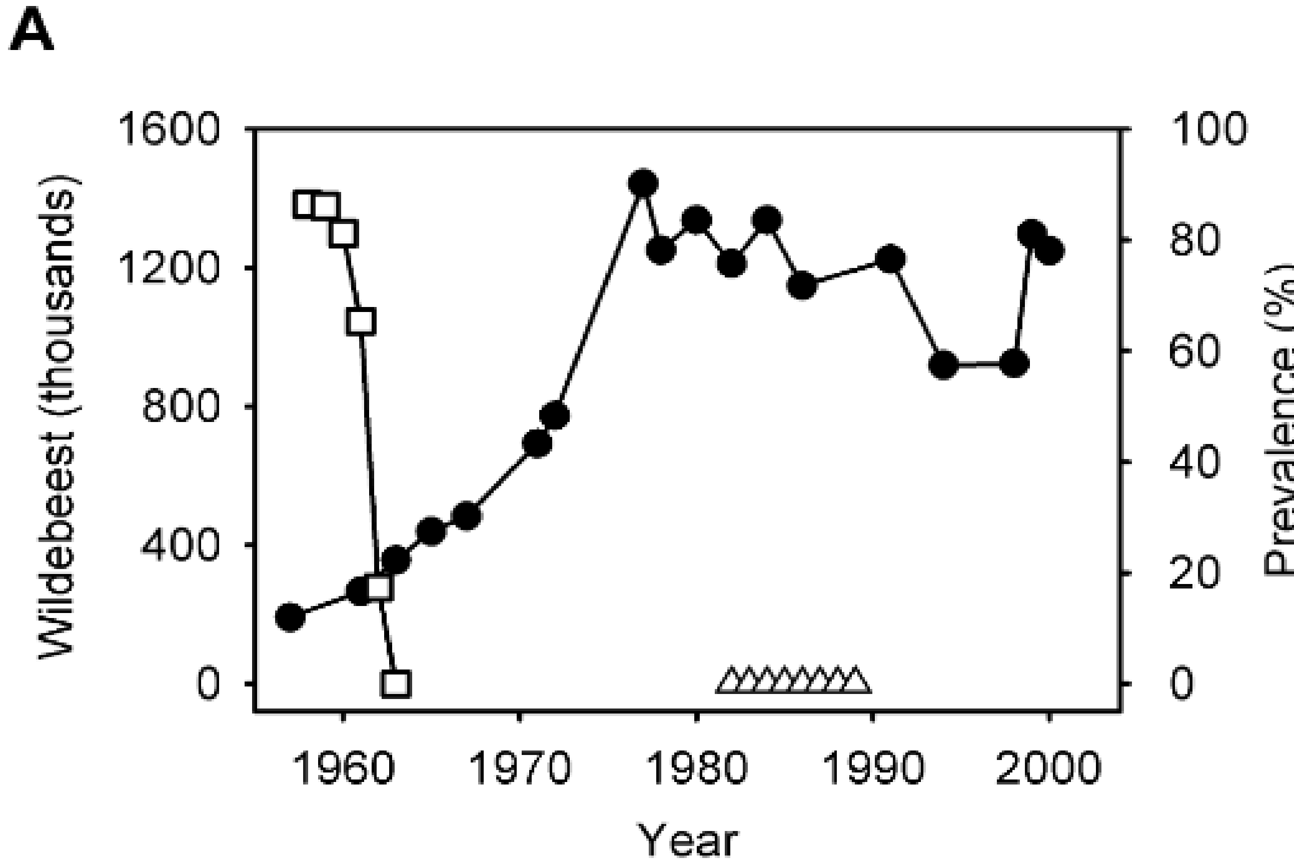
HOW TO USE THIS RESOURCE

Show the figure below to your students along with the caption and background information. The “Interpreting the Graph” and “Discussion Questions” sections provide additional information and suggested questions that you can use to guide a class discussion about the characteristics of the graph and what it shows.



Caption: Number of wildebeest in the Serengeti ecosystem (shaded circles, left y-axis) and the prevalence (i.e., percentage) of individuals infected by rinderpest disease (unshaded squares and triangles, right y-axis) from 1958 to 2003.

