What is Biodiversity?
A Comparison of Spider Communities

Exercise

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OBJECTIVES

To explore through classification of life forms the concept of biological diversity as it occurs at various taxonomic levels.

PROCEDURES

Spiders are a highly species rich group of invertebrates that exploit a wide variety of niches in virtually all the earth's biomes. Some species of spiders build elaborate webs that passively trap their prey whereas others are active predators that ambush or pursue their prey. Spiders represent useful indicators of environmental change and community level diversity because they are taxonomically diverse, with species inhabiting a variety of ecological niches, and they are easy to catch.

This exercise focuses on classifying and analyzing spider communities to explore the concept of biological diversity and experience its application to decision making in biological conservation. The exercise can be undertaken in three parts, depending on your interest level.

LEVEL (1)

You will gain experience in classifying organisms by sorting a hypothetical collection of spiders from a forest patch and determining if the spider collection accurately represents the overall diversity of spiders present in the forest patch.

LEVEL (2)

If you wish to explore further, you can sort spider collections from four other forest patches in the same region and contrast spider communities in terms of their species richness, species diversity, and community similarity. You will apply this information to make decisions about the priority that should be given to protecting each forest patch in order to conserve the regional pool of spider diversity.

LEVEL (3)

If you wish to explore the concepts of biodiversity yet further, you will next take into account the evolutionary relationships among the families of spiders collected. This phylogenetic perspective will augment your decision making about priorities for patch protection by accounting for evolutionary distinctiveness in addition to diversity and distinctiveness at the community level.

Once you have worked through these concepts and analyses you will have a much enhanced familiarity with the subtleties of what biological diversity is.

LEVEL 1

SORTING AND CLASSIFYING A SPIDER COLLECTION AND ASSESSING ITS COMPREHENSIVENESS

1) Obtain a paper copy of the spider collection for forest patch “1.” The spiders were captured by a biologist traveling along transects through the patch, stroking a random series of 100 tree branches. All spiders that were dislodged and fell onto an outstretched sheet were collected and preserved in alcohol. They have since been spread out on a tray for you to examine. The spider collection is hypothetical but the species pictured are actual spiders that occur in central Africa (illustrations used are from Berland 1955). The illustrations of the spiders are aligned in rows and columns so that it is easy to cut them out with scissors, for subsequent examination and identification.

2) The next task is for you to sort and identify the spiders. To do this you have to identify all the specimens in the collection. To classify the spiders look for external characters that all members of a particular group of spiders have in common but that are not shared by other groups of spiders. For example, look for characteristics such as **leg length, hairiness, relative size of body segments, or abdomen patterning and abdomen shape.**

3) Look for groups of morphologically indistinguishable spiders, and describe briefly the set of characters unique to each group. These operational taxonomic units that you define will be considered separate species. To assist you in classifying these organisms, a diagram of key external morphological characters of spiders is provided (Figure 1). Note that most spider identification depends on close examination of spider genitalia. For this exercise, however, we will be examining gross external characteristics of morphologically dissimilar species.

