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## LICHENOLOGICAL STUDIES IN SICILY: A THOROUGH BIBLIOGRAPHY (1692-2020)

### SUMMARY

A bibliography on lichens in Sicily has been compiled and is here provided, as a comprehensive source to facilitate further studies focused on the regional territory. We checked the available literature from 1692 to 2020. We listed alphabetically a selection of 397 key publications and provided some comments on their distribution in time and space, and on the main studied topics. The complete reference list is freely available online.

*Key words:* Lichenology, literature, Mediterranean

### RIASSUNTO

*Studi lichenologici in Sicilia: una bibliografia completa (1692-2020).* Si riportano i risultati della ricerca bibliografica condotta sugli studi lichenologici in Sicilia come contributo alle future indagini ed esplorazioni lichenologiche focalizzate sul territorio regionale. Le pubblicazioni analizzate sono state date alla stampa in un lasso di tempo compreso tra il 1692 ed il 2020; ne è stata ricavata una bibliografia di 397 riferimenti che viene presentata e commentata. L'elenco delle pubblicazioni è liberamente consultabile online.

*Parole chiave:* Lichenologia, bibliografia, Mediterraneo

### INTRODUCTION

Sicily, as islands in general, is commonly regarded as a biodiversity hotspot and therefore many animal and plant groups, as well as relationships among them, have been extensively studied. While many reviews can be found on natural sciences topics, Sicily still lacks a synthesis of the lichen-

logical knowledge. Indeed, some lichenological papers were mentioned in the Sicilian Geobotanic Literature (RAIMONDO *et al.*, 1982) a repertory that includes 11 references in the 1848-1981 timespan.

According to the catalogue of Italian lichens (NIMIS, 2016), 960 lichen species are known from Sicily. This can be considered a medium level of exploration compared to other Italian regions: in 2016 the maximum number of known lichen species per administrative region in Italy was 1582 (Trentino-Alto Adige), the minimum was 490 (Molise).

This bibliography is a stock-taking of what has been published about lichens in Sicily, as thorough and accurate as possible. The project aims at building and maintaining a complete and updated dataset, freely available online, to allow easy consultation and use of data on lichens in Sicily. Undoubtedly, a reference list represents an essential step to build and deepen knowledge on a specific topic: we hope this paper can be a useful tool for further lichenological research in the region.

## MATERIALS AND METHODS

### *Data source*

The main data source was the scientific literature analysed by consulting the major editorial portals of scientific publications ([www.scopus.com](http://www.scopus.com); [www.sciencedirect.com](http://www.sciencedirect.com); [www.tandfonline.com](http://www.tandfonline.com)). Previously specialized bibliographies (PIERVITTORI *et al.*, 1991, 1994, 1995, 1996, 1998, 1999, 2001, 2004) and the two volumes on the lichens of Italy (NIMIS, 1993, 2016) provided further information. The information collected was also implemented through the thematic consultation of the OPAC SBN, the collective catalogue of libraries participating in the Italian National Library Service. Finally, the prepared list was cross controlled by consulting the Recent Literature on Lichens (CULBERSON *et al.*, 2015) a series that lists all recently published papers in lichenology.

As to the type of material included herein, most of the references are scientific papers, but selected general-interest articles are included when they report lichen species occurring in Sicily. In general, we listed all those papers in which species are mentioned for at least one locality in Sicily, lists of species, all monographic works, and taxonomic revisions in which species growing in the island are mentioned, general papers that touch upon Sicilian lichens. Unpublished theses were not taken into account. Similarly, technical reports (such as environmental and forestry assessments, risk management plans), with rare exceptions, have been excluded. It must be said that in these

last types of documents the lichen component is often absent or underestimated.

### *Data processing*

Articles were classified according to the type of journal, relevance, topics, geographical information and date of issue, to obtain a screening on national or international relevance, temporal trend of the lichenological studies, sub-regional distribution in Sicily. One of the following categories has been assigned to each document in regard to the type of journal/editors:

- Paper published in journal
- Monograph
- Congress proceedings
- Abstract
- Other (cartographies, technical reports, theses).

