

GOLD STUDENT WORKSHEETS AND DISCUSSION QUESTIONS

Comparison of Small Mammal Communities in Cacao Agroforestry and Tropical Broadleaf Forest Habitats in Belize, Central America

Now that you have gained experience trapping, handling, and identifying tropical small mammals, it is time to summarize and interpret your data. The following exercises will assist you in understanding your results and will hopefully spur additional questions and points of discussion. You can use the results from previous trap cycles (Table 1) to compare to your results.

Table 1. Number of unique individuals of small mammal species caught in cacao and forest habitat on BFREE property during 4 trapping cycles. Trapping was conducted by Dr. Sara Ash, Sipriano Canti, and students from University of the Cumberland.

	Jan 2015		June 2015		Jan 2016		May/June 2016	
	Cacao	Forest	Cacao	Forest	Cacao	Forest	Cacao	Forest
<i>Heteromys desmarestianus</i>	0	8	1	10	2	15	2	16
<i>Sigmodon hispidus</i>	9	5	3	7	2	2	1	0
<i>Marmosa mexicana</i>	2	8	0	0	1	3	0	1
<i>Handleyomys spp.</i>	14	4	18	3	5	6	0	0
<i>Ototylomys phyllotis</i>	1	0	0	3	1	1	0	1
<i>Oryzomys couesi</i>	3	0	0	1	0	0	0	0
Total	29	25	22	24	11	27	3	18
Trap nights*	7	7	7	6	3	3	7	7

*Number of trap nights varies across trap cycles.

A. Species composition and richness: what can they tell us about a community?

The most basic question that ecologists ask about the structure of a community is “what species live there?” A list of species living in a community is called the **species composition** of a community. Following are tables which list the species that were captured in the two small mammal grids during 2015 and 2016 trap cycles.

Table 2. Presence of small mammals trapped in 2015 in cacao and forest habitats at BFREE.

Species	Forest Grid		Cacao Grid	
	January	June	January	June
<i>Marmosa mexicana</i> , Mexican mouse opossum	Present	Absent	Present	Absent
<i>Heteromys desmarestianus</i> , Forest spiny pocket mouse	Present	Present	Absent	Present
<i>Handleyomys spp.</i> , rice rats	Present	Present	Present	Present
<i>Oryzomys couesi</i> , Coues’ rice rat	Absent	Present	Present	Absent
<i>Sigmodon hispidus</i> , Hispid cotton rat	Present	Present	Present	Present
<i>Ototylomys phyllotis</i> , Big-eared climbing rat	Absent	Present	Present	Absent

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Table 3. Presence of small mammals trapped in 2016 in cacao and forest habitats at BFREE.

Species	Forest Grid		Cacao Grid	
	January	June	January	June
<i>Marmosa mexicana</i> , Mexican mouse opossum	Present	Present	Present	Absent
<i>Heteromys desmarestianus</i> , Forest spiny pocket mouse	Present	Present	Present	Present
<i>Handleyomys</i> spp., rice rats	Present	Absent	Present	Absent
<i>Oryzomys couesi</i> , Coues' rice rat	Absent	Absent	Absent	Absent
<i>Sigmodon hispidus</i> , Hispid cotton rat	Present	Absent	Present	Present
<i>Ototylomys phyllotis</i> , Big-eared climbing rat	Present	Present	Present	Absent

1. Compare the **species composition** between these two habitats and between years. Summarize in the space below.

2. How does the **species richness** (number of species) of these two habitats compare? Are there differences between the two years?

3. Complete the table below using the results from your group's trap cycle. Be sure to indicate **the date** in the space in the title. There are extra rows for any new species that your group captured.

Table 4. Presence of small mammals trapped in _____ in cacao and forest habitats at BFREE.