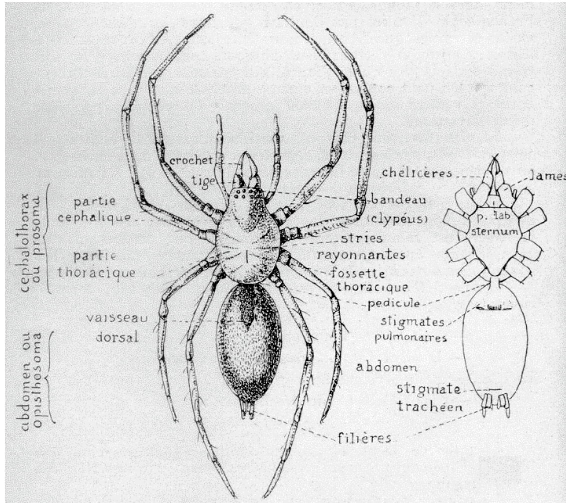
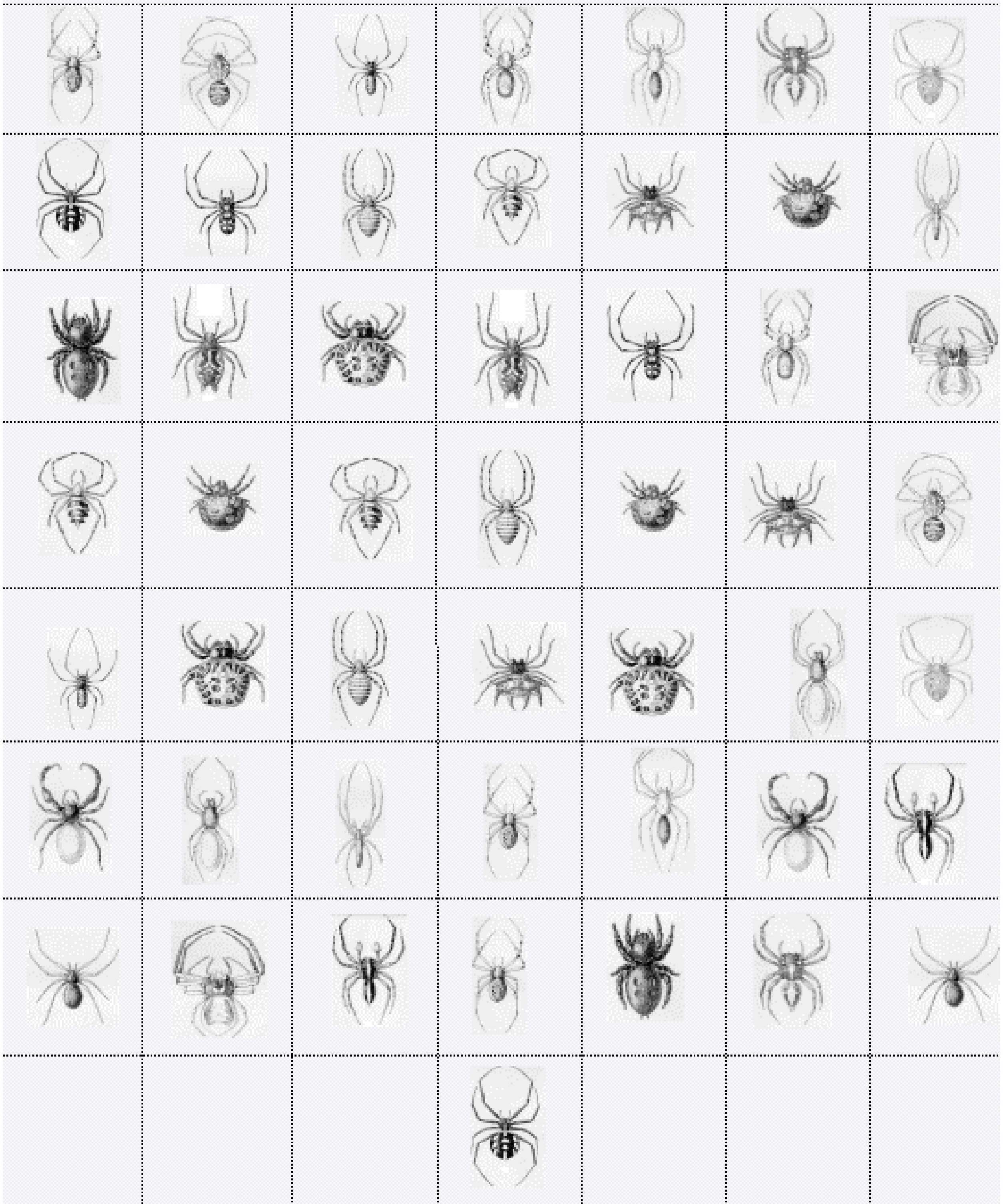


Figure 1. Basic external characteristics of spiders useful for identifying individuals to species.

