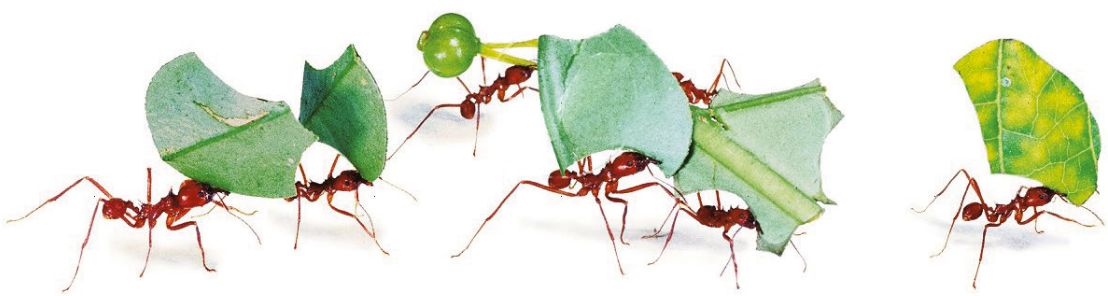
Bunker Hill Community College
Study Abroad Program

Tropical Field Studies

ENV120

Field Investigation Manual



Costa Rica

May 2023

Leaf Litter Microfauna Diversity - Simpson's Index

Introduction

Leaf Litter Microfauna

Species diversity is a characteristic that is unique to a community level of biological organization. The biodiversity in different communities has been severely affected by human activities.
A community is said to have high species diversity if it has many species present in approximately equally abundant numbers. If it is composed of only a few species or if only a few species are abundant, then the biodiversity is considered to be low.

If a community had 100 individuals distributed among 10 species then the maximum possible diversity would occur if there were 10 individuals in each of the 10 species. The minimum possible diversity would occur if there were 91 individuals belonging to one species and only 1 individual in each of the other nine species. The number of species in a community is very important. There seems to be evidence that the greater the species diversity, the more stable the community. When diversity is low, the community is less stable. A community with low diversity is less able to rebound from severe disturbance such as pollution and habitat disruption.

With destruction of the rainforests and other natural habitats we are currently facing the loss of biodiversity at an unprecedented rate. It is essential that field biologists have methods to measure the biodiversity of ecosystems as a means to monitor changes that may be occurring because of human interference with natural processes. A number of different mathematical indices have been developed that allow biologist to quantify the diversity of an ecosystem and produce standardized values for future comparisons.

In this field activity you will be using one index called the **Simpson's Index** to compare the diversity of microfauna in the leaf litter of two very different forests. You will be collecting leaf litter samples from a **northern hardwood forest** and from a **lowland tropical rainforest** to analyze. A **Berlese funnel apparatus** will be used to separate the microfauna from the their leaf litter microhabitat. The organisms will then be organizing into similar taxonomic categories and counted. The species diversity of the two leaf litter samples will then be calculated using the Simpson's Index. Most of the diversity of the leaf litter microhabitat will be comprised of various types of **microarthropods**.

Measuring Biodiversity Using Simpson's Index

An index is a mathematical formula used to quantify and assess any number of properties in a natural system. The Simpson's Index has been developed to assess biodiversity. It is based on the probability of finding a specific species if you were to select random samples from an area. It places greater weight on more common species than on rare ones. The Simpson's Index is used by many biologists to quantify biodiversity.

The Simpson's Index

Diversity $(D_S) = 1 - \Sigma(P_i^2)$

Σ = this means to take the sum or add everything up

P_i = the proportion of a specific species in an sampling area.

$$P_i = \frac{\text{\# of individual of one species } (n_1)}{\text{Total \# of individuals of all species } (N)}$$

An example of how to calculate the Simpson's Index is on the next page.

