DP IB Environmental Systems & Societies (ESS): SL

Your notes

Species & Populations

Contents

Your notes

Species, Habitats & Niches

Species

- A species is a group of organisms sharing common characteristics that interbreed to produce **fertile** offspring
  - Members of the same species share a gene pool, meaning that they can breed and produce offspring with **similar traits**
- The scientific name of a species consists of two words, the genus and the specific epithet (the second part of the name that identifies the species as unique), e.g. *Homo sapiens* (humans)
  - The naming system is called binomial nomenclature and is internationally recognised

Habitat

- A habitat is the environment in which a species normally lives
- Habitats can be characterised by **abiotic** and **biotic** factors
- Organisms **adapt** to their habitat through natural selection, in order to survive and reproduce successfully

Niche

- A niche describes the particular **set** of abiotic and biotic conditions and resources to which an organism or population responds
- A niche can only be occupied by **one species**, meaning that every individual species has its own unique niche
- If two species try to occupy the same niche, they will **compete** with each other for the same resources
  - One of the species will be more successful and out-compete the other species until only one species is left and the other is either forced to occupy a new, slightly different niche or to go extinct from the habitat or ecosystem altogether
- For example, the three North American warbler species shown below all occupy the same habitat (spruces and other conifer trees) but occupy slightly different niches as each species feeds at a **different height** within the trees
  - This **avoids competition** between the three species, allowing them to co-exist closely with each other in the same habitat

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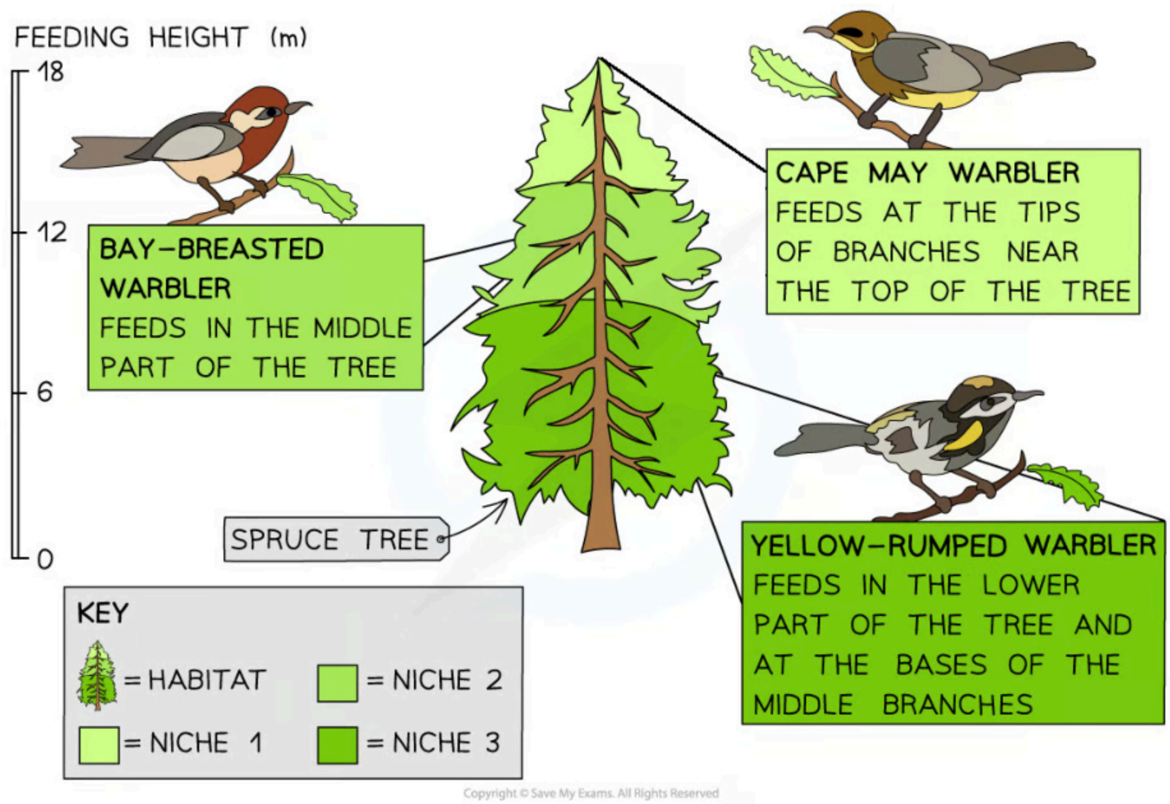


Although it appears as though these three species share the same niche, they actually spend their time feeding in different parts of spruces and other conifer trees

Fundamental vs Realised Niche

- The fundamental niche describes:

