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Lesson 3: Population and Community Ecology

Objectives

By the end of this lesson, students will be able to:

- distinguish between the three patterns of dispersion found in nature
- explain the four methods scientists use to determine population size
- describe the factors that create changes in population size
- list potential limiting factors in a population
- distinguish between a habitat and a niche
- explain the differences between the three major interspecific interactions in a community

Click here for the course glossary

Introduction

Think about your town's population. How many people live there? Does the population change? Why? Could more people live in your town? What interactions do people have on a daily basis?

These two children are having an interaction. Both children are benefiting since they are both laughing and enjoying themselves. (Photograph by Nils Fretwurst)

Populations of organisms, including humans, are always changing. This lesson discusses factors that

affect population size and the interactions between populations. Organisms interact on a daily basis. Shaking hands and eating as a family are both examples of interactions. Some interactions benefit both people involved. Other interactions benefit one person and harm the other. When one person steals money from another, the thief benefits. The victim suffers. Similar interactions occur in nature.

Populations

A **population** is a group of organisms of the same species that live together in the same area. A group of green tree frogs living in the same part of a forest is a population. They will likely breed with one another. They also use many of the same resources.

A population of Royal penguins

Populations also vary in size. A population of white rhinoceroses in Africa may have only five individuals. A population of ground squirrels may have 500 individuals.

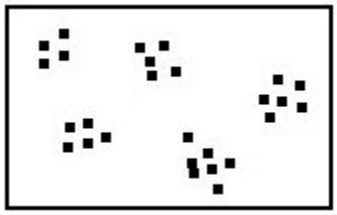
The study of populations is called **demography**. Demographers look at population size. They measure how populations increase or decrease. They also study the distribution of organisms in a population. Many other scientists also use statistics to draw conclusions about populations.

Dispersion

Populations arrange themselves in various ways. Examine the picture above of the Royal penguins. Look at how far apart one penguin is from the next. Why might they stand like that? What do you do when you are cold? You may huddle close to another person for warmth. The pattern by which individuals arrange themselves within a certain area is called **dispersion**. Several factors affect dispersion. These include the availability of food, resources, and mates.

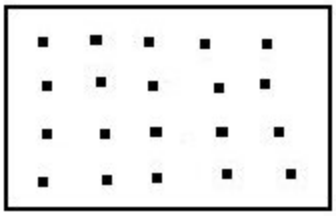
Below are three patterns of dispersion common to nature:

Clumped



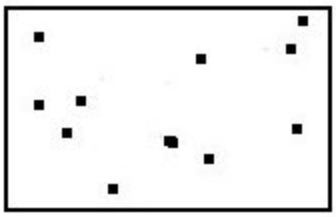
Clumped organisms are arranged in patches. Plants are often clumped in places with good soil conditions. Clumping is also seen in fish when they school. This behavior may reduce the risk of predation. It can also help fish swim more effectively. Clumping is also associated with mating. Some insects clump together to increase their chances of finding a mate. Clumping is the most common type of dispersion discussed in this lesson.

Uniform



Uniformly dispersed organisms are evenly spaced from one another. Take another look at the penguins above. They are uniformly arranged in a breeding colony. Uniform dispersion is a result of individual interactions within a population. For example, individuals acting aggressively toward one another can bring about a uniform aggregation of organisms. With plants, competition for resources (such as water) in the area can cause them to be distributed in this manner as well.

Random



Organisms that are spaced in an uneven, unpredictable way are randomly arranged. The location of one individual does not affect where other individuals are located. This type of spacing can occur in areas with many resources. Trees in forests exhibit random dispersion. Truly random arrangement, however, is rare in nature.

How Do You Find the Size of a Population?

Scientists use a few different methods to determine the size of given populations. These include direct observation, indirect observation, sampling, and mark-recapture studies.

Direct Observation

Direct observation involves the direct counting of individual organisms. This method is rarely used. It can be done when a researcher can count the number of large animals from an airplane. The methods below, however, are usually more practical than direct observation.

