Extreme Environments

Getting voted off = Selection against

Natural selection is a lot like a reality TV show. Contestants aren't chosen because they are the best and should win, instead, the worst contestants are weeded out so that only the best remain. You don't win, so much as you lose the least. Reality shows tend to only have one type of selection...

Selection on Survivor

+

+

= Generalist

They have many different challenges, that use many different skills. Often the winner wasn't the best at any of them, they just were reasonably good at them all. In nature, this can happen, and we get plants and animals that grow well almost everywhere...

Selection on Survivor

+

+

= Generalist

Brown Rat distribution

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Selection on Survivor

+

+

= Specialist

but that's not the only way to win. If all the challenges involved swimming, we'd expect the best swimmer to win, even if they were bad at running and jumping. Natural selection can produce specialists: organisms that are really good at one thing.

Survivor: What's missing?

But reality shows are missing one very important part of natural selection: differential reproduction. In nature, the winners have more offspring than the losers, so the next generation looks more like the winners on average. If we could take all the children from the winners of survivor and pit them against the children of all the losers in a new series 20 years from now, we might expect that the winners children would be better adapted to the conditions of survivor than the losers children. So we can see how selection works in a TV show, but that's people voting, not natural selection. And we clearly can't run an experiment on the contestants children, but we can test these ideas on other organisms. To see how it works in the real world, lets go on a short walk to see what natural selection actually works on. (Go on nature walk, or look for variation using photos of natural areas)

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Survivor: What's missing?

OUTWIT • OUTPLAY
SURVIVOR
OUTLAST

The Offspring 2033

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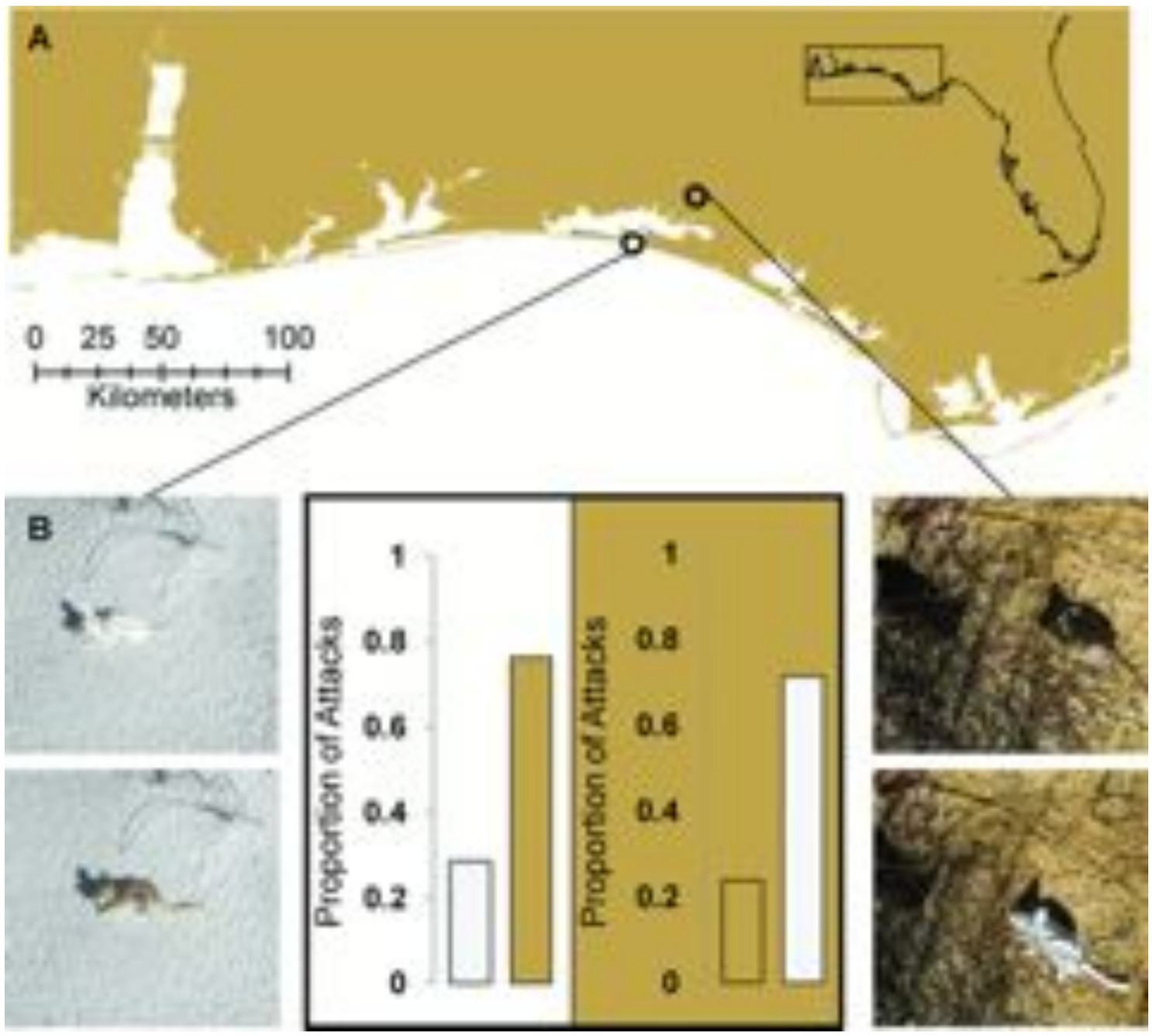
Experimental Preparation