  The full range of conditions and resources in which a species could survive and reproduce

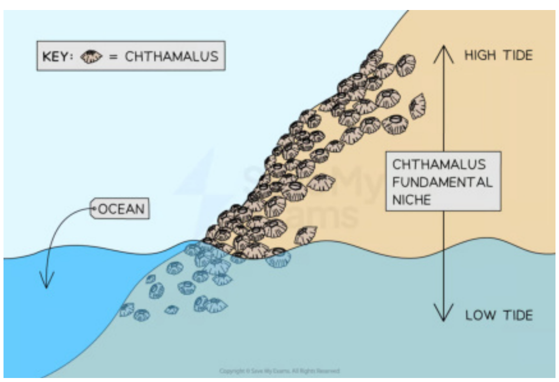
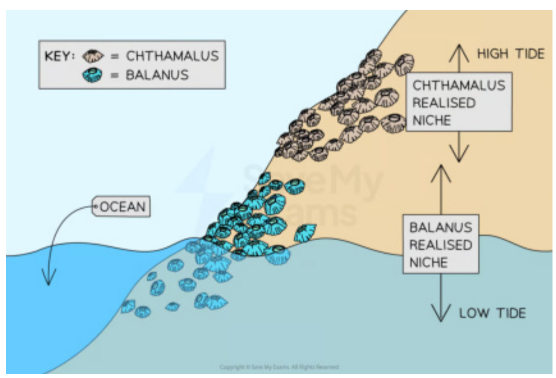
- The realised niche describes:

  The actual conditions and resources in which a species exists due to biotic interactions

- An example of a fundamental niche compared to a realised niche can be seen in the case of the **barnacle** species *Chthamalus dalli*
  - Its fundamental niche includes a wide range of rocky intertidal areas in the Pacific Northwest, where it can attach to a variety of **substrates** and tolerate a wide range of temperature and salinity conditions
  - However, in reality, the realised niche of this species is much smaller or 'narrower' due to **competition** with other barnacle species, such as *Balanus glandula*, for space and resources

- As a result, the actual range of *Chthamalus dalli* is **restricted** to areas where *Balanus glandula* is absent or scarce, such as higher up on the shore, where it is exposed to air for longer periods of time and can avoid competition with *Balanus glandula* for **space** and **resources**
- Therefore, the realised niche of *Chthamalus dallia* is smaller than its fundamental niche due to the **biotic interactions** with other species

An Example of a Fundamental Niche and a Realised Niche

Fundamental Niche	**Realised Niche**
The theoretical niche of a species	Where a species actually lives
The niche a species would occupy if there were no limiting factors on the environment or resources the species could use	The niche that a species actually occupies, in the presence of competitor species
No competition for resources, no predation	Competition for resources and predation occurs
Large in size	Small in size
	

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Abiotic & Biotic Factors

Abiotic & Biotic Factors

Abiotic Factors

- The **non-living**, physical factors that influence ecosystems and the communities of organisms within them are termed abiotic factors
- These include factors such as:
  - Temperature
  - Sunlight
  - pH
  - Salinity
  - Precipitation
- Changes in abiotic factors can affect the survival and reproduction of organisms, and the overall **functioning** of ecosystems

Examples of Abiotic Factors

Abiotic Factor	How it Affects Communities
Light intensity	Light is needed by plants for photosynthesis. More light leads to an increase in the rate of photosynthesis and an increase in plant growth rates.
Temperature	Affects the rate of photosynthesis in plants. Also affects the rate of metabolism, growth and reproduction of organisms. Certain species have adapted to specific temperature ranges and cannot survive outside of those ranges.
Moisture and precipitation levels	Determines the amount of water available to organisms, which can impact their survival, growth and reproduction. Some species are adapted to areas with high precipitation, while others are adapted to arid environments.
Soil pH and mineral content	Different species of plants are adapted to different soil pH levels and nutrient concentration levels.

Wind intensity	Wind speed affects the transpiration rate in plants. Transpiration affects the rate of photosynthesis as it ensures water and mineral ions are transported to the leaves.
Carbon dioxide levels for plants	CO_2 is required for photosynthesis in plants. CO_2 concentration affects the rate of photosynthesis.
Water chemistry	Affects the health and survival of aquatic organisms, particularly those that are sensitive to changes in pH, salinity, and dissolved oxygen levels. Some aquatic animals, such as fish, can only survive in water with high oxygen concentrations.