Calculating Simpson's Index – An Example

Assume you have a small sample plot to analyze for its invertebrate diversity. After a careful search of your plot you find:

n_1 = 10 red ants

n_1 = 2 black beetles

n_1 = 3 pill bugs

n_1 = 5 grasshoppers

n_1 = 1 earthworm

Overall you found 5 different types of critters each with a different number of individuals. The total number of individuals N = (10 +2 + 3 +5 +1) = 21. To calculate the Simpson's Index number you would follow the procedures in Table 1 below.

Table 1. Calculating Simpson's Index

Using data from above and rounding off numbers to three decimal places

	Species 1	Species 2	Species 3	Species 4	Species 5
Absolute Abundance	10 (red ants)	2 (black beetles)	3 (pill bugs)	5 (grasshoppers)	1 (earthworm)
P_i (relative Abundance)	10/21 = 0.476	2/21 = 0.095	3/21 = 0.143	5/21 = 0.238	1/21 = 0.048
P_i^2	$(0.476)^2$ = **0.227**	$(0.095)^2$ = **0.009**	$(0.143)^2$ = **0.020**	$(0.238)^2$ = **0.057**	$(0.048)^2$ = **0.002**

Again the formula is **D_S (diversity) = $1 - \sum (P_i^2)$**

$D_S = 1 - (\mathbf{0.227 + 0.009 + 0.020 + 0.057 + 0.002})$

$D_S = 1 - 0.315$

D_S = 0.685 (biodiversity of this plot)

D_S values closer to 1 = greater diversity. D_S values closer to 0 = lower diversity.

Procedure

The following procedure will be used to collect samples from both a northern hardwood forest and a lowland tropical rainforest for comparison.

In the Field

1. Select a small area that appears to be a general representation of the overall forest floor. Mark off a 20cm X 20cm plot.
2. Gather all the leaf litter and the top 1-2 cm of humus under the litter (down to the extent that you can remove it with your fingers). Place the litter material in a plastic bag to bring back to the lab for analysis.

Back at the Lab

1. Obtain a Berlese funnel apparatus and set up as pictured in the diagram below.
2. Fill the funnel with your forest floor sample to about 5 cm from the top edge.
3. Place the lamp over the top of the funnel and run the extraction for at least 24 hrs. The heat from the lamp will slowly dry out the litter material and drive the micro organisms down to the bottom where they will eventually fall through the screen and into the vial of alcohol.
4. After the litter throughly dries out remove the vial of alcohol and pour contents into a white specimen dish.
5. Observe the specimens under the stereo field microscope and identify the different species that you see and the number of each species present. Record on the data sheet. It is not critical that you exactly identify each species. You are more interested in the number of different critter types (diversity). A photo page of some typical leaf litter critters is included in this manual to help with your identification. If you don't know exactly what type of organism you have found just call it species X, Y, etc. Most of the critters you will find will probably be microarthropods.
6. Record your data in the tables on the following page.

Berlese Funnel Apparatus

Data for Northern Hardwood Forest

Date sample collected ______________ Weather Conditions ___________________________

Location where sample collected ____

Organism Type ("Species")	Absolute Abundance (n_1)	Relative Abundance P_i (n_1/N)	P_i^2
Total number of individuals of all species (N) =		$\Sigma\ (P_i^2)$ =	

D_S (diversity) = $1 - \Sigma\ (P_i^2)$ = $\boxed{}$

Notes:

Data for Lowland Tropical Rainforest

Date sample collected ______________ Weather Conditions ___________________________

Location where sample collected ____

Organism Type ("Species")	Absolute Abundance (n_1)	Relative Abundance P_i (n_1/N)	P_i^2
Total number of individuals of all species (N) =		$\Sigma\ (P_i^2)$ =	

D_S (diversity) = $1 - \Sigma\ (P_i^2)$ = ☐

Notes:

Examples of Leaf Litter Microfauna


Nematode Worms


Ant


Beetle Larvae


Bristletail


Centipedes

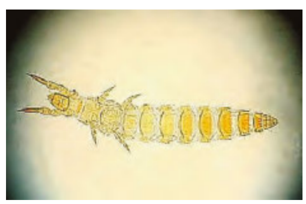

Springtails


Diplura


Fly Larvae


Isopods


Millipedes


Protura


Pseudoscorpions


Psocoptera


Rove Beetle


Spiders


Symphila


Soil Mite


Thrip

Conclusions

How does the diversity of the leaf litter microfauna of the northern hardwood forest compare to that of the lowland tropical rainforest? What might be an explanation for this difference?

