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CHANGING LICHENS IN A CHANGING WORLD

Silvana Munzi[1,2], Lourdes Morillas[2]

[1]*Centro Interuniversitário de História das Ciências e da Tecnologia, Faculdade de Ciências, Universidade de Lisboa, Portugal;*
[2]*Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências, Universidade de Lisboa, Portugal*

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Changing lichens in a changing world

Lichens: small ecosystems, great colonizers

While until few years ago lichens were defined as the partnership between a fungus and algae or cyanobacteria, we now know that they are much more than that. It has been recently discovered that lichens host in and on their thallus *(the body of the lichen)* a great variety of microorganisms like bacteria, yeasts, non-lichen fungi, etc. Although these microorganisms contribute to the functioning of the lichen association, they cannot be seen at a naked eye and we still identify lichen species based on their main component: the fungus. The name of a lichen is actually the name of the fungus. The fungus represents almost the totality of a lichen thallus and is responsible for the interactions between the lichen and the external environment. That means that it provides the alga, that lives inside the thallus, with protection from the sun and the drought and with water and nutrients. The alga, being a photosynthetic organism, supplies the nutrients necessary for the survival of all the partners.

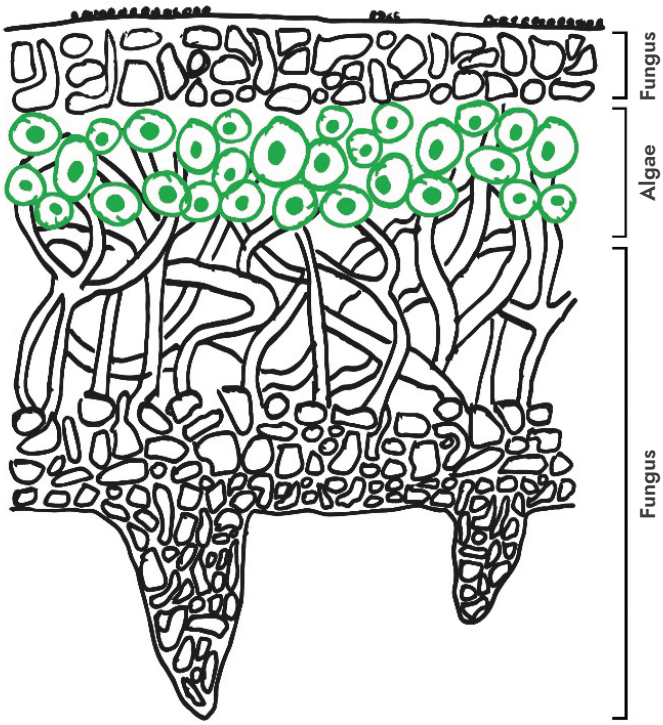


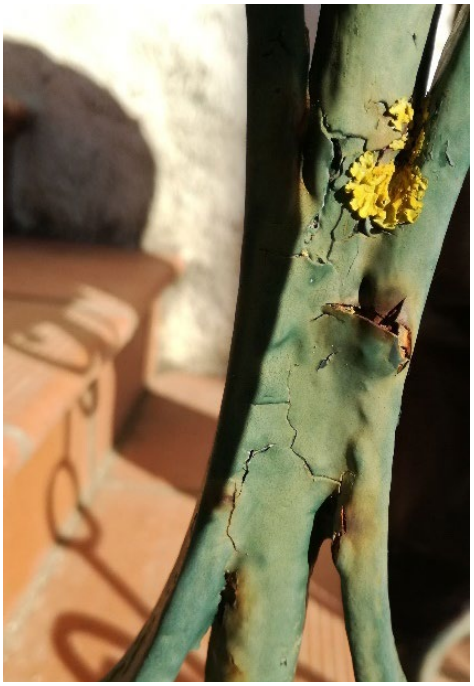
Figure by Javier Roales and Lourdes Morillas

Since lichens can produce their own food thanks to the photosynthesis, they can live on a wide range of substrates because they use them only as a support. Therefore, we find lichens growing on bark, wood, rocks, but also glass, plastic, shoes and even bones!

Remember, when we see a dead tree full of lichens, the lichens did not kill the tree, but they are colonizing the empty space without leaves!

Due to their structure, mainly to the lack of a cuticle, lichens are unable to regulate their water content that depends on the moisture in the surrounding environment. As a consequence, they are hydrated most of the time in humid climates, but stay almost always dry in hot, arid environments. When they are dry, their metabolism stops and they stay in a dormant status, that allows them to survive in extreme environments like deserts, poles or in other harsh conditions.

Photo by Silvana Munzi



Changing with the environment

Although well adapted to the sometimes difficult habitats where they live, lichens can be seriously harmed by pollution. They are like sponges and cannot avoid absorbing any element in the atmosphere, including the toxic ones. Low levels of pollution can put lichens under physiological stress and cause limited damages to the thallus. If pollution escalates, some sensitive species will disappear completely, and other more tolerant will appear or become more frequent in the polluted area. When pollution reaches intolerable levels for any species, all lichens disappear originating what is called a "lichen desert". Thanks to policies and measures aimed at reducing the pollutant emissions, many cities characterized by extensive lichen deserts are being colonized again and we witness to the coming back of lichens. However, lichens do not only respond to air quality, but to any environmental parameter able to influence their functioning, like temperature, humidity, light and nutrients availability (although they are autotrophic organisms, they need nitrogen and other nutrients for their metabolism). If we track the changes along time and space of the lichen communities' composition, we can retrieve important indications about how the environment is changing. In other words, we can use lichens as indicators of environmental, global and climate, changes.

