



Wanted: virtual or live! How lichens are becoming part of mass internet culture

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Abstract

While restrictions imposed by the COVID-19 pandemic have strongly limited and affected the work of scientists and communicators, the pandemic has also encouraged the development of new ways of networking and public engagement. People have had to resort to virtual events, with a subsequent proliferation of webinars, online meetings, and digital resources. In this situation we have had to find new ways of measuring the impact of these activities. Using the activities of the Italian Lichen Society (Società Lichenologica Italiana, SLI), Google Trends and colleagues' contributions, we evaluated the performances and impacts of virtual tools on lichenological literacy. We compared the relative success of virtual and in-person events and the effort required; we evaluated followers' appreciation of various categories of posts on SLI Facebook page; and designed a questionnaire to collate information on individual experiences of in-person and virtual events linked to lichens. As expected, online events generally required less effort to put together and deploy than in-person events and engaged more people, especially when recorded and made available online for a long time. Using online searches for the word "lichens" we found an association with national events, and there was a notable increase in membership of SLI over the last 10 years, demonstrating an increasing interest by people in lichens. Without excluding the positive effects of in-person experiences, we believe that online events offer a powerful tool to help increase interest in, and knowledge about lichens. This interest may help to mitigate the impact of anthropogenic activities on this sensitive component of the ecosystem and help human-lichen relationships.

Keywords Conservation · Covid-19 · Culturomics · Google trends · Online events · Science communication

Every day, the so-called democratization of technology allows an increasing number of people to access knowledge about topics that until now were mostly restricted to insiders. Google and Wikipedia, which is the largest and most widely used encyclopedia in existence, have been able to provide answers to questions in almost any field of knowledge (Medelyan et al. 2009). The internet has become a vast repository of information, and the technology has made it possible for people with a common interest to collaborate and communicate. In order to assess the

power of online information the effectiveness of information on the web needs to be measured. From business to politics the role of the internet has been addressed: as in e-commerce and the conversion of traditional business models to the virtual space (Zaitseva et al. 2019), or regarding forms of online and offline participation and its influence on election results (Campante et al. 2018; Gavazza et al. 2019). The age range and typology of users has been widening due to the availability of different virtual arenas for source searching, content sharing and discussion (Khoros 2021). Among social media platforms, Facebook, Twitter and Instagram have become important channels for networking and dissemination even in scientific areas. Applying the scientific approach to the virtual system, new fields of investigation have emerged that exploit this large body of information. It is possible to pinpoint relevant topics and trends in science, providing tools to explore and influence human interactions with the environment (Correia et al. 2016). For example, culturomics, defined as the quantitative analysis of changes in word frequencies in large bodies of digital texts, has become a powerful tool in conservation (Ladle et al. 2016).

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Aside from schools, some traditional ways in which scientific knowledge reached the public were through newspaper, magazines, television programs, museums and botanical gardens. These were passive ways to transmit information, exposing the public to fascinating examples of the variety of nature. More recently, new modes of communication have appeared. For example, museums and botanic gardens have become interactive platforms offering visitors unique experiences using a combination of multidisciplinary approaches (Giovanetti et al. 2020; Waylen 2006). Moreover, new pathways to collect data have emerged. Citizen science is a good example of this; citizen volunteers offer help in tracking animal/plant species, usually under the supervision of research programs run by specialists, and the citizens reinforce their knowledge on given topics. Recently, new technologies (the use of apps on smartphones) have been included in citizen science programs and will certainly become more prominent in the future (Newman et al. 2012). While citizens reinforce their knowledge, researchers and decision-makers gain by increasing their potential for monitoring and managing natural resources as well as re-distributing recent advances in science (Jordan et al. 2012). Citizen science boosted participant interest, positively influencing environmental changes at the local level (Conrad and Hilchey 2011) and has been recognized as an opportunity to influence nature conservation (MacPhail and Colla 2020).