Design a field investigation that may provide you with further insight into the conditions that affect the diversity of leaf litter micro-fauna (either natural or human induced).

Notes

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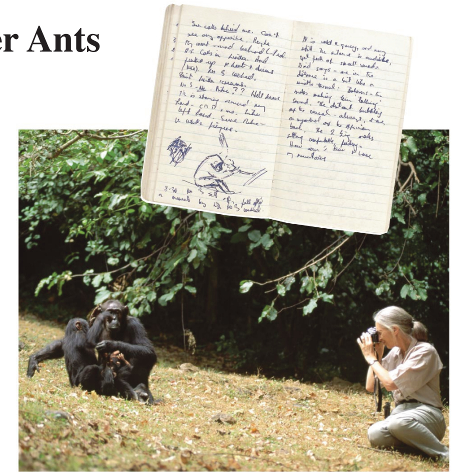
Discovery Science with Leaf Cutter Ants

Introduction



Jane Goodall & Her Journal

Biologist use two types of scientific inquiry: **discovery science** and **hypothesis-based science**. Discovery science is mostly about describing nature. Hypothesis-based science is mostly about explaining nature. Most scientific inquires combine these two research methods.

Sometimes called descriptive science, discovery science describes natural structures and processes as accurately as possible through careful observations and analysis of data. For example Jane Goodall has spent most of her adult life living with the chimpanzees in Africa observing and recording all aspects of their community interactions and behavior. From her field observations we now have a better understanding of the complexity of the social behavior of chimpanzees and it has also given us some insight into our own human social behavior.

In this field study you are going to observe the behavior of leaf cutter ants (*Atta cephalotes*). The procedure here is fairly simple. You will locate an active colony of leaf cutter ants and observe their activity. You will also record some quantitative data to analyze. In your field notebook record the following observations and provide an answer to the following questions.

1. How many different types of ants do you see? What do you think is the function of each ant type in the colony? Observe both the ants at the entrances to the colony and those on the trail. Be careful that you do not stand directly in the middle of the ants. If you disturb them the will crawl up your legs and can give you a painful bite. However they do not sting like many tropical ants.

2. Observe closely the ants on the trail carrying leaves back to the colony. Do you see a smaller ant hitching a ride on the cut leaf? Why is this smaller ant on the leaf?

3. Observe one leaf carrying ant and calculate its speed in meters per sec (you will need a measuring tape and stop watch for this). Record the time it takes for it to travel a 2 meter distance. Assume that this ant has cut its leaf section from a tree that is 10 meters high and 50 meters from the colony entrance. How long will it take the ant to make a round trip? Assuming that this ant will carry leaves for 10 days without stopping, how many trips does it make and how many kilometers does it travel? Repeat with two more leaf carrying ants.

4. Collect 50 pieces of leaf that have been dropped by the ants. Record their total weight in grams then calculate the average weight of a single piece. From the total number of lifetime trips for a single ant calculated in the previous question calculate the total weight in grams of the leaf material brought back to the colony by a single ant.