Organisms have many traits that help them to survive and adapt to their environment. These traits can be physical and easy for us to see like height or flowering time, or they can be molecular traits which need to be tested for in a lab, like being faster than average at processing sugar. For the exercise, we're going to focus on the physical traits of coloration, size and shape, but ANY trait could be selected for in the same basic ways. For this experiment, we're going to locally adapt seeds to different environments based on their camouflage.

THE SELECTIVE ADVANTAGE OF CRYPSIS IN MICE



Evolution
Volume 64, Issue 7, pages 2153-2158, 15 FEB 2010 DOI: 10.1111/j.1558-5646.2010.00976.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1558-5646.2010.00976.x/full#f1

There have been lots of studies to show that looking similar to your environment can protect you from predators. In this study, scientists made perfect clay moulds of native beach mice in both their white and tan colors, and put some of the mice in each habitat. This is a good experiment because it controls for all sorts of things like smell, motion and prey removal. If the scientists had used live mice, they could have only counted who survived, but the clay bodies collected imprints from each predator that attacked them, so they could count how many times each one was attacked. You can see from this bargraph that in the white sand habitat, the brown mice were attacked most of the time, but in the brown habitat the white mice were attacked most of the time. This means that the mice are locally adapted, the white mice survive better on white sand, and the brown mice survive better on brown sand. But this is a pretty simple example, and most habitats are more complex than brown and white sand.

Most habitats are more like this one, with many colors and textures. Does anyone know what this is a picture of? (It’s a giraffe, on the right, just next to the foreground tree)

Now, camouflage doesn't always mean "dull and brown", sometimes the best camouflage is to be bright...Can anyone find the animal in this picture? (This is a Blue Dacnis, which is a green bird with a blue head and yellow backside, it is about a third of the way in from the left, halfway down)

But we aren't just interested in blending in, we're interested in adaptation, so we want to see what variations within a species help it to survive. So, if you were a bird, which of these would you eat first?

Did you see the white one first, or the dark one? An individuals adaption to the environment isn’t just one trait, it’s often dependent on the traits of those around it. If all of you who saw the white one first were predators in the same area, you would select for dark moths in your region, while the rest of the class would select for white ones. How about these two?

These Australian Painted Snipe are using behavioral as well as physical camouflage. The one hiding up in the bush is more difficult to see and might be better protected from predators. One more example of variation in species

Which seal would you make a dinner of? (you may need to give them a couple minutes to search, answers on next slide)

Even though the two at the top are further away, they are darker and sitting in a more conspicuous fashion. The one very close to us is nearly impossible to see because of his position and coloration. So now we have enough knowledge about camouflage that you should be able to make some good hypothesis about our experiment, so lets see what our experiment is.

Ecosystems

- Soil
- Multicolored Stone
- Sand
- White stone

Each group has an ecosystem in front of them. Some of the ecosystems are simple, like the sand, and some are quite complex, like the multicolored stone. We also have some organisms...

Sunflower:

Helianthus annuus

Annual plant, native to North and South America

(substitute in your own new seed slide here) The biggest are what you would call sunflower seeds, but are know to plant scientists as Helianthus annuus. They're native to the americas, and make a delicious snack. Technically, what we're using today are the sunflower fruits, not the seeds. The flower you see when you look at sunflowers isn't really the flower, its just decorative. Each little spot inside the "sunflower" is a tiny flower that produces a single fruit. The seeds are hidden inside the fruits.