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Biotic Factors

- The **living**, biological factors that influence ecosystems and the communities of organisms within them are termed biotic factors
  - In other words, biotic factors are the **interactions** between the organisms within a community
- These interactions include:
  - Competition
  - Predation
  - Herbivory
  - Parasitism
  - Mutualism
  - Disease
- These biotic interactions mean that each species in an ecosystem has an influence on the **population dynamics** of the other species

Examples of Biotic Factors

Biotic Factor	How it Affects Communities	Example
Availability of food	More food means organisms have a higher chance of surviving and reproducing. This means their populations can increase.	Rainforest ecosystems have a rich food supply and this allows many species to live there. Deserts have a poor food supply and this allows fewer species to live there.

New predators	In balanced ecosystems, predators catch enough prey to survive but not so many that they wipe out the prey population. If a new predator is introduced to the ecosystem, it may become unbalanced.	Red foxes were introduced for recreational hunting in Australia in the 1800s but have since caused the decline of many native species that they feed on, such as small mammals and birds. This has also reduced the food supply for native predators.
New pathogens	If a new pathogen enters an ecosystem, the populations living there will have no immunity or resistance to it and the population may decline or be wiped out.	Avian flu can cause population declines in wild bird species - an outbreak of the H5N1 virus in the bar-headed goose (*Anser indicus*) in Qinghai Lake, China in 2005 caused the deaths of over 6,000 birds in the area, representing a significant proportion of the bar-headed goose population.
Competition	If two species compete for the same resource(s) and one is better adapted to take advantage of these resources, then that species will outcompete the other. This may continue until there are too few members of the less well-adapted species to breed successfully.	North American grey squirrels were introduced to the UK in the 1800s and have since caused the decline in our native red squirrel population. Grey squirrels have outcompeted red squirrels for resources such as food and nest-sites. They also carry a virus (a new pathogen) that red squirrels have no resistance to.

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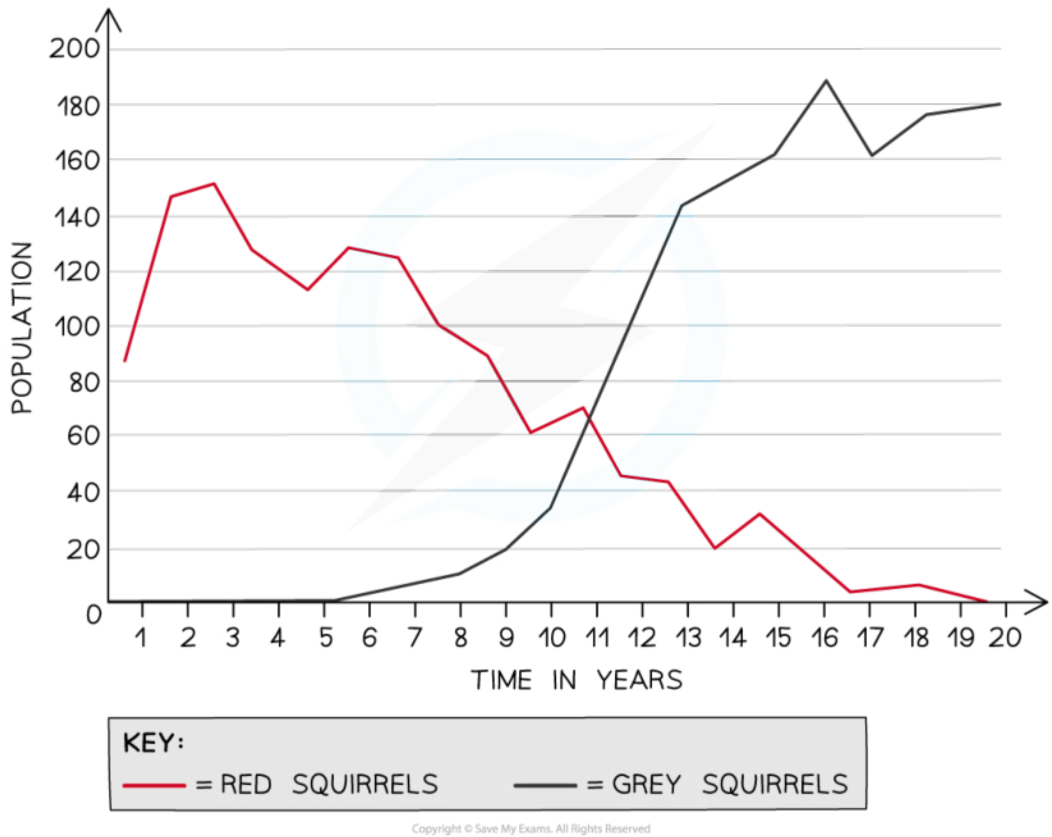
Worked Example

A study recorded the number of red and grey squirrels in a particular woodland habitat for 20 years. Grey squirrels were introduced to the habitat in year 5 of the study. What conclusions can you draw from the graph about the effect of introducing grey squirrels to a habitat that is occupied by red squirrels? Explain why this might have occurred.