5. Record any other observations concerning the ants that you find curious or interesting.

Morphological Ant Types

Type 1

Size ______mm

Function in Colony

Behavior Observed

Type 2

Size ______mm

Function in Colony

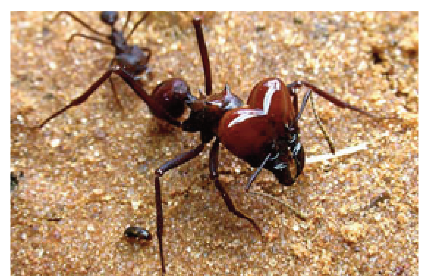
Behavior Observed

Type 3

Size ______mm

Function in Colony

Behavior Observed



Other Observations

Calculations

A. Time for ant to travel 2 meters

a. Trial 1 ________sec

b. Trial 2 ________sec

c. Trial 3 ________sec

d. Average for 2 meter ________sec

e. Average for 1 meter ________sec

B. Average speed of leaf carrying ant (1 meter ÷ e.) __________ m/sec

C. Time for ant to make 1 round trip (120m x sec/m x 1min/60 sec x 1 hr/60 min) __________ hrs/trip

D. Number of foraging trips per ant (10 days x 24hr/day ÷ C) __________ trips

E. Total distance covered in 10 days (D x 120m x 1km/1000m) __________ km

F. Weight of 50 average pieces of leaf (grams) __________ g

G. Weight of one average piece of leaf (F ÷ 50) __________ g

H. Total weight of leaf material transported by one ant in 10 days (D x G) __________ g

I. Assume there are 2 million active foragers in this colony in any given 10 day period. Approximately how many Kg of leaf material is turned into compost for this colony per year? 2.0×10^6 ants x H (*grams per ant in 10 days*) x 36.5 (*10-day periods per year*). __________ g

__________ Kg

These calculations are made with the assumption that the ants forage non-stop for 10 days. What might interrupt the foraging of the ants?

Further Instigation

Select a question you had while observing the ants and describe how you might go about investigating a possible answer to your question.

Notes

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Capture – Recapture: a method of estimating local population size

Background

If you were to go into an ecosystem, lets say a field, and then you spent some time trying to capture a few organisms, let's say crickets, it is very unlikely that you caught all of the crickets in that field. The fact is you caught some fraction of the entire population of crickets in the area. You can think of it like a fraction:

Let's call the entire population N
Let's call the number caught n_1

So we get:

$$\frac{\text{number of crickets caught}}{\text{the entire cricket population}} = \frac{n_1}{N}$$

Now assume that you put a small paint mark on the crickets that you caught and then put them back where you caught them. The next day you go out and catch some crickets again. You will probably catch some that you marked with paint and some new ones. The number of marked (recaptured crickets) compared to the total number of crickets that you caught on the second try is a fraction:

Let's call the total number of crickets caught on the second day n_2
Let's call the number of marked or recaptured crickets R

So we get:

$$\frac{\text{marked or recaptured crickets on 2}^{\text{nd}}\text{ day}}{\text{total number of crickets caught 2}^{\text{nd}}\text{ day}} = \frac{R}{n_2}$$

In most cases the ratio of R/n_2 is similar to the n_1/N. So the ratio of recaptured crickets to total number of crickets caught on the second day is similar to the number of crickets caught on the first day compared to the total number of crickets in the area sampled (or cricket population).

By combining the fractions we get:

$$N = \frac{n_1 \times n_2}{R}$$

N = total population
n_1 = total organisms captured on the first day
n_2 = total organism captured on the second day
R = total number recaptured organisms on the second day

If we capture organisms one day, mark them, release them, then go back on a second day and capture organisms again we can use the formula above to estimate the entire population of that organism in the area. Let's use our crickets as an example.

Example

Day 1: You capture 23 crickets in a 4 m^2 area (this is your n_1). You mark them with a little dot of paint on their backs and let them go in the same place where we caught them.

Day 2: You go to the same 4 m^2 plot. You catch 21 crickets (this is your n_2). Of the 21 crickets you catch on this day 10 are marked with paint dots. Thus, you recaptured 10 crickets (this is your R).

You use the formula to estimate the number of crickets in our plot.

$$N = \frac{n_1 \text{ x } n_2}{R} = \frac{23 \text{ x } 21}{10} = 48.3 \text{ crickets/ } 4 \text{ m}^2$$

Procedure

In this field investigation you are going to determine the approximate population size of hermit crabs (Coenobita sp.) on a beach in Costa Rica.