Photos by Silvana Munzi

Leafy, yellow and with apothecia: the key features of lichens

Identifying lichen species used to be a hard task (and still is in some cases), but nowadays there is plenty of online material (e.g., https://liquencity.org/que-especies-buscamos/ and https://www.britishlichensociety.org.uk/activities/twenty-common-lichens/), field guides (e.g., https://echanges.fc.ul.pt/docs/2015/guia_campo_PT.pdf) and illustrated identification keys (e.g. https://www.nhm.ac.uk/take-part/identify-nature/lichen-id-guide/ and http://dbiodbs.units.it/carso/chiavi_pub20_z?tutti=si&org=italic) that make the identification of the most common lichen species not only possible, but also fun. If you never used one, identification keys are sequences of identification steps, each one regarding a diagnostic character of an organism with usually two alternatives, the choice of which determines the next step, until you arrive at the (hopefully) right species.

Growth form:

The first feature to examine in a lichen is the growth form that can be one out of three:

– *Foliose lichens* have a leafy, lobed thallus, attached to the substrate in several points of the lower surface through specific structures called rhizines *(similar to small roots)*. The thallus can therefore be easily detached from the substrate. The upper and the lower surface are of different colours and present different structures.

Photos by Valentina Caradonna

– *Fruticose lichens* resemble small shrubs, with the thallus more or less branched or in form of cups. Usually, they are attached to the substrate in one or very few points and can be erected or pendulous. The branches can have a circular section *(spaghetti–like)* or can be flat *(fettuccine–like)*; the lower and the upper surfaces can have the same or different colour.

Photos by Valentina Caradonna

– *Crustose lichens* are tightly attached to the substrate and cannot be removed without taking part of it. Observations can therefore be done only on the upper surface. They can be fertile or sterile, depending if they have reproductive structures or not.

Photos by Valentina Caradonna

Colour:

Another feature that calls the attention is the colour. Lichens are very colourful, thanks to compounds produced by the fungus. These compounds perform various functions in the partnership like protection from ultraviolet radiation or herbivorous animals and were found to have antibacterial properties among others.

Reproductive structures:

Lichens can have sexual or asexual (vegetative) reproduction. In the first case, the fungus produces spores that are dispersed and need to meet the algal partner to start a new symbiotic association. In the second case, fungal and algal cells are dispersed together mainly through different types of thallus fragmentation. Reproductive structures are crucial features for species identification:

– *Apothecia:* an apothecium is the fruiting body of the fungus, where the spores are produced. It can have the shape of a small cup or a small globe. The colour can be the same or different from the rest of the thallus.

Photos by Silvana Munzi

– *Lirellae:* a lirella is an apothecium with a long or at least elongated shape, and can be simple or branched, black or white.

Photo by Silvana Munzi

– *Soredia:* are propagules composed of fungal and algal cells and are common vegetative reproductive structures in lichens. They have a powdery look and can be either diffuse across the thallus' surface or produced in structures called soralia.

Photos by Valentina Caradonna

– *Isidia:* an isidium is another type of vegetative reproductive structure. They are basically outgrowths of the thallus surface containing both algal and fungal cells. They can be simple or branched, cylindrical (in this case they seem like small fingers) or button-like. Their tips are black in some species.

Photo by Silvana Munzi

Other structures:

Other important structures for the identification of lichen species are:
– *Cilia:* black hairs coming out from the margin of the thallus.

Photo by Valentina Caradonna

– *Rhizines:* rhizines are structures located on the lower surface of the lichen which serve to anchor the lichen to their substrate. Although similar to plant roots, they do not absorb nutrients. They can grow only on the center of the thallus or up to the margin.

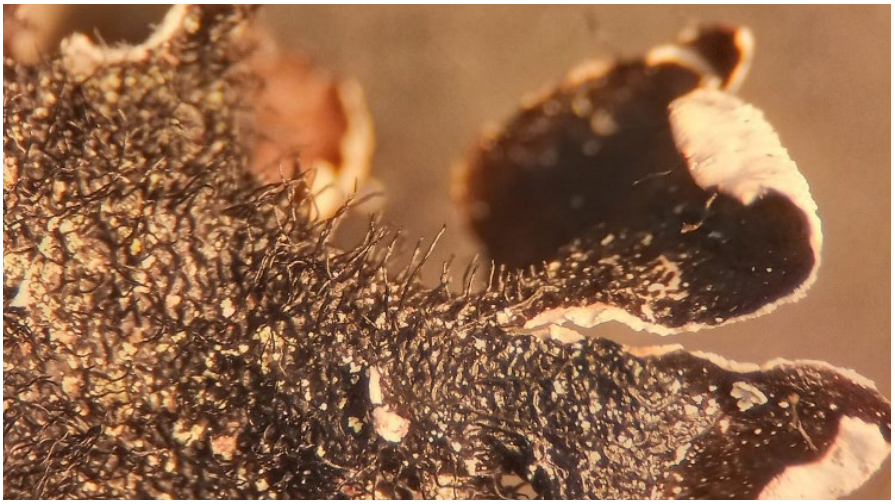


Photo by Silvana Munzi

– *Pseudocyphellae:* are openings in the upper or lower surface of the thallus to facilitate gas exchange. They can resemble tiny pores or reticulate networks on the surface, usually white and rarely yellow.