We distinguished papers also according to their relevance:

- National Relevance: papers with a local to national dissemination (e.g. local scientific journals, studies presented at national conferences)
- International Relevance: papers with international dissemination (e.g. international journals, studies presented at international conferences).

Documents have been classified according to their subjects too. The chosen categories are:

- Flora and vegetation: dealing with the presence and distribution of lichens and lichen communities
- Taxonomy: revision of taxonomic groups, description of new species, phylogenetic studies, nomenclatural revisions
- Applied lichenology: dealing mainly with the use of lichens as biomonitors, bioaccumulators and weathering agents
- Embryophytes: including researches devoted to vascular plants or bryophytes in which lichen data occur
- Lichenicolous: including researches devoted to fungi in which lichens are reported as fungal host
- Others (studies on chemical compounds in lichens, studies on algal partner, ecology and ecophysiology, popularization papers, herbaria, lichenometry).

Distribution data (number of documents and their typology) are given for the nine administrative provinces of Sicily and the main surrounding islands (Aeolian Islands, Aegadian Islands, Pelagian Islands, Island of Ustica, and Island of Pantelleria). Although from an administrative point of view islands belong to one province, we preferred to keep them separated to make data available on a geographical basis. In the same way, administrative

provinces are a first approximation to obtain a more accurate information on lichen geographic distribution on a regional scale.

## RESULTS AND DISCUSSION

The results of data processing show that a total of 397 papers relating to Sicilian lichenology, covering a time-span of 328 years, have been published; 133 of them with international relevance and 264 published at the national level.

References published by August 2020 are listed. The references are arranged alphabetically by author and are freely accessible on the internet at the address [www.ssn.it/lichenologica.html](http://www.ssn.it/lichenologica.html). Furthermore, we included the references reporting at least one species in the Italian Floristic Bibliography, a project of the Italian Lichen Society ([slifloristica.wixsite.com/licheni/sicilia](http://slifloristica.wixsite.com/licheni/sicilia)). In order to make our data available for the maximum number of users, PDF files have been linked to correspondent documents within the limits of the current legislation on copyright.

The earliest records date back to some pre-Linnaean authors. In this period lichens, due to their scarce economic value, were not been thought worthwhile studying and only sporadically reported in botanical works. Francesco Cupani (1657-1710), a friar and a botanist of the seventeenth century, reported in his papers (CUPANI, 1692, 1695, 1696, 1697) some species, in polynomial nomenclature, which can be recognized as lichens (e.g. *Muscus pyxidatus*, *minor*, *fimbriatus*, *laceratus*, *saxatilis*; *Muscus pulmonarius*, *arboreus*, *incanus*). Even if the specific identification of these lichens cannot be certain, these records can be considered – as far as we know - the first lichen records for Sicily. Cupani was probably aware of lichens: in his posthumous *Panphyton Siculum* (CUPANI, 1713), a collection of drawings and engravings aimed to illustrate a never issued volume of “Natural History of Sicily”, we found some lichen drawings. Moreover, in an herbarium housed at the University of Catania, and attributed to Francesco Cupani (PULVIRENTI *et al.*, 2015; COSTA *et al.*, 2016), a single lichen exsiccatum (*Lobaria* sp. according to PULVIRENTI *et al.*, 2015) occurs.

Paolo Boccone (1633-1704), another eminent Sicilian botanist who was in contact with many European naturalists, included in his main book (BOCCONE, 1697) six lichens under the polynomial description of *Muscus*. ROCA & NIMIS (2002) attribute these species, on the base of descriptions and drawings, to *Roccella phycopsis* and some *Cladonia* species. One of these species, unfortunately the less identifiable one, was surely collected in Sicily.

