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DO LICHENS AND MOSSES DRINK FROM TREE BARK?

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YOUNG REVIEWERS:

ANSHUL
AGE: 11

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AGE: 14

Lichens and mosses often live on tree branches in the forest canopy. They store large amounts of rain, fog, or dew, because they cannot reach water in the soil. However, we do not know what their most important source of water actually is. For example, is water uptake from wet bark important? This is hard to answer, because these lichens and mosses live high above us, so it is difficult to make direct measurements. Computer mathematical simulations can be useful to answer this question. We used a computer model of lichens and mosses to calculate how much water these organisms may take up from bark. We found that water from bark supports about 20% of the growth of lichens and mosses per year, so it *is* important for their survival. We also found that lichens and mosses are well adapted to taking up water from bark.

WHAT ARE LICHENS AND MOSSES?

Lichens and mosses are small organisms that live almost everywhere, all over the world. They not only cover the surfaces of rocks or the forest floor, but they also often live on the trunks and branches of trees. Plants that live on other plants are called **epiphytes**, and epiphytic lichens and mosses grow in many forests, in all climate zones.

EPIPHYTES

Plants that live on other plants.

Mosses are plants, but they do not have roots like grasses or trees. Lichens, however, are *not* plants—they are composed of a fungus and a green alga (or a type of photosynthesizing bacteria) that live together as one organism. Without roots, lichens and mosses must take up water by collecting rainfall or the moisture from dew or fog. Rainfall, dew, and fog are not available all the time, but this is not a big problem for the epiphytes—they simply dry out and become inactive. When water is available again, they "wake up." This is the main difference between lichens/mosses and plants like grasses or trees, which die when they dry out.

ARE LICHENS AND MOSSES IMPORTANT FOR THE FOREST?

Even without roots, lichens, and mosses can have large impacts on the **water cycle** in forests. Like sponges, they soak up the water that collects on their surfaces. Since they are often bushy and have a large surface area, lichens and mosses can take up a lot of water. The water evaporates from their bodies back into the atmosphere. This means that the water does not enter the soil, so trees have less water available. However, the sponge effect of the epiphytes can also help trees: it cools the forest, because energy from warm air goes into the water, to turn it from liquid into vapor. This energy is then transported into the atmosphere as water vapor. Cooling of forest air can reduce heat stress for trees.

WATER CYCLE

The movement of water between several storage locations, including the oceans, soil, rivers, and lakes, and the atmosphere (as water vapor and clouds).

It is still not entirely understood how important lichens and mosses really are for water availability and temperature regulation in forests, because relatively little research has been done on this subject.

DO LICHENS AND MOSSES GET ENOUGH WATER?

If we want to better understand how epiphytic lichens and mosses affect forests, we need to know how many there are and how much they can grow in a given forest. In other words, how big is the "sponge"? To answer this question, we first need to know how much water is available for the epiphytes. Even though they may cope well with drying out, they need to be active to grow, and to be active they need water.

We want to shed some light on a source of water that may have been overlooked until now, and that may be important to sustain the growth of epiphytic lichens and mosses: tree bark.

THE OVERLOOKED ROLE OF BARK WATER

Rain, dew, and fog are not the only sources of water for epiphytes living in the forest canopy. After it rains, water runs down the branches and stems of trees. This water is called **stemflow**. Some of the stemflow is stored in the cracks and pores of tree bark. Maybe the epiphytes can use this water for their growth.

STEMFLOW

Water that runs down the trunks of trees during and after rainfall.

We say "maybe" because we do not yet know how important water uptake from the bark is for epiphytic lichens and mosses—it is certainly possible, but rain, dew, and fog could be much more important for these organisms; not enough research has been done. Also, individual species of lichens and mosses could differ a lot in their ability to take up water from bark, but we have no idea how important these differences are for the water cycle of the forest.

IS BARK WATER IMPORTANT?

In our study, we wanted to find out how important bark water is for epiphytic lichens and mosses [1]. We also wanted to know if there are differences between species in this regard. Unfortunately, it is very difficult to measure bark water uptake, because we cannot simply switch it off to see how that affects the organisms.