4) Assign each species a working name, preferably something descriptive. For example, you might call a particular species "spotted abdomen, very hairy" or "short legs, spiky abdomen" Just remember that the more useful names will be those that signify to you something unique about the species. **Construct a table listing each species, its distinguishing characteristics, the name you have applied to it, and the number of occurrences of the species in the collection.**

Site 1



5) Last, ask whether this collection adequately represents the true diversity of spiders in the forest patch at the time of collection. **<u>Were most of the species present sampled or were many likely missed?</u>** This is always an important question to ask to ensure that the sample was adequate and hence can be legitimately contrasted among sites to, for example, assign areas as low versus high diversity sites.

To do this you will perform a simple but informative analysis that is standard practice for conservation biologists who do biodiversity surveys. This analysis involves constructing a so-called "collector's curve" (Colwell and Coddington 1994). These plot the cumulative number of species observed (y-axis) against the cumulative number of individuals classified (x-axis). The collector's curve is an increasing function with a slope that will decrease as more individuals are classified and as fewer species remain to be identified (Fig. 2). If sampling stops while the collector's curve is still rapidly increasing, sampling is incomplete and many species likely remain undetected. Alternatively, if the slope of the collector's curve reaches zero (flattens out), sampling is likely more than adequate as few to no new species remain undetected.

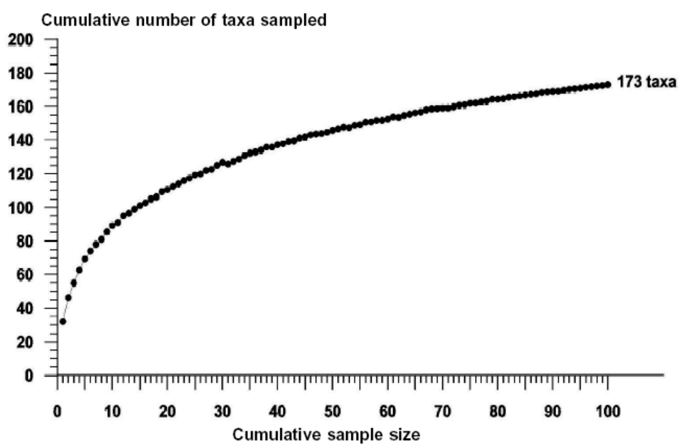


Figure 2. An example of a collectors curve. Cumulative sample size represents the number of individuals classified. The cumulative number of taxa sampled refers to the number of new species detected.

To construct the collectors curve for this spider collection, choose a specimen within the collection at random. This will be your first data point, such that X = 1 and Y = 1 because after examining the first individual you have also identified one new species! Next move consistently in any direction to a new specimen and record whether it is a member of a new species. In this next step, X = 2, but Y may remain as 1 if the next individual is not of a new species or it may change to 2 if the individual represents a new species different from individual 1. **<u>Repeat this process until you have proceeded through all 50 specimens and construct the collector's curve from the data obtained (just plot Y versus X). Does the curve flatten out? If so, after how many individual spiders have been collected? If not, is the curve still increasing?</u>**