Photos by Valentina Caradonna

What do I see in the playground of my school?

The lichen community occurring in a certain place is influenced by many factors, among which climatic conditions are of paramount importance. Therefore, the lichen community will be different in different countries, cities or environments. Species that I see every day can be rare in Northern Europe and vice versa. However, there are some cosmopolitan species with wide distribution that can be found almost everywhere.

We list here some of these species with a brief description that will help you in the identification task, but we suggest looking for papers and other material that deal with lichens of a specific country or habitat for further help. All the listed species can be found in urban environments and have a certain tolerance to atmospheric pollution.

Photo by Valentina Caradonna

CANDELARIA CONCOLOR

Thallus: *foliose but with very minute lobes often granular at the tips; forming rosette of few cm.*

Color: *bright yellow but can be greenish in shaded situations.*

Lower surface: *white to pinkish.*

Rhizines: *simple, white.*

Apothecia: *very rare.*

Photo by Valentina Caradonna

DIPLOICIA CANESCENS

Thallus: *crustose, densely pruinose, forming 1–4 cm wide rosettes.*

Color: *white.*

Soredia: *finely granular, greenish white to grey.*

Apothecia: *very rare.*

Photo by Silvana Munzi

EVERNIA PRUNASTRI

Thallus: *fruticose, erect and tufted to subpendent, composed of flattened branches up to 10 cm long.*

Color: *green to yellowish green.*

Lower surface: *white.*

Soralia: *marginal with white granular soredia.*

Apothecia: *very rare.*

Photo by Silvana Munzi

FLAVOPARMELIA CAPERATA

Thallus: *foliose, with wide, elongate lobes, forming regular rosettes of 5–20 cm.*

Color: *yellowish green.*

Upper surface: *smooth but rugose and folded in central parts.*

Soredia: *granular or similar to pustules, often covering the centre of the thallus.*

Lower surface: *black at the centre and brown towards the margins of the lobes.*

Rhizines: *simple, black.*

Apothecia: *very rare.*

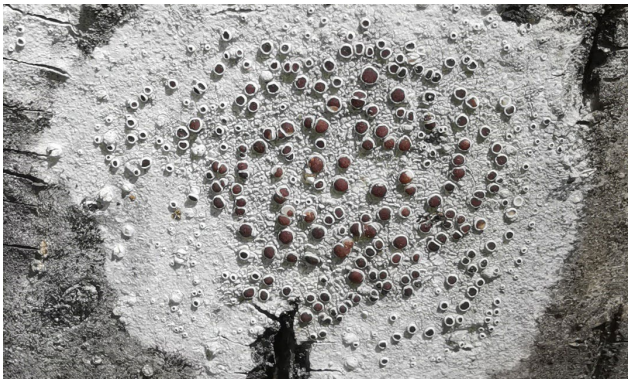


Photo by Silvana Munzi

LECANORA SP.

Thallus: *crustose.*

Color: *white to grey or greenish, depending on the species.*

Apothecia: *very common, with the margin and the disc of different color. In some species apothecia can be covered with pruina and have a powdery look.*

Photo by Silvana Munzi

LECIDELLA ELAEOCHROMA

Thallus: *crustose.*

Color: *whitish to greenish grey.*

Apothecia: *common, with the disc and the margin of the same color, black (brown in old or damaged specimen).*

Photo by Valentina Caradonna

NORMANDINA PULCHELLA

Thallus: *composed of isolated to crowded squamules, small, shell-like in shape.*

Color: *bluish green.*

Lower surface: *whitish.*

Photo by Silvana Munzi

PARMELIA SULCATA

Thallus: *foliose, loosely attached to the substrate, forming rosettes.*

Color: *grey.*

Upper surface: *grey surface, marginal parts usually with a network of white pseudocyphellae developing linear soralia with granular soredia.*

Lower surface: *black up to the margins.*

Rhizines: *present up to the margins, simple but often basally squarrose (similar to small brushes), black.*

Apothecia: *rare.*

Photo by Valentina Caradonna

PARMOTREMA PERLATUM

Thallus: *foliose, composed of broad lobes loosely attached to the substrate, 3–20 cm wide.*

Color: *grey.*

Upper surface: *smooth, but lobes sorediate at the margins; black marginal cilia not always visible.*

Lower surface: *black, with a brown marginal zone.*

Rhizines: *simple and black at the centre of the thallus, absent at the margins.*

Apothecia: *very rare.*

Photo by Valentina Caradonna

PERTUSARIA PERTUSA

Thallus: *crustose.*

Color: *white to grey.*

Upper surface: *present semiglobose warts with often slightly flattened apex, each wart with 2–10 black pores.*