COMPUTER SIMULATION MODEL

A simplified "copy" of a process or an organism, in form of a computer program. It can be used for tests that cannot be conducted in the real world.

CLIMATE DATA

Numerical information that describes climate, such as temperatures or rainfall for a certain time period and location.

A **computer simulation model** is a good tool to answer these kinds of questions, because a computer model can be changed much more easily than real ecosystems or organisms can. Our computer model is called LiBry, short for lichen and bryophyte computer model (bryophytes are mosses). The computer model works like a complicated pocket calculator: when we input certain **climate data**, such as temperature or the amounts of rainfall or light, the model calculates how much the epiphytic lichens and mosses can grow. The computer model can do this for many species of lichens and mosses.

Calculating the growth of lichens and mosses based on climate conditions is relatively complicated, because these organisms carry out many processes, like photosynthesis or respiration, that are affected by climate factors. The LiBry computer model calculates many of those important processes using dozens of mathematical equations (Figure 1). The equations usually have the form:

flow of carbon or water = some climatic condition × the state of the organism × additional factors

In the computer model, the equations are all connected, similar to what happens in a real organism. You can imagine the carbon or water flows as arrows between boxes, with the boxes representing pools of carbon or water. A small part of these flows and pools is shown below in Figure 2.

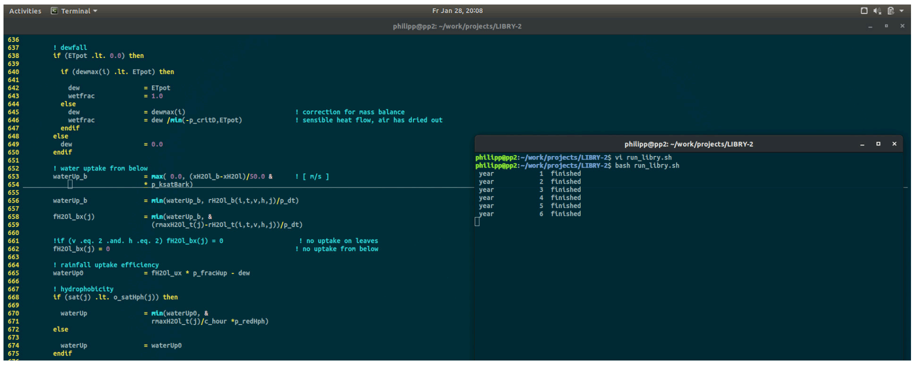

Figure 1

Figure 1

Screenshot of the LiBry computer model. Since the model is made of a bunch of equations coupled together, it does not have a user interface. It is a collection of text files that contain the equations. Some of the equations are shown on the left, in the programming language Fortran95. The gray line is where bark water uptake is calculated. The inset window on the right shows the run command and the output of the computer model, which lists how many years of epiphytes growing have been simulated so far.