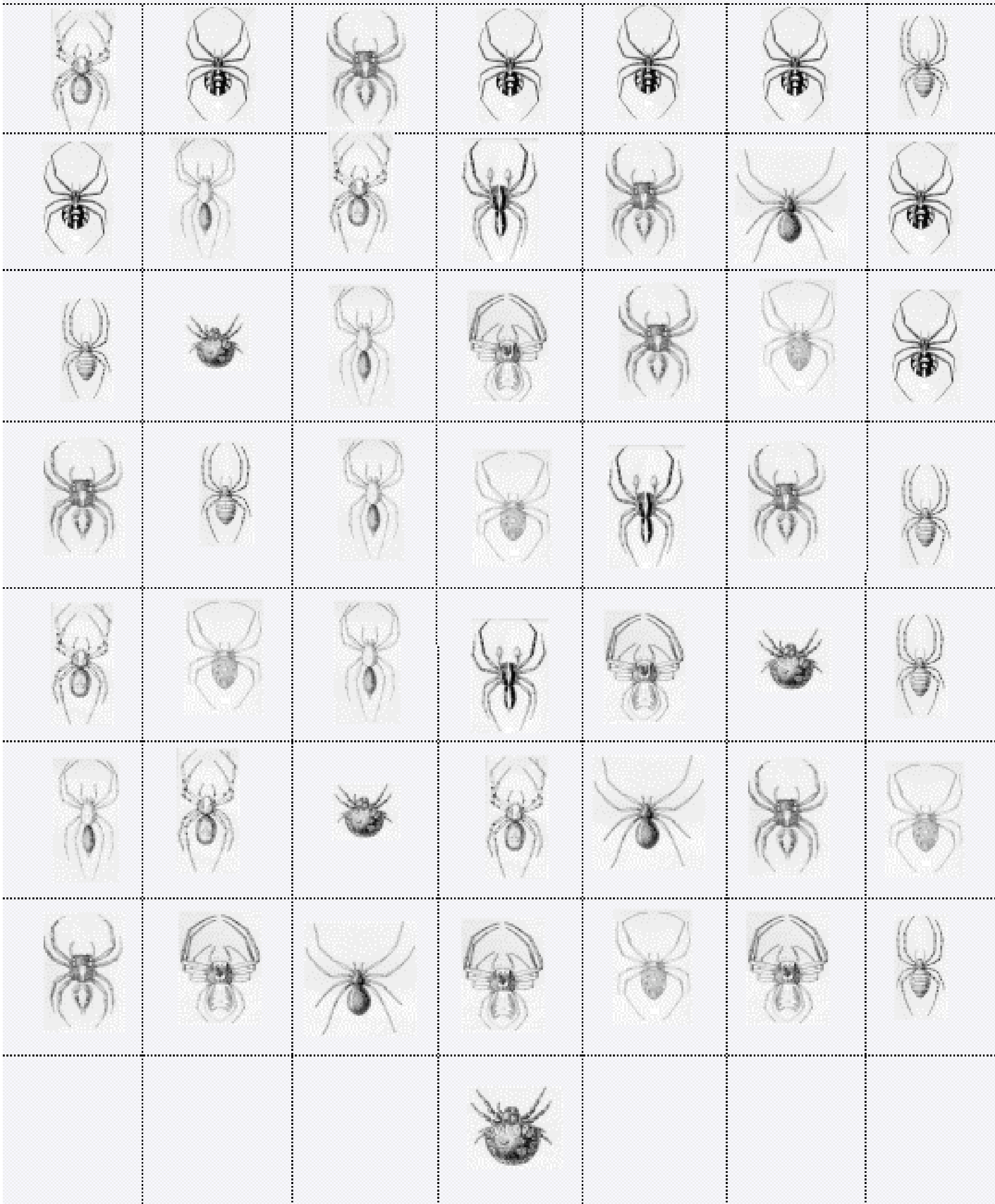
What can you conclude from the shape of your collector's curve as to whether the sample of spiders is an adequate characterization of spider diversity at the site?