Apothecia: *present, completely immersed in the warts.*

Photo by Silvana Munzi

PHAEOPHYSCIA ORBICULARIS

Thallus: *foliose, closely attached to the substrate, forming rosette 3–5 cm wide.*

Color: *grey to brown.*

Lower surface: *black.*

Rhizines: *simple, black.*

Soralia: *on the thallus surface or at the margin of the narrow lobes, round to irregular.*

Apothecia: *rare.*

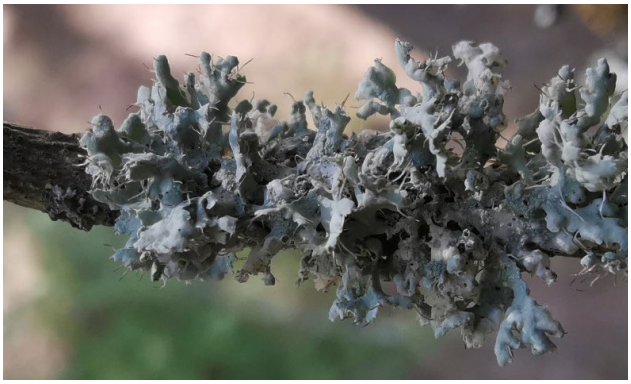


Photo by Valentina Caradonna

PHYSCIA ADSCENDENS

Thallus: *foliose to subfruticose, composed of narrow lobes forming irregular patches.*

Color: *grey.*

Upper surface: *sometimes with white macules; with pale marginal cilia often dark on the tips.*

Lower surface: *whitish.*

Soralia: *terminal, in the shape of a hood.*

Rhizines: *few, sparse, sometimes with a brown tip.*

Apothecia: *very rare.*

Photo by Valentina Caradonna

PUNCTELIA BORRERI

Thallus: *foliose, forming 5-10 cm wide rosettes*

Color: *grey.*

Upper surface: *with numerous, punctiform, white pseudocyphellae.*

Lower surface: *black in centre, dark brown at margins.*

Soralia: *rounded, laminal, originating from the pseudocyphellae.*

Rhizines: *simple, black, becoming less frequent at the margins.*

Apothecia: *very rare.*

Photo by Valentina Caradonna

RAMALINA FARINACEA

Thallus: *fruticose, shrubby or tufted, then pendulous, can reach 15 cm of length.*

Color: *greenish.*

Soralia: *elliptical or rounded, marginal.*

Apothecia: *very rare.*

Photo by Silvana Munzi

USNEA SP.

Thallus: *fruticose, with rounded section, erect to pendulous, can reach relevant length.*

Color: *greenish, reddish or blackened in some parts, depending on the species.*

Apothecia: *present in some species. Other structures that can be found are fibrils, soralia and isidia.*

Photo by Valentina Caradonna

XANTHORIA PARIETINA

Thallus: *foliose, sometimes forming regular rosettes.*

Color: *yellow to orange, but green in shaded situations.*

Lower surface: *mainly white, sometimes pale yellow.*

Rhizines: *absent but hapters (other structures to anchor to the substrate) present.*

Apothecia: *very common with yellow margin and orange disc.*

What's happening in your schoolyard?

Equipment

Before heading to your sampling site, try to retrieve these tools that will make your sampling easier:

- ✓ Data sheets and a pencil: You can print your data sheets to work in the field, but then all the information must be typed in the excel file available at https://mednchange.weebly.com/uploads/1/2/7/5/127571633/changinglichens_datasheets.xlsx and send to us in this format with all the associated pictures. This is essential if you want your data to be used in our work.
- ✓ Smartphone with internet connection: With your Smartphone you will be able to take pictures, the coordinates and altitude and fill in the data sheets if you decided not to print them. Alternatively, you can also use a camera, compass and laptop.
- ✓ Hand lens: Lichens are generally small, and some structures are quite hard to see. A hand lens could be very useful for your observations.
- ✓ Measuring tape.
- ✓ Sampling grid: Down below you will find instructions on how to build your very own sampling grid for lichens.

Now you are ready to collect lichen data, but before that, we need to know more about the environment where they live. If your school doesn't have a schoolyard or lichens to be observed, you can look for a suitable site in the surroundings.

1) Record environmental data:

Use the data sheet to record the key characteristics around the lichens: the climate surrounding them, the presence of green areas in their proximity, the distance from pollution sources, the species of tree they're on... all these features are important factors affecting the lichens development and we need to account for them. To do so, go to the "environmental data" sheet and fill in as many fields as possible.