Sunflower:

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Lentils:

Lens culinaris

One of the first domesticated crops

(substitute in your own new seed slide here) shaped like a contact lens. lens is the latin word for **lentil**.

Adaptive Variation

We grow over
136 million
tons annually

Pearl Barley

Hordeum vulgare

(substitute in your own new seed slide here)

Navy Beans:

Phaseolus vulgaris

Also called haricot or pea beans

(substitute in your own new seed slide here) It is commonly known as the "Navy Bean" due to its use as a staple of United States Navy rations in the 19th century.

Sunflower

Navy Beans

Pearl Barley

Lentils

(substitute in your own seed slide here) These are our organisms for this experiment. Find your sheet that says Part 1 and we'll begin (leave this slide up during the experiment so they can easily identify their seeds)

Invasive Species

Zebra mussels clustered on beach

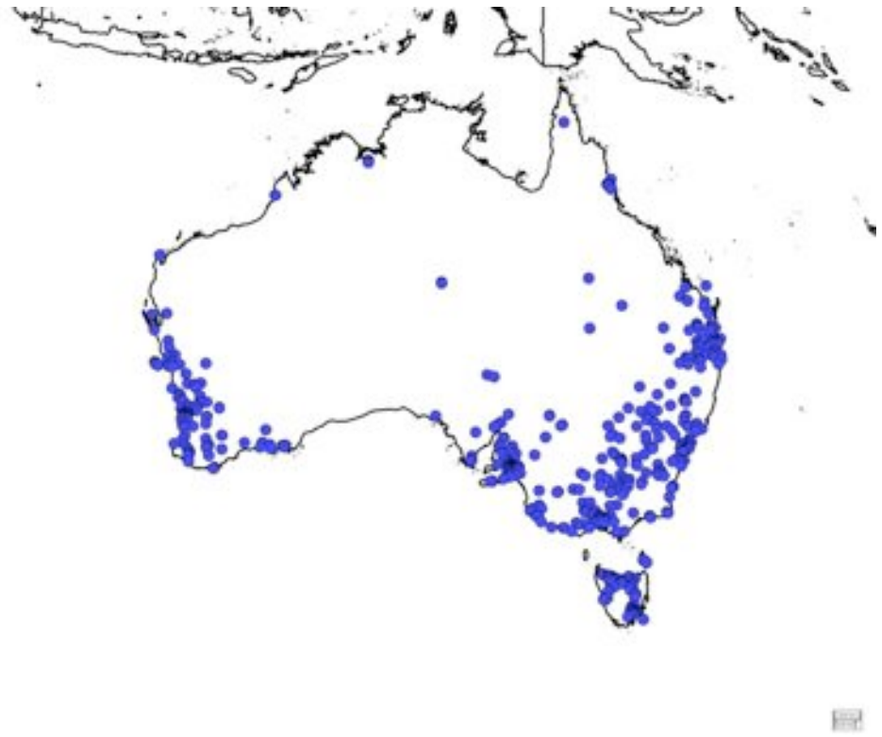
Part 2 of our experiment is to look at some strategies that invasive species use to invade new environments. There are lots of different invasive species, and lots of different strategies. Some have lots of fast growing babies like hogs. Or grow very, very fast like Kudzu. Others are so big that they can eat ANY native animal they want. Other things like lionfish are toxic, so when they invade nothing will eat them. This makes it very hard to study invasive species because they're all so different, and have different ways of invading.

(photos across from top left: Burmese python that ate an alligator, Lion fish, Kudzu, Asian Carp, Wild Hogs, Emerald Ash Borer, Sea lamprey, Autumn Olive, Zebra Mussels)

Weedy Radish: Raphanus raphanistrum

So instead of talking about all invasive species together, lets focus on one kind, agricultural weeds for instance. The weeds that grow in farmers fields are bad for lots of reasons, they take away space and food from the crops we want to grow, and they get their own seeds and pieces into our food when the farmer harvests. One very bad weed is weedy radish. It looks like (the picture on the left) and is one of the worst weeds all over the world.

