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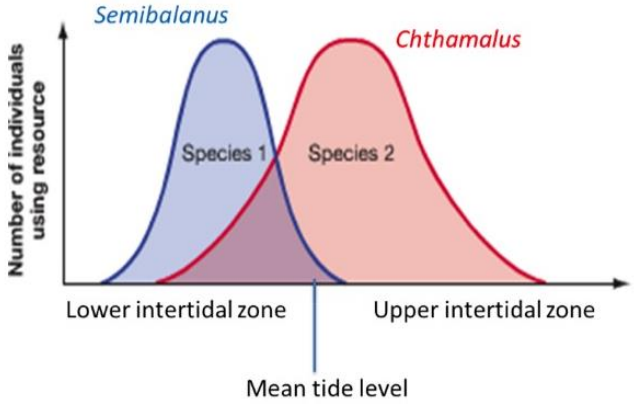
SPECIES INTERACTIONS: WORKSHEET ACTIVITY - **SAMPLE SOLUTIONS**

1. What are some factors that might determine whether a species can live in the upper intertidal zone? List at least three:

- *E.g.*, increased time exposed to air in upper intertidal vs. lower intertidal that is submerged most of the time means that they are not able to breathe when the tide is low, and there is high risk of desiccation.
- food availability is much lower because of decreased time available for suspension feeding (suspension feeding requires being under water to emerge from the shell and use the feeding appendages to capture food);
- changes in temperature: daily exposure to air (and sunlight) results in relatively extreme fluctuations in temperature compared to the average temperature of ocean water (ocean temp does not usually fluctuate as much);
- when tide levels drop, isolation in tidepools can lead to large changes in water temperature due to high or low air temperatures - extremes in water temperature can be fatal, damage tissues, or lead to lower metabolic rate;
- when tide levels drop, isolation in tide pools can lead to large decreases in dissolved oxygen availability (Due to increases in temperature, or from O2 levels dropping in the presence of other animals that respire), which decreases respiration rate in barnacles;
- terrestrial and intertidal predators are able to access barnacles in the upper intertidal zone when the tide levels drop, which leads to increased death rate due to predation.
- barnacles can only mate when they are submerged in water, so living in the upper intertidal zone may decrease their opportunities for mating. Likewise for dispersal of larvae (larvae must be suspended in water to disperse and settle so if there is no water this will limit their ability to reproduce). Check out this video! https://www.youtube.com/watch?v=zVi8qjb-NuQ

2. The figure below shows the overlap in *fundamental niches* (i.e., what range of the intertidal zone they are able to inhabit when <u>alone</u>) for the two species of barnacle.



a. How do the fundamental niches of the two species differ? (Compare/contrast the curves in terms of their ranges):

- Species 1 has a narrower (= more specific or specialized) niche than Species 2. The fundamental niche of Species 1 is mostly limited to the lower intertidal (i.e., below mean tide level).
- Species 2 has a wider (= more generalist) fundamental niche than Species 1. Although most of Species 2's fundamental niche is above mean tide level, the range extends from the upper intertidal to the lower intertidal.

b. Imagine *Chthamalus* sp. (Species 2) is the only species present on a particular beach. What sorts of predictions can you make about the relative fitness of *Chthamalus* sp. individuals living in different regions of the intertidal? What specific factors might influence individual fitness in this population?

- State your assumptions about estimating <u>fitness</u>: assuming that individuals have an equal chance of settling anywhere in the intertidal (i.e., settling location is not heritable), then <u>the number of individuals at each location</u> reflects how many individuals are able to survive at that location after settling (= expected survival success). We will <u>assume that survival is linked to fitness</u> (i.e., is a good estimate of fitness of barnacles at that location). This may depend partially on the abundance of resources.