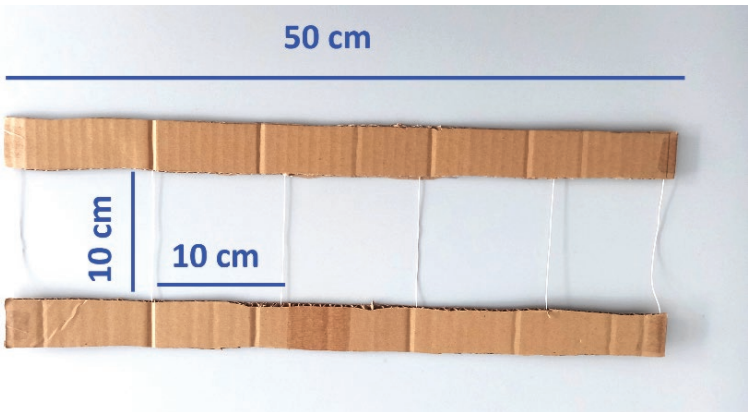
First thing is to characterize the place where you observed the lichen, what we call the "sampling site". The following indications will help you through the process of filling in the fields that you will find in this sheet.

- ✓ *Name, date and school*, you know.
- ✓ *Sampling site:* the proper geographic name of the public place where you are sampling (the name of the city park, or town, etc.).
- ✓ *Coordinates:* Find the place on the Google Earth app (press and hold the location to reveal the coordinates of your sampling site) or use your smart phone' s GPS.
- ✓ *Altitude:* Find the place on the Google Earth app (press and hold the location to reveal the altitude of your sampling site).
- ✓ *Type of stand:* Indicate if you are sampling in an urban park, a natural ecosystem, a plantation, a school yard, a private garden, a tree along a road or other type of environment.
- ✓ *Description:* Notes related to the stand (type of vegetation, activities occurring in this place, potential disturbances/management, whatever you consider relevant).
- ✓ *Type of climate:* Characterize the climate (temperate, continental, Mediterranean, etc)

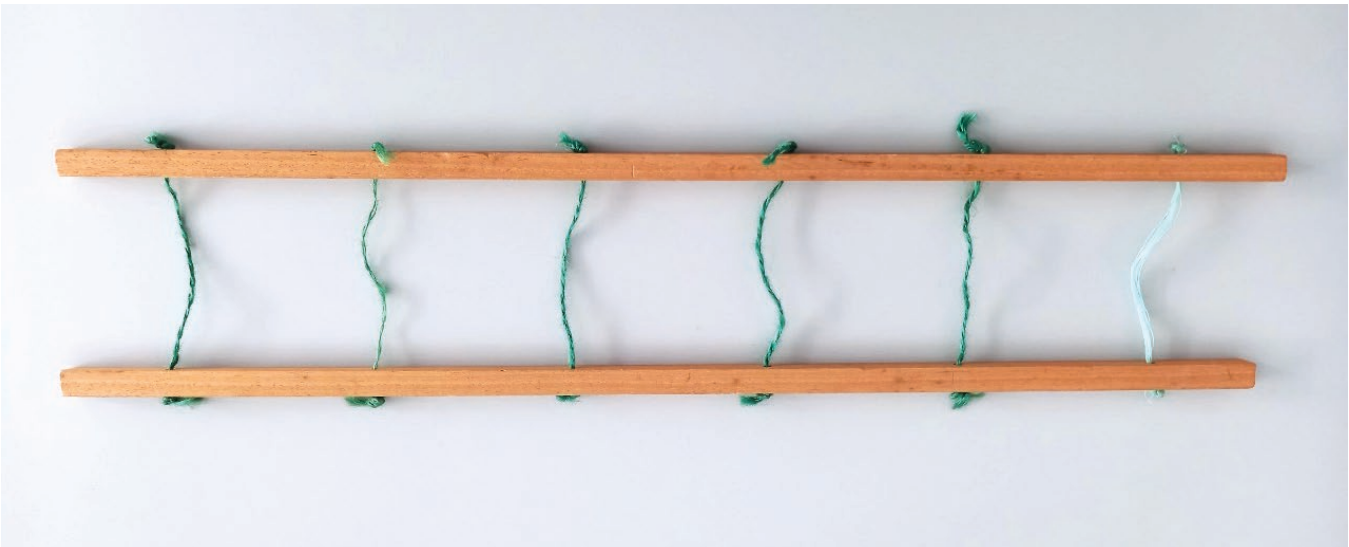
- ✓ *Precipitation and temperature data:* To fill in the climate data you must look for national or local sources providing this information. There are many websites providing meteorological information that also analyze the data roughly. Ideally, you would retrieve this data from the closest meteorological station to your sampling site.
- ✓ *Green areas in the surroundings:* Are there green areas in the surroundings? Just type yes or not.
- ✓ *Type:* If the previous answer was "yes", indicate if the green area is an urban park, a natural ecosystem, a plantation, a private garden, etc.
- ✓ *Distance:* Estimate or measure the distance in meters to the closest green area (it can be done also using Google Earth).
- ✓ *Size:* Estimate the dimensions (m^2) of the green area.
- ✓ *Pollution source:* Several pollution sources might be affecting your sampling site. Indicate if there are major roads, farms, industries ... close to your sampling site
- ✓ *Distance:* Estimate the distance in meters to the aforementioned pollution source.
- ✓ *Attached photos:* Take pictures of your sampling site and attach them to your data sheet.

