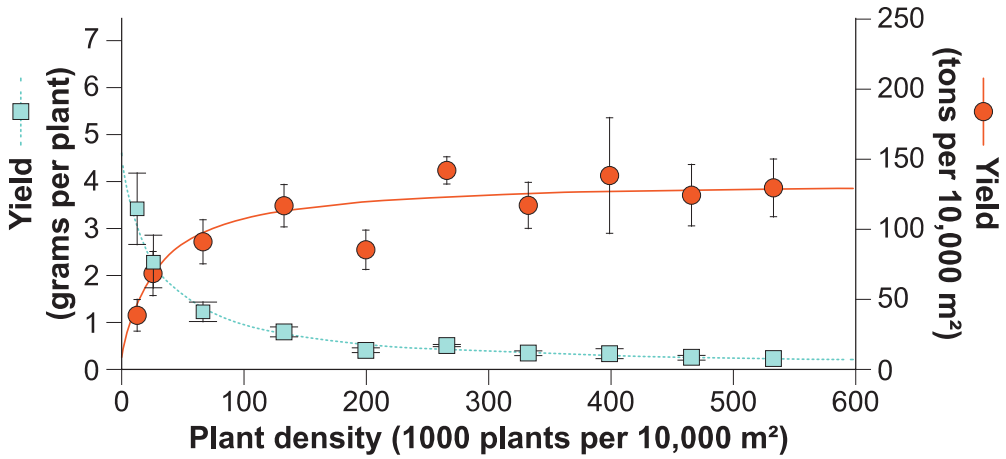
CASE STUDY 1: Fruit production in paprika peppers

Paprika pepper (*Capsicum annuum var. annuum* L.) is a plant that is commonly grown for its fruits, which are dried and ground up to make the spice paprika. Cavero and colleagues (2001) wanted to know what factors affect a pepper plant's yield, which is the total dry weight of the fruits it produces. A plant's fruit yield is a measure of the reproductive output of an individual.

The scientists planted paprika pepper seeds and let them grow for one month. They then removed some of the plants to create 10 groups with different densities, which ranged from 13,333 plants per 10,000 m^2 to 533,333 plants per 10,000 m^2. Six months later, the scientists picked the fruits from a small section of each group. The fruits were counted, dried, and weighed to determine the fruit yield per plant — as well as the overall yield of all plants within 10,000 m^2 — for each of the 10 groups.



The effect of density on the yield (total dry weight of the fruit produced) of pepper plants over one year. Each point represents the mean of four replicates at a given density. The error bars show ±1 standard deviation.

1. Describe the relationship between plant density and the yield *per plant*.

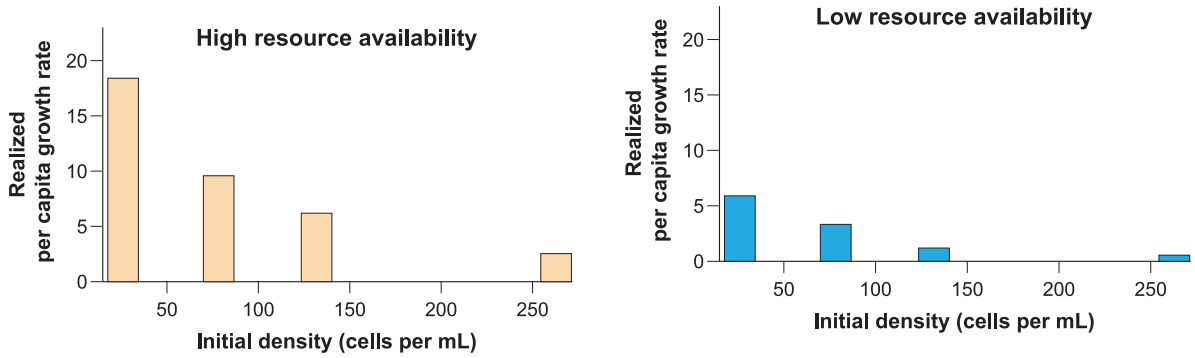
2. Predict how the yield per plant (fruit production) might affect the population growth rate.

3. What pepper plant density would you recommend to a farmer to maximize the yield *per 10,000 m^2*? Why did you choose that density?

