

## HOW WARMING TEMPERATURES AFFECT BREEDING BEHAVIOR IN GRAYLAG GEESE

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### YOUNG REVIEWERS:



**JOSI**

AGE: 11



**TEJAS**

AGE: 14

You might have heard that dedication and perseverance are important elements for success. This is particularly true for science, specifically the study of animal behavior. Collecting biological data for decades can help scientists to better understand slow environmental changes and their consequences. For instance, globally increasing temperatures may affect animal behavior and reproduction. We investigated if and how environmental changes, such as a long-term increase in temperature and milder winters, affect the reproduction of a population of graylag geese. To do that, we collected data for 29 years—by monitoring temperature, the number of eggs laid, and the number of young birds that survive to adulthood. We found a temperature increase over time (an effect of climate change), and that higher average temperatures had a positive effect on the reproductive success of the geese. This suggests that the flock of graylag geese we studied could profit from warming

temperatures, perhaps because the time window favorable for laying eggs and raising young is prolonged when winters are milder.

## THE IMPORTANCE OF COLLECTING DATA FOR LONG PERIODS OF TIME

How do we know what was happening in a certain place at a specific time in the past? For instance, how could we know if there was a flood in Venice on the same day as today, but 147 years ago? One possibility is to rely on a data-collection technique called **long-term monitoring**. This involves collecting information in a standardized way, over many years. Many of these observations are part of our history books, and some of these facts are extremely important to scientists. In biology, for instance, long-term monitoring allows scientists to examine trends in animal populations—for example, if population size is increasing, decreasing, or remaining stable over time. Therefore, data collected by long-term monitoring programs can help raise an alarm if populations need to be protected from extinction, for instance.

## HOW CLIMATE CHANGE CAN INFLUENCE ANIMAL BEHAVIOR

Over the last few decades, several biological changes have been linked to climate change, such as changes in time of migration and reduction of suitable living places for many species. Indeed, climate change can be considered one of the most serious challenges that humans are facing (To read more about climate change and what can be done to address it, see [this Frontiers for Young Minds article](#)). One important way to measure climate change is to track the increase in Earth's average temperature over the years. Did you know that changes in temperature can influence animal behavior? Temperature changes might cause a shift in the **phenology** of plants and animals—which means changes in the timing of periodically recurring events, such as egg laying or plant flowering. For example, if temperatures increase, winters will be milder, and spring will start earlier. Earlier springs mean a shift in the growth and flowering of plants and can cause a shift in the timing of reproduction for many species. Earlier springs and longer frost-free periods can lead to earlier egg-laying in birds, for instance. There is evidence that earlier egg-laying is associated with milder temperatures, which can be helpful for some species. Other species will avoid changes in climate by seeking new breeding areas or spending winters in new locations [1].

## OUR STUDY SPECIES—THE GRAYLAG GOOSE

Among birds, graylag geese (*Anser anser*) have been extensively studied and can be considered fairly tolerant of environmental

### LONG-TERM MONITORING

Watching a specific situation carefully and in a standardized way for a long period of time, to discover something about it.

### PHENOLOGY

The relationship between climate and periodic biological phenomena (such as bird migration or plant flowering).

conditions, as they breed from the Mediterranean to the Arctic circle. This means that these geese might be able to successfully cope with climate change. Graylag geese might respond positively to a warmer climate because they forage on grass and seeds, so they could profit from a climate in which vegetation appears earlier in the spring.

Graylag geese live in big flocks for most of the year and pair-partners (male and female) usually stay together for several years, similar to the way humans maintain their relationships as couples. Paired birds spend a lot of time together, including feeding, resting, and of course breeding. They greet each other after short separations, which could signal their pair status to others and might also reconfirm their commitment to each other [2]. In our study, we wanted to find out more about the influence of climate change on graylag goose reproduction.