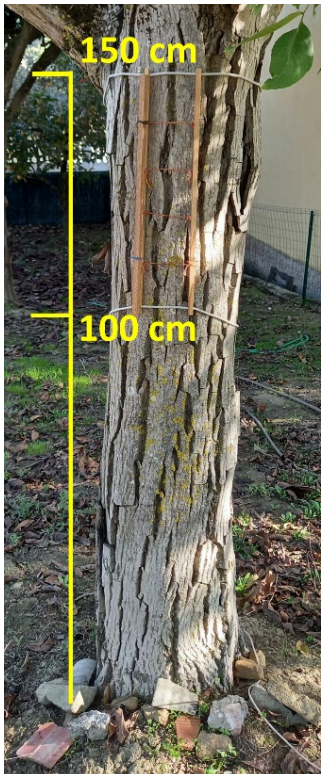
2) *Identify lichens: Diversity and frequency*

Although all lichens are sensitive to environmental changes, the most broadly used as bioindicators are lichens growing on trees.



There are several methodologies to record lichen diversity and frequency. In Europe, a standard method has been implemented that makes use of a sampling grid with a specific size and position on the trees. The sampling grid is composed by 5 squares of 10x10 cm. You can build your own grid using wood or cardboard and twine.





In your sampling site, if possible, choose at least 3 trees with straight trunk, without damages or mosses growing on it, and without branches in the portions of the bark where you are going to sample. Once you have them, start with the first one:

a. measure the girth at 120 cm from the ground;

b. place the grid vertically against the tree trunk toward the 4 directions (one at a time): north, east, south and west, between 100 and 150 cm from the ground (see the image).

c. Now, you observe the lichen species that fall on the grid: for each species found in the grid, you count the frequency of the species, meaning the number of squares in which the species is, and record it in your sheet. In the example of the figure, the yellow lichen, Xanthoria parietina, is in 5 squares (arrows), while the white one, Lecanora sp., is in 3 squares (circles). Note that it does not mind if in the square there are more than one thallus of the species, it always counts as 1 square. That means that the highest possible frequency, meaning the maximum number of squares in which you can find your species in a certain direction of a tree, is 5 (when the species is present in all the squares of the grid).

Direction	N	S	E	w
Height of the grid (cm)	100			
Xanthoria parietina	5			
Lecanora sp.	3			

Fill in the fields of the Grid Sampling data sheet with the following information.

- ✓ *Sampling site:* the proper geographic name of the public place where you are sampling (the name of the city park, or town, etc.). This must be the same you used for the "Environmental Data" sheet that will provide information about the sampling site
- ✓ *Tree number:* Assign a number to each tree that you sample
- ✓ Tree species: Try to determine the species of the tree or take pictures of the leaves/ flowers/fruits if you don't manage
- ✓ *Tree coordinates:* Try to find the tree on Google Earth or use your smart phone' s GPS.
- ✓ *Circumference (cm):* Measure the girth of the trunk at 120 cm from the ground, as shown in the picture
- ✓ *Observations:* Register any factor that can have an impact on the tree or on the lichens
- ✓ *Inclination:* Estimate the inclination of the trunk and in which direction is inclined (for ex., 45° North)
- ✓ *Hight of the grid:* if any obstacle prevents you to put the grid at the ideal height of 100 cm, note the real height at which you manage to put it

After recording the frequencies of the lichens, you can calculate some indexes of Lichen Diversity (LD):

- *LD of the direction:* it is the sum of the frequency of all the species in one direction of a tree
- *LD of the tree:* it the sum of the frequencies found in the 4 directions for a tree (N + E + S + W)
- *LD of the stand:* it is the average frequency of a tree [(LD of the tree 1 + LD of the tree 2 + LD of the tree 3)/3]
- If you compare these values with other schools or sampling sites in your city, you will have an indicator of the environmental quality.

3) Record relevant lichen parameters:

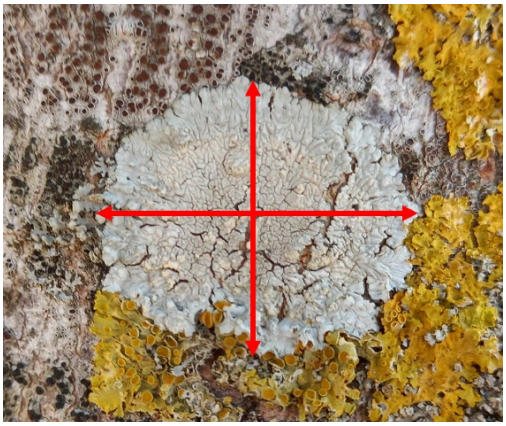
Lichens are slow growing organisms. That means that to notice some changes we need to observe them for a long period. Select some special lichens that you will assess over time: measure their size, observe their surface and their reproductive structures, and take notes in the data sheet of any change occurring to them. This long-term project can be started by a certain group of students and then continued by following students, so there will be time series collected by different students through the years. This procedure will require the involvement of teachers that will lead and promote the initiative. It requires few minutes every year and provide precious information about the way lichens grow and colonize the substrate.

Each "Lichen Parameters" sheet allows observations for 3 years and from 1 to 5 lichens. Use more data sheets if you want to observe more lichens. Each "Lichen Parameters" sheet must be associated to one "Environmental Data" sheet.