The COVID-19 pandemic situation in 2020 forced people to reduce interpersonal contacts and boosted another mode: webinars and virtual presentations (communication among remotely located participants), that in many cases facilitated outreach activities even in science (Aristeidou and Herodotou 2020). The use of interaction from feedback and questions became a new source of data (Gegenfurtner et al. 2020). Figure 1 traces the sources of data that can be used to evaluate scientific involvement and to search for data online.

Due to the COVID-19 pandemic, the scientific community had to reorganize part of its knowledge-transfer activities, especially those related to interactions with the public or students. Also, people interested in science and nature had to turn to online sources of information, since avoidance of in-person meetings/contacts was strongly recommended. We expected that a virtual system would provide evidence of this switch and its impact. We looked for a framework to track the direct or indirect impacts of democratization of technology and information on the relationship of humans to their environment. We thought lichens could serve the scope for three main reasons. First, lichens have a relevant role in countless programs spread around the world (e.g., Casanovas et al. 2014; Lichens CitiSci 2021; LichenCity 2021; Welden et al. 2017). Second, we are aware of in-person and virtual activities of a scientific society precisely interested in lichens: the Società Lichenologica Italiana (SLI, Italian Lichen Society). We could access information related to a period before the start of the

COVID-19 pandemic, and during it (2018–2021). The information may help to disentangle possible links between memberships' number and in-person / virtual activities (comparing virtual/online vs. in-person when possible), increased literacy, and the performance of Facebook (FB) posts. We designed a questionnaire to circulate among SLI members and others interested in lichens to identify ways in which knowledge of lichens was acquired and its effect on the relationship of humans with their environment. Another reason for turning the attention towards a lichen-focused approach is that the translation of the terms in some languages (as Italian and German) is unambiguous. This would allow the use of Google Trends with a high data precision. We did so, combining the results with national events and interviews of colleagues on lichen-related activities.

1 Why should we be concerned about lichens?

Including more than 17,000 species (Lumbsch et al. 2011), lichens are multi-partnered symbiotic associations including a fungus, green algae or/and cyanobacteria, yeasts and a wide range of bacteria and other microorganisms (Pankratov et al. 2017; Sigurbjörnsdóttir et al. 2016). Lichens cover approximately 8% of the Earth's land surface and carry out a crucial role in regulating ecosystem nutrient inputs and fluxes, improving water cycling (Berryman and McCune 2006; Stanton et al. 2014), providing food and habitat for microfauna (Asplund and Wardle 2016) and as part of soil biological crusts providing other ecosystem services (Rodríguez-Caballero et al. 2018). Nevertheless, their existence and importance in ecosystem functioning is often overlooked, unknown or ignored by most people. This lichen illiteracy often puts lichens at risk, representing a threat to biodiversity conservation in many ecosystems. As an example, at the global level, only the species *Cladonia perforata* and *Erioderma pedicellatum* were evaluated according to IUCN criteria and included in the IUCN red list, and only a few are included in national and regional conservation lists (e.g. Nascimbene et al. 2013).

While pollution, habitat loss, and climate change constitute the main threats to lichens on a global scale, unregulated collection, poor site management and lack of conservation policies, are relevant at the local level (Gheza et al. 2020; Giordani et al. 2020). Although able to grow in harsh environmental conditions, the impact of anthropogenic activities on lichens is considerable and their use as sensitive bioindicators of environmental change is widely established (e.g. Abas 2021; Nimis et al. 2002; Sutton et al. 2020). When extensive or rapid environmental changes occur, some species are unable to adapt (Munzi et al. 2020), yet lichens respond to climate changes and environmental stress with shifts in community composition (Nimis et al. 2002; van Herk 2001),