BACKGROUND INFORMATION

In the 1960s, wildlife managers in Serengeti National Park, Tanzania, noticed that the wildebeest population was increasing rapidly. Researchers began studying the cause of the sudden increase. To do this, they first had to understand what was controlling wildebeest numbers before the increase, and what changed in the 1960s. One candidate they considered was disease. Rinderpest is a viral disease that infects cattle, wildebeest, and other hoofed animals. The disease had affected cattle and wildlife in the Serengeti region for decades. Death rates were extremely high, especially among wildebeest calves. A program to vaccinate cattle began in the 1950s, and scientists monitored how the program affected wildebeest populations. In 2011, the United Nations declared that vaccination efforts had eradicated rinderpest across the globe. Rinderpest became the second viral disease, after smallpox, to be wiped out.

The researchers later went on to explore how the eradication of rinderpest, and the rise in wildebeest numbers, affected other species in the ecosystem. They found that larger wildebeest populations consumed more grass, which in turn reduced the wildfires in the region. Wildfires also suppress trees, so the decrease in wildfires resulted in an increase in tree density.

INTERPRETING THE GRAPH

The graph shows a rapidly declining percentage of wildebeest infected with rinderpest from 1958 to 1963, which coincides with the beginning of a vaccination program in 1960. This suggests that vaccines administered to cattle reduced rinderpest transmission from cattle to wildebeest. Eradication of the virus allowed the wildebeest population to rebound from around 200,000 animals in 1958 to around 1,200,000 in the late 1970s. Following this steep increase, the population stabilized. This suggests that the wildebeest population may have been controlled by disease before 1960 and was later controlled by a factor other than rinderpest disease, such as food availability. Both are examples of density-dependent population regulation.

Through a series of additional studies not shown in the figure, the researchers found that the eradication of rinderpest (playing the role of the top predator) triggered a trophic cascade that led to an increase in wildebeest, reduced grass biomass, fewer fires, and ultimately resulted in increased tree density. In addition, removal of rinderpest changed how the wildebeest population was regulated, from top-down control by disease to bottom-up control by resource limitation. In other words, the wildebeest population became limited by the availability of grasses to graze instead of by disease.

Teacher Tip: Prompt your students to explain the parts of the graph as applicable:

- Graph Type: Line graph with two *y*-axes. The line with shaded black circles represents the wildebeest population. The line with unshaded squares and triangles represents the percentage of the wildebeest population infected by rinderpest.
- Y-Axis: The left *y*-axis shows the wildebeest population on a scale of thousands of animals. The right *y*-axis shows the prevalence (i.e., percentage) of the wildebeest population infected by rinderpest (prevalence).
- X-Axis: The *x*-axis shows time in years from 1958 to 2003.

DISCUSSION QUESTIONS

- Describe the trends in the wildebeest population over time.
- What are some possible factors that could cause an animal population, like wildebeest, to increase?
- Describe the trends in rinderpest prevalence over time. How do these trends relate to the vaccination program that began in the 1950s?
- Explain how vaccinating cattle, but not wildebeest, could have caused the change in rinderpest prevalence in wildebeest.
- What was limiting (i.e., regulating) the wildebeest population before 1960? Is this a density-dependent or density-independent factor? Explain your reasoning.
- What is the connection between virus prevalence and the wildebeest population? Use evidence from the graph to support your claim.
- Based on the trends in the graph, what do you think the approximate carrying capacity for the wildebeest population is?
- What are some possible factors that could be controlling the wildebeest population after 1980? Are these density-dependent or density-independent factors? Explain your reasoning.
- Create a model that includes rinderpest, wildebeest, grass, fire, and trees. Draw arrows to show the positive or negative effects (not energy flow). Label the arrows with + or - to indicate positive or negative effects.
- Using evidence from your model, explain how it is possible for a virus to affect tree density in the Serengeti.

KEY TERMS

bottom-up control, density-dependent, population, regulation, rinderpest, top-down control, trophic cascade, wildebeest

SOURCE

Figure 4A from:

Holdo R. M. (2009). A disease-mediated trophic cascade in the Serengeti and its implications for ecosystem C. *PLoS Biology*. https://doi.org/10.1371/journal.pbio.1000210

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