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# Ant (Formicidae) diversity, species richness, and abundance in response to different food sources

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# Ant (Formicidae) Diversity, Species Richness, and Abundance in Response to Different Food Sources

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## ABSTRACT

More than 500 species of ants (family Formicidae: order Hymenoptera) have been found in Costa Rica (Gauld & Hanson 2000), and 46 of the 80 genera found in Costa Rica are known to live in the Monteverde area (Longino 2000). Some species of ants are known to exhibit food preferences for or against sugar and/or specific prey taxa (Dejean *et al.* 1999). The purpose of this study was to determine if species richness and diversity change in response to varying bait in traps. One hundred and twenty traps containing one of 6 kinds of bait (crustaceans, tuna, honey, peanut butter, and tuna/honey and peanut butter/honey mixtures) were left on the ground near the trails in the Bajo del Tigre area, Monteverde, Costa Rica. Captured ants were identified to morphospecies and their abundance was recorded for each trap. Crustacean bait attracted the greatest diversity of species (Shannon Weiner diversity index: H' = 0.74) and tuna and peanut butter baits attracted the lowest diversity (Shannon Weiner diversity index: H' = 0.33, 0.31). Peanut butter/honey bait attracted significantly more individuals than crustaceans, honey, tuna and tuna/honey (Fisher's PLSD, P = 0.0010, 0.0009, 0.0360, 0.0037, respectively). This study demonstrated that there are significant differences in both the diversity and number of ants trapped when using different kinds of bait, and that researchers should be selective in choosing the bait that best suits the purpose of their study.

## RESUMEN

Se han encontrado en Costa Rica más que 500 especies de hormigas (familia Formicidae: orden Hymenoptera) (Gauld & Hanson 2000), y 46 de los 80 géneros encontrados en Costa Rica viven en el área de Monteverde (Longino 2000). Se sabe que algunas especies de hormigas exhiben preferencias de comida a favor o en contra de azúcar y/o taxa especificos (Dejean *et al.* 1999). El propósito de este estudio fue determinar si la riqueza de especies y la diversidad cambia en respuesta a un cambio en el cebo de las en trampas. Ciento veinte trampas que contenían uno de los seis tipos de cebo (crustáceos, atún, miel, mantequilla de maní, y mezclas de atún/miel y mantequilla de maní/miel) fueron quedado en el suelo cerca de los senderos en el área del Bajo del Tigre, Monteverde, Costa Rica. Se identificó hormigas capturadas a nivel de morphoespecies y sus abundancias fueron anotadas para cada trampa. El cebo de crustáceos fue el que atrajo la mayor diversidad de especies (Índice de diversidad Shannon Weiner: H' = 0.74) y atún y mantequilla de maní atrajo la menor diversidad de especies (Índice de diversidad Shannon Weiner: H' = 0.33, 0.31). Mantequilla de maní/miel baits atrajeron significantivamente más individos que crustáceos, miel, atún, y atún/miel (ANOVA, P = 0.0010, 0.0009, 0.0360, 0.0037, respectivamente). Este estudio demostró que hay una diferencia significativa en la diversidad y número de hormigas atrapadas cuando se usaron tipos diferentes de cebo, y los científicos deben ser selectivos cuando escogen cebo que sea mejor para el propósito de su estudio.

## INTRODUCTION

Ants are an incredibly adaptable group of organisms and are found from the Arctic Circle to the Southern most reaches of America and Africa (Holldobler and Wilson 1990). Ants aerate soil, serve an important role in food webs, and are some of the most diverse and abundant of all insects (Holldobler and Wilson1990). More than 500 species in the family Formicidae (order Hymenoptera) have been found in Costa Rica (Gauld & Hanson 2000), and 46 of the 80 genera found in Costa Rica are known to live in the Monteverde area (Longino 2000).

Neely (2004) found that there was a negative correlation between elevation and the diversity of Formicidae in the Monteverde area. Musser (2001) found that there was no significant difference in species richness between old growth and secondary growth forests, but little species overlap. Similarly, in a comparison of forest and pasture habitats, Pelayo (1998) found there was little difference in diversity and little species overlap. Corbett (2001) used peanut butter and honey traps and found a greater diversity between a coffee/banana plot and a secondary forest. All these experiments used traps that contained a mixture of protein and honey. Some species of ants are known to exhibit food preferences for or against sugar and/or specific prey taxa (Dejean *et al.* 1999), which could mean that these previous studies did not include species that were not attracted to the kind of bait used.