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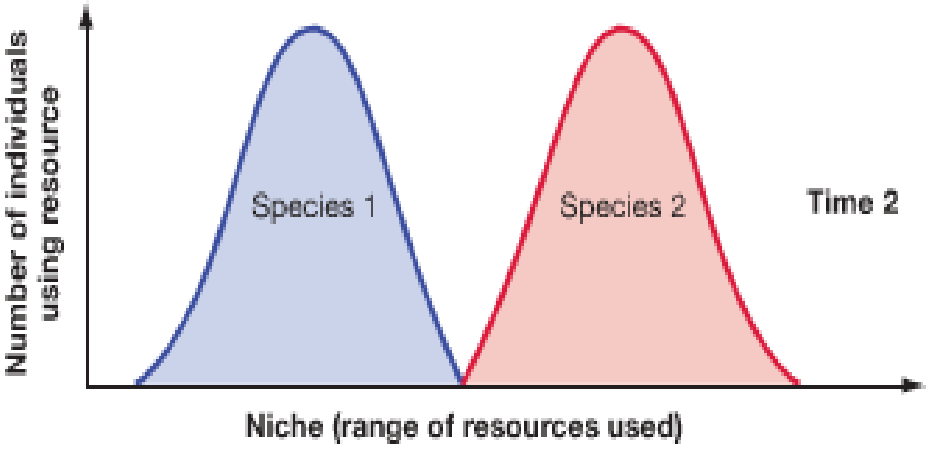
- If resources are limited, intraspecific competition may reduce the fitness of individuals in more densely populated areas (where the greatest numbers of *Chthamalus* barnacles in the same area of the intertidal zone are competing for the same resources, *e.g.,* space on the rocks or mating opportunities (See the graph)).
- However, whether or not individuals survive and reproduce at a particular location will also depend upon their ability to avoid predation, desiccation, and other causes of death in different regions of the intertidal. Individuals at the extreme ends of their fundamental niche are more likely to be impacted by the factors that limit their fundamental niche (e.g. in the upper intertidal - time exposed to air, changes in temperature; in the lower intertidal they may be crowded out by other competitors such as mussels, or predators such as sea stars), while individuals near the middle of their fundamental niche are more likely to be impacted by intraspecific competition.

c. Now imagine that both *Semibalanus* sp. (Species 1) and *Chthamalus* sp. (Species 2) are found together on the same beach. What sorts of predictions can you make about the fitness of *Chthamalus* sp. individuals living in different regions of the intertidal when *Semibalanus* sp. individuals are also present?

In areas where the two species overlap, individuals will be influenced not only by intraspecific competition, but also by interspecific competition. In some locations, interspecific competition may simply replace intraspecific competition (as individuals from one species replace individuals from the other species). In areas where intraspecific competition was previously low, however, interspecific competition could decrease individual fitness below what it might have been in the absence of another competing species.

When *Semibalanus* and *Chthamalus* are found together (overlap) in the lower intertidal zone, the fitness of *Chthamalus* individuals will decrease due to interspecific and intraspecific competition for resources. The fitness of *Chthamalus* in the upper intertidal zone will likely stay the same even in the presence of *Semibalanus*, because the fundamental niche of *Semibalanus* does not extend very far into the upper intertidal - there will be much less interspecific competition in the upper intertidal. In the upper intertidal zone, fitness of Chthamalus individuals will be affected by intraspecific competition. {At the upper extremes of its fundamental niche, Chthamalus will be affected by other abiotic and biotic factors that determine distribution.}

3. Assume Species 1 is a stronger competitor than Species 2 (i.e., if the two species are directly competing for the same resource, Species 1 is more likely to "win"). What might the intertidal distribution of the two barnacle species look like when they are found in the same area? Draw your prediction below.



(note: the complete absence of Species 2 in the lower intertidal zone is evidence that there was competitive exclusion: In the presence of Species 1 (where the fundamental niches of each species would have overlapped), the fitness of Species 2 decreased, whereas the fitness of Species 1 does not appear to have been affected.)

4. Imagine that we removed all of the Species 2 (*Chthamalus* sp.) individuals from the beach. After removing Species 2, would you expect Species 1 (*Semibalanus* sp.) to colonize the upper intertidal zone soon after? Explain why or why not.

No, we would not expect Species 1 to colonize the upper intertidal – Species 1's fundamental niche is restricted to the lower intertidal, which means that even in the absence of competition, Species 1 isn't able to inhabit the upper intertidal. (In other words, it was not the presence of Species 2 or interspecfic competition that prevented Species 1 from inhabiting the upper intertidal - there are some other abiotic or biotic factors that set the upper limit of Species 1's distribution.)

5. **Imagine that several hundreds of years later, colonies of Species 1 (*Semibalanus* sp.) are found in the upper intertidal zone.** What series of events must have occurred to allow this?

Initially, the *Semibalanus* fundamental niche was restricted to the lower intertidal, which means that individuals could not survive in the upper intertidal even in the absence of competitors (i.e., traits that increase survival in the upper intertidal zone did not exist in the population).

However, if a subsequent heritable mutation resulted in a individual with a heritable trait (or set of traits) that did allow them to exist in the upper intertidal, AND this individual happened to settle in the intertidal, AND survived, it may have produced more offspring that could survive in the upper intertidal. Assuming there was no evolutionary mechanism that removed this allele from the population (i.e., natural selection, or genetic drift), then the beneficial allele(s) could have increased in frequency in the population (due to mechanisms such as natural selection) until many more *Semibalanus* individuals in the population were able to colonize the upper intertidal zone.