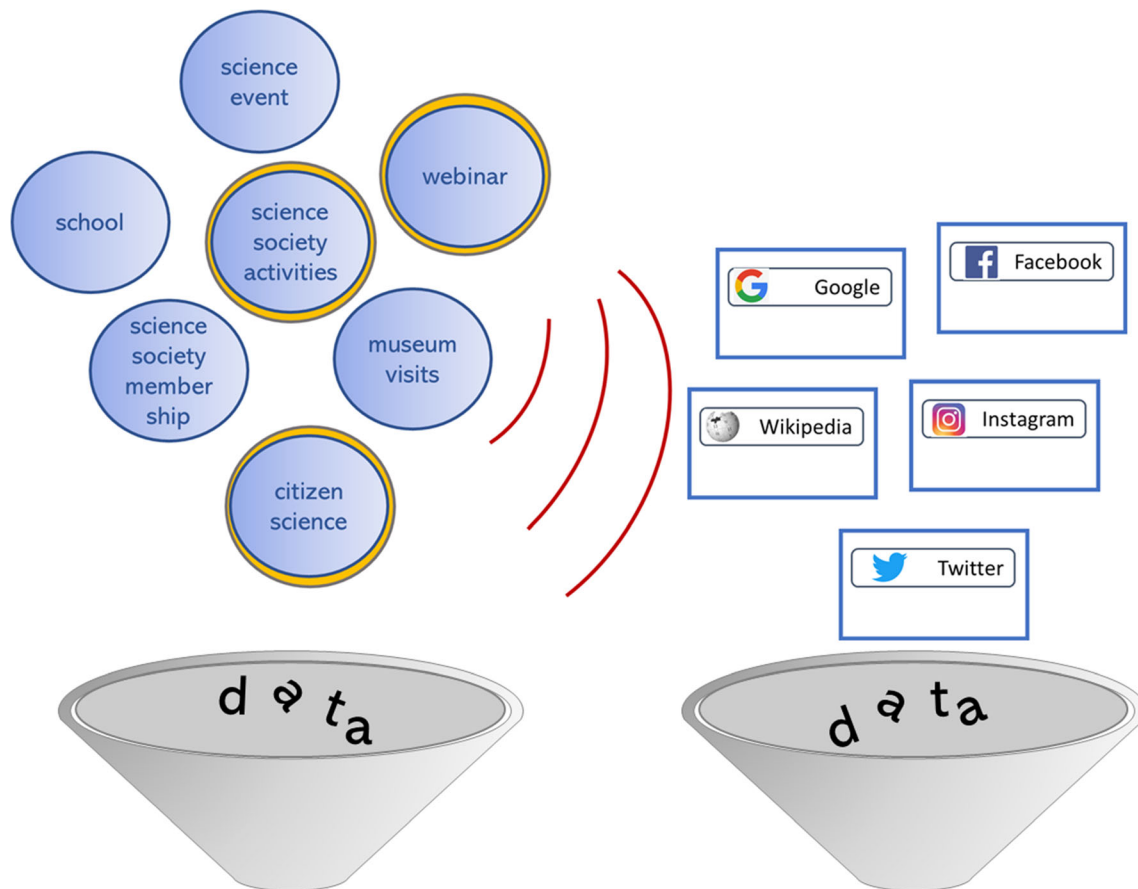


Fig. 1 New sources of data available from recent advances in scientific activities including online search engines and networking channels. Scientific activities available online are highlighted by a yellow circle.

“Science event” refers to events in-person often dedicated to a large public (i.e., science festivals organized in city centers or museums)

physiological impairment (Paoli et al. 2015; Yemets et al. 2015) and finally, with their disappearance (Isocrono et al. 2007; Munzi et al. 2007).

Caring for lichens is not only about their beauty, but about their contribution to a balanced ecosystem and their use as indicators, they help inform science-based environmental policies (Geiser et al. 2010; Manninen 2018). In order to raise awareness among the general public and stakeholders, the dissemination of knowledge about lichens is essential.