Land Hermit Crab
Coenobita sp.

1. Mark a study plot along the beach that is 15 meters wide and parallel to the shoreline. You will collect hermit crabs in this 15 meter area from the edge of the forest and on to the beach approximately 5 meters beyond the high tide mark (may be less distance if the tide level is high).
2. First Night: Collect as many hermit crabs in your study area that you can in a twenty minute time period and mark each shell with a small spot of nail polish. Release the hermit crabs exactly where you found them. Record the number of crabs you captured and marked. Your total will be added to the other groups totals.
3. Second Night: At approximately the same time as the previous night and in your assigned study area capture a second population. Record the total number of **captured** crabs and the number of **recaptures** that you collect in the same twenty minute time period as the previous night. Your totals will be added to the other groups totals.
4. Using the combined totals for all the groups calculate the approximate night population size of hermit crabs for this particular beach.

Data

Night Population (combined totals for all groups)

__________ Number of Individuals Captured: day 1 ($\boldsymbol{n_1}$)

__________ Number of Individuals Captured: day 2 ($\boldsymbol{n_2}$)

__________ Number of Recaptures: day 2 (***R***)

__________ Total Calculated Population in Study Area: (***N***)

Calculations

$$N = \frac{n_1 \times n_2}{R}$$

May 2011 Total: 2531
May 2012 Total: 3160
May 2013 Total: 9629
May 2014 Total: 3054
May 2015 Total: 2234
May 2016 Total: 2690
May 2017 Total: 3513
May 2018 Total: 2885
May 2019 Total: __________

Questions

1. How does this year's total hermit crab population compare to the previous years?

2. Is there anything in the investigation procedures that may have lead to an incorrect conclusion of the approximate population size of the hermit crabs on this particular beach?

3. Did you observe any interesting behavior in the hermit crabs as you were doing this study?

Notes

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Forest Geocaching Scavenger Hunt Rules

1. Each team will be given a GPS unit to locate hidden caches. There are four caches for each team to find. The caches are Ziplock bags.
2. In each cache is a packet of 4 cards with a picture and description of an item to find in the forest. Take only one packet.
3. Keep the cache in the same location for the next team to find.
4. There are a total of 16 forest items in the hunt. Collect as many of the items you can in the specified time limit. Your collection must include at least one item from each of the 4 caches.
5. The team that returns with the greatest number of “finds” will be the winner. In case of a tie the team that returned to the station first will be the winner.
6. If you return to the station after the designated end time one item will be deducted from your total for every 10 minutes you are late.

Safety Rules

1. When searching for the caches stay on the trails. Do not bushwhack through the forest. If the GPS points you into the forest find a trial that will take you in the general direction e.g. you may have to head east before you can go north. The caches will be along the trails or in open areas.
2. The caches will be visible while standing. Do not turn over logs or look through piles of brush.
3. Stay in site of each other. Do not wander off in different directions.
4. Bring a whistle in case of an emergency.

Notes

Costa Rica Fauna Checklist - May 2013

Arthropods

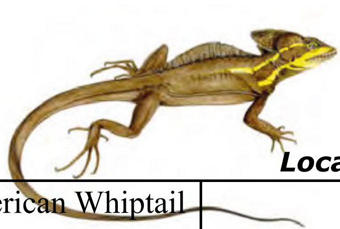
	Location	Date	Time	Conditions	Notes
Blue Morpho Butterfly *Morpho peleides*					
Heliconia Butterfly *Heliconius sp.*					
Army Ant *Eciton burchelli*					
Leaf-cutter Ant *Atta cephalotes*					
Hooded Mantis *Choerododis rhombifolia*					
Rhinocerous Beetle *Megasoma elephas*					
Scorpion *Centruroides limbatus*					
Golden Orb-Spider *Nephila clavipes*					
Tarantula Aphonopelma sp.					
Wandering Spider (caution) *Phoneutria sp.*					
Wolf Spider *Lycosa sp.*					
Whipscorpion *Phrynus parvulus*					
Katydid *Tettigonioidea (family)*					
Millipede *Nyssodesmus python*					
Other: ________________					