LEVEL 2

CONTRASTING SPIDER DIVERSITY AMONG SITES TO PROVIDE A BASIS FOR PRIORITIZING CONSERVATION EFFORTS

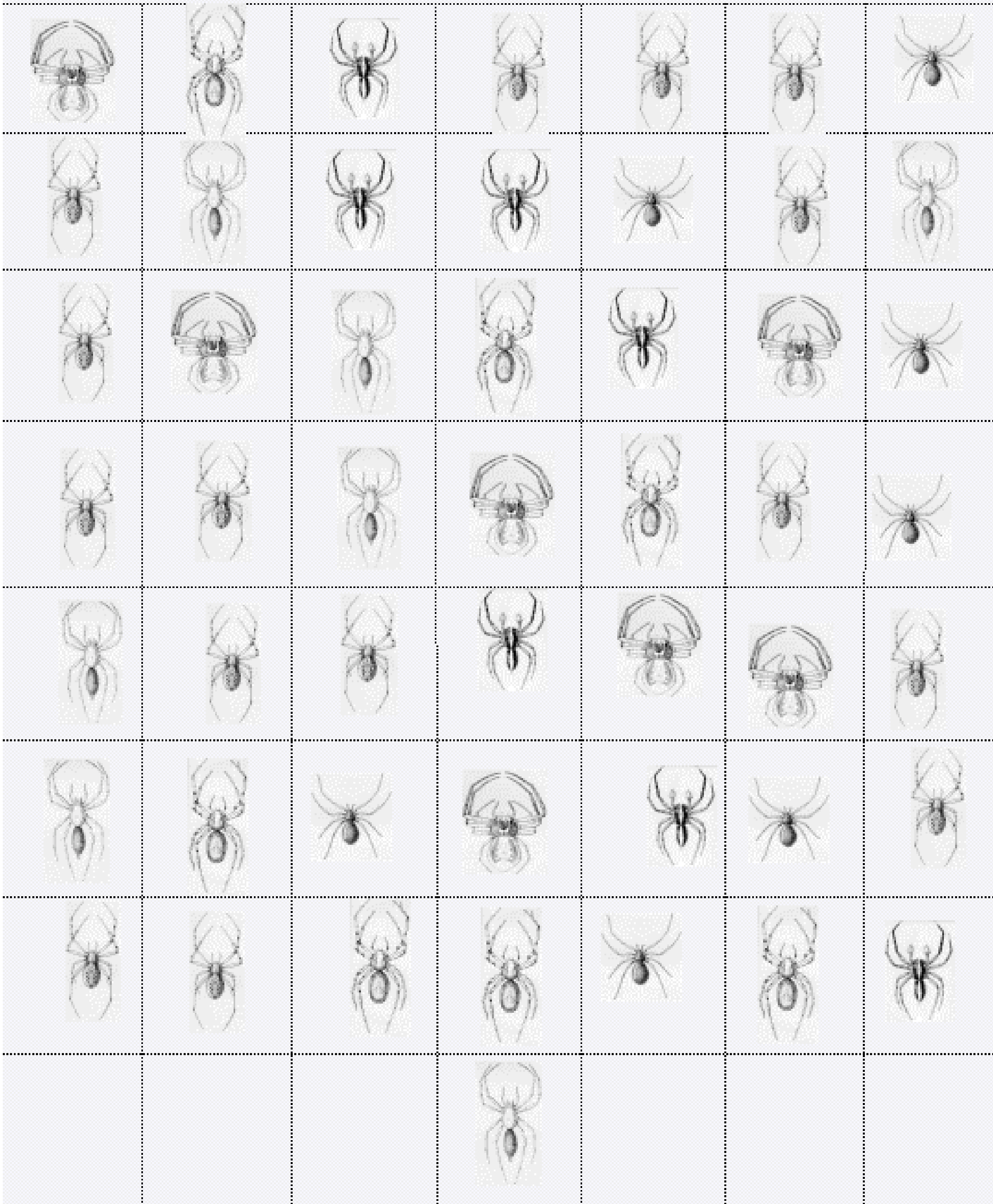
In this part of the exercise you are provided with spider collections from 4 other forest patches. The forest patches have resulted from fragmentation of a once much larger, continuous forest. You will use the spider diversity information to prioritize efforts for the five different forest patches (including the data from the first patch which you have already classified). Here are the additional spider collections:

Site 2

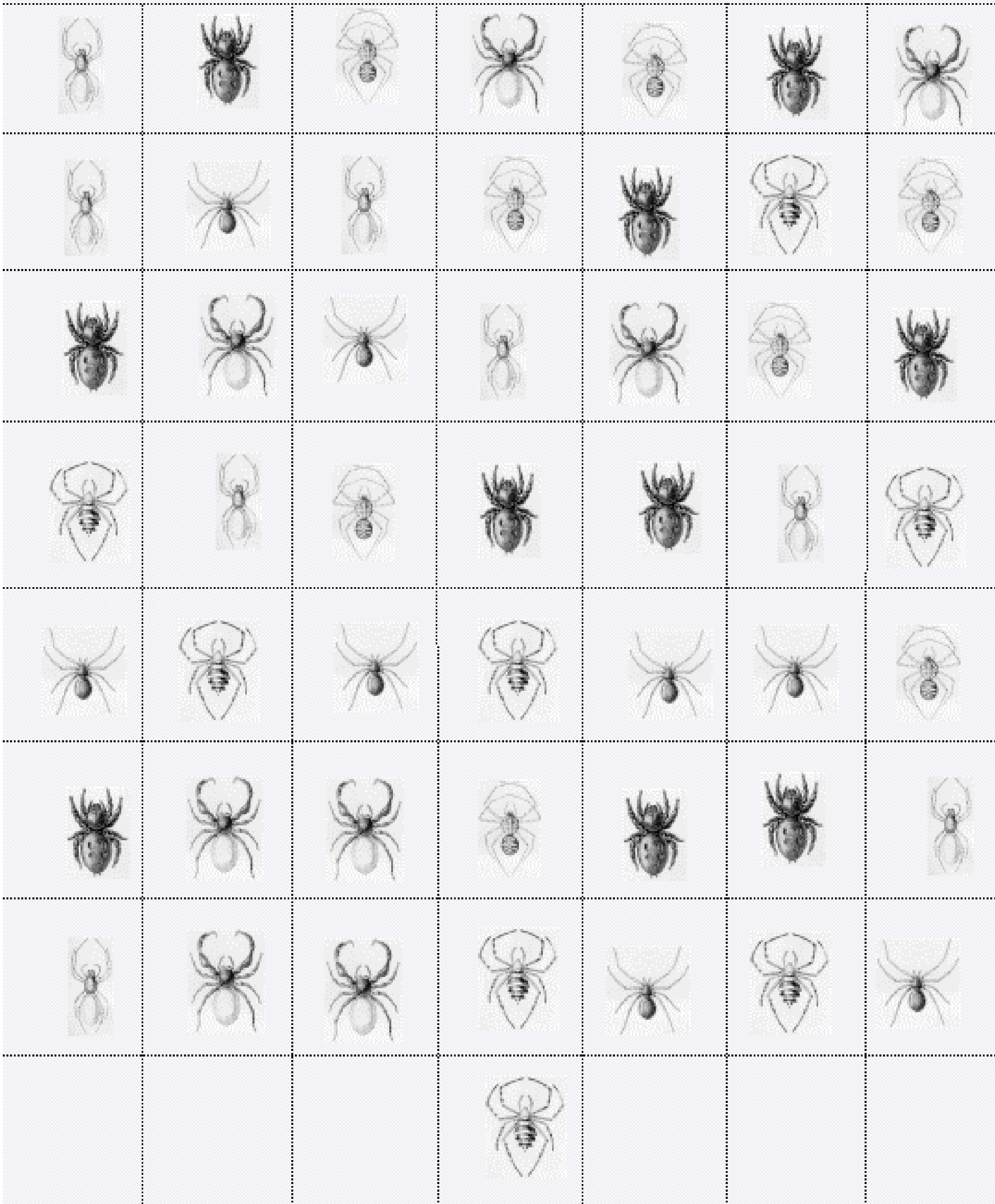


Site 3

Site 4



Site 5



Again, tally how many individuals belonging to each species occur in each site's spider collection (**use your classification of spiders completed for Site 1 during Level 1 of the exercise**). Specifically, construct a table of species (rows) by site (columns). In the table's cells put the number of individuals of each species you found in the collection from the island. You can then analyze these data to generate different measures of community characteristics to help you to decide how to prioritize protection of the forest patches. **Recall that you need to rank the patches in terms of where protection efforts should be applied, and you need to provide a rationale for your ranking.**