2 A case study: The “Società Lichenologica Italiana”

The “Società Lichenologica Italiana” (Italian Lichen Society, hereafter SLI) is a non-profit scientific association created in 1987 and devoted to the dissemination and progress of lichenological studies in Italy (<http://www.lichenologia.eu/>). The society organizes an annual congress, introduction and advanced courses, educational events and field excursions. SLI cooperates with other scientific societies having similar aims, both in Italy and abroad. The “Notiziario della Società

Lichenologica Italiana” is the official yearly publication of SLI and contains the proceedings of the annual meeting, original articles both in Italian and English and reports of the social activities. SLI holds a Facebook (<https://www.facebook.com/SLichenologica>) and Twitter (@SLichenologica) account open to the public and ensures communication among members through a mailing list. Unavoidably, the restraints due to the COVID-19 pandemic have affected the SLI’s activities resulting in the cancellation of the annual congress in 2020 and the creation of several online events to replace live events. Here, we analyze SLI’s activity in the period 2018–2021 to evaluate the effect of new training and dissemination methods on the increase in lichenological interest among participants.

The list of activities (detailed description in Supplementary Material) and related information presented in Table 1 was compiled from the minutes of the meetings of the SLI general assembly of 19 September 2019 and 27 July 2020; from Facebook and Twitter posts; and by contacting and interviewing the organizers. Unfortunately, it is not straightforward to determine the work and effort behind any event. We tried to compare events by estimating

Table 1 List of activities included in the SLI program from November 2018 to February 2021

	Activity	Type	Participants/ Visualizations	Effort	Date
1	Open day at a natural reserve	Live	50	1 person 4 h	Nov 2018
2	Science Festival	Live	1000	3 persons /day 8 h/day 10 days	Oct-Nov 2018
3	Seminar in a center for natural studies	Live	40	1 person 2 h	Apr 2019
4	Seminar for association	Live	NA	1 person 2 h	Apr 2019
5	Seminar Fascination of Plants Day	Live	40	1 person 2 h	May 2019
6	School lesson	Live	30	1 person 2 h	May 2019
7	Bioblitz	Live	50	1 person 1 day	May 2019
8	Seminar European Week of Parks	Live	60	1 person 2 h	May 2019
9	XXXII SLI Congress	Live	85	25 persons 13 h	Sep 2019
10	Scientific talk	Online	70	1 person 2 h	Apr 2020
11	Videoconference	Online	30	1 person 1 h	May 2020
12	Webinar	Online	22	1 person 1 h	Jun 2020
13	Seminar	Live	NA	1 person 2 h	Jul 2020
14	Workshop Biodea	Live/Online	80/>1000	1 person 1 h	Dec 2020
15	Webinar	Online	710	1 person 1.5 h	Nov 2020
16	European Researchers' Night video	Online	169	1 person 6 min	Nov 2020
17	European Researchers' Night video	Online	153	1 person 5 min	Nov 2020
18	European Researchers' Night webinar	Online	153	1 person 3 h	Nov 2020
19	Instagram direct	Online	418	1 person 2 h	Dec 2020
20	Introductory course (11 lessons)	Online	170	1 person 1.5 h	Dec 2020-Feb 2021

the “organizational effort” considering a) the duration of the activity (in terms of hours-dedication time of the specialists, and number of days-duration of the event) and b) the number of lichenologists (i.e., qualified as speakers or promoters of the event). We acknowledge that it does not include the time required to prepare the activity (backstage effort), that would be impossible to compare due to the difference in each kind of event and the variability of working schedules. In case of events first held live, then recorded and made available online, we also reported the number of participants in the live event and the number of visits of the online resource (last accessed on 13 February 2021).

Several conclusions can be drawn from the information in Table 1. First, comparing two similar time periods, from January to December, the number of activities organized by SLI members was 7 in 2019 and 11 in 2020, with 285 and 2600 participants respectively (excluding an event with an unknown number of participants that occurred in both years). Second, comparing the two largest events in the 2018–2021 period, with a similar number of participants (> 1000), the live Science Festival required 240 person-hours while the mixed live/online workshop Biodea only required 1 person-hour. Both the events were devoted to a wide variety of topics that incorporated lichens in their programs, thus the single topic

vs. multi-topic events provided another subject deserving attention. Third, the workshop Biodea was given live and then made available online, engaging 80 and > 1000 people respectively in the two formats. In addition, some virtual events were recorded and are still available online, allowing people that missed the event to access the content at any time in the future.

