



# The influence of caste ratio on the colony investment in the dimorphic ant---*Pheidole megacephala*



Minghui Lin, Undergraduate; Supervisor: Dr. Benoit Guénard  
The University of Hong Kong, Major in Biological Sciences

## Abstract

In social insect colonies, the division of labor and morphological differences, are commonly encountered and might explain the evolutionary and ecological success of these species. Within a colony, the performance rates of different tasks directly influence fitness. Previous studies assumed that colony activities and reproductive outputs depend on the presence of an optimal caste ratio, but did not tested it directly. In this project, I choose a **dimorphic ant genus *Pheidole*** to investigate how the social investment in the ratio of workers influences their foraging activities. These results will provide a new light on the ecological importance of polymorphism in social insect colonies and the trade-offs between colony investment and performance

## Introduction

Many species of eusocial insects exhibit worker polymorphism, in which morphologically specialized individuals are distinct in their behaviour and perform different tasks. Species of the ant genus *Pheidole* typically have **dimorphic workers** in their colony (Wilson 2003). Minor workers represent the majority and perform most of the tasks such as queen and brood care, food foraging, nest construction, etc. while major workers with their large head are specialized for carrying large items, breaking up large food and colony defence (Wilson 2003). Several studies have shown that with the caste ratio disturbed in a colony, majors will compensate for the deficiency of the minors by maintaining a high-performance rate (Wilson 1984; Burkhardt 1998). Therefore, we are interested in whether there would be any change in the performance rates of colony activities as the caste ratio changes.

In summary, there is a need for a better understanding of the effects of caste ratios on the ant colony. In this study, our goal is to investigate the influence of caste ratio on the colony investment. More specifically, the following research questions need to be addressed:

- **Research question: Caste ratios** in disturbed colonies affect the **foraging performance** of colonies



Figure 1. Dimorphic head structures of major workers and minor workers in *Pheidole braueri*. By Brian L Fisher

## Methods and Materials

### Sample collection

*Pheidole* nests were located by searching near the top surface of leaf litter. Once a nest was located, all leaves within a 2 m radius were removed and one or more drops of honey-water solution (1-part honey to 10 parts water) were placed on a leaf or stem near *Pheidole* foragers. After a forager filled its crop, it was followed back to its nest. Then the nest was removed so that the contents could be counted. 40 colonies in wild conditions will be examined in total to get a caste ratio curve plot between majors and minors. Then all foragers were collected in each colony for further manipulation experiments.

### Experimental manipulation of the caste ratio

Four experimental treatments with 10 replicates per treatment are used with all adults. Each experimental colony consisted of 100 mg of workers with 0%, 10%, 20%, 30% of major workers in numbers. Each experimental colony will be housed in a plastic test tube and reared under constant conditions. An artificial lighting was timed on a 12:12-h light: dark regime and the temperature was kept constant at 24±1°C. The nest queen and workers were transferred into the tube 48h before the experiment began as a fasting period. Moistened plaster was poured to a depth of 2 cm in the bottom of the tube. Fragments of decaying leaves from the vicinity of the original nest were scattered over the soil surface to imitate the microenvironment. Each tube was constantly moistened with wet cotton plugs at the opening. The foraging area was 8 cm away from the soil surface (near the opening). Colonies will be fed each time with 0.1 gram of whole fish pellet food

The food was served on a plastic plate (3-cm diameter). After 3 hours for feeding, the food pellet was removed and recorded for the weight loss after the measurement. One week always elapsed between two successive feeding. For an equal size of the food, the characteristics of food availability are the same. This treatment aimed at stressing the role of major workers for prey cutting and participation in recruitment. Time to resource exploitation completion will be measured in each treatment. The experiment will be repeated multiple times over a period of one month.

### Statistical Analysis

The statistical analyses were performed at the  $\alpha = 0.05$  level using R for Windows version 4.0.3 with statistical software packages.

## Results

Based on the results of one-way ANOVA, the F statistic equals to 106.1317 ( $p=1.74 \times 10^{-7}$ ), indicating a great significance of the treatment effects.

ANOVA Table				
Source of Variation	SS	df	MS	F
Treatments	0.05512	3	0.018373	106.1317
Error	0.027007	37	0.000173	
Total	0.082127	40		

Table 1. ANOVA analysis for the main effects of caste ratios (n=40)