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Answer

As the number of grey squirrels increases, the number of red squirrels decreases. This might have occurred because the two squirrel species are competing for one or more of the same resources. Grey squirrels are better adapted to use these resources and have outcompeted the red squirrels until eventually there are too few red squirrels left to breed successfully. At this point there are no red squirrels left in the habitat - they have become locally extinct.

Population Interactions, Limiting Factors & Carrying Capacity

Population Interactions

- A population is a group of organisms of the same species living in the **same area** at the **same time**
  - Populations can be characterised by their size, density, distribution, age structure, and growth rate
- The **carrying capacity** of a habitat or ecosystem is the maximum number of individuals of a particular species (i.e. the maximum population size) that can be **sustained** in a given area over a given time period
- Ecosystems consist of numerous species with different **interactions** occurring between populations, including:

Competition

- Competition can be divided into **intraspecific** competition (competition between members of the same species) and **interspecific** competition (competition between members of different species)
- Intraspecific competition can lower the carrying capacity of a population due to a **decrease in food availability** caused by high population density
- Interspecific competition occurs between species with **similar niches**, causing a decrease in the carrying capacity of one or both species

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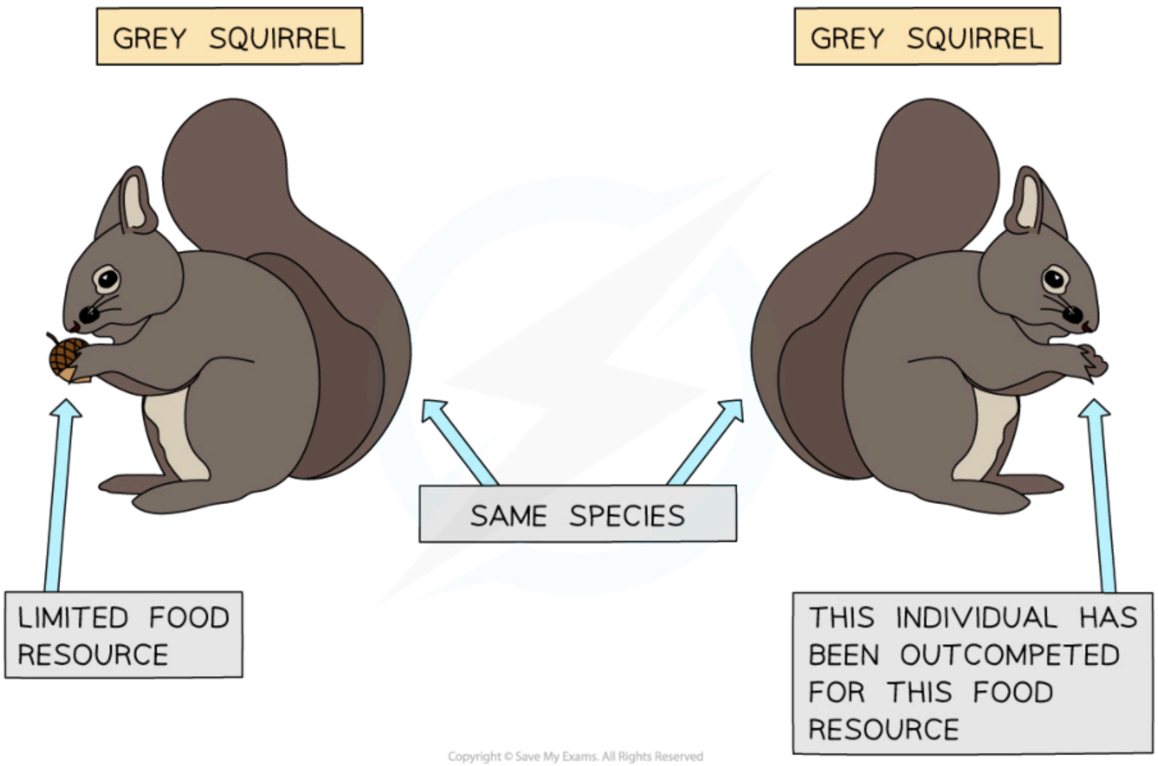

Intraspecific competition between two grey squirrels (same species) for a limited resource