Species	Forest Grid	Cacao Grid
<i>Marmosa mexicana</i> , Mexican mouse opossum		
<i>Heteromys desmarestianus</i> , Forest spiny pocket mouse		
<i>Handleyomys</i> spp., rice rats		
<i>Oryzomys couesi</i> , Coues' rice rat		
<i>Sigmodon hispidus</i> , Hispid cotton rat		
<i>Ototylomys phyllotis</i> , Big-eared climbing rat		

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4. How do the species composition and species richness from **your trap cycle** compare to the 2015 and 2016 trap cycles? Brainstorm some hypotheses that might explain any differences.

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B. How do you know when you have sampled enough?

When trying to describe the structure of a community, ecologists want to be sure that they invest enough time and energy to capture all the species, but not so much time and energy that they waste precious resources. A **species accumulation curve** allows them to plot the **accumulated** number of species captured against their **sampling effort**. Sampling effort could be defined either spatially or temporally. For example, you might want to know how many grids you need to capture all species of small mammals in the cacao (spatial) or you might want to know how many nights you should trap in order to capture all the species present in your grid (temporal). We have only 1 grid for each habitat type. We probably would get more species if we trapped in more grids across the habitats but we are limited by equipment and manpower. But for our single grid in each habitat, we can ask if the number of trap nights is adequate to capture all the species present. For example, below is a species accumulation curve from the January and June 2015 trap cycles. Notice that after day 2 in January, we captured no new species in the forest grid. However, we were still adding new species to our sample at day 6 in the cacao grid.

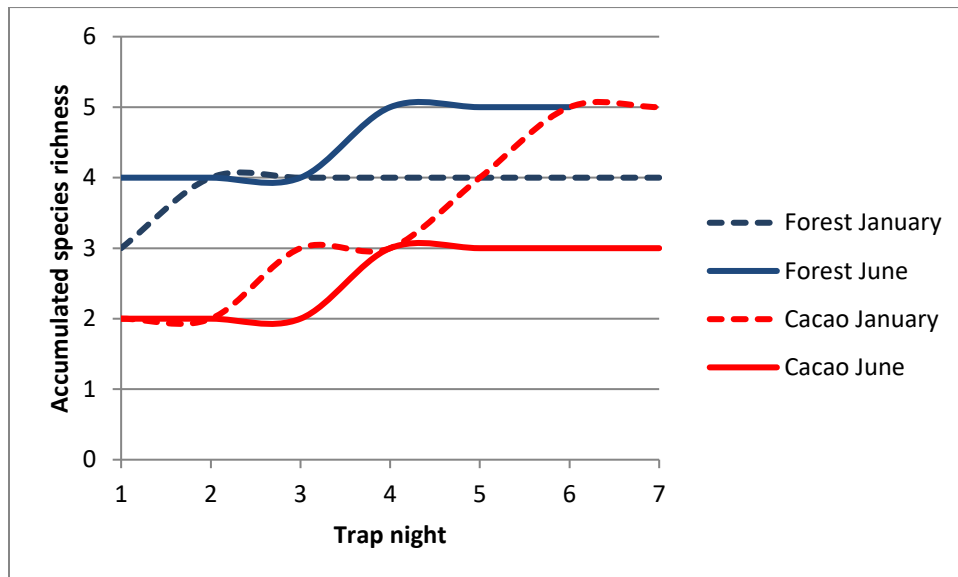


Figure 1. Species accumulation curve for small mammals in cacao and forest habitats sampled in January and June 2015.

5. What do these graphs suggest about the sampling effort required in these two habitats and during different seasons?

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C. Relative abundance of species is an important component of community structure.

One of the pieces of information you probably listed is the relative abundance of each species. For example, consider two communities, A and B. Community A has 25 pocket mice and 27 cotton rats while community B has 2 pocket mice and 50 cotton rats. Although the species composition and richness values are equal between these communities, intuitively, we would say that the community B is less diverse than A. Knowing the relative abundance of the species allows us to see which species are rare and which are common. See the table below that summarize the numbers of individuals of each species captured during the 2015 and 2016 trap cycles.

Table 1. Number of unique individuals of small mammal species caught in cacao and forest habitat on BFREE property during 4 trapping cycles. Trapping was conducted by Dr. Sara Ash, Sipriano Canti, and students from University of the Cumberland.