Direct observation is used on populations of chimpanzees. (Photograph by Cody Pope)

Indirect Observation

Indirect observation involves counting signs or evidence of individuals. Biologists could count the number of animal droppings in an area to estimate its population size. This is common for bears and deer, for instance. Other methods include counting holes in the ground for signs of smaller mammals and reptiles. Scientists who study birds often count the number of nests in an area.

A gopher tortoise hole

Sampling

Many populations are too big for indirect or direct observation. In these cases, biologists use sampling. The scientist counts the number of individuals in a small area. For example, in a forest that is 2,000 square meters, the scientist counts the number of pine trees in 2 square meters and multiplies the number of trees by 1,000. This gives the approximate number of pine trees in the whole forest.

Mark-Recapture Studies

Scientists also perform mark-recapture studies, also called capture mark-recapture studies. Scientists capture an animal and mark it with a tag, band, collar, or paint. When the animal is caught again, it can be identified.

For example, biologists use the mark-recapture approach to study a population of sub-adult marine turtles off the eastern coast of Florida. Every time a scientist catches a new turtle, a tag with an identification number is placed on the turtle's flipper. The number of new captures and recaptures allows the biologists to keep track of

the population size.

What Factors Create Changes in Population Size?

Populations can increase and decrease. Factors affecting population size either add individuals or take them away.

Populations of this bird, a cattle egret, moved into the US from Africa. They are immigrants to the US.

Factors that add individuals to a population:

Births add individuals to a population. Scientists determine a population's **birth rate** by tracking the number of births during a particular time period.

Immigration increases a population. Consider a population of 100 beetles. During the month of September, 50 beetles from another area move to this current population because of the resources there. This immigration increases the population from 100 to 150.

Factors that decrease the number of individuals in a population:

Death decreases population size. Scientists determine **death rates** by counting the number of deaths during a certain time period. Suppose 20 lizards die in a period of one year. The death rate would be 20 lizards per year.

Emigration (leaving a population) of individuals decreases population size. Suppose a group of fish moves from location A to location B. This group is emigrating to another area. People emigrate as well. A person that decides to move from France to Spain leaves the French population. Therefore, they decrease France's population.

Factors that Limit Individuals in a Population

A population will increase so long as the conditions in the area are favorable for growth. Certain factors limit the growth of a population. They may even cause a population to decrease. These factors are called **limiting factors**. Limiting factors include:

- temperature and rainfall
- space
- food and other resources

Temperature and Rainfall

Extremely cold temperatures can affect the size of plant populations.

Organisms have adapted in many different ways to certain climates (Lesson 2). Unusual weather can reduce population size. Ants that live in a forest may die off during a flood. Low temperatures in a normally warm region can kill plants and animals that cannot tolerate the cold. Similarly, very high temperatures and little rainfall could harm organisms that are used to a colder, wetter environment. Harsh conditions can kill organisms and thereby affect population size.

Amount of Space to Inhabit

Trees compete for space to grow their roots underground.

All organisms need space to survive. The amount of space required varies. The number of organisms that can live in an area is limited by the space available.

Plants need enough space to obtain water, nutrients, and sunlight for **photosynthesis**. Crowded conditions can endanger plant survival and therefore decrease a given plant population.

Animals need space to live as well. Marine turtles need beach area to lay their eggs. Deer need grazing areas. Birds need trees for nesting. If a bird cannot find a tree in which to nest, the bird cannot reproduce and its population cannot grow.

Food and Water Resources Available

Organisms need food and water to survive. Plants make their own food. However, they need water to produce their food. Without water, plants cannot grow or reproduce. This affects the size of the plant population.

Different species eat different types of food. All animals need food to survive. Some animals are predators. Others are **herbivores**. Regardless of their diet, animals require food for growth, reproduction, and survival.

The section below explores interactions among species in a community. Most interactions relate to the way organisms obtain food and use resources to survive.