Costa Rica Fauna Checklist - May 2013

Snakes

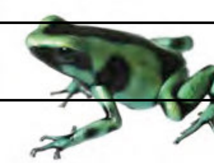
	Location	***Date***	***Time***	***Conditions***	***Notes***
Boa Constrictor *Boa constrictor*					
Mussurana *Clelia clelia*					
Green Vine Snake *Oxybelis fulgidus*					
Hognosed Viper (caution) *Porthidium nasutum*					
Eyelash Viper (caution) *Bothriechis schlegelli*					
Ver-de-Lance (caution) *Bothrops asper*					
C. American Coral Snake (caution) *Micrurus nigrocin*					
Cat-eyed Snake *Leptodeira septentrionalis*					
Other: ________________					

Costa Rica Fauna Checklist - May 2013



Lizards

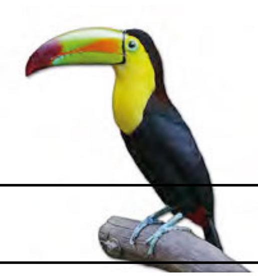
	Location	*Date*	*Time*	*Conditions*	*Notes*
Central American Whiptail *Ameiva chisbala*					
House Gecko *Hemidactylus frenatus*					
Brown Basilisk *Basiliscus basiliscus*					
Green Iguana *Iguana iguana*					
Anole *Norops sp.*					
American Crocodile *Crocodylus acutus*					
Other: ________________					



Frogs

Cane Toad *Bufo marinus*					
Green and Black Dart Frog *Dendrobates auratus*					
Smoky Jungle Frog *Leptodactylus pentadactylus*					
Red-eyed Tree Frog *Agalychnis callidryas*					
Glass Frog *Hyalinobatrachium sp.*					
Litter Frog *Eleutherodactylus sp.*					
Other: ________________					

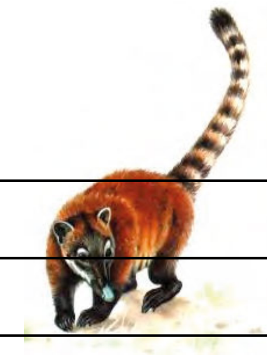
Costa Rica Fauna Checklist - May 2013



Birds

	Location	Date	Time	Conditions	Notes
Great Kiskadee *Pitangus sulphuratus*					
Blue-gray tanager *Thraupis episcopus*					
Scarlet-rumped Tanager *Ramphocelus passerinii*					
Scarlet McCaw *Ara macao*					
Toucan *Ramphastos swainsonii*					
Fiery-billed Aracari *Pteroglossus frantzii*					
Resplendent Quetzal *Phharomachrus mocinno*					
Blue-crowned Motmot *Momotus momota*					
Trogan *Trogon sp.*					
Blue-crowned Manakin *Pipra coronata*					
Red-capped Manakin *Pipra mentalis*					
Hermit Hummingbird *Phaethornis sp.*					
Brown pelican *Pelecanus occidentalis*					
Great Tinamou *Tinamus major*					
Great Curassow *Crax rubra*					
Tiger Heron *Tigrisoma sp.*					

Costa Rica Fauna Checklist - May 2013



Mammals

	Location	*Date*	*Time*	*Conditions*	*Notes*
White-faced Capuchin *Cebus capucinus*					
Spider monkey *Ateles geoffroyi*					
Howler monkey *Alouatta palliata*					
Three-toed Sloth *Bradypus variegatus*					
Collared Peccary *Tayassu tajacu*					
White-nosed Coati *Nasua narica*					
Agouti *Dasyprocta puctata*					
Kinkajou *Potos flavus*					
Dolphin Family: *Delphinidae*					
Bat *various genera*					
Other: ________________					

Miscellaneous

Notes