The purpose of this study was to determine if ant species richness and diversity vary in relation to type of trap bait. Tuna and honey mixes or peanut butter and honey are supposedly used to obtain both nectivorous and carnivorous ants. However, this mixture may not attract a representative sample of ant diversity that is present at a given location because of specific food preferences of certain species. It was hypothesized that there would be a difference in species richness and diversity among the different protein baits as well as among the different kinds of bait.

## METHODS

The experiment was conducted over six days between 17 July and 2 August 2004. Sites were sampled in the Bajo del Tigre area of the Bosque Eterno de los Niños, in Monteverde, Costa Rica. Data were collected from 20 sites, each containing 6 traps. The sites were approximately 5 meters from a trail and 10 meters apart, at the corners of a rectangular shaped plot. Sites were located in the forested areas found along the lower trails (Senderos Jaguar, Mirador, and the ends of the Sendero los Monos and Sendero las Caladrias). Four sites were sampled on each data collection day.

Each experimental site contained 6 plastic 35 mm film canisters (traps) each containing 1 of 6 different baits. The baits used were tuna, honey, dead crustaceans, peanut butter, a tuna/honey mixture, and a peanut butter/honey mixture. The crustaceans, *Cerrorchestia hyloriana* (Taltridae), were collected by a student from farms in the nearby area. The canisters were arranged in a half-meter circle with the openings of the canisters facing out. The sites were placed in a location without plants or trees blocking the traps. After three hours, the traps were collected, labeled with the location and time of collection, and the ants inside were saved for later counting and identification.

For identification, the traps were cleaned out and the contents were placed in petri dishes with alcohol. The ants were identified to morphospecies using a dissecting microscope and number of individuals of each morphospecies found in each trap was

recorded. Each morphospecies was assigned a number and reference specimens for each morphospecies were saved in vials.

A Shannon Weiner diversity index (H') was calculated for each bait type. A t-test was used to see if the differences in diversity indices were significant between the 15 possible combinations of two different baits. A Jaccard similarity index was used to measure the overlap in species between each combination. A one-way ANOVA was used to compare the mean values of number of species captured per trap versus type of bait. A one-way ANOVA test was also used to compare mean number of individual ants per trap versus type of bait.

## RESULTS

In total, 16 morphospecies of ants and 2467 individuals were collected using the 6 different kinds of bait. Ants were found in at least one trap at every site. Data was not collected when sites were disturbed by agoutis (*Dasyprocta punctata*) or coatis (*Nasua narica*). Three species were found on all 6 kinds of bait and 4 species were only found on one bait (Table 1). The crustaceans attracted the greatest diversity of species (H' = 0.74; Table 2) and the tuna and peanut butter baits attracted the lowest diversity (H' = 0.33, 0.31, respectively; Table 2). There was a significant difference in species richness found between all combinations of two different baits except for tuna versus crustaceans and peanut butter/honey versus honey (t-test; Table 3). The lowest species overlap was found between crustaceans and honey (Jaccard: 0.25; Table 3) and the greatest overlap was between tuna/honey and peanut butter/honey (Jaccard: 0.78; Table 3). There was no significant difference in the number of ant species collected between any of the baits (ANOVA, P = 0.310; Figure 1). There was a significant difference in the number of individual ants attracted by different baits (ANOVA, P = 0.004; Figure 2). Peanut butter/honey attracted significantly more individuals than crustaceans, honey, tuna and tuna/honey (Fisher's PLSD, P = 0.0010, 0.0009, 0.0360, 0.0037, respectively). Peanut butter attracted significantly more individuals than crustaceans and honey (P = 0.0310, 0.0287, respectively).