## WHAT DID WE INVESTIGATE?

We collected data over 29 years, from 1990 to 2018. During this time, we monitored a population of graylag geese, and, at the same time, we collected information about the weather. We were interested in how the changing climate conditions influenced the reproduction of the breeding pairs. Particularly, we looked at how the average temperature per year and the amount of snow cover were linked to the start of the flock's reproductive period. To do so, we looked at the date when the first and last eggs were laid, at the size of the individual **clutches**, and at the number of **fledged goslings**, which means the number of young geese that become independent from their parents. The first measurement told us whether increasing temperatures might result in earlier egg laying; the second measurement told us if the geese were laying more eggs, and the last measurement told us whether reproductive success was improving during the gosling period, when parents guide their young to suitable foraging sites and protect them against predators. To collect this information, we carefully monitored each goose two to three times per week. During the egg-laying period, we checked the laying days and the number of eggs in the nests (Figure 1A), and after hatching we observed the goose families until the goslings fledged.

## WHERE DID WE CONDUCT THE STUDY?

To conduct such a long-term study, animals must be individually marked—otherwise it would be impossible to distinguish one family, or one goose, from another. Our study was conducted at a Research Center of the University of Vienna (the same center as [this Frontiers for Young Minds article](#)). The center is found in the Alm Valley in the northern part of the Austrian Alps, which are in central Europe. A flock of graylag geese was introduced there in 1973 by the late

### CLUTCH

A group of eggs produced and incubated by the same bird, located in the same nest.

### FLEDGE

To become independent, learn to fly.

### GOSLING

A young goose <3 months old and unable to fly.



## Figure 1

**(A)** Regular monitoring of our graylag goose clutches includes checking the number of eggs at the beginning of the breeding season (Source: Bayerisches Fernsehen, Credit: Camera A. Petrovan). **(B)** Graylag geese form long-term relationships. We can identify them by the colored rings on their legs. In this photograph, you see the goose named Karamell (Photograph credit: Benedikt Heger).

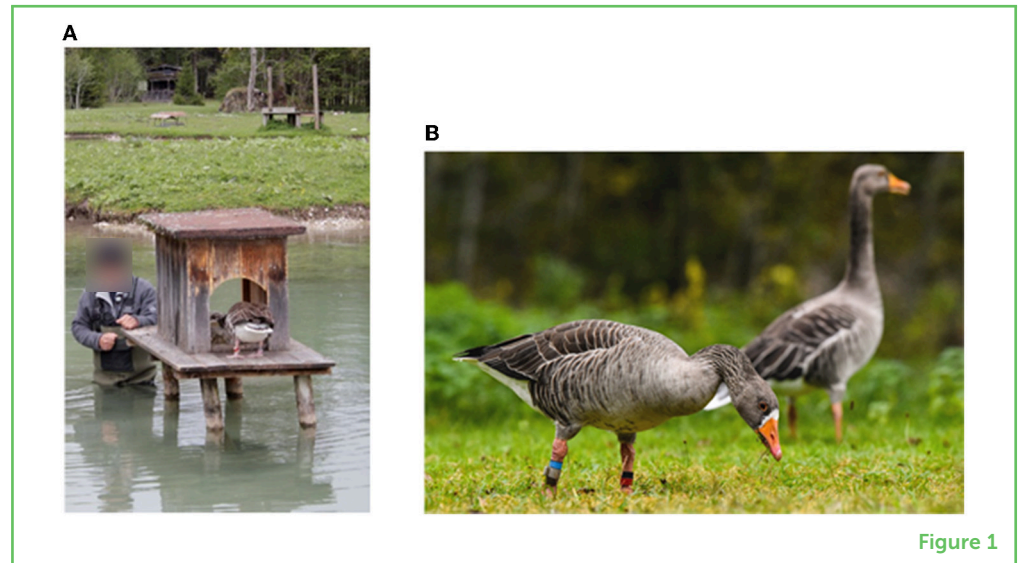


Figure 1

Nobel Prize winner Konrad Lorenz. The birds are fully free and can move around as they wish, but they receive food from us so that they do not have to migrate during the winter like other local geese do. All geese are tagged with colored leg rings, and they are used to the close presence of humans. Data about every individual goose has been collected since 1973, and therefore we know their partners, friends, and relatives, within the flock (Figure 1B) [3]. We also know that, over the period of the study, the total number of geese in the flock averaged 150. During the study, we collected a total of 614 laying dates for 300 individuals (148 males, 155 females), with an average of 21 breeding pairs followed per year.