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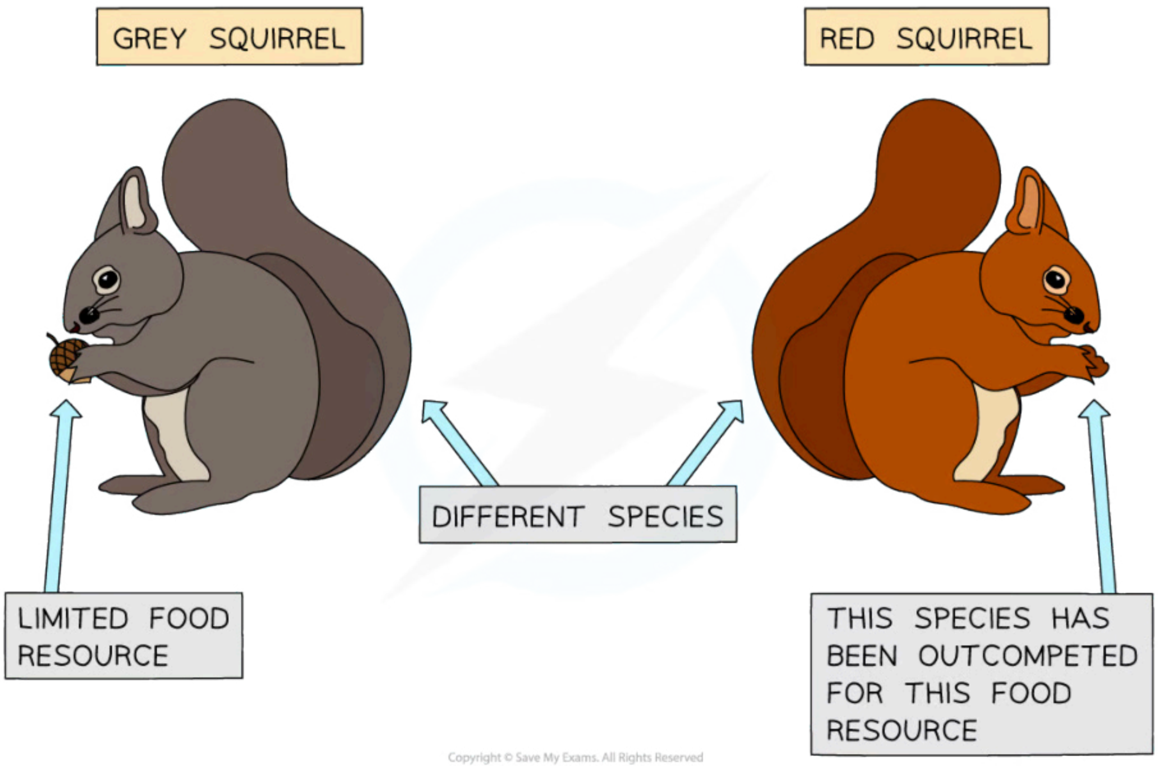

Interspecific competition between a grey squirrel and a red squirrel (different species) for a limited resource

Predation

- When one animal eats another
- This lowers the carrying capacity of the prey species
- This can have **negative feedback effects**, lowering the carrying capacity of the predator species due to a decrease in prey numbers

Herbivory

- When an organism (known as a herbivore) feeds on a plant
- The carrying capacity of herbivore species is affected by the quantity of plants they feed on
- An area with more plant resources will have a higher carrying capacity for herbivore species
- This can also have negative feedback effects - the carrying capacity of the herbivore species may decrease if **herbivory rates** are **too high** and the plant population decreases too much

Parasitism

- Parasites are organisms that are adapted to live very closely with another species, known as the **host** species
- A parasitic relationship is one in which the parasitic organism **benefits** from the host organism
- The parasite lives either in or on the body of the host species and gains **resources** (i.e. what it needs in order to survive) from the host, including food, shelter and a suitable location to reproduce (where offspring can feed and grow)
- However, the host does not benefit from this relationship and parasites often harm the host in some way
- This can lower the host's carrying capacity
- An example of a parasitic relationship is fleas being a parasite to mammals (e.g. dogs) - the fleas feed on the host's blood but don't provide anything to the host in return and may transmit diseases to the host
- Another example is the parasite that causes malaria
  - This parasite infects red blood cells in humans and causes recurrent episodes of fever and can be fatal in certain instances
  - The malarial parasite has a life cycle that includes the mosquito as a **vector**