Inspection of gathered data clearly shows that there was a significant increase in the field of lichen studies in Sicily at the turn of the 20th century, this trend goes on all along the century and exploded in recent years (Fig. 1). Surprisingly, during the “Golden period” of Italian Lichenology - i.e. the period starting in 1846 and ending in 1880 - in which Italy became the main centre of Lichenology worldwide (NIMIS, 2016), Sicily doesn’t show a very high lichenological production. Only 7 papers were issued in this period, *Lichenographia Sicula* by TORNABENE (1848-1849) being the only one specifically dedicated to lichens in Sicily.

Most of the documents (268 = 67.5%) are scientific papers published in national (149) and international (119) journals. Remarkably, as much as 65 documents are one-page abstracts, 30% of these never published as a full article.

The majority of the papers are written in Italian (164) and English (154); this is obvious since Italian is the national language and English is the most widely used language for the transmission of scientific knowledge. The presence of 53 papers (13%) written in German is worth of interest, as it can be considered evidence of the intense exploration and affection for Sicily by German speaking lichenologists.

Analysing the German (s.l.) contribute on the whole – regardless of the language used – many works are related to lichen *exsiccata* collected in Sicily in the period 1960-1990 by Poelt, Hafellner, Hertel, Honegger and revised for taxonomical or nomenclature problems to be solved.

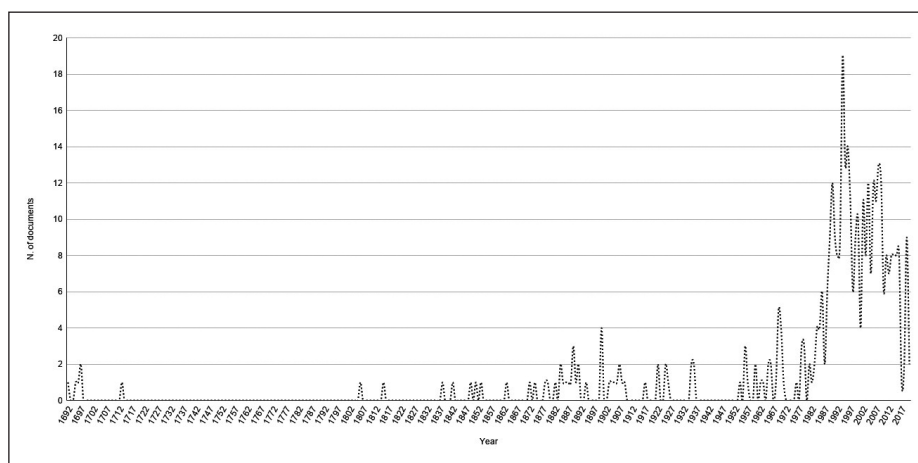


Fig. 1 — Diachronic overview on the publishing date of the 397 documents concerning Sicilian lichens.

An equal distribution among topics arises in our list (Fig. 2). A third of the analysed studies (124) deals with lichen flora and vegetation. The floristic works provide, obviously, the highest number of citations. Floristic studies, although basic, are useful to answer questions on the occurrence or non-occurrence of a species, biogeography, conservation and evolutionary biology and they are helpful to locate areas with high species richness or, on the other side, areas in need of further exploration. Generally speaking, floras were popular early in the history of botanic sciences. After falling into disfavour, nowadays they are once more taken into account, mainly due to concerns about the loss of biological diversity worldwide. This trend is clearly recognizable in Sicilian data: after the relevant floristic contributions appeared between 1850 and 1920, over half of floristic papers (55%) were published in the last 25 years.