## WHAT WE FOUND

Our results confirmed both our expectations and the global climate trend: the average annual temperature in the valley increased by around 2°C across the three decades of the study. This increase is at the lower end of the warming range in the alpine areas. Snow cover was highly variable over the study period and did not show a specific trend. As we expected, the annual average temperature had a significant impact on the reproduction of the graylag geese. Birds started to breed earlier when the winter was warmer, which means that the first eggs were laid earlier in the season (end of February instead of beginning of March, Figure 2). Additionally, we found that the higher the average annual temperatures, the more goslings reached independence (Figure 3). This means increasing average temperatures had a positive effect on the reproductive success of the geese. When we considered the timing of breeding in relation to reproductive success, we found some additional interesting insights. For instance, clutches that were laid earlier in the season contained more eggs, and more goslings fledged from earlier eggs. Thus, an early breeding time improved breeding success.

### Figure 2

The winter temperature had a clear influence on the timing of the first eggs laid: **(A)** the colder it was, the later the birds started laying, as indicated by the calendar on the left. **(B)** The graph plots the original data (large blue dots) as well as the trend line (green dots). The x-axis indicates the average winter temperature and the y-axis indicates the date of the first laid egg (day/month).

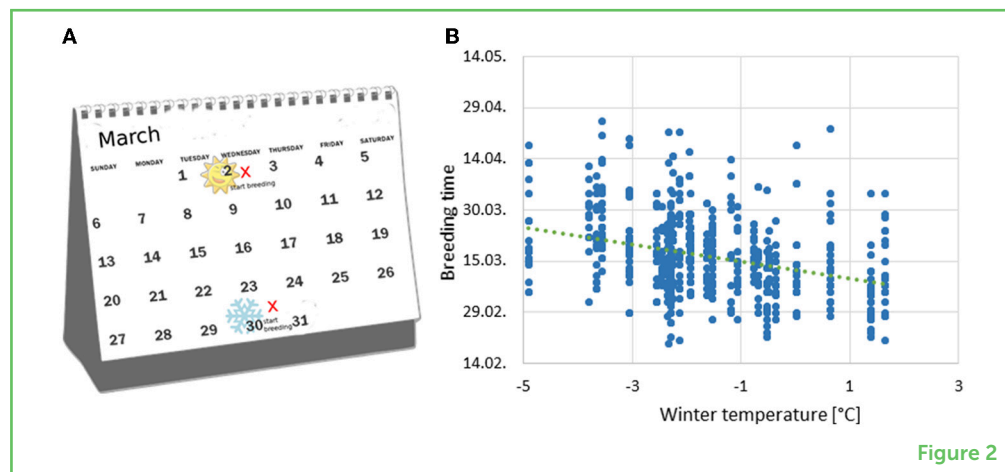


Figure 2

### Figure 3

Here you can see that the average annual temperature influenced positively the percentage of fledged goslings. **(A)** The warmer the year, the higher the reproductive success of the flock. **(B)** The plot of the original data (blue dots) and the trend line (green dots). The x-axis shows the average annual temperature and the y-axis shows the percentage of fledged goslings.