## DISCUSSION

As predicted, there was a significant difference in both richness and diversity found between most of the different kinds of bait. The high species diversity in the crustacean traps is reflective of the high number, nine, of species attracted by the bait as well as the lower number of individuals per species attracted to other types of bait. The largest number of individuals of a species on crustacean bait was 32, while it was 50 on tuna bait and at least 140 on every other bait. Two of the five species found on only one bait were found in the crustacean traps (Table 3). The species found that were unique to the crustacean bait suggest that researchers should not depend solely on the traditional peanut butter/honey or tuna/honey mixture when attempting to measure the ant diversity of an area.

The highest species overlap between the peanut butter/honey and tuna/honey traps was not surprising considering that these traps are the two protein/sugar combinations (Table 3). All of the species that were in tuna/honey traps were also found in the peanut

butter/honey traps, with additional species found on the peanut butter/honey trap. When number of individuals collected is taken into account, there was a significant statistical difference between these traps (Figure 2). There was a significant preference for the peanut butter/honey over the tuna/honey.

There was no significant difference between the numbers of species found on each bait (Figure 1). If a researcher were simply looking to collect ant species, any of the baits would work equally well. However, in terms of total individuals collected, peanut butter/honey and peanut butter were the most popular baits and honey and crustaceans were the least popular (Figure 2). This result suggests that peanut butter may be a better food source than any of the other baits tested. This difference could be important if a researcher wanted to study recruitment, competition, or other social behaviors relating to food. Traps that had peanut butter/honey could provide the best opportunity to watch such behaviors.

It is also interesting that the lowest number of individuals was found in the two traps with the lowest species overlap, crustaceans and honey (Table 1). More than half of the species on those baits were found in greater abundances on the peanut butter or peanut butter/honey traps (Figure 2). This result shows that the low abundance is not necessarily a result of the kinds of ants found, but the type of bait used.

This study shows that there are significant differences in both the diversity and number of ants trapped when using different kinds of bait. The same species diversity as found with all six kinds of bait could have been obtained by only using three kinds of bait: peanut butter/honey; crustacean; and honey. If a researcher were only using one kind of bait, the peanut butter/honey bait would probably be the best choice because it attracted the greatest number of ants and, although not statistically significant, the greatest number of species.

Further research could be done using arthropods that are known to be eaten by the ants. It would also be interesting to study recruitment and how it changes with bait type. One species had both soldiers and workers at many traps, perhaps there would be a difference in the ratio of soldiers to workers depending on bait type and presence of other ants. This study omitted the aspect of competition between colonies, which could have a significant impact on which ants are found on a given type of bait. A greater sample size with more elevations, species of ants, and locations could provide better insight into ant food preferences.

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**Table 1.** H' values for each bait type using the Shannon Weiner Diversity Index, listed in ascending order. (PB – Peanut Butter)

| Bait Type | H' |
|---|---|
| PB | 0.308 |
| Tuna | 0.327 |
| PB/Honey | 0.424 |
| Honey | 0.425 |
| Tuna/Honey | 0.532 |
| Crustaceans | 0.740 |

**Table 2.** Comparisons of H' values using a t-test to find if there is a significant difference between every possible combination of bait types. Jaccard values are based on the number of overlapping species between each of the bait types. Listed by ascending Jaccard values. (PB – Peanut Butter)

| | Shannon Weiner Diversity Index | | | |
|---|---|---|---|---|
| **Bait Comparisons** | **t value** | **variance** | **Significance** | **Jaccard** |
| Crustaceans v. Honey | 5.850 | 166.110 | 0.001 | 0.25 |
| PB v. Honey | 2.505 | 122.685 | 0.02 | 0.33 |
| PB/Honey v. Honey | 0.026 | 103.235 | X | 0.33 |
| Tuna/Honey v. Crustaceans | 5.123 | 166.253 | 0.001 | 0.36 |
| Tuna/Honey v. Honey | 4.384 | 130.217 | 0.001 | 0.40 |
| PB v. Crustaceans | 11.431 | 159.985 | 0.001 | 0.42 |
| PB/Honey v. Crustaceans | 8.969 | 122.995 | 0.001 | 0.42 |
| Tuna v. PB/Honey | 13.715 | 786.183 | 0.001 | 0.50 |
| PB v. PB/Honey | 5.113 | 1219.308 | 0.001 | 0.50 |
| Tuna v. Crustaceans | 0.720 | 169.894 | X | 0.56 |
| Tuna/Honey v. PB | 2.717 | 214.729 | 0.01 | 0.60 |
| Tuna v. Tuna/Honey | 7.381 | 684.696 | 0.001 | 0.63 |
| Tuna v. Honey | 6.734 | 124.652 | 0.001 | 0.63 |
| Tuna v. PB | 12.826 | 1051.085 | 0.001 | 0.67 |
| Tuna/Honey v. PB/Honey | 8.570 | 558.426 | 0.001 | 0.78 |