Almost a third of the retrieved papers (113) is specifically focused on

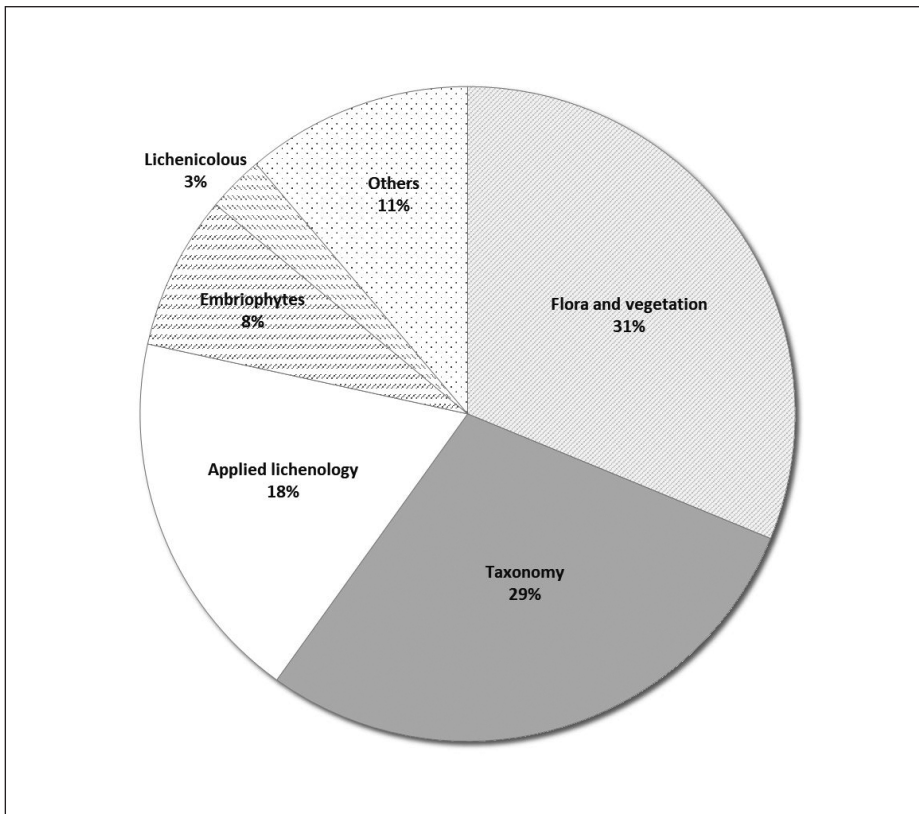


Fig. 2 — Distribution of publications among topics.

taxonomic issues (revision of lichen groups, phylogenetic studies, nomenclatural changes, etc.) and generally contains few species records. The number of taxonomy-focused papers has been increasing over time: in fact, in the last years taxonomy continues to speed up and new techniques and instruments cause a big amount of new data and publications.

In Italy, in the last decades, the use of lichens as biomonitors increased a lot, both in disturbed environments and more recently in forests. In Sicily, 43 papers deal with biomonitoring, mainly (78%) using lichens as accumulators. Some of these studies focus on trace metal contents in volcanic areas (Mt. Etna and the island of Vulcano) to compare the emissions introduced into the atmosphere by volcanoes with those derived from anthropogenic activities.

Even if studies about lichen and forests are receiving increasing attention in the last decades, this topic is yet scarcely present in the lichenological literature in Sicily: research about lichens as indicators of environmental conditions and management in forest ecosystems, as well as those related to fire and lichen dynamics, have not yet been developed (we found only one preliminary study on old-growth forests marginally reporting lichen data) and deserves more attention.

In the end, about 12% of the studies deals with organisms other than lichens. About 30 documents are devoted to phanerogams. These are mainly old studies issued in a period when lichens were not given attention for themselves and they were treated with plants and studied by vascular plant specialists as part of local floras. In addition, the lichenicolous fungi are a highly specialized group of species that form obligate associations with lichens. In the last decades, our knowledge of the fungi growing on lichens has continued to rise exponentially, and we found, in the period 1995-2016, 11 papers regarding this topic.

Moreover, 13 papers concern lichen herbaria. In these works, and in many taxonomic papers, data relies on lichen exsiccata. It is quite common that lichens, widely collected during several botanical excursions in Sicily, were then distributed as exsiccata and later revised for taxonomical purposes. Lichen specimens, with the related possibility of checking them, enriches literature data. Their role is crucial not only in plant taxonomy but also for new tasks as monitoring and conservation actions.