Follow these instructions to fill in the "Lichen Parameters" data sheet:

- ✓ *Growth form:* Indicate if the lichen is foliose, fruticose or crustose.
- ✓ *Color:* Indicate the color of the lichen.
- ✓ *Height (cm):* Indicate the height at which the lichen grows from the ground.
- ✓ *Size (cm; hor.):* Measure the size of the thallus in the horizontal direction at its largest point *(see the image)*.
- ✓ *Size (cm, ver.):* Measure the size of the thallus in the vertical direction at its largest point *(see the image)*.
- ✓ *Rep. Str.:* Indicate which reproductive structure the lichen has and, if possible, how many *(for example: 7 apothecia)*.
- ✓ *Damage:* Take note if the thallus is damaged, like necrosis, discoloration, missing part of the thallus.
- ✓ *Notes:* Write notes about the type of substrate, if a tree, a wall or other, and any characteristic you can observe of it.

Take pictures of the lichens you selected with a ruler or a meterstick near them (see the image) for further image analyses. Remember to label the pictures correctly to facilitate the comparison of the same thallus among different years.



The ultimate goal of researchers involved in this citizen science project is to use the data provided by students to be able to detect when environmental changes are beginning to affect the surroundings of the school. But researchers are not the only ones able to interpret this data, with the help of their teachers, students can also reach conclusions by analyzing their own recorded data. A rough but simple way is to explore the relationships between environmental variables and lichen parameters in Excel, what is called a linear regression analysis. Obtaining the trendline and its equation will allow them to find out if the assessed variables are positively or negatively related by looking at the slope of the line. For example, they can plot the lichen size against the year to find out if lichens are following a trend towards growing or dying. They can also plot the lichen size against total annual precipitation of last year to investigate the effect of this variable on lichens growth. Tutorials for the use of Excel are widely available online. By doing these simple statistical analyses, students will be able to interpret their own data and draw conclusions about the effect of environmental changes in their surroundings.

4) Share your data with the scientific community

You can now share all the data you have collected online so that other researchers can use it for their work. You can send the data sheets and any pictures you may have to us, and you can also upload the picture and location information onto the project "schooled lichens" in the app iNaturalist. This collaboration between students and researchers will create the first monitoring network of schools in Europe, while providing a baseline lichen status to compare with future samplings that would alert us to potential environmental impacts in the schools surrounding. Other citizen science projects dealing with lichens, such as the ones listed down below, have drawn valuable conclusions as a result of the collaborative work between researchers and citizens. Citizen science allows the society to deepen its understanding of the environment, ecosystem services and risks related to global change, and it frequently implies a great social involvement in improving the environmental conservation and health. Therefore, both the scientific community and society profit from these synergistic initiatives. Do not miss this opportunity to engage with these outstanding and mysterious organisms while collaborating with scientist to protect our environment!

Examples of citizen science projects:

https://liquencity.org/

https://eu-citizen.science/project/122

https://lichenscitisci.org/

https://www.tcd.ie/research/start/lichen.php

https://www.imperial.ac.uk/opal/surveys/airsurvey/

https://blog.nature.org/science/2015/05/12/citizen-science-likin-lichens-monitoring-project-tardigrades-air-quality/

Examples of scientific publications resulting from this kind of activities:

https://www.sciencedirect.com/science/article/abs/pii/S0006320713004412

https://www.sciencedirect.com/science/article/abs/pii/S0269749117317700?via%3Dihub

https://pubmed.ncbi.nlm.nih.gov/23631940/

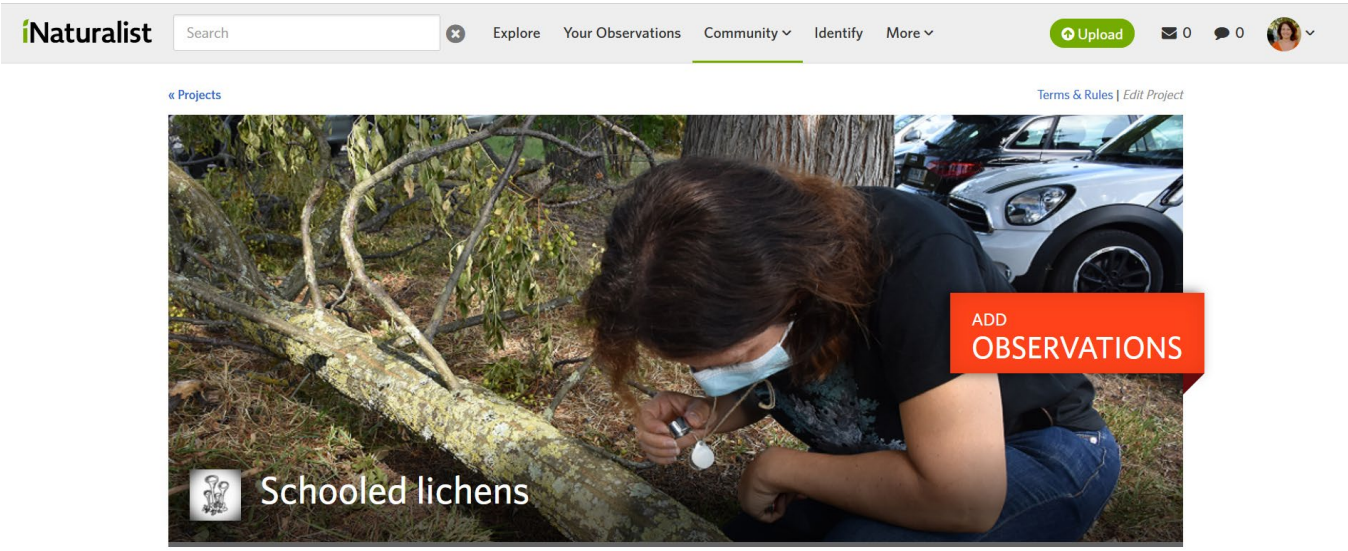
https://pubmed.ncbi.nlm.nih.gov/23992684/