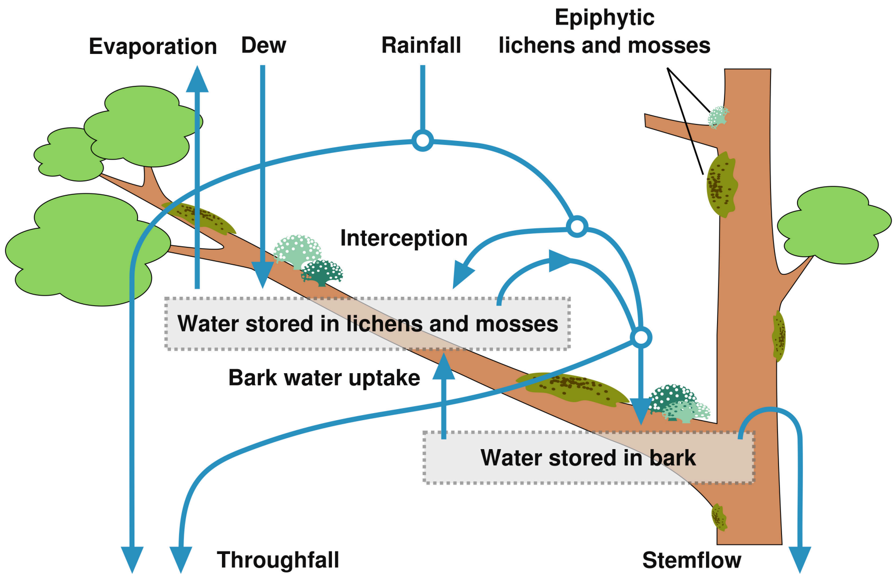

Figure 2

Figure 2

Part of the water cycle in a forest. Water can enter the canopy in the form of rainfall, dew, or fog. That water is then either intercepted by trees and their epiphytes or falls/drips to the forest floor as throughfall. Water intercepted by trees can be stored in the bark or flow down the bark as stemflow. Water stored in epiphytes like lichens and mosses can be used by those organisms to grow before it evaporates back into the atmosphere.

To test if the computer model works, we selected a **field site** in Sardinia, an island in the Mediterranean Sea close to Italy. In the forests and woodlands of Sardinia, many species of epiphytic lichens and mosses can be found (Figure 3).

FIELD SITE

An outdoor location (in a forest, for instance) where measurements are taken and experiments are carried out.

SWITCHING WATER FLOWS ON AND OFF

With the LiBry computer model, we simulated 3,000 species of epiphytic lichens and mosses for a location in Sardinia. This means that

Figure 3

Many types of mosses and lichens can be found in the forests of Sardinia, and the types growing in an area often depend on how dense the forest is. **(A,B)** Some grow on isolated trees. **(C,D)** Some grow in shady forests composed of old trees. **(E,F)** Some mosses and lichens can grow as thin sheets. **(G,H)** Other mosses and lichens can form larger bodies.

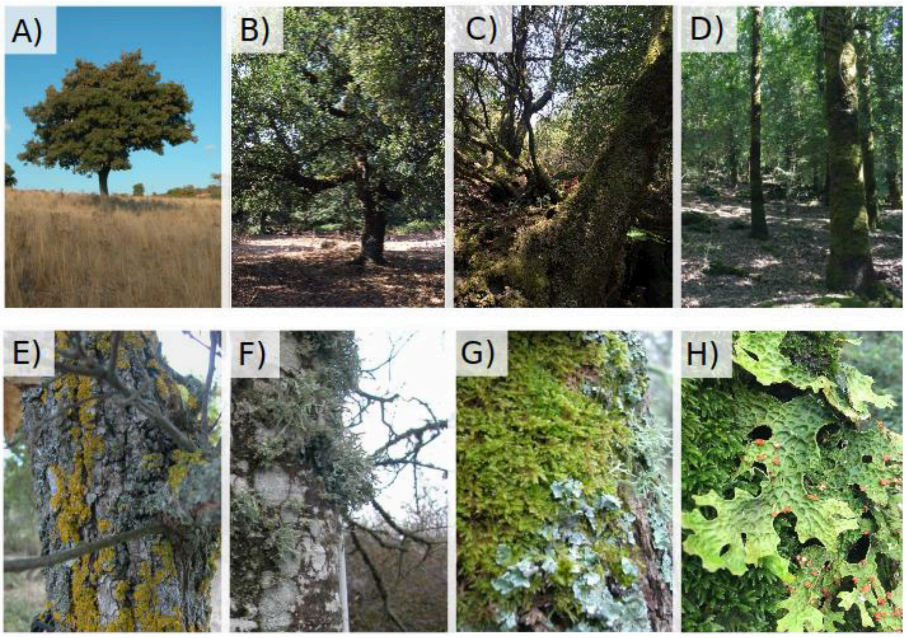

Figure 3

we used climate data for this region from the last 40 years and, for each hour, LiBry calculated how much each species could grow.

Sounds simple, but we must admit, it is a bit more complicated: the species in the computer model were not the actual species that live at the field site in Sardinia. It is not possible to collect enough samples and make all the measurements that would be needed to represent all the real species. Instead, the 3,000 simulated species are examples of all species that could *potentially* occur there. The computer model then checks whether each species would be able to survive in the climate of the field site. Usually, many species "die out" in the computer model, and the "surviving" ones are those that are adapted to the climate of the field site. This is helpful, because we do not have to measure the properties of all the real species in the field site—instead, we simply see which species "survive" the computer model simulation.

