Access to Plant-based Carbohydrate Resources and Colony Investment for Two Ant Species

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Introduction

Body size is a key life history trait that directly impacts an organism's survival and reproductive success. In social insects, differential investment into worker size or number is thought to play an important role in determining colony success. Colony investment into a colony's worker force may shift in response to resource availability. Moreover, investment in offspring size is subject to trade-offs associated with resources allocation. For example, resources devoted to one function (i.e. increasing individual size) cannot be allocated to another (increasing offspring number). Access to carbohydrate-rich resources can influence colony growth, and the monopolization of carbohydrate-rich resources has been implicated in the ecological success of certain groups of ants.

Questions

1. How does access to carbohydrate resources influence colony investment in worker number, size, or morphology?
2. Is there a trade-off investment in worker number and worker size?

Methods

Study organism

The red imported fire ant (*Solenopsis invicta*) is continuously polymorphic (**Fig. 1**), and an invasive ant species. The monomorphic, *Forelius pruinosus* is a native monomorphic ant species. All colonies were collected in the spring 2009 from around the campus of Texas A&M University (College Station, Brazos County, Texas, USA).

Experiment design

Experimental lab colonies of *S. invicta* consisted of 1g wet mass of workers (+ 50 brood) and *F. pruinosus* colonies consisted of 0.5g wet mass of workers (+ 50 brood).

Each experimental colony was provided access to cotton plants (*Gossypium hirsutum*). The aphid treatment was created by adding cotton aphids (*Aphis gossypii*) to plants (*S. invicta*: 13 colonies; *F. pruinosus*: 14 colonies). The control treatment was maintained by searching cotton plants twice a week and killing any aphids found (*S. invicta*: 17 colonies; *F. pruinosus*: 13 colonies). Aphid populations were monitored weekly and ant predation on aphids was not significant.

All colonies were:

- Provided vials of water and two crickets 3x a week.
- Housed under a 12:12 photoperiod at 27ºC.
- Colonies were maintained for 60 days then culled.

For each colony we counted the total number of workers and took the individual worker dry mass (*S. invicta*: n = 30 workers; *F. pruinusus*: n = 10 workers). The head length, head width, pronotal width, hind tibia length was measured for each dry massed worker (**Fig. 2**).

Statistical tests

To compare worker number and worker body size by treatment we used a t-test and compared morphology between treatments using a PCA. To explore potential trade-offs between colony size and worker body size using a regression analysis.

Methods Cont.

Figure 1. Morphological features measured for each dry massed individual of **A)** *Solenopsis invicta* and **B)** *Forelius purinosus*. The measures include: head length (green) head width (blue), pronotal width (orange), and hind tibia length (black). Photos: Antweb.org

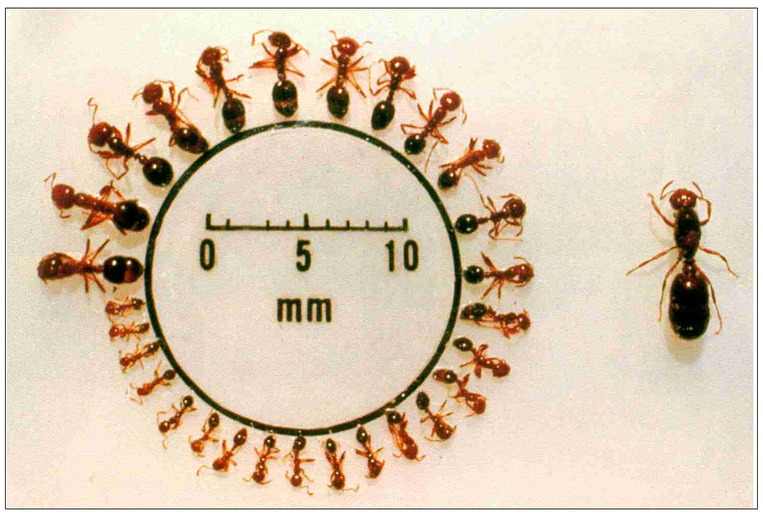

Figure 2. Morphological variation in worker body size found within a single colony of *Solenopsis invicta* and a queen on the right. Photo: Sanford Porter

Results

Solenopsis invicta

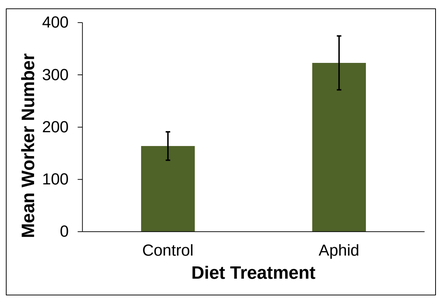

Figure 3. The mean (± SE) worker number per colony without access to carbohydrates (Control) and with access to carbohydrates (Aphid). Colonies with access to aphids were larger than those without access to aphids (t-test, p = 0.03).

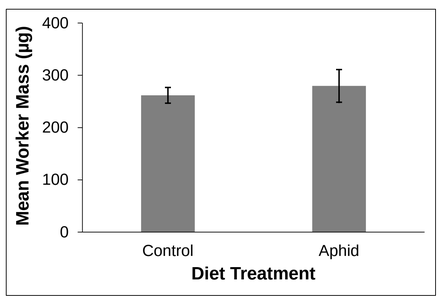

Figure 4. Mean (± SE) worker body mass (µg) per colony without access to carbohydrates (Control) and with access to carbohydrates (Aphid). We found no significant difference between diet treatments (t-test, p = 0.59).

