampling areas. △ Ants collected on lowland sites. ■ Ants collected highland sites. Pa.S - Paratrechina stigmatica, Pa.V - Paratrechina vaga, Pa.C - Paratrechina consuta, Pa.O - Paratrechina oceanica, Ph.O - Pheidole oceanica, Ph.sp2 - Pheidole sp. 2, Po. Sp1 - Polyrachis sp.1, An.G - Anoplolepis gracilis, Ca.sp1 - Camponotus sp.1, Rh.sp1 - Rhytidoponera sp.1, Oc.S - Oecophylla smaragdina, Od.sp1 - Odontomachus sp.1, Wa.A - Wasmannia auropunctata, ⇨ = comparison without significant difference.

Effect of W. auropunctata on Tarophagus sp (Taro pest) and Cyrtohinus fulvus (natural predator of Tarophagus sp.)

Introduction of W. auropunctata to taro plants did not significantly affect the population of Cyrtohinus fulvus (predator) in taro plants but has significantly influenced the population abundance of Tarophagus sp. There is no significant difference in the mean density of C. fulvus per taro plant in the taro gardens found in the two areas (lowland sites – taro gardens infested with W. auropunctata and highland sites – taro gardens free of W. auropunctata), (t(54) = -1.61, p = 0.11), although taro plants in highland sites show a slightly higher mean density of C. fulvus (Fig.3). In contrast, the mean abundance of Tarophagus sp per taro plant (same taro plants surveyed for C. fulvus) in the two areas is significantly different (t(54) = 7.1, p < 0.05). In the presences of W. auropunctata, more Tarophagus sp is observed in taro plants compared to when W. auropunctata is absent.

Fig. 3. The mean abundance of Tarophagus sp. and C. fulvus on each taro plant sampled. ▲ Tarophagus sp. (pest). ♦ C. fulvus per plant (predator).

DISCUSSION

Abundance and richness of other ant species

To our knowledge, this is the first study to determine the ecological as well as the agricultural consequence of the invasion and presence of W. auropunctata in Solomon Islands. W. auropunctata has inflicted disruption to both the native ant species diversity and abundance.

Wasmannia is widespread across the region. Movement of garden crops and planting materials appeared to be the most obvious means of spreading W. auropunctata (pers. obs.). Planting materials of desired crops are often moved from one village to another. It is likely that the ants are transported with these materials.

This study has demonstrated that in sites where W. auropunctata is absent, 12 species of ants were collected compared to only 4 species found where W. auropunctata is present. With the four species of ants (Paratrechina stigmatica, Paratrechina vaga, Paratrechina oceanica and Oecophylla smaragdina) found to be common in sites free and infested with W. auropunctata, it was noted that except for P. oceanica and O. smaragdina, the other two ants were found to be significantly abundant in W. auropunctata free sites. Where it was present, W. auropunctata was always by far the most abundant ant species, representing over 95% of the total catch in invaded areas.

It seems clear therefore, that W. auropunctata is causing major disruption to the native ant fauna. Such disruption could be by means of disturbance to the native ant community or direct elimination of many of the native ants. It may be that if W. auropunctata is allowed to spread to the different habitats normally used by the native ants, W. auropunctata could drive species to at least local extinction. This finding is consistent with other studies conducted in other W. auropunctata invaded areas, including New Caledonian, Vanuatu and the Galapagos.

Given that the Bauro area is typical, both in terms of geography and agricultural usage, of a cross section of agriculturally-altered coastal environment of the Solomon Islands, it can be assumed that this result represents the general status of impact of W.
AUropunctata on the native ant fauna in other islands in Solomon Islands.

The abundance of Pests and Predators in the presence of W. auropunctata

We found evidence that the presence of W. auropunctata could lead to agricultural costs. Tarophagus sp. were more abundant in taro gardens infested with W. auropunctata than in taro gardens free of W. auropunctata. No significant difference was observed in the mean population abundance of C. fulvs per taro plant on taro plants infested and free of W. auropunctata (Fig. 3). Based on the concept of “food for protection”, a common and important ecological interaction between Formicidae and honeydew producing insects,[6,17,18] and in an ideal situation based on similar studies,[19,20] the population of C. fulvs or other natural enemies would have been reduced significantly in the presences of tending ants and an increased population of the insect pest would be more obvious. Instead population abundance of C. fulvs per taro plant in both W. auropunctata infested and un-infested taro plants is about the same. Hemipteran tending ants provide a range of benefits to the hemipterans, including protection against natural enemies and increased fecundity. It has been shown that the benefits to the hemipterans, including protection against natural enemies, and in an ideal situation based on similar ecological interaction between Formicidae and honeydew producing insects. These studies should improve our understanding of the impact of W. auropunctata to the ecology and agriculture. Solomon Islands as an introduced range is vulnerable to the invasiveness and aggressiveness of W. auropunctata.

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REFERENCE


Hence, there is a positive increase in the population density of Tarophagus sp. in the presence of W. auropunctata compared to a decreased density in the absence of W. auropunctata in the taro gardens surveyed. Mutualistic relationship developed between W. auropunctata and Tarophagus sp or any other crop pests has a tendency to favour the W. auropunctata – tended pests. Presence and abundance of W. auropunctata may therefore provide an opportunity for an increase in a number of pests in many subsistence crops due to their forged alliance as natural enemies of the pests are normally suppressed or preyed upon. An association as such is often at the detriment of the host plant. This is one of the risks subsistence farming or agriculture activities will have to put up with as W. auropunctata continue to increase its presence and dominance in subsistence gardens, farms and agricultural sites. W. auropunctata therefore does pose a new threat to subsistence farming and agriculture because although pests such as Tarophagus sp. are common even in W. auropunctata free taro gardens, their relationship with W. auropunctata might give them an added advantage to inflict damage on crops unseen earlier.

Further study on the impact of W. auropunctata on other invertebrates and vertebrates in Solomon Islands is needed especially in the light of the finding of this study but more importantly from anecdotal reports where domesticated dogs, cats and birds are being blinded from the stinging venom of W. auropunctata. Further work on the direct or indirect impact of W. auropunctata on subsistence farming and agriculture is needed.