"Schooled lichens", an iNaturalist project

How does iNaturalist work? iNaturalist is a friendly-user app that will allow you to join a growing community of citizens interested in contributing to science while learning about their environment. By recording and sharing your observations you will enrich scientific data repositories, which is crucial to advance in biodiversity science.

How can I use iNaturalist?

First you need to install the iNaturalist app in your smartphone, or link to the website (https://www.inaturalist.org), register, and join the project "Schooled lichens" (https://www.inaturalist.org/projects/schooled-lichens).



Now you are ready to go! You can start sharing your observations. To do so, you need to provide the following information:

- ✓ *What you saw:* Identify the lichen you saw with as much detail as possible *(species and genus).*
- ✓ *Where you saw it:* Record both the coordinates of the observation, as well as its accuracy.
- ✓ *When you saw it:* Record the date of the observation *(not the date you post it to iNaturalist).*
- ✓ *Pictures of what you saw:* By including pictures of your observation, you will allow other members of the community to help you out with the lichen identification. Add several high-quality pictures from different angles.

How does the project "Schooled lichens" work?

Only lichens must be recorded in this project. Provide pictures of the entire lichen as well as details of small structures needed for its identification. Indicate how did you identify the specie *(what identification key you used, chemical reactions, microscopic observation…).*

Let´s record your first observation together! To do so, follow these step-by-step instructions:

- ✓ Tap the "observe" button.
- ✓ Add the pictures of the lichen you saw.
- ✓ Identify the lichen in the field "what did you see?".

- ✓ When you saw the lichen should be added automatically.
- ✓ The coordinates should be added automatically. If it does not happen, check app permissions in the settings app.
- ✓ Save your observation.
- ✓ Tap the "upload" button if you have an iPhone and the "Sync" button if you have an Android.
- ✓ Check back for activity on your observation from the community or be notified by email to the address in your account settings.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 793965

Silvana Munzi

Lourdes Morillas

Hi,

We really hope you enjoyed this short trip in the world of lichens enough to deepen the topic and, who knows, maybe becoming a lichenologist!

There are many websites, groups and material of any kind about lichens available on the internet, but if you have doubts or questions, feel free to contact us at changinglichens@gmail.com.

In the meanwhile, we appreciate your help in developing this project. Now that you collected the data like a scientist would do, send the data sheets and the photos to changinglichens@gmail.com. Make sure that the data sheets are in the excel format and that the photos are accurately labelled.

We'll keep you updated on the progresses of the project on the page https://mednchange.weebly.com/changinglichens

Data sheet (v.1) - Stand-level data

Changing lichens in a changing world

Name:		Date:	
School:			
Sampling site:			
Coordinates:		Altitude (m asl):	
Type of stand:			
Description:			
Type of climate:			
Average annual precipitation (mm per year):			
Total annual precipitation of last year (mm per year):			
Average temperature (°C):			
Highest annual temperature (°C):		Lowest annual temperature (°C):	
Green areas in the sorroundings (y/n):		Type:	
Distance (m):		Size (m^2):	
Pollution source 1:		Distance (m):	
Pollution source 2:		Distance (m):	
Pollution source 3:		Distance (m):	
Attached photos:			

Grid Sampling sheet

Name:												
School:												
Sampling site:												
Tree number												
Tree species												
Tree coordinates												
Circonference (cm)												
Observations												
Inclination												
Direction	**N**	**S**	**E**	**W**	**N**	**S**	**E**	**W**	**N**	**S**	**E**	**W**
Height of the grid (cm)												

LD of the direction												
LD of the tree												
LD of the stand												

Lichen Parameters sheet

Name:	
School:	
Sampling site:	

Year	**Lichens**				
	1)	2)	3)	4)	5)
Growth form					
Color					
Height (cm)					
Size (cm; hor.)					
Size (cm, ver.)					
Rep. Str.					
Damage					
Notes:					

Year	**Lichens**				
	1)	2)	3)	4)	5)
Growth form					
Color					
Height (cm)					
Size (cm; hor.)					
Size (cm, ver.)					
Rep. Str.					
Damage					
Notes:					

Year	**Lichens**				
	1)	2)	3)	4)	5)
Growth form					
Color					
Height (cm)					
Size (cm; hor.)					
Size (cm, ver.)					
Rep. Str.					
Damage					
Notes:					