Niche Partitioning Activity

INTRODUCTION

In the African savanna ecosystem, many species of large herbivores share similar habitats. How do all these species coexist, or live together, without some species outcompeting the others? These species can coexist due to a mechanism called **niche partitioning**, which is when species partition, or divide up, resources by using their environment in different ways. (A species' **niche** is its place and role in an ecosystem, including where it lives and how it gets the resources it needs to survive.)

In this activity, you'll use scientific data and videos to explore different examples of niche partitioning in the African savanna. The concepts you'll learn can be applied to many other organisms and ecosystems, to help us better understand how species behave and interact.

PART 1: Niche Partitioning by Time and Grass Height

One type of niche partitioning in the savanna is shown in Figure 1. The resource partitioned in this example is a typical savanna grass called *Panicum maximum*. This grass's growing season starts after the peak rain and continues for six months. When the grass is tall, it has lots of stems, which are relatively low-quality food for herbivores. The more nutritious parts of the grass are closer to the ground. If a grass-eating herbivore, or **grazer**, eats the top of the grass, the new parts of the grass that grow back are also more nutritious.

Figure 1 shows three types of grazers — zebra, wildebeest, and Thomson's gazelle — that graze, or eat, this grass over time. Zebras, the first grazers to use this resource, thrive when the grass is tall and abundant, even if it is less nutritious. The zebras have paired upper and lower teeth that help them bite off tall stems on the tops of the grass.

Zebras can also digest food much more quickly than the other two grazers. This is because wildebeests and Thomson's gazelles are **ruminants**, mammals with four-chambered stomachs that take longer to digest food. Sometimes ruminants must also regurgitate and rechew partly digested food before they can fully digest it.

However, when the ruminants digest their food (via fermentation in the foregut), they take up more nutrients and proteins than when zebras digest food (via fermentation in the hindgut). So, a ruminant can extract more energy from a smaller amount of food if that food is more nutritious. Smaller ruminants, such as Thomson's gazelles, need less energy than larger ruminants, such as wildebeests.

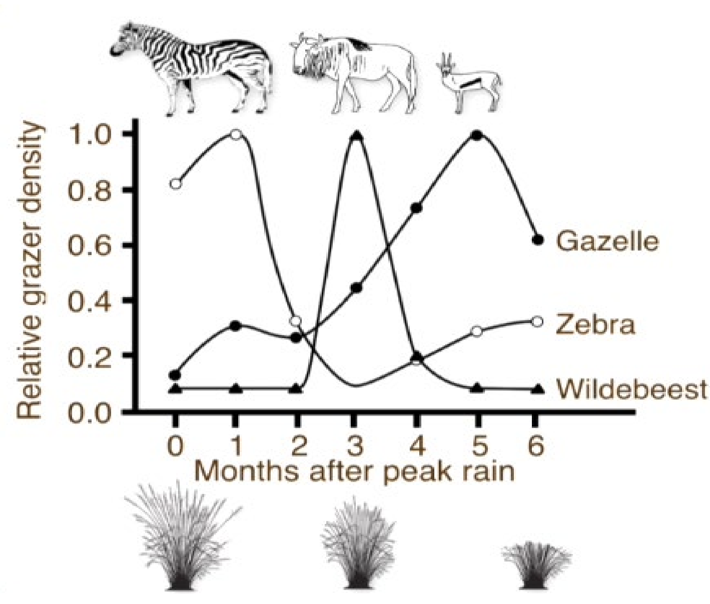

Figure 1. The relative population densities of three different grazers — zebras, wildebeests, and Thomson's gazelles — for six months after the peak rain in the African savanna. (All animals were counted in the same area, and the numbers were normalized to the maximum count for each species.) The images at the bottom show the relative heights of the *P. maximum* grass over this time period.

Answer the following questions based on Figure 1 and the information above.

1. Describe how the relative zebra density changes over time. What characteristics of zebras could explain why zebra densities are greatest when the *P. maximum* grass is tallest and most abundant?

2. Describe how the relative wildebeest density changes over time.

3. Propose a reason or reasons why the relative wildebeest density spikes when it does. Support your idea with evidence from what you know about wildebeests and *P. maximum* grass. (*Hint:* Remember that the more nutritious parts of the grass are closer to the ground. The grasses continue to grow after being grazed, and the parts that grow back are also more nutritious.)

4. Describe how the relative Thomson's gazelle density changes over time, in relation to the changes in the relative wildebeest density and in the grass height. Why do you think this is so?

5. Would you describe the interactions between zebras, wildebeests, and Thomson's gazelles as competition or facilitation among species? Support your answer with data from Figure 1.

PART 2: Types of Niche Partitioning

Watch the video clip "Niche Partitioning" to learn about several other types of niche partitioning.

6. Complete the following table based on what you learned. Include both a general description and a specific example for each row.

Type	Description	Example
Spatial niche partitioning		
Dietary niche partitioning		
Niche partitioning by resource height		
Niche partitioning by time (temporal niche partitioning)		

PART 3: Investigating Dietary Niche Partitioning with Metabarcoding

To investigate dietary niche partitioning, we first need to determine the diets of different animals. This can be done using a technique called **DNA metabarcoding**, which uses DNA to accurately identify what plant species an animal ate. Watch the video clip "Metabarcoding" to learn more about this technique.

The results of DNA metabarcoding can be displayed as shown in Table 1, which has individual animals in rows and plant species in columns. If an animal ate a specific plant, the corresponding table cell is marked "Yes."

Table 1. An example of data that could be determined through DNA metabarcoding.