You will find it most useful to base your decisions on three community characteristics:

- ***species richness*** within each forest patch
- ***species diversity*** within each forest patch,
- the ***similarity*** of spider communities between patches

Species richness is simply the tally of different spider species that were collected in a forest patch. Species diversity is a more complex concept. We will use a standard index called Simpson Reciprocal Index, 1/*D* where *D* is calculated as follows:

$$D = \sum p_i^2$$

where p_i = the fractional abundance of the i^{th} species on an island. For example, if you had a sample of two species with five individuals each, *D* = 1 / ((0.5)^2 + (0.5)^2) = 2. The higher the value, the greater the diversity. The maximum value is the number of species in the sample, which occurs when all species contain an equal number of individuals. Because this index not only reflects the number of species present but also the relative distribution of individuals among species within a community it can reflect how balanced communities are in terms of how individuals are distributed across species. As a result, two communities may have precisely the same number of species, and hence species richness, but substantially different diversity measures if individuals in one community are skewed toward a few of the species whereas individuals are distributed more evenly in the other community.

Diversity is one thing, **distinctiveness** is quite another. Thus another important perspective in ranking sites is how different the communities are from one another. We will use the simplest available measure of community similarity, that is, the Jaccard coefficient of community similarity, to contrast community distinctiveness between all possible pairs of sites:

$$CC_J = c/S$$

where ***c* is the number of species common to both communities** and ***S* is the total number of species present in the two communities**. For example, if one site contains only 2 species and the other site 2 species, one of which is held in common by both sites, the total number of species present is 3 and the number shared is 1, so 1/3 = 33%. This index ranges from 0 (when no species are found in common between communities) to 1 (when all species are found in both communities). Calculate this index to compare each pair of sites separately, that is, compare Site 1 with Site 2, Site 1 with Site 3, …, Site 4 with Site 5 for 10 total comparisons. You might find it useful to determine the average similarity of one community to all the others, by averaging the CC_J values across each comparison a particular site is included.