Weedy Radish: Raphanus raphanistrum



Weedy Radish distribution in Australia

Australias Virtual Herbarium,
http://avh.ala.org.au/occurrences/search?taxa=Raphanus+raphanistrum#mapView

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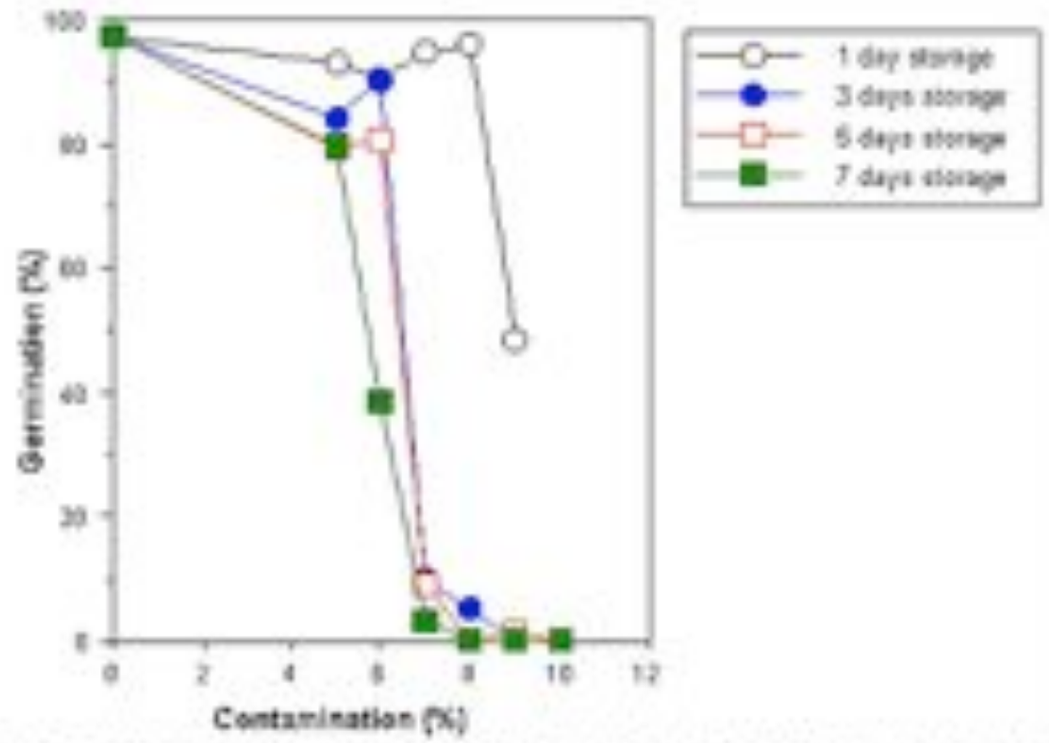

Figure 1. Shows the percentage of lupin seeds remaining viable after storage with different amounts of green wild radish pods at field temperatures over a period of one to seven days.

Figure 2. Wild radish seed pods (left) and wheat seeds (right).

You've probably only experienced radish as part of a salad, but the weedy kind does lots of things that farmers don't like. It makes chemicals that kill other seeds that are around it (graph on left) and its seeds are the same size and shape as wheat seeds, so its very hard to separate them.

Adaptive Variation - Invasive plants

So those are a couple of ways that weedy radish is invasive, but there are lots of ways to be an invasive plant, and some are more common than others. What kind of variation do you think would help you to become invasive? (write in answers here)
(Example answers: tastes bad/poisonous, very large, grow quickly, can live in lots of places, no predators, adapted to people, easily spread, lots of progeny, etc)

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White Meadowfoam:

Limnanthes alba

Lives in wet habitats.
Native to California and Oregon

(substitute in your own new seed slide here) Now we're going to do the same experiment, but with a new seed as an invasive who reproduces 50% faster than the natives. Our new species is Limnanthes alba, or White Meadowfoam, which might be invasive if it got out of our classroom. It lives in vernal pools, ponds that dry up in the peak of summer. It has the small prickly seeds. This plant is actually sometimes grown commercially to make meadowfoam seed oil, which is very similar to whale oil from sperm whales. The fruit of the plant, a nutlet, is 20 to 30% oil. Grab your data sheets and answer the questions about invasive species and your experimental predictions.

Sunflower

White Meadowfoam

Navy Beans

Lentils

(substitute in your own seed slide here) So these are the seeds we're working with so you can keep track of them on your worksheet. Everyone should grab their worksheets that say Part 2 so we can get started with our experiment.