**Table 3.** Types of bait and the morphospecies that were found on them. An X shows that at least one individual of that species was captured with that type of bait. (PB – Peanut Butter)

| Species | Honey | Crustaceans | PB | PB/Honey | Tuna | Tuna/Honey |
|---|---|---|---|---|---|---|
| 1 | X | | X | X | X | X |
| 2 | X | X | X | X | X | X |
| 3 | X | X | X | X | X | X |
| 4 | X | X | X | X | X | X |
| 5 | | | X | X | | X |
| 6 | | X | X | | | |
| 7 | | X | | | | |
| 8 | | | | X | | |
| 9 | X | | X | | X | |
| 10 | | X | X | X | X | X |
| 11 | X | | | | | |
| 12 | | | | X | | X |
| 13 | | X | | X | | |
| 14 | | X | | | | |
| 15 | | X | X | | | |
| 16 | X | | | | | |

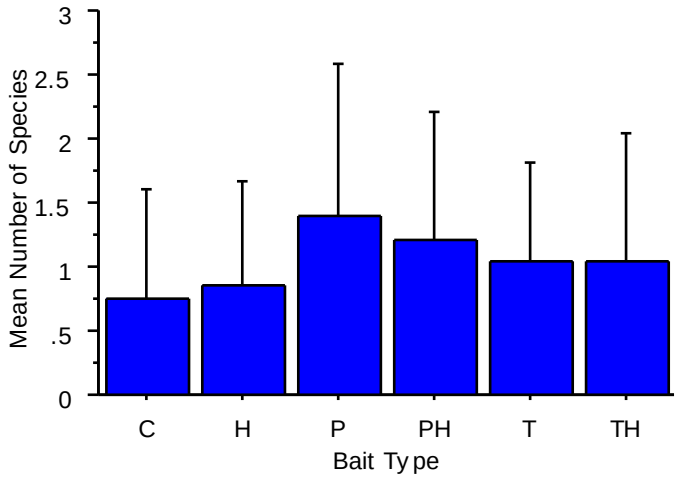


**Figure 1:** Mean number of species captured per trap against bait type. Error Bars: ± 1 Standard Deviation(s) (C – Crustaceans, H – Honey, P – Peanut Butter, PH – Peanut Butter/Honey, T – Tuna, TH – Tuna/Honey)

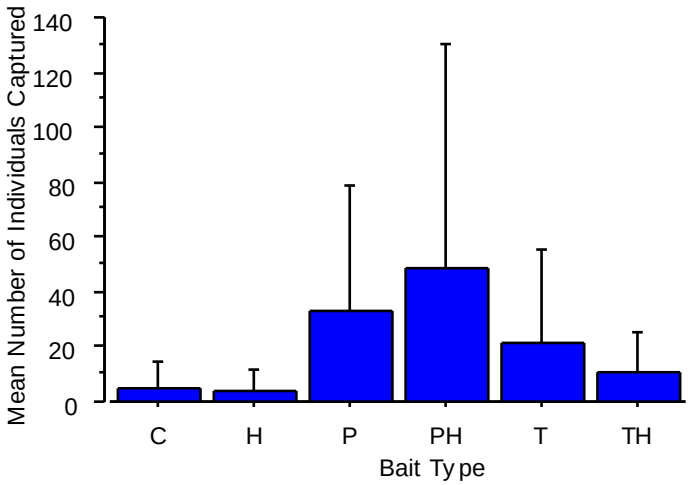


**Figure 2:** Mean number of individuals (regardless of species) caught per trap against bait type. Error Bars: ± 1 Standard Deviation(s) (C – Crustaceans, H – Honey, P – Peanut Butter, PH – Peanut Butter/Honey, T – Tuna, TH – Tuna/Honey)