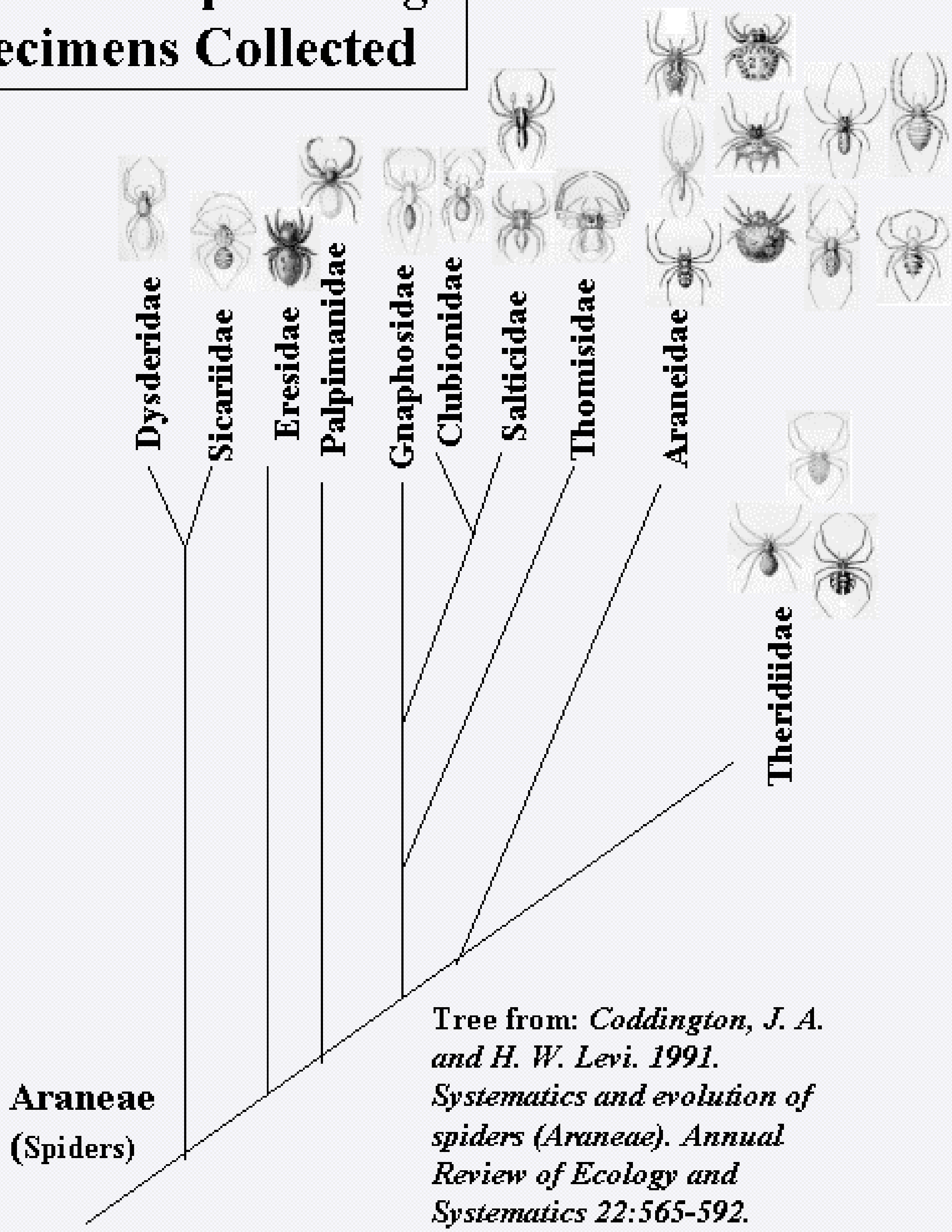
Once you have made these calculations of diversity (species richness and Simpson's Reciprocal Index) and distinctiveness, you can tackle the primary question of the exercise: **How should you rank these sites for protection and why? Making an informed decision requires reconciling your analysis with concepts of biological diversity as it pertains to diversity and distinctiveness. What do you recommend?**

LEVEL 3

CONSIDERING EVOLUTIONARY DISTINCTIVENESS

When contrasting patterns of species diversity and community distinctiveness, we typically treat each species as equally important, yet are they? What if a species-poor area actually is quite evolutionarily distinct from others? Similarly, what if your most species-rich site is comprised of a swarm of species that have only recently diverged from one another and are quite similar to species present at another site? These questions allude to issues of biological diversity at higher taxonomic levels. Only by looking at the underlying evolutionary relationships among species can we gain this additional perspective. We have provided below a phylogeny of the spider families that occur in your collections (a genuine phylogeny for these families based in large part on Coddington and Levi 1991). In brief, the more closely related families (and species therein) are located on more proximal branches within the phylogeny. **Based on the evolutionary relationships among these families, will you modify any of the conclusions you made on prioritizing forest patches for protection based on patterns of species diversity alone? If so, why?**

Phylogenetic Relationships among Specimens Collected



Tree from: *Coddington, J. A. and H. W. Levi. 1991. Systematics and evolution of spiders (Araneae). Annual Review of Ecology and Systematics 22:565-592.*

LITERATURE CITED

Berland, L. 1955. Les arachnides de l'Afrique noire française. Dakar, IFAN, 130 p.

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