As far as the geographical distribution of literature references is concerned, most of them report precise geographical data, while only 12% can be considered inaccurate (Sicily or very large areas). Apart from the seventeenth-century papers, these geographically wide-interest works are mostly taxonomic papers (descriptions of new taxa, genera and species revisions) and national checklists in which data are treated at the regional level.

Most of the studies, particularly the floristic ones, has been carried out at the local level, only few pertained to a wider area (Sicily, South Italy, or Italy). From a geographical point of view (Fig. 3), the best-known province (with the highest number of lichenological publication) is Catania, mainly because of the environmental impact and problems of volcanic areas. The main topics found in these lichenological works are studies on flora and vegetation of Mount Etna; lichen-rock interaction; weathering of lavas and bioaccumulation of trace elements (heavy metals, fluorine) by volcanic emissions. Palermo province (particularly Madonie Mountains and other mountains around Palermo) also results to be a rather well studied area. This can be explained, as for Catania, with the presence of some lichenologists active in local university during the last decades of the XXth century. For the same reason, Messina (the third Sicilian university) is the third province in order of number of publications.

It is interesting to note also the high level of exploration of some circum-Sicilian islands (like Marettimo, Pantelleria, and Lampedusa) by both Italian and foreign lichenologists. This trend matches what happened also with vas-

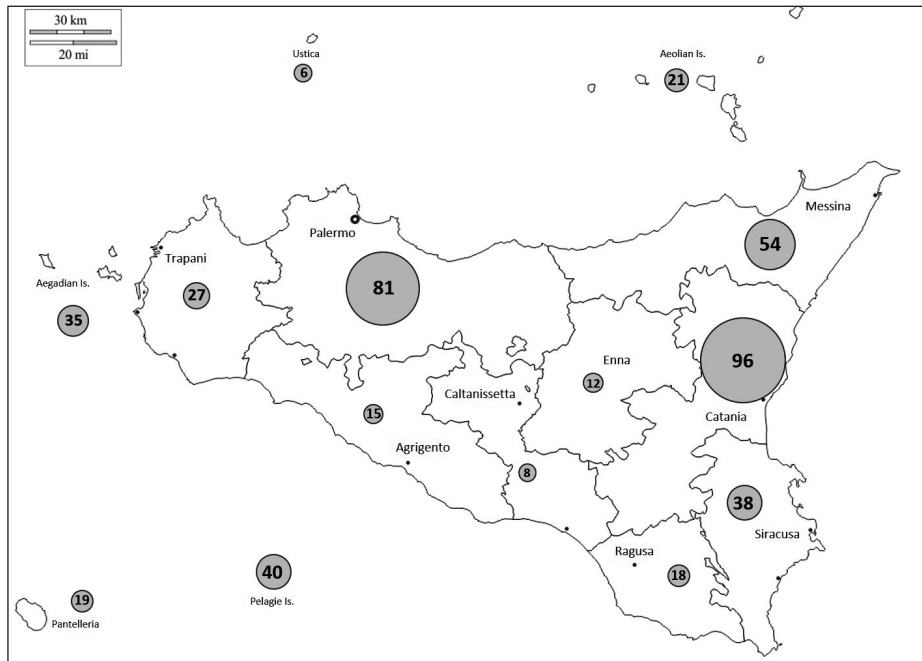


Fig. 3 — Geographical distribution (administrative provinces and satellite islands) of the papers featuring in the Sicilian lichens' reference list. Numbers refer to the number of publications.



cular flora. In the Aegadian Islands, undoubtedly the best studied island is Marettimo: over 300 lichens and lichenicolous species are reported in 28 papers. Favignana (3 species in 4 papers) and Levanzo (2 species in 2 papers) are much less investigated, as well as the Isole dello Stagnone (13 species in 2 papers) here included.

This review represents a baseline for lichen investigation in Sicily; it can be useful for researchers to choose new or scarcely studied research topics and it can be relevant also for decision-makers as a base for taking informed environmental decisions. The on-line availability of this reference list allows its regular update and provides open access to information making the data more visible and reachable to users.

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