CASE STUDY 2: Population growth rates of protozoa

This study investigated population dynamics in *Colpidium* protozoa, single-celled organisms that live in freshwater environments and eat bacteria. Holdridge and colleagues (2016) grew groups of protozoa at four different initial densities. After three days, they measured the final densities to calculate the realized per capita population growth rate ($r_{realized}$) for each group.

The scientists also wanted to know how the population growth rate at a given density is affected by resource availability. So, they studied the four densities of protozoa under two different conditions: high and low resource availability. Protozoa under the "high resource availability" condition got about four times as much food (bacteria that grew on dried bloodworms) as protozoa under the "low resource availability" condition did.



The effect of initial density and resource (food) availability on the realized per capita population growth rate ($r_{realized}$) of *Colpidium* protozoa. $r_{realized}$ was calculated by subtracting the initial cell density from the final cell density, then dividing that difference by the initial cell density.

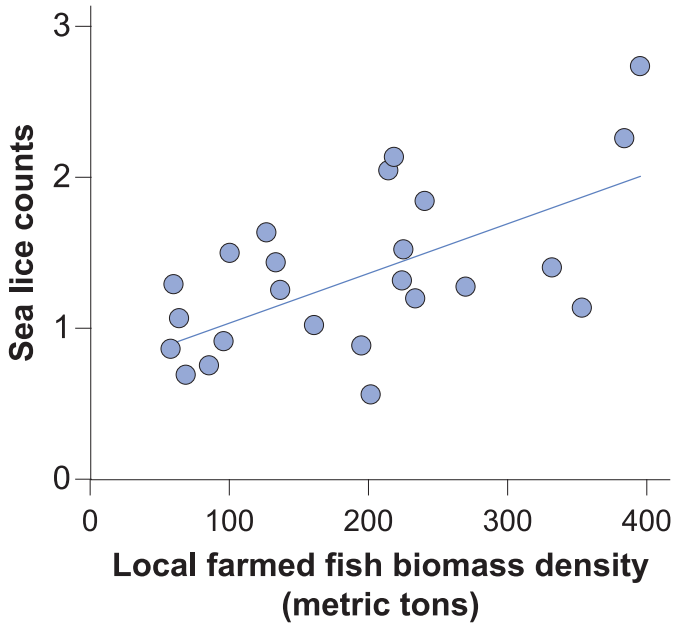
1. Use evidence from the graphs to make a claim about how $r_{realized}$ is affected by the initial population density. In other words, how does $r_{realized}$ differ between populations that start small and those that start big?

2. Use evidence from the graphs to make a claim about how resource availability affects $r_{realized}$.

CASE STUDY 3: Parasites on fish farms

Many fish eaten as seafood are bred and raised in fish farms. The fish on a farm can be infected by parasites called sea lice: small crustaceans that feed on a fish's blood and skin, which may injure or even kill the fish.

Jansen and colleagues (2012) analyzed sea lice infections on trout and salmon farms. They used data reported by many fish farms on the numbers of sea lice found on their fish. The scientists compared the number of sea lice with the "local farmed fish biomass density," which is a measure of population density that accounts for both the number and biomass (or size) of fish on a farm.



The effect of local farmed fish biomass density on the counts (numbers) of sea lice per fish. Each point represents the mean fish density and sea lice count for a group of farms in a specific year.

1. How does density of fish on a farm affect the number of sea lice per fish?

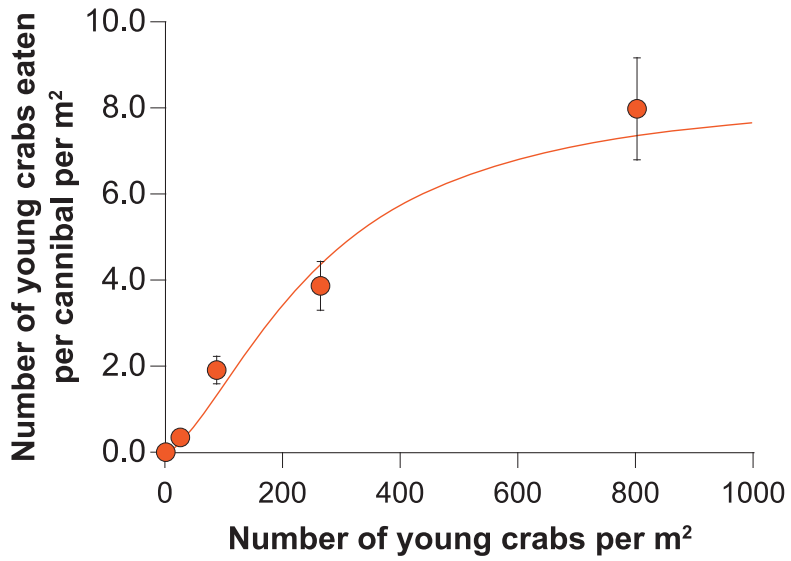
2. Other research reported a link between sea lice infestation and mortality. If that is the case here, what do you predict will happen to high-density fish populations?