The organization of virtual events was shown to be more efficient than the traditional live activities: providing lichen information with lower person effort and without limits of time and space. Virtual activities had a considerable impact on the SLI. In the last decade, it has not been possible to organize introductory courses every year, often due to lack of subscriptions. In addition, dates and places for in-person-gatherings were not always suitable for people interested in attending, while 170 enthusiastic people registered for the online introductory course. The activity resulted in 91 new members for the Society, a greater increase in a single year than any other in the last decade (Fig. 2).

3 New tools to detect a growing interest in the subject

Google Trends is a platform created by Google LLC to analyze the popularity of top search queries in Google Search. Google Trends compares the searches of different queries over time and provides the results as graphs or rough data. It is a tool largely used in culturomics (Ladle et al. 2016). Notwithstanding relevant limitations, it allows us to assess the popularity of a specific topic. Google Trends also organizes information by a given region of the world, and/or a given language. Setting the search for the word “licheni” (lichens in Italian), in Italy, in 2020, we looked for correlations between the SLI events and the number of lichen-related searches in Google in the last decade. The word “licheni” in Italian has no other meaning beside the symbiotic association, and this increases the reliability of the data. While the results

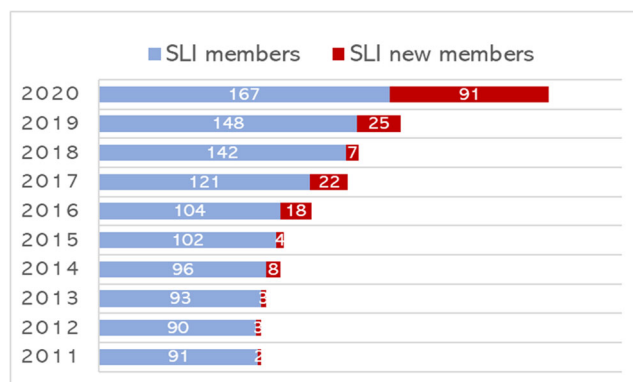


Fig. 2 Yearly increase in membership of the Italian Lichen Society between 2011 and 2020 (data from the official statistics on the SLI website http://lichenologia.eu/index.php?procedure=pres_stat)

returned by Google Trends showed moderate oscillations for most of the time, a relevant peak occurred in the period 15–28 November 2020 (weeks 46 and 47 in Fig. 3 upper graph). Looking at the list of SLI’s events (Table 1 and SM), the ones numbered 15–18 coincide with the sudden increase of interest in lichens. The event 15 (held on the 25th of November) is a webinar intended for students of an academic association, while events 16–18 are one seminar and two videos that were included in the program of the European Researchers’ Night 2020 (28th of November). No other lichenological events occurred in that period, and we can conclude that many of the lichen-related searches were undertaken by people wishing to attend these events given that they preceded the actual event. We also searched for trends in other European countries. A search in Germany for “flechten” (German for lichens) provided similar results to the Italian results. The peak during the week 5–11 April 2020 (week 14 in Fig. 3, bottom graph) coincides with two field excursions in the parks of Berlin that focused on lichens at the beginning of April 2020 (detailed description in SM).

Social media are another powerful tool to assess the interest raised by topics shown in posts and tweets (e.g., Alsaif et al. 2019; Khan et al. 2021). Since the SLI Twitter account has only been resumed recently, after a gap in the frequency of posts, we focused on the official Facebook (FB) page of the Society. To understand how online events are appreciated by