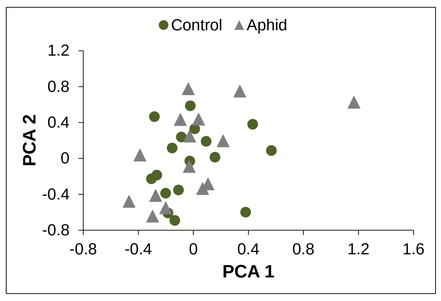

Figure 5. PCA of *S. invicta* colonies with access to carbohydrates (orange squares) and without access to carbohydrates (blue triangles). PC1 and PC2 explain 98% of variation in morphological measurements. We found no significant difference in morphology between diet treatments (t-test, p = 0.9).

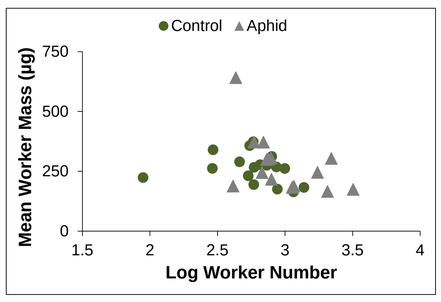

Figure 6. Relationship between worker number and mean worker size (Control: green circles; Aphid: gray triangles). We find no investment trade-off between worker number and worker body size in the "Control" (R^2 = 0.05, p = 0.39) or "Aphid" (R^2 = 0.26, p = 0.053) diet treatment.

Results Cont.

Forelius pruinosus

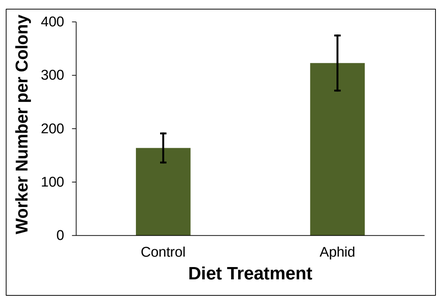

Figure 7. Mean (± SE) worker number per colony without access to carbohydrates (Control) and with access to carbohydrates (Aphid). Colony number was significantly greater in aphid treatments than control treatments (t-test, p = 0.02).

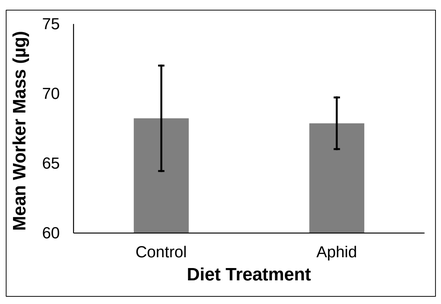

Figure 8. Mean (± SE) worker body mass (µg) per colony without access to carbohydrates (Control) and with access to carbohydrates (Aphid). We found no significant difference between diet treatments (t-test, p > 0.93).

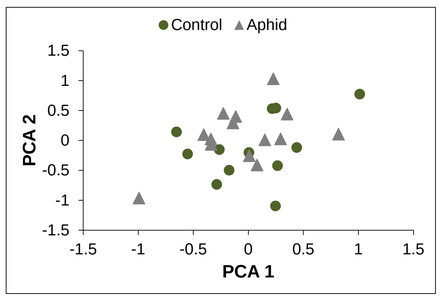

Figure 9. PCA of *F. pruinosus* colonies with access to carbohydrates (green circles) and without access to carbohydrates (gray triangles). PC1 and PC2 explain 90% of variation in morphological measurements. We found no significant difference between diet treatments (t-test, *p > 0.62).*

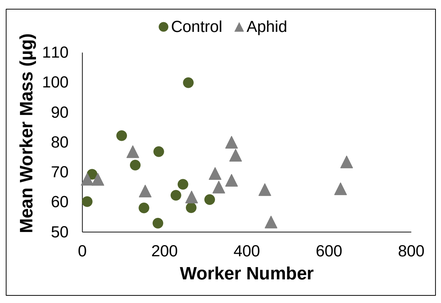

Figure 10. Correlation between worker number and mean worker size (Control: green circles; Aphid: gray triangles). We find no evidence of investment trade-off between worker number and worker body size with "Control" (R^2 = 0.0005, p = 0.94) or "Aphid" (R^2 = 0.007, p = 0.78) treatment.

Conclusions

Access to carbohydrate-rich resources, in this case aphid exudates, increases the total number of workers for *S. invicta* (**Fig. 3**) and *F. pruinosus* (**Fig. 7**) colonies. However, we did not find that increased access to aphid exudates increases the mean individual worker size for *S. invicta* (**Fig. 4**) or *F. pruinosus* (**Fig. 8**) colonies. We also find no difference in worker morphology between diet treatments for both species (*S. invicta*: **Fig. 5**; *F. pruinosus* **Fig. 9**). For the continuously polymorphic *S. invicta* there is some evidence for trade-offs in worker number and size for colonies with access to aphids (**Fig. 6**) but none for *F. pruinosus.*

Worker number is an important trait in determining colony growth, foraging success, and reproductive output. For invasive species, like *S. invicta*, increased access to carbohydrate-rich resources may play an important role in invasion success. However, carbohydrate-rich resources are also important for the native species like *F. pruinosus*. This suggests that carbohydrate limitation is an important factor in reproductive investment in all ants species.

Future Directions

We find that only the polymorphic ant species displayed a potential trade-offs in reproductive investment in worker size and worker number. We plan to explore if polymorphic species are more likely to show worker number versus size trade-offs than monomorphic ant species.

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