	Jan 2015		June 2015		Jan 2016		May/June 2016	
	Cacao	Forest	Cacao	Forest	Cacao	Forest	Cacao	Forest
<i>Heteromys desmarestianus</i>	0	8	1	10	2	15	2	16
<i>Sigmodon hispidus</i>	9	5	3	7	2	2	1	0
<i>Marmosa mexicana</i>	2	8	0	0	1	3	0	1
<i>Handleyomys spp.</i>	14	4	18	3	5	6	0	0
<i>Ototylomys phyllotis</i>	1	0	0	3	1	1	0	1
<i>Oryzomys couesi</i>	3	0	0	1	0	0	0	0
Total	29	25	22	24	11	27	3	18
Trap nights*	7	7	7	6	3	3	7	7

*Number of trap nights varies across trap cycles.

8. What patterns in relative abundance do you see between the two grids and between the seasons? Hypothesize about some explanations for these patterns. Could the relative abundance of these species explain, in part, the species accumulation curves of January 2015?

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9. Using the abundance data from your trap cycle, construct either a table or a figure summarizing your results. Be sure to include an appropriate title. How do your results compare to the 2015 and 2016 trap cycles?

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D. An evenness index quantifies the distribution of individuals among the species.

The Simpson's measure of evenness is one of many indices we could use to quantify the equitability of small mammal species in our 2 habitats.

Simpson's measure of evenness

$$E = \frac{1}{\sum_{i=1}^s \left[\frac{n_i(n_i - 1)}{N(N - 1)} \right]} \times \frac{1}{s}$$

Where E = Simpson's measure of evenness

n_i = Number of individuals of species i in the sample

N = total number of individuals in the sample

s = number of species in the sample

Values for this index will range from 0 to 1. A value equal to 1 would indicate individuals are perfectly distributed among the species. A value closer to zero means that one to a few species are much more common than others.

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Below is an example of how to calculate the Simpson's measure of evenness using results from the June 2015 trap cycle.

Species	Forest Grid		Cacao Grid	
	n	n(n-1)	n	n(n-1)
<i>Heteromys desmarestianus</i> , Forest spiny pocket mouse	10	90	1	0
<i>Handleyomys</i> spp., rice rats	3	6	18	306
<i>Oryzomys couesi</i> , Coues' rice rat	1	0	0	0
<i>Sigmodon hispidus</i> , Hispid cotton rat	7	42	3	6
<i>Otodylomys phyllotis</i> , Big-eared climbing rat	3	6	0	0
	N = 24 N(N-1) = 552	$\sum n_i(n_i-1) = 150$	N = 22 N(N-1) = 462	$\sum n_i(n_i-1) = 312$

Forest grid:

$$E = \frac{1}{\sum_{i=1}^S \left[\frac{n_i(n_i - 1)}{N(N - 1)} \right]} \times \frac{1}{S}$$

$$E = \frac{1}{\left[\frac{150}{552} \right]} \times \frac{1}{5}$$

$$= 0.735$$

Cacao grid:

$$= \frac{1}{\sum_{i=1}^S \left[\frac{n_i(n_i - 1)}{N(N - 1)} \right]} \times \frac{1}{S}$$

$$E = \frac{1}{\left[\frac{312}{462} \right]} \times \frac{1}{3}$$

$$= 0.494$$

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10. Complete the table below with the results of your trap cycle and then calculate a Simpson's index of evenness for each of the grids.

Species	Forest Grid		Cacao Grid	
	n	n(n-1)	n	n(n-1)
Total	$N =$ $N(N-1) =$	$\sum n_i(n_i-1) =$	$N =$ $N(N-1) =$	$\sum n_i(n_i-1) =$

Forest grid:

Cacao grid:

E. Interpret your index values for each grid.

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Diversity: How can we quantify both species richness and relative abundance in one measure?