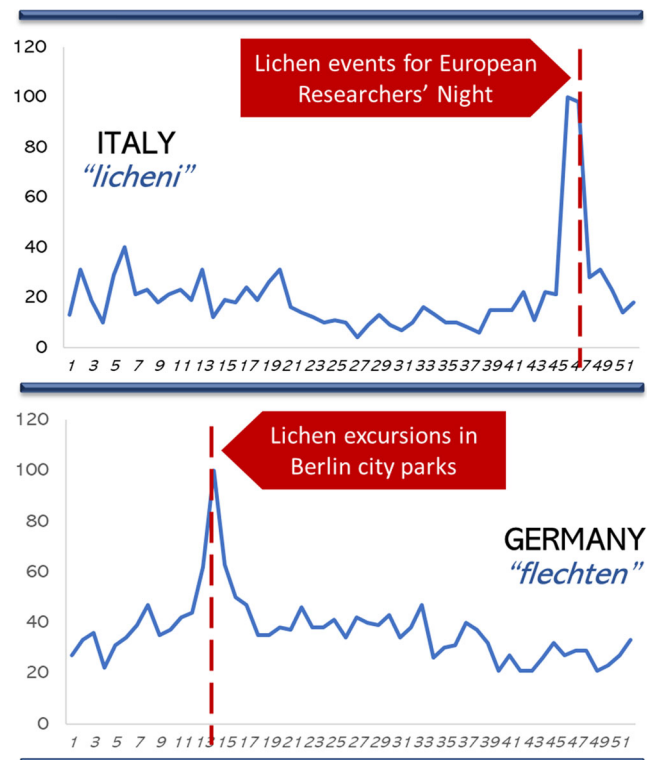


Fig. 3 Weekly frequencies of word searches returned from queries in Google Trends for the words “licheni” and “flechten” (last accessed 13 February 2021)

SLI followers we analyzed all the posts published from 1 November 2020 until 14 of February ($n = 60$ posts), representing the variety of topics usually posted on the page. We grouped posts (Table 2) as follows: **Members activity** - updates on ongoing projects, participation at congresses and courses, individual notes; **SLI unrelated** - news about other scientific societies, museums, congresses, and awards not promoted by SLI; **Other** - enquiries about lichens, photos, references to lichens in other contexts; **Publications** - papers, books, and other publications from SLI members; **Resources** - freely available resources such as identification keys, floras, training material; **Awards and Scholarships** - announcements of scholarships or positions; and **Online events** - announcements, programs and reports of online events organized by SLI and SLI members. Posts' performance (parameters: likes, people reached, and engagements) was calculated as the average, based on the total number of posts for each group. For each of the parameters, the greatest interest of SLI followers was in online events. Posts on the announcement of online events and presentation of the events' programs had the best performance individually (Fig. S1).

4 Evaluating participants experience

After an outreach course organized by SLI in January 2021, we launched a questionnaire through the society itself. Participants and SLI members were asked questions (full list reported in SM) focusing on lichens and experience with in-person and online events. For example, this included questions about: when their interest in lichens began, whether this interest was linked to online or in-person events or search channels, and if an appreciation of lichens was linked to environmental issues and conservation. We got 181 respondents to our online questionnaire. Our first question grouped the age of respondents in four categories: 16–25 years old, 26–40, 41–50, more than 50. Results showed that respondents were

evenly distributed, with more people in the last group (34%). Many respondents (60%) got their first contact with lichens through studies at school, while 35% from field excursions. We expected the first result as lichens and mosses are often introduced in Italian school textbooks, while the response to field excursions is probably linked to the growing interest in nature and open-air activities, as well as students' attendance at preliminary courses. Events (in-person or online) rarely sparked an interest in lichens; however, only people over 40 age found events an opportunity that raised their interest. The reasons behind this result may be explained by the following. As respondents were linked to SLI, we asked questions related to their sources for obtaining further information. We investigated the modes applied to the search of information: books, outreach or academic material online, social media. The increased availability of material online, from academic sources as scientific papers to thematic websites plays a major role (Fig. 4, left side), combined with access to social media. However, for gathering information on lichens, 21% of our participants still refer to books or articles in paper format. Events may be disregarded partly by shortening of frequency of in-person ones, that may result attractive also due to the inclusive social perspective. However, also events as the Researchers' Night or universities open days did not impress a large audience. We addressed the participation to different type of events: online and/or in-person. Our questions were separated for online and in-person events to possibly highlight participation at specific dissemination events. A relatively small number of events raised interest, either online or in-person: the majority of persons never followed an event, online or in-person. Using results based on type of events (academic or outreach activities), we observed two different paths (colored triangles in Fig. 4, right side). Respondents interested in outreach activities followed them more frequently online, while respondents interested in academic activities preferred them in-person. Therefore, possibly a different approach based on expected networking

