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Macromycetes of the hills of the Province of Bologna (Italy): presentation of a new check-list

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Abstract

The authors present a 2014 updated list of 1,110 macromycetes found in the hilly territory of the Province of Bologna , Italy, covering about 1,200 km^2 at an altitude ranging mainly between 100 and 600 m. a.s.l..
Moreover, some shorter lists have been extracted from the data, including 36 "very rare" mushrooms (in Italy known only in the Province of Bologna), 20 "rare" (known only in Emilia-Romagna), 86 "vulnerable" (no longer found in the last 22 years in the territory investigated) and 6 which the European Council for Conservation of Fungi has proposed for protection at the European level.
The authors suggest a deepening of studies of the entities on these lists, with a census of locations and habitats, aimed at their protection and at the conservation of their natural environments.

Keywords: mycological diversity; macromycetes; rare fungal taxa; species conservation

Riassunto

Viene presentata una lista aggiornata al 2014 dei 1.110 macromiceti noti per il territorio collinare della provincia di Bologna, esteso circa 1.200 km^2 e con altitudine per lo più compresa tra i 100 e i 600 m. s.l.m. Da essa vengono estratti gli elenchi di 36 funghi “rarissimi” (noti in Italia solo per il Bolognese), 20 “rari” (noti solo per l’Emilia-Romagna), 86 “vulnerabili” (non ritrovati negli ultimi 22 anni nel territorio indagato) e 6 proposti dall’European Council for Conservation of Fungi per la protezione a livello europeo.
Viene suggerito un approfondimento degli studi delle entità contenute in questi elenchi, con censimento delle località ed habitat di crescita, finalizzato alla loro protezione e alla tutela degli ambienti naturali.

Parole chiave: diversità micologica; macromiceti; specie rare; conservazione delle specie

Introduction

In 2006, after many years of bibliographical and field research done by a large group of mycologists, the Atlas of macromycetes of the Region Emilia-Romagna (hereinafter referred to simply as Atlas) was published, which reported the enumeration and a partial mapping of known regional macromycetes (PADOVAN 2006).
The Atlas check-list includes a total of 2,797 taxa (2,676 species, 89 varieties, 32 forms), known from the various Provinces of the Region in varying proportions, as shown in Table 1. The Atlas combined all results

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of research carried out on macrofungi in the cartographic units in which they were found (Chapter 4.4 "Cartine distribuzionali delle specie" and Chapter 4.5 "Specie rare senza cartina distribuzionale"). Only 177 species were without a clear location (Chapter 4.6 "Specie senza precisa localizzazione").

Tab. 1 Number of macromycetes in Emilia-Romagna, divided by Province
Tab. 1 Numero dei macromiceti in Emilia-Romagna divisi per provincia

Piacenza	Parma	Reggio Emilia	Modena	Bologna	Ferrara	Ravenna	Forlì-Cesena	Rimini	Emilia-Romagna
263	1,219	879	939	1,260	682	1,219	952	151	2,797

In the years after 2006, we collected a good amount of new records on macromycetes of the Province of Bologna (including many taxa not listed in the Atlas for the same Province), deriving in part from our previous surveys and in part from further research in the area.
The selected area is approximately 1,200 km^2 and corresponds to the hilly territory of the Bolognese, south of the Via Emilia, which ranges between 100 and 600 meters above sea level. This represents about 1/19 of the Region Emilia-Romagna and nearly 1/3 of the Province of Bologna (the other two portions are the larger lowland north of the Via Emilia and the smaller Apennine and sub-Apennine zone, south of the investigated territory). The total number of taxa found (551) has induced us to integrate them into the list of the Atlas.
A comparison was done to specifically verify how many and which species found in the past were no longer found in the last 22 years, characterized, among other things, by a changing climate (higher temperature and less rainfall).

Materials and methods

To perform this analysis as correctly as possible it was necessary to define exactly the area of investigation, in order to have the same for the three lists under comparison: the bibliographic list of the Atlas (data before 1993), the research list of the Atlas (data mostly between 1993 and 1998, and in smaller part until 2005) and our current list (data mostly between 2005 and 2014, and in smaller part from 2000 to 2004).
Taking into account all available elements, we thought the best way was to use the cartographic method adopted in the Atlas, previously developed for mapping regional protected flora (ALESSANDRINI & BONAFEDE 1996). This method, compatible with that used in the "Floristic cartography of Central Europe" (EHRENDORFER & HAMANN 1965) and often applied, consists in the subdivision of the territory into cartographic units, corresponding to "rectangles" of approximately 147,1 km^2 (about 13.25 km x 11.1 km at the latitude of Emilia-Romagna) (ALESSANDRINI & BONAFEDE 1996).
The codes of the nine cartographic units examined, in reference to the Atlas and to Figure 1, are as follows: 1532 (= 2203 = 220SO), 1632 (= 2374 = 237NO), 1533 (= 2202 = 220SE), 1633 (= 2371 = 237NE), 1534 (= 2213 = 221SO), 1634 (= 2384 = 238NO), 1734 (= 2383 = 238SO), 1635 (= 2381 = 238NE) e 1735 (= 2382 = 238SE); only mycological data of the province of Bologna were evaluated excluding those of neighboring provinces (Modena, Ravenna and Firenze). This area includes, in whole or in part, the territory of 24 of the 52 municipalities of the Bolognese: Bologna, Borgo Tossignano, Casalecchio di Reno, Casal Fiumanese, Castel d'Aiano, Castel del Rio, Castel San Pietro Terme, Castenaso, Dozza, Fontanelice, Grizzana Morandi, Imola, Loiano, Marzabotto, Monghidoro, Monterenzio, Monte San Pietro, Monzuno, Ozzano dell'Emilia, Pianoro, San Lazzaro di Savena, Sasso Marconi, Valsamoggia and Zola Predosa. The minimum altitudinal levels investigated are in small portions of the lowland and urban areas of the municipalities of Bologna, Castenaso, Imola and Ozzano dell'Emilia (about 40-70 m a.s.l.), which are, however, almost without

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mycological data, while the highest altitudes are identified in the small mountains of the municipalities of Vergato and Monghidoro that approach 800 m a.s.l.. The selected cartographic units here reported (Figure 1) sometimes overlap with the territory of neighboring provinces. In this case the data were compared with those of regional checklists referring to the provinces of discovery (Chapter 4.3 "Tabella delle presenze nelle Province, nelle aree protette e in alcuni boschi notevoli") and to the source used (Chapter 4.1 "Check-list dei macromiceti della Regione Emilia-Romagna"), in order to extract only the data referring to the Bolognese territory.