INTERCEPTION

Rainfall that is captured by the canopy surfaces (leaves, bark, epiphytes) and evaporates from there instead of falling to the ground.

THROUGHFALL

Rainfall that is not intercepted by the canopy, but hits the ground, or drips from leaves to the ground.

Back to the bark water: water fluxes are important for the growth of the lichens and mosses in the LiBry computer model. The more water that is available, the longer the organisms can stay active and grow. Figure 2 shows the routes by which water can flow from the atmosphere through the canopy to the ground. Rainfall that is captured by the canopy surfaces (a process called **interception**) can leave the canopy as stemflow or drip off leaves and other surfaces to the ground, as **throughfall**. Water can be stored in epiphytes, on leaf surfaces, or in the bark.

Since we wanted to find out how important bark water uptake is for epiphytic lichens and mosses, we used the LiBry computer model for an experiment. In one simulation, we simulated the growth of lichens and mosses using all the "normal" climate conditions of the field site. In a second computer model simulation, we set the size of the bark water storage to zero, so the simulated organisms could not take up water from the bark. Then we compared the results of these two computer model simulations.

THE BARK MAKES A DIFFERENCE

We found that bark water had a large influence on epiphytic lichens and mosses in Sardinia, all thanks to the LiBry computer model. In the "normal" computer model simulation, the organisms could grow around 20% more than they could in the simulation without bark water uptake. The effect was strongest in spring. In winter and fall, water was likely not limiting growth, because rainfall was sufficient and temperatures were lower, so bark water did not matter as much. In summer, rainfall and dew were so low that bark-water storage also did not make a difference—the lichens and mosses were inactive most of the time.

Without bark water uptake, not only did the epiphytes grow less, but fewer species survived the whole computer model simulation. The species that *did* survive without bark water were slightly different from those in the "normal" simulation: they were more resistant to water evaporation, which helped them to store more water in their tissues. They were also adapted to higher temperatures, which makes sense if you remember the cooling effect that we explained earlier. With no bark water, there was less water to evaporate, so the temperature in the canopy would be higher, favoring those species that could tolerate warmer conditions.

In conclusion, in our computer model experiment we found that bark water storage is important for the growth of epiphytic lichens and mosses in Sardinia, and it can influence which species will be successful in an ecosystem. These findings are important because Earth's climate is changing. Changes in bark water uptake due to climate change could affect the survival of the epiphytes—not only in Sardinia, but also in other locations around the world. So, our research can be used to predict which epiphytic lichen and moss species are threatened by climate change, and these predictions will become more accurate by including the role of bark water.

ORIGINAL SOURCE ARTICLE

Porada, P., and Giordani, P. 2021. Bark water storage plays key role for growth of Mediterranean epiphytic lichens. *Front. For. Glob. Change*. 4:668682. doi: 10.3389/ffgc.2021.668682

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1. Porada, P., and Giordani, P. 2021. Bark water storage plays key role for growth of Mediterranean epiphytic lichens. *Front. For. Glob. Change*. 4:668682. doi: 10.3389/ffgc.2021.668682

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ANSHUL, AGE: 11
Hello! My name is Anshul and I am a sixth grader at Germantown Academy, which is close to Philadelphia. I am very interested in Biology and Entomology. I am an active member of the Johns Hopkins CTY program, and my favorite hobby is to read.

PRANATEE, AGE: 14
Hello! I love to bake, especially around the holidays. In school, my favorite subjects are English and lunch. I like spending time outdoors and going hiking. I am a creative person who loves painting in my free time, and live off of music. In the future, I would like to study science, especially psychology.

AUTHORS

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Philipp Porada is a junior professor of ecological modeling at the University of Hamburg, Germany. He studied geo-ecology, which lies at the intersection of geosciences and biology. He conducted his Ph.D. project at the Max-Planck-Institute

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PAOLO GIORDANI

Paolo Giordani is a professor of botany at the University of Genoa, Italy. Since his thesis and doctorate at the University of Trieste, Italy, he has been studying various aspects of lichen life, to try to understand how organisms from two different kingdoms (a fungus and an alga) can form a new organism and live successfully in any terrestrial ecosystem.