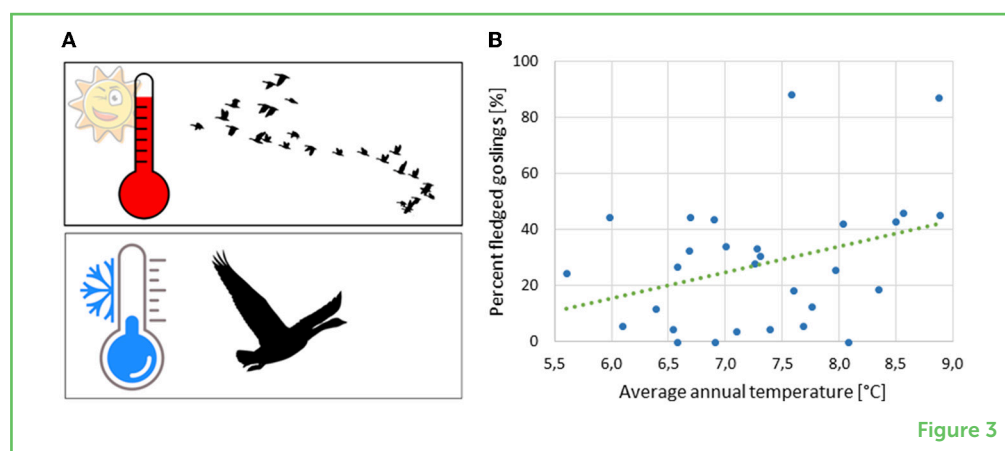


Figure 3

## CONCLUSION

In summary, in the graylag geese that we studied, the increase in local temperatures at the end of winter led to an increase in the number of eggs and offspring. This example shows that some animal populations can take advantage of climate change. But is this always like the case? And how does it happen? Some individuals can adjust the timing of breeding to take advantage of new environmental conditions and increase the number of eggs they lay, for example. In general, birds from **temperate zones** must deal with a range of environmental conditions as the seasons change, and these birds seem to be adapted to cope with greater environmental variability. Birds from temperate zones must time their reproduction so their offspring survive and have enough to eat when they fledge [4]. In general, the earlier a bird hatches, the more time it has to feed during the season—provided the correct food is available. If a bird hatches late in the season, food might run out and it may not survive. However, the timing is complex because the egg-laying female may benefit from waiting to lay eggs, since that gives her more time to feed before egg laying, which takes a lot of energy. Long-term studies contribute valuable information that

### TEMPERATE ZONE

The parts of the Earth between the Arctic and the Antarctic Circle and the Tropics; characterized by mild, moderate temperatures and pronounced seasonal differences.

can help scientists to clarify the benefits and costs involved in these complex situations.

It is also important to point out that our results might not apply to migrating birds, since our study flock does not migrate. Migrating birds must adjust their arrival time at their breeding grounds according to the local environmental conditions, they do not have a weather forecast in advance. Also, climate change might have different effects on graylag goose populations in the Mediterranean as compared to those in the Alps and the Arctic regions, because the temperature increase was less pronounced in the Mediterranean region.

Overall, our long-term study showed how changes in the environment can have long-term consequences on an organism (in our case, a goose), as these changes can affect reproductive success, which can determine the future of a species. This work is important because it sheds light on the complex interactions between climate change and animal behavior and fosters awareness about potential unbalanced environment. In fact, when one species is increasing, another one is generally decreasing, with a general loss of biodiversity.

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## ORIGINAL SOURCE ARTICLE

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## YOUNG REVIEWERS

### JOSI, AGE: 11

My name is Josi. I love to read and write stories. My favorite animals are pigs because they are really cute. Pink is my favorite color. Science is one of my favorite subjects. I like doing projects to help me understand science. My recent project examined the staining effects on teeth of different drinks.

### TEJAS, AGE: 14

Hi, I am Tejas. I am a teenager from Australia who is passionate about science, chemistry and biology to be particular. In my spare time, which I do have a lot of, I play sports like badminton and golf. I also play video games which keep me entertained.



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Didone Frigerio is a behavioral biologist. Her main interest is the relationship between sociality and the processes that are going on inside the body (physiology) in group-living birds. She loves to work with graylag geese, even though northern bald ibises have also caught her attention recently. She applies citizen science as a research approach in her behavioral investigations. \*[didone.frigerio@univie.ac.at](mailto:didone.frigerio@univie.ac.at)



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Josef Hemetsberger is a biologist and an ornithologist (bird scientist). He loves observing birds and collecting information about changes in their breeding habits.