	Stargrass (*Cynodon plectostachyus*)	**Brihati (*Solanum indicum*)**	**Burr grass (*Tragus berteronianus*)**
Elephant #1	Yes	Yes	No
Dik-Dik #1	No	No	Yes

Data like these can be analyzed using a statistical technique called **nonmetric multidimensional scaling (NMDS)**, which calculates similarities among data points across many different dimensions — for example, similarities in animals' diets across many different plant species. NMDS simplifies information from these many dimensions into two-dimensional scatterplots that are easier to interpret.

Figure 2 shows an NMDS plot where each data point represents the overall variety of plant species found in an individual animal's diet. Animals whose points are *closer* together have a more *similar* diet than animals whose points are farther apart.

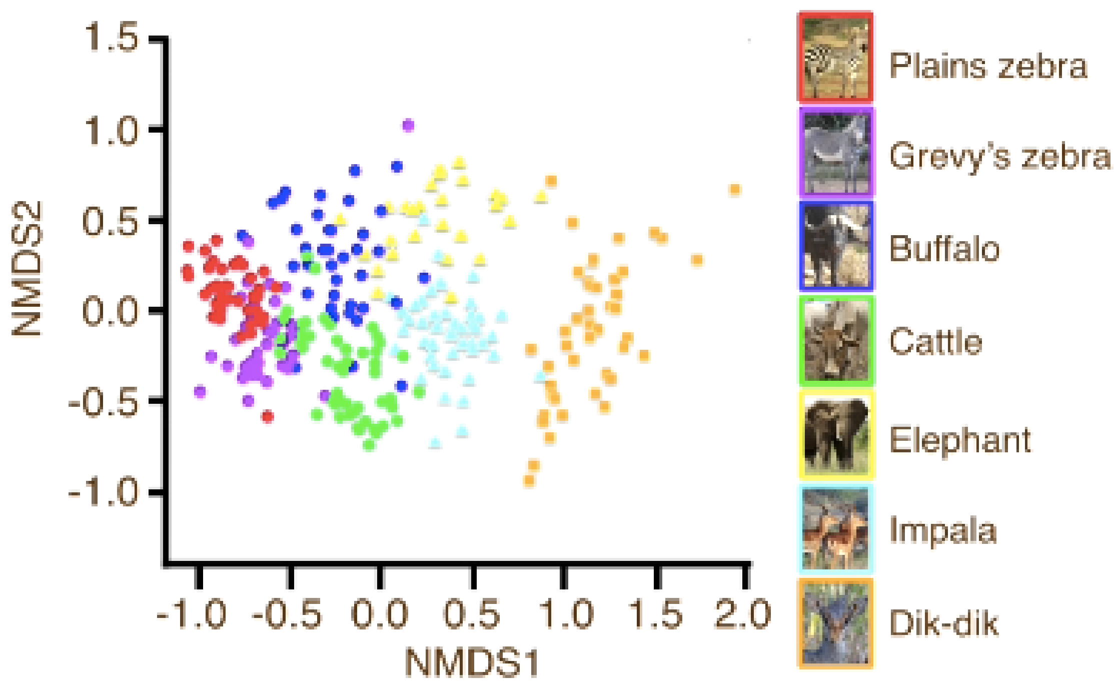

Figure 2. An NMDS plot comparing herbivore diets during a single wet season. Each point represents the diet of an individual animal, and they are color-coded by species. In NMDS plots like these, the axes (NMDS1 and NMDS2) do not correspond to specific variables. Instead, they represent a combination of multiple variables.

Use Figure 2 to answer the following questions.

7. In general, how does the diet of the plains zebra compare to that of the Grevy's zebra? Are they eating the same species of plants?

8. In general, how does the diet of the plains zebra compare to that of the impala?

One classic mechanism of dietary niche partitioning is the **grazer-browser spectrum**, which suggests that some herbivores (**grazers**, such as zebras) eat only grasses, some (**browsers**, such as dik-dik) eat only plants that aren't grasses, and others eat both. The *x*-axis of Figure 2, NMDS1, appears to be related to the grazer-browser spectrum: higher values correspond to browsers, and lower values correspond to grazers. The *y*-axis, NMDS2, is more complicated but does show separation between some species (such as the elephant and impala).

9. How might the data in Figure 2 provide a greater understanding of the grazer-browser spectrum?

10. Figure 2 includes six wild species and one domesticated species: cattle. How might these data inform wildlife management near areas with farming and/or ranching of domesticated animals?

11. The data in Figure 2 are from a single wet (rainy) season. Why would it be important to run the experiment again during other seasons?

PART 4: Applications of Niche Partitioning

12. For each of the examples in the following table, identify the mechanism by which the resources, and thus the niches, are divided. Use the niche partitioning mechanisms you described in Question 6.

Mechanism	Description and example
	During the warm daylight hours, bees collect nectar from the flowers on a linden tree. In the evening, different types of moths are on the flowers.
	Two types of birds, pileated woodpeckers and yellow-bellied sapsuckers, get food from the same tree. Sapsuckers drill rows of little holes to eat the tree's sap and insects in the sap. Pileated woodpeckers dig deep holes to find insects in the tree trunk.
	Prairie grasses use their roots to get water and nutrients from the soil. Smartweed roots reach nearly 100 cm underground, Indian mallow roots reach 70 cm, and bristly foxtail roots reach only about 20 cm.

13. Which of the following statements best describes niche partitioning?
    a. Varying prey species maintains biodiversity.
    b. Superior species enjoy success because of competitive exclusion.
    c. Coevolution between two species means they can always share the same niche.
    d. Similar species can coexist because of slight differences in each one's niche.

14. How can niche partitioning increase biodiversity?