Table 2 The first column lists the groups assigned to FB posts (SLI FB page, from 1 November 2020 to 14 February 2021). Posts' performance (likes, people reached and engagements) is reported with averages and ranges in parenthesis. Likes - number of people who liked the post; People reached - number of people who included content from the post

	Number of posts	Likes	People reached	Engagements
Members' activity	8	14 (6–43)	287 (130–963)	71 (10–405)
SLI unrelated	6	14 (6–26)	261 (147–342)	33 (10–55)
Other	5	16 (5–25)	477,147–1203)	84 (10–240)
Publications	15	11 (2–30)	297 (101–583)	31 (4–87)
Resources	3	18 (8–37)	661 (161–1632)	52 (14–126)
Awards and Scholarships	2	12 (10–14)	712 (651–773)	36 (25–47)
Online events	21	22 (7–46)	750 (146–1148)	110 (19–487)

in their profile. This includes posts, check-ins, ads, social information and more (Unique Users); Engagements = number of people who engaged with the post. Engagement includes any click or story created (Unique Users)

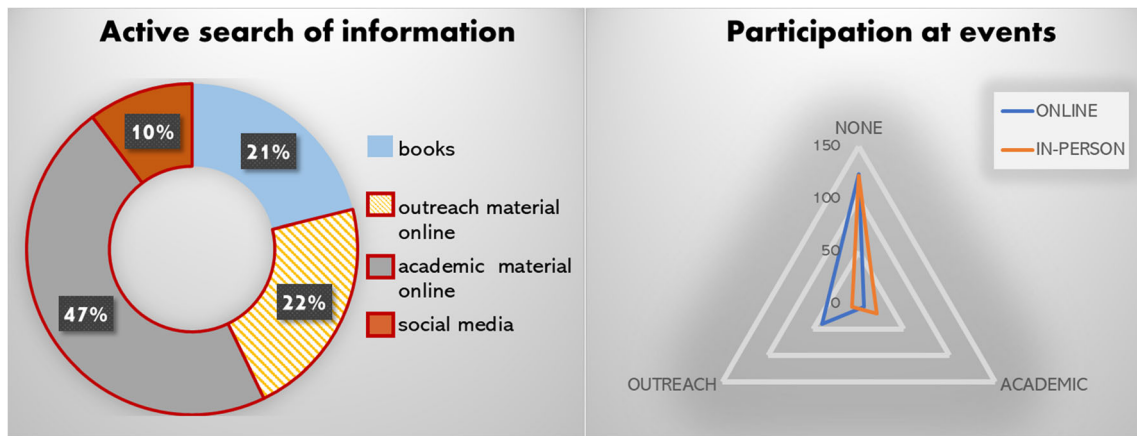


Fig. 4 Results of the questionnaire circulated among participants and members of SLI. On the left, online search of information was preferred (red-highlighted portions of the circle) as opposed to printed material; relative percentages are reported. On the right: despite a strong avoidance

of direct participation at events, online events were preferred for outreach activities while in-person events for academic activities; axis represented the total number of replies

opportunities is at the base of participation at events, excluding the topic itself.

We also found that most people increased their online searches in 2020 (Fig. 5), even if online tools were already available before. Curiously, people over 50 showed the highest decrease in online searches among the age groups.

The great majority of respondents (93.26%) think that their participation in online events increased their awareness of the role of lichens in the environment. The main drivers were considered to be: the contribution of lichens to biomonitoring environmental pollution (40%); the role of lichens in conservation of biodiversity (36.11%); the direct effect of lichens on the ecosystem (16.67%). However, a small number of respondents (7.22%) were not convinced of the potential of lichens to increase awareness of environmental issues, notwithstanding half of them participated in an online outreach event.