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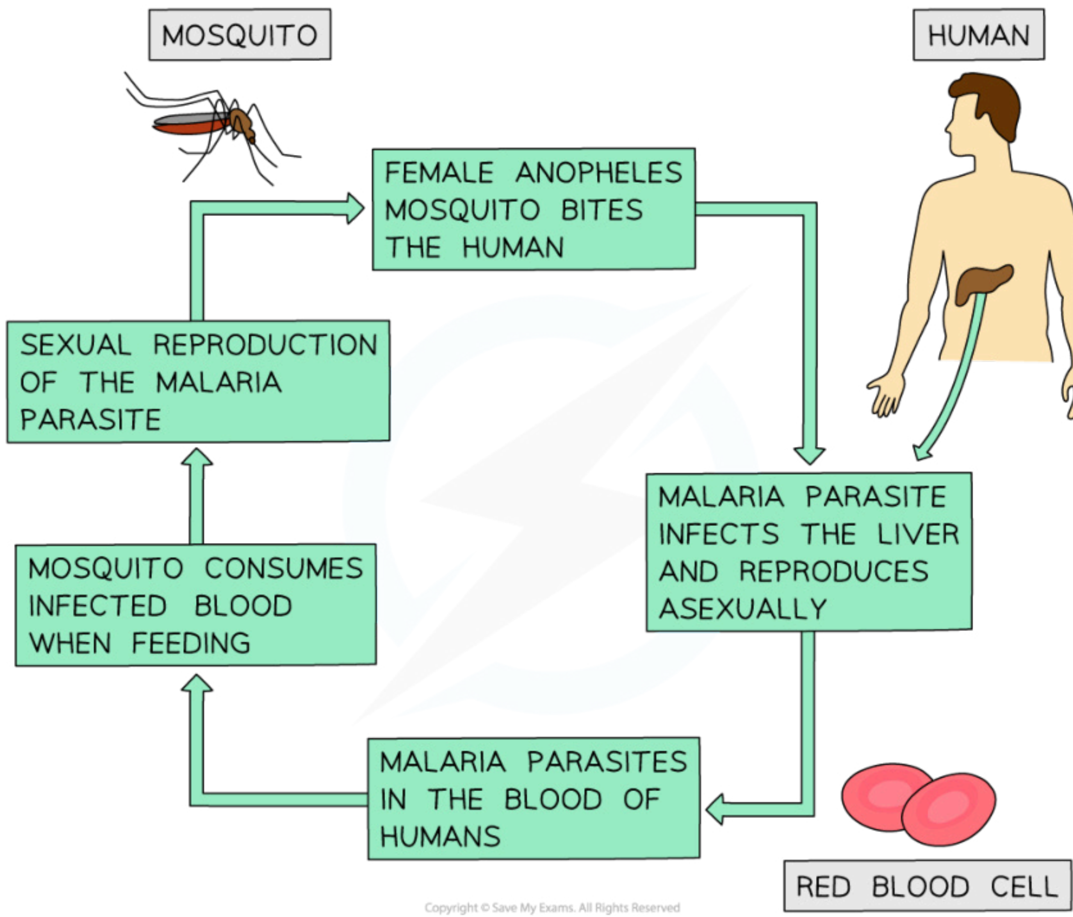

Part of the malaria parasite's life cycle is in humans and the other part is in mosquitos

Mutualism

- A mutualistic relationship between species is one in which **both species benefit**
- This increases the carrying capacity of both species in the relationship
- An example of a mutualistic relationship is the one that exists between bees and many species of flowering plants
- Bees gain nectar (i.e. food to provide them with energy) from flowers
- When bees visit flowers, pollen is transferred to their bodies
- As bees visit multiple different flowers, they spread the pollen to these flowers, pollinating them
- In this way, the flowers gain help in **reproducing**

Disease

Your notes

- **Pathogens** (bacteria, viruses, fungi, and protozoa) are organisms that cause diseases
- These diseases lower the carrying capacity of the species that the pathogens infect
- Changes in the incidence of diseases can cause populations to **fluctuate** around their carrying capacity

Limiting Factors and Carrying Capacity

- Limiting factors **restrict** the growth of a population (prevent it from increasing further)
  - Plant populations have several limiting factors, including light, nutrients, water, carbon dioxide, and temperature
  - Animal populations have several limiting factors, including space, food, mates, nesting sites, and water
- Limiting factors will slow the growth of a population as it approaches the carrying capacity of the system

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Population Growth

Population Growth

- S and J population curves describe a **generalised response** of populations to a particular set of conditions (abiotic and biotic)

S-population Curves

- For most populations, when population growth is plotted against time, an S-population curve is produced
- An S-population curve describes the growth pattern of a population in a **resource-limited** environment
- The S-population curve has four distinct phases:

1. Lag phase

- The initial growth is slow when the population is small

2. Exponential growth phase

- With low or reduced limiting factors, the population expands exponentially into the habitat

3. Transitional phase

- As the population grows, there is **increased competition** between individuals for the same limiting factors or resources - this competition results in a **lower rate** of population increase