Now that we have information on both species richness and relative abundance, we can calculate a **species diversity index** for each of the grids. One of the most commonly used indices is the **Simpson's index of diversity**. The Simpson's index is a nonparametric measure of diversity and its use in ecology is described in detail in Krebs (1998) and Magurran (2004). The Simpson's index is less sensitive than other measures of diversity to changes in species richness, making it a more robust measure of diversity (Magurran 2004). Keep in mind that scientists will usually calculate species diversity using several different indices. However, calculation of only the Simpson's index will be reviewed here. Further reading about diversity measures and their uses are provided in both Krebs (1998) and Magurran (2004).

When working with a small sample size (<1,000), we use the following equation:

$$1 - D = 1 - \sum_{i=1}^s \left[\frac{n_i(n_i-1)}{N(N-1)} \right]$$

Where $(1 - D)$ = Simpson's index of diversity

n_i = Number of individuals of species i in the sample

N = total number of individuals in the sample

s = number of species in the sample

The Simpson's index of diversity calculated this way gives the probability of picking two organisms at random in the community that are *different* species.

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Below is an example of how to calculate the Simpson's index of diversity using results from the June 2015 trap cycle.

Species	Forest Grid		Cacao Grid	
	n	n(n-1)	n	n(n-1)
<i>Heteromys desmarestianus</i> , Forest spiny pocket mouse	10	90	1	0
<i>Handleyomys</i> spp., rice rats	3	6	18	306
<i>Oryzomys couesi</i> , Coues' rice rat	1	0	0	0
<i>Sigmodon hispidus</i> , Hispid cotton rat	7	42	3	6
<i>Otodylomys phyllotis</i> , Big-eared climbing rat	3	6	0	0
Total	N = 24 N(N-1) = 552	$\Sigma n_i(n_i-1) = 150$	N = 22 N(N-1) = 462	$\Sigma n_i(n_i-1) = 312$

Forest grid:

$$1 - D = 1 - \sum_{i=1}^s \left[\frac{n_i(n_i - 1)}{N(N - 1)} \right]$$

$$1 - D = 1 - \left[\frac{150}{552} \right]$$

$$= 0.728$$

Cacao grid:

$$1 - D = 1 - \sum_{i=1}^s \left[\frac{n_i(n_i - 1)}{N(N - 1)} \right]$$

$$1 - D = 1 - \left[\frac{312}{462} \right]$$

$$= 0.325$$

So how do we interpret these numbers? If you were to select 2 small mammals from the forest grid AT RANDOM, the probability that those individuals are different species would be 0.728.

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11. What possible consequences did lumping the rice rats into one species have for the diversity index?

12. Using your table from # 10, calculate a Simpson's index of diversity for each of the grids.

Forest grid:

Cacao grid:

13. Interpret your diversity index values for each grid. Which grid shows higher diversity?

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F. Putting it all together!

14. Write a summary paragraph using your results to describe the structure of the small mammal community in the cacao and nearby forest. Discuss if your hypotheses and predictions were supported.

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G. Further points of discussion

15. We already mentioned the limitation of using only one grid in each of the two habitats.

Obviously any interpretation of our results will apply only to these two sites. We would need more samples across a larger landscape to reach any conclusions about the differences in small mammal communities between tropical broadleaf forest and cacao habitats. Pretend you are a graduate student and your research goal is to evaluate the changes that occur to the small mammal community when a rustic cacao plantation is established within a forest community. Brainstorm about methods you would use, number of sample sites needed and locations of those sites. What factors other than changes to the forest habitat structure would you expect to influence small mammal communities living in cacao plantations? How would you account for these factors in your experimental design?

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16. Other than community structure (composition, richness, evenness and diversity), what other information would be valuable to know about the small mammals living in cacao habitats? For example, suppose that the forest spiny pocket mice use the cacao habitat as a “spillover” area where young dispersing individuals can escape for the short term but do not establish home ranges. How would you determine if this was happening and why would this information be important to know when assessing the relationship between cacao agroforestry and biological conservation? Brainstorm a list of other ecological data that would be valuable.

Literature Cited

Krebs, C.J. 1998. Ecological methodology. 2nd edition. Benjamin Cummings. 620 pages.

Magurran, M. 2004. Measuring biological diversity. Blackwell Publishing.