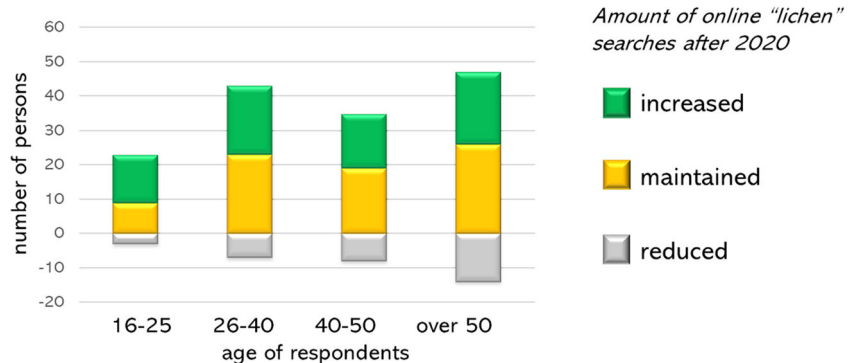
5 From virtuality to reality

Travel and meeting restrictions imposed by the COVID-19 pandemic are considered a threat to research and education

(Swing et al. 2021). Nevertheless, virtual events are here to stay.

Although practical lessons, excursions and networking benefit participants with a physical presence and increased human/social contact, we cannot ignore that online communication is easier, cheaper, more sustainable, and more inclusive. Health-security priorities during the COVID-19 pandemic forced people to turn to virtual events, platforms where sharing was an option in absence of other in-person modes of communication. In health-secure conditions, the webinar organized by the International Symbiosis Society on 30 July 2020 titled: “Symbiosis: when living together is a win-win”, was a two-hour event attended by more than 500 people from all over the world. A main achievement of the event was the inclusion of countries that, due to economic or administrative constraints, are not usually represented at international meetings. Similarly, the advanced course “Until death do us apart: Living in a symbiotic world” (organized by the Centre for Ecology, Evolution and Environmental Changes of the University of Lisbon, Portugal) included only the participating speakers from Portugal in the 2020 live version. In the 2021 online version, speakers participated from Germany, Italy,

Fig. 5 Frequency of online searches for lichens during 2020 arranged by age. Increased online searches - green, maintained online searches - yellow, reduced online searches - grey



India, Netherlands, Portugal, and United States of America, and at no extra cost.

In the field of lichenology, it has been some time since scientific societies organized introductory and advanced courses, or educational activities for citizen science. Training courses usually involve people that are already studying or working in the fields of ecology, biology, natural science and related areas. Even if this type of audience is already aware of environmental issues, further training increases scientific knowledge about lichens, highlighting the most recent findings and fostering transdisciplinary perspectives. For the public, citizen science activities are a good way to increase knowledge and concerns about lichens. The data we analyzed suggest that the “reach” of outreach activities can greatly benefit from virtual experiences, although more data are needed to evaluate other aspects, for example the efficiency of in-person vs. online-only events for increasing technical knowledge and lichen identification skills of participants.

How does this translate into environmental conservation? As conservationists stress, people care and value what they are familiar with (Jepson and Barua 2015). Among lichens, a good example is *Lobaria pulmonaria*: a relatively rare lichen mainly threatened by habitat destruction (Bianchi et al. 2020). In 2017, a local environmental association in the Murlo Municipality (Siena, Italy; Comitato Amici del Crevole, 2017) added the presence of a rich community of *L. pulmonaria* to the list of ecological features requiring protection in a forested area. Although not as cute as a panda, *Lobaria* can be considered a flagship lichen species: big (for a lichen), beautiful, easily recognizable, and linked to ancient forests of long ecological continuity.

The analysis of results from SLI members over a specified period of time has shown that virtual events can be powerful instruments for increasing knowledge and awareness of lichens in a range of audiences. Virtual events can certainly be increased (thankfully not to replace live ones) and developed to support increasing interest in lichens in the public arena. Results of continued efforts could be expressed in future years by a Google Trend plateau, instead of the present isolated peaks that were observed to follow individual one-off events.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s13199-021-00780-6>.

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