4. Plateau phase

- The population reaches its carrying capacity and fluctuates around a set point determined by the limiting factors - changes in limiting factors cause the population size to increase and decrease (these increases and decreases around the carrying capacity are controlled by **negative feedback** mechanisms)

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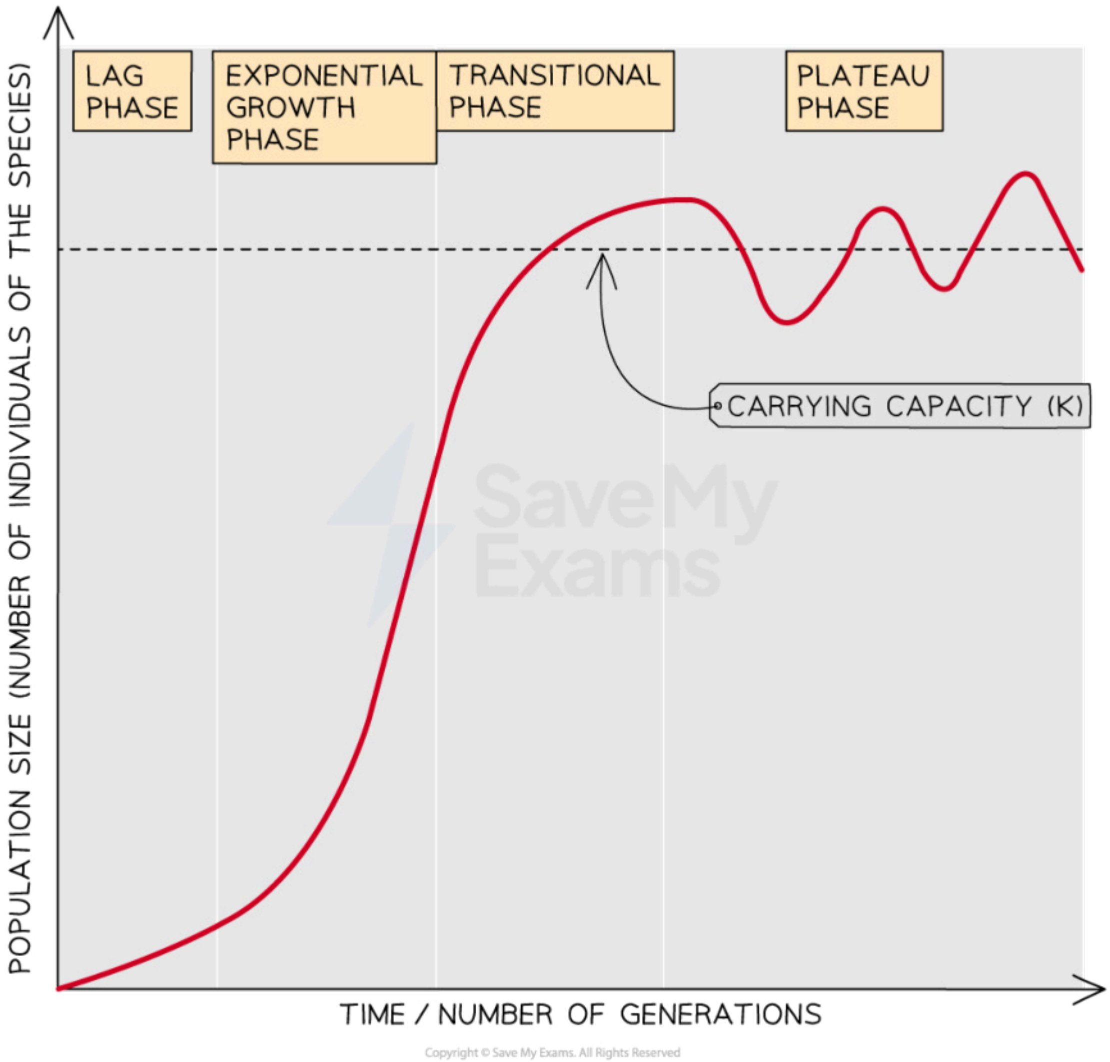

An S-population curve describes the growth pattern of a population in a resource-limited environment

J-population Curves

- For some populations, when population growth is plotted against time, a J-population curve is produced
- A J-population curve describes the growth pattern of a population in an environment with **unlimited resources**
- The J-population curve has three distinct phases:

1. Lag phase

- The initial growth is slow when the population is small

2. Exponential growth phase

- Population growth accelerates exponentially as the number of individuals increases
- The curve takes a J-shape due to exponential growth, as resources are not limiting the growth of the population
- The population will continue to grow until a limiting factor such as disease or predation occurs