Think About It

Think of a population of animals in your area. What would be the best way to determine the size of this population? What factors in your area may limit the growth of this population?

Communities

An undersea community that includes fish, algae, invertebrates, worms, mollusks, and many other organisms

A **community** includes all populations in a given area that live close enough to interact with one another.

Like populations, communities differ in size. A dead antelope that has microorganisms, insects, and worms living inside of it is considered a community. Sarasota Bay, Florida is also considered a community. It is comprised of manatees, dolphins, sea grass, shrimp, fish, algae, lobster, clams, oysters, and other types of marine life.

Habitat vs. Niche

Every species that lives in a community has a **habitat**. A habitat is a physical place where a species lives. A crayfish lives at the bottom of a pond. The bottom of the pond is its habitat. Many species can live in the same habitat. Worms and snails live at the bottom of ponds as well.

Each species also has a **niche**. A niche is a role in the community, including the biotic and abiotic resources that the organism uses. An

Real Life Scientist

organism's niche includes:

- its habitat
- its interactions
- the way it obtains food
- the resources it requires
- factors that limit its distribution
- the way it reproduces

Think of it this way:

Habitat = organism's address
Niche = organism's job

Suppose you want to figure out a given organism's niche. You should ask yourself what the organism *does*. The answer will describe the niche of the organism.

The niche of a crayfish includes the bottom of the pond, the temperature of the pond it requires to survive, the size of the insects it eats, and the time of day at which it is most active. Ask yourself: What does a crayfish do? A crayfish lives at the bottom of a pond, tolerates water temperatures within a certain range, eats small insects, crawls away from predators such as turtles, and is active during the day.

If two different species have the same niche, they will not live in the same community. If they did, one would "out-compete" the other for the niche.

Dr. Peter E. Busher is an ecologist who studies population and community structure of mammals. His main focus is on the population growth of the North American beaver, also known as *Castor canadensis*.

Dr. Busher examines the impact of human activity on beaver populations. The beaver population has been increasing and expanding in various regions in North America. Consequently, this expansion has brought beavers into conflict with humans for land use. Dr. Busher's goal is to discover the response of the beaver population that has been exposed to human activity.

Dr. Busher is in the process of developing and organizing a joint American-European beaver research program that will examine the populations of two species of beavers in Finland.

Interactions in a Community

Interactions constantly take place within species. Interactions also occur between species. Interactions between two different species are **interspecific**. Interactions within a species are **intraspecific**. This section will discuss three major interspecific interactions between organisms in a community.

Competition

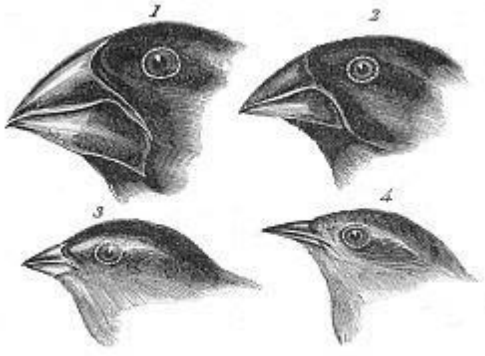
Resources are limited in nature. Resources include food, shelter,

nutrients, and nesting sites. These are necessary for survival. There is **competition** for limited resources. Competition exists as long as demand is greater than supply.

In Africa, vultures and hyenas compete for the flesh of dead animals. In other parts of the world, squirrels and birds compete for nuts to eat in a forest. These are just two of many examples of competition in nature.

Competition can exist between two or more individuals. The results of a competitive interaction can be either of the following:

- a decrease in the number of individuals from either or both of the species that are competing
- complete elimination of one of the competitors



Four species of finches that live on the Galapagos Islands. Notice the difference in beak sizes.

Organisms can coexist without competing. They do so by acquiring different niches. For example, different types of finches live on the Galapagos islands and are similar in size and habitat, but they do not compete for food. This is because they occupy different niches. They can do this because they have different sized beaks. This allows them to eat different types of foods.

A cuttlefish blending in with its environment

Predation

Predation is when one organism (a predator) consumes another organism (prey). A hawk grabbing a mouse with its claws is an example of a predator-prey interaction. The hawk is the predator and the mouse is the prey.

Many species have adaptations that decrease their chances of being eaten (or becoming prey). These adaptations include:

Camouflage: This adaptation enables an organism to hide from predators. An organism can camouflage by changing its shape, color, or behavior.

Warning coloration: Many organisms are toxic. Some advertise this to predators through bright coloration. The bright colors serve as warnings to predators. The predator may die if it eats toxic prey. This is common in poison dart frogs and butterflies.

A Monarch butterfly is shown here. Many of these butterflies are toxic; they warn predators with the presence of bright colors.

Mimicry: Mimicry is when a species resembles an unrelated species. Harmless species sometimes mimic the look of a different, harmful species. Non-toxic organisms may mimic a toxic species with bright coloration. This tells predators that they are toxic, even if they are not.

Scarlet king snake

Compare this non-venomous snake (scarlet king snake) to the venomous snake (coral snake). The king snake is demonstrating mimicry. Look carefully at the color patterns of these snakes. The coral snake has red stripes against yellow stripes. The scarlet king snake has red stripes against black stripes.

Coral snake

Given these adaptations, how then are predators able to catch their prey? Predators also have adaptations. Some plants excrete a toxin so that insects will not eat them. Some insects, however, can tolerate such toxins. This enables them to eat the plant. Predators' adaptations (and examples) include:

- hunting in groups (wolf packs)
- speediness to catch prey (cheetahs)
- camouflage so as not to be seen by prey (tigers' stripes)
- large eyes for nocturnal hunting (owls)

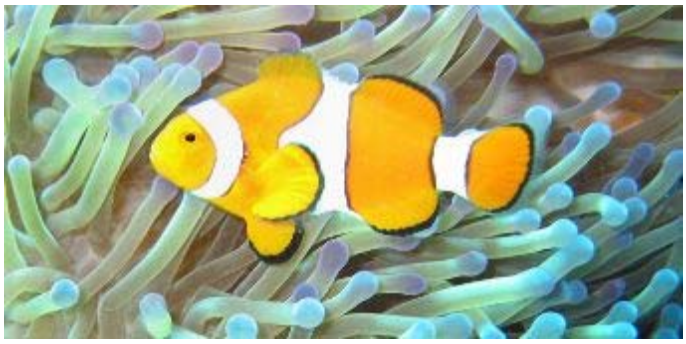
Symbiotic Relationships

Symbiosis is an interaction between two species that form a close relationship. The effects of the interaction depends on the type of symbiotic relationship. In this section, you will see the following signs: "+", "0", and "-" next to an interaction.

- A "**+**" means the individual benefits from an interaction.
- A "0" means that an interaction has neither a positive nor a negative effect on an individual.
- A "**-**" means that an interaction has an undesirable effect on an individual.

In the following section, you may see two of these signs separated by a slash mark. A "(+/+)" sign tells you that both organisms benefited from a given interaction. There are three types of symbiosis: **mutualism**, **parasitism**, and **commensalism**.

Mutualism (+/+)



A mutualistic relationship between a clownfish and a sea anemone

This picture shows a mutualistic relationship between a clownfish and a sea anemone. The fish rids the anemone of parasites, making it healthy and clean. In turn, the fish obtains food from the anemone. The fish also uses the anemone to hide from predators.

Both species involved benefit in this type of interaction. Such interactions are characterized by obtaining food or avoiding predation.

Protozoa live in termites' intestines. Without these protozoa, termites could not digest the wood they eat. This is a mutualistic relationship. The termite benefits from the protozoa's aid in digestion. The protozoa also benefit. They obtain nutrients from the wood that they help break down.

A few species of fish, including Wrasse and Gobies, are called "cleaner fish." They set up stations underwater where they remove parasites and dead skin from other fish. This is a mutualistic relationship. The cleaner fish obtain food from the particles they remove from other fish. The other fish also benefit. Cleaner fish help the other fish get rid of unhealthy parasites.

Parasitism (+/-)

In this type of interaction, a **parasite** gets nourishment from its **host**. Parasites do not have to kill their hosts but sometimes they do. The parasite benefits by getting food, a place to live, or a place to reproduce. The host does not benefit. Bacteria are examples of parasites. Strep throat is caused by bacteria (the parasite) that live in humans (the host). They can make the host quite ill.

Commensalism (+/0)

In this interaction, one species benefits while the other remains neutral. Commensalism is rare in nature.

A shark with a remora attached to its belly (Photo by James Watt)

Remora, a type of fish, attach to sharks. In doing so, these fish get a free ride. They also feed on the remains of sharks' meals. Therefore, the remora benefits from this interaction. The shark neither benefits nor is harmed.

Epiphytes, which are air plants, grow on trees. They do not obtain nutrients from the trees. Rather, epiphytes grow on trees to be closer to the sunlight they need. They obtain nutrients and water from the air. Therefore, the epiphyte is benefits. The tree remains unaffected.

Review of Three Types of Symbiotic Relationships

Interaction	Effect on Populations
Mutualism (+/+)	Interaction is beneficial for both species
Parasitism (+/-)	One species benefits, the other species is disadvantaged
Commensalism (+/0)	One species benefits, the other species is unaffected

Making Connections

Like people, communities of organisms in nature interact. Some of these interactions benefit organisms, while others harm them.

Now you understand how different factors affect individuals in a population. Some of these factors exist in human populations. People give birth, and people die. People need a place to live and resources for survival. Sometimes overpopulation can occur. For example, too many people can lead to disease, resource scarcity, or environmental damage.

Overpopulation in wild animals is common. Numbers get out of control for many reasons. If a certain predator is killed off in a given area, the prey's population goes unregulated. Therefore, the prey population increases. Overpopulation can lead to starvation. It may also lead to more disease. In the U.S., overpopulation occurs in deer and rat populations. In Australia, koalas overpopulate some areas. There is much debate over how to handle animal overpopulation. Should they be killed or should they be allowed to reproduce?

Overpopulation greatly affects food chains and food webs. Too many animals leads to over-eating or over-grazing of food in an area. This in turn affects other organisms in that region. The next lesson will discuss the importance of a balanced food chain.

Practice Problems

Answer each question in your notebook. Click on the "Check Answers" button to check your answers.

1. A leech is found feeding on a frog's blood. What type of interaction is this?

2. A scientist counts the nests in an area to determine the population of birds there. What method of observation is the scientist using?

(a) direct observation
(b) indirect observation
(c) sampling
(d) mark-recapture

3. Identify two adaptations of a prey species that reduce their chance of being eaten?

Check Answers Hide Answers

Homework Questions

Click here to view a printable copy of this homework assignment.

1. What four methods do scientists use to estimate population size?

2. Yellowstone Park is a national park that stretches across Wyoming, Montana, and Idaho. You want to estimate the population of grizzly bears in the park. Their population is not that big, but grizzlies are known to be quite aggressive towards humans. Which method of estimation would be the best? Which method would you definitely not use? Explain why.

3. Why is the birth rate just as important as the death rate? How can a change in just one of these rates affect a population or an entire ecosystem?

4. Humans have captured animals and put them in zoos for centuries. In the best zoos, animals are well-cared for, fed, and have plenty of space. They do not have to worry about predators, drought, or any other issues they may face in nature. Humans can observe the animals for entertainment, education, and the benefit of science. Is the animal/human relationship in a zoo environment a type of symbiosis? Why or why not? What is your personal opinion about zoos?

Click here for the course glossary

Useful External Resources
• High School Ace •
• Dictionary — Thesaurus — Encyclopedia — Almanac •