Barplot of Foraging Rate in Ant Colonies

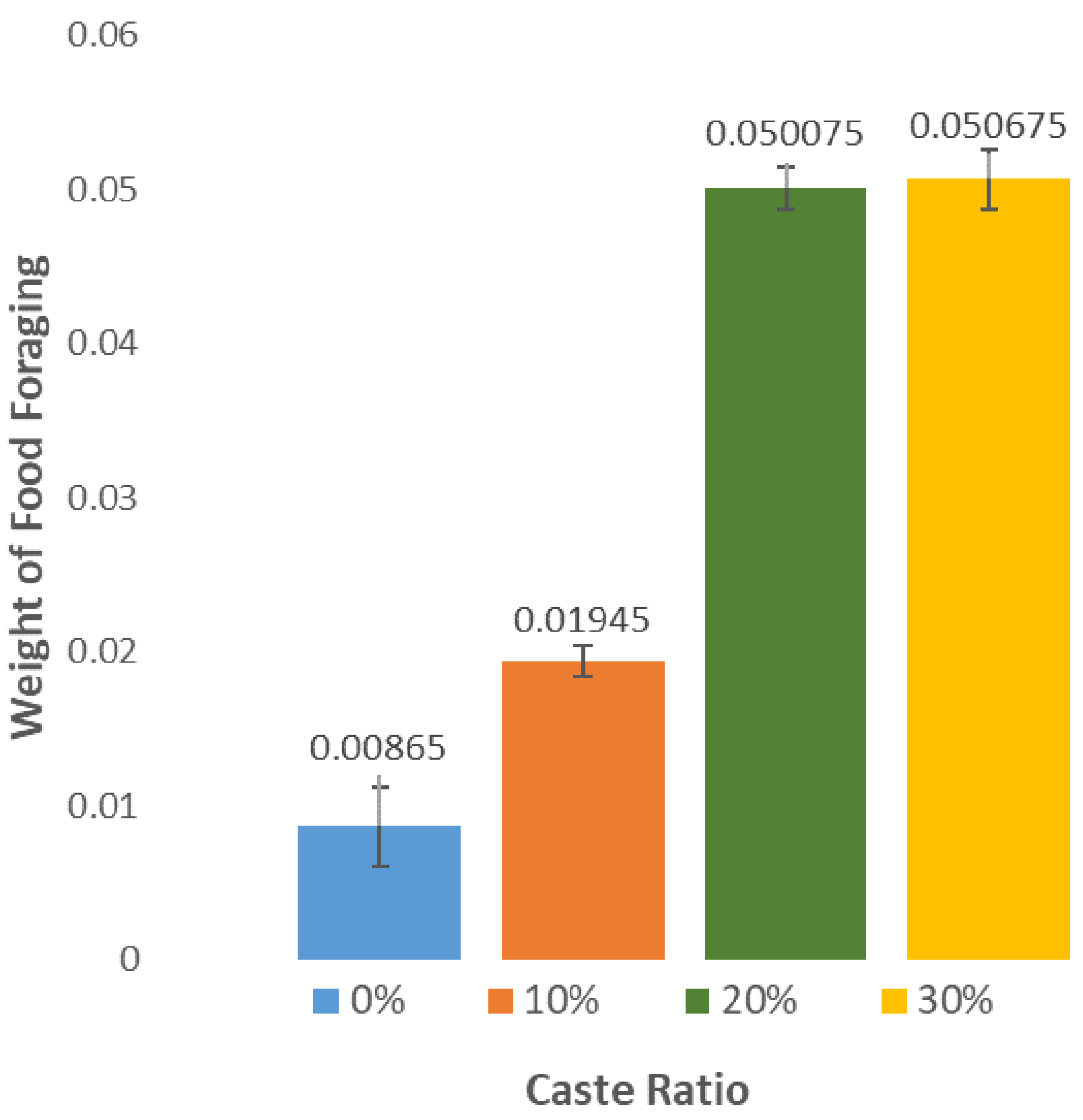


Figure 2. Comparison of foraging rate among colonies with different caste ratios.(mean ± S.D.)

## Discussion

The colonies with 30% of major workers exhibited the highest foraging rate while the colonies with total minor workers exhibited the lowest foraging rate. These results indicate that the caste ratio of major workers would have a positive impact on the foraging behaviour within the range of 0~30%.

- Based on the findings of these studies, recommendations for future research studies include:
- Repeat this study to verify or refute these findings by using different ant species and with a large sample size to increase the power of the statistical analyses and reduce the spread of the confidence intervals.
  - Investigate whether there is a optimal caste ratio within the tested range that can maximize the foraging rate for the ant colonies.
  - Investigate the effects of other environmental factors would have a confounding effect on the ant foraging behaviour.

## Conclusions

Based on the results, the caste ratio of major workers have a positive impact on the foraging behaviour within the tested range of ratio. This corresponded with previous observations that major workers are responsible for carrying large particles of food in foraging activities.

Further hypothesis could be made to investigate whether there is an optimal caste ratio within this ratio range among several local *Pheidole* species.

The importance of recognizing the effects of dimorphism may offer us a comprehensive method for controlling the population in an ant colony. It could be useful either in reviving endangered ant species with dimorphism or in inhibiting the population growth of non-indigenous ant species.

## Author Information

Summer Research Fellowship (SRF)  
Poster No.: F11  
Name: Lin Minghui  
University No.: 3035449126  
Student's Major: Biological Sciences

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