3. How might the results of Jansen et al. (2012) impact policies about fish farming — in particular, the size of fish farms?

Case study 4: Cannibalism in shore crabs

The shore crab is a common crab species found all over the world. These crabs are cannibals that will eat younger, smaller individuals even when other food sources are available. Certain factors make the crabs more likely to eat each other.

To investigate these factors, Dr. Per-Olav Moksnes (2004) set up tanks with different densities of young, small shore crabs. He then added two older, larger crabs to each tank. After 24 hours, he determined how many of the young crabs had been eaten by the older crabs (the "cannibal crabs").



The effect of density (number of young crabs per m^2) on the number of young crabs that are eaten per cannibal crab within 24 hours. Each point represents a mean of five trials at the corresponding density. The error bars show ±1 standard error.

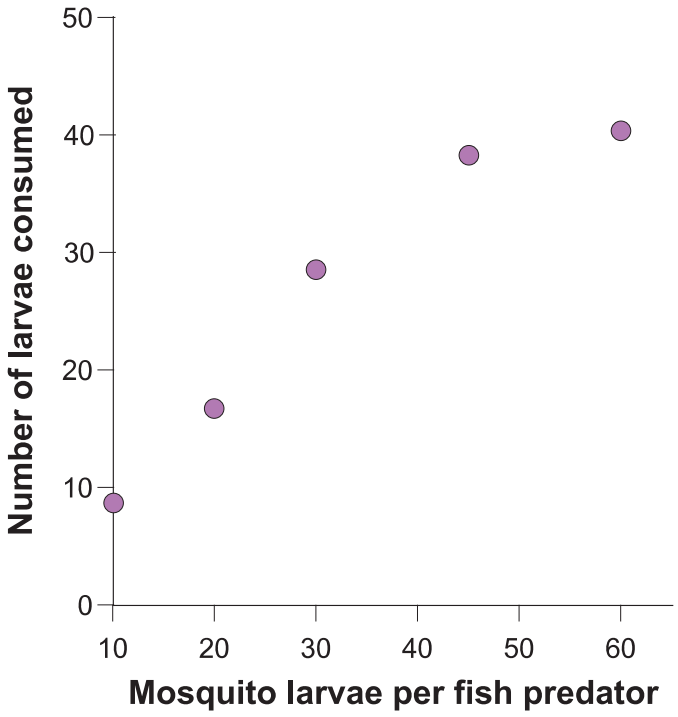
1. Describe the pattern shown in the figure.

2. As density increases, how might changes in the frequency of cannibalism affect the population growth rate?

3. Although the cannibal crabs in this study had another food source, they did not eat all of it during the experiment. This result suggests that cannibalism was not a response to starvation. How else might these crabs benefit from cannibalism?

Case study 5: Predation of mosquito larvae

Young mosquitoes, called larvae, are small, wormlike, and live in the water. They are eaten by a variety of predators, including a species of small fish called the banded killifish (*Fundulus diaphanus*). Bickerton and colleagues (2018) used killifish and mosquito larvae to investigate factors that affect predation. The scientists placed pairs of killifish in tanks with mosquito (*Culex pipiens*) larvae at five different densities. They then used digital images to record how many larvae were eaten by the killifish over time.



The effect of density (number of mosquito larvae per predator) on the number of larvae consumed by killifish after 1.5 hours.

1. How did the number of mosquito larvae killed by predators change as the density of larvae increased?

2. Based on your answer to the previous question, how might the mosquito population growth rate change as the density of mosquito larvae increases?