3. Crash phase

- At this point, if there has been a significant population **overshoot** (the population has increased far beyond the natural carrying capacity), there may be a sudden decrease in the population, known as a population **crash**

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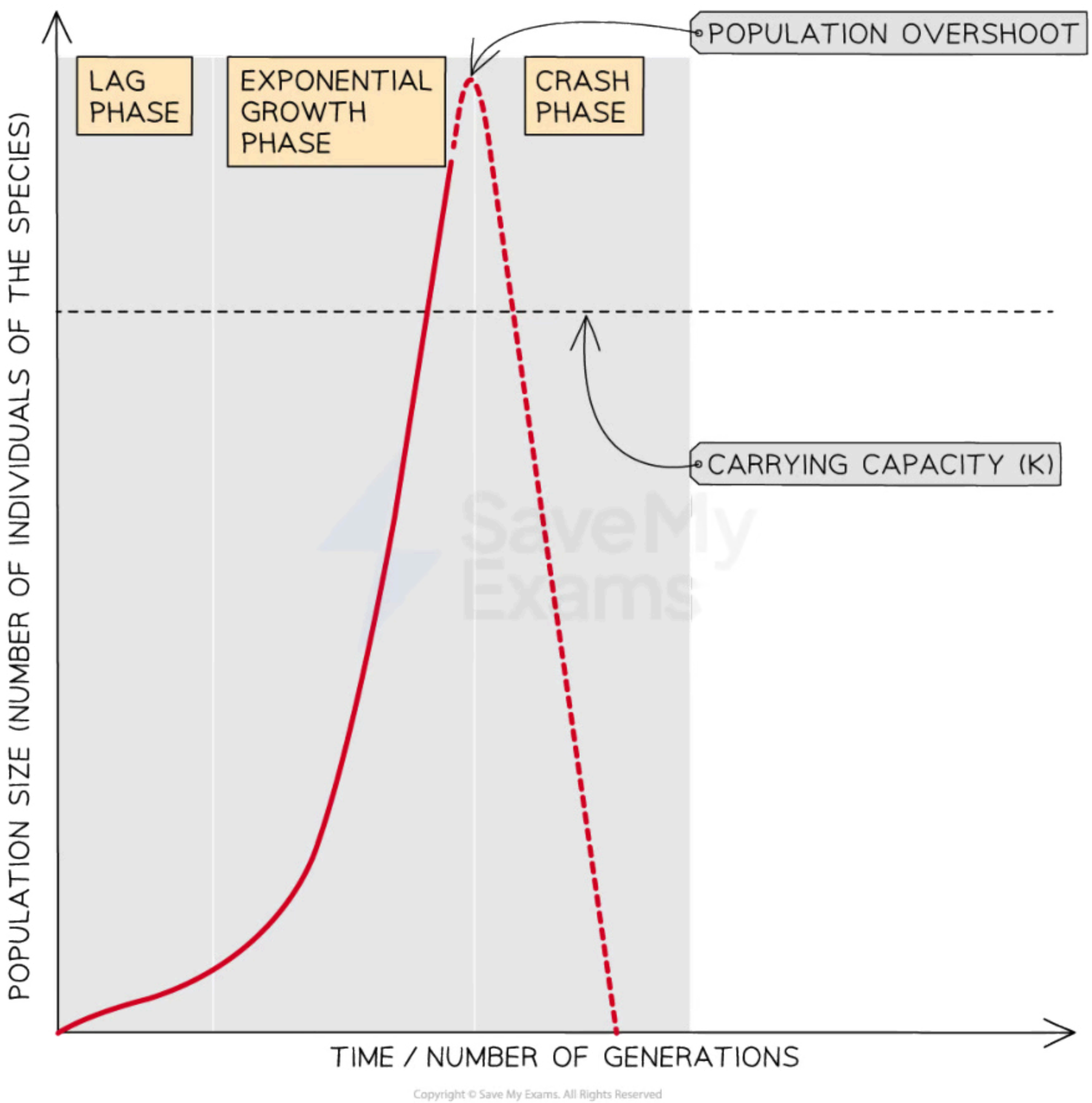

A J-population curve describes the growth pattern of a population in an environment with unlimited resources

Comparing S-population Curves and J-population Curves

- Both curves show how populations grow and reach a carrying capacity
- The S-curve occurs in a limited environment, while the J-curve occurs in an unlimited environment

- The S-curve represents logistic growth, while the J-curve represents exponential growth
- The S-curve eventually levels off at the carrying capacity, while the J-curve continues to increase until a limiting factor is encountered
- The S-curve is more common in nature, while the J-curve is less common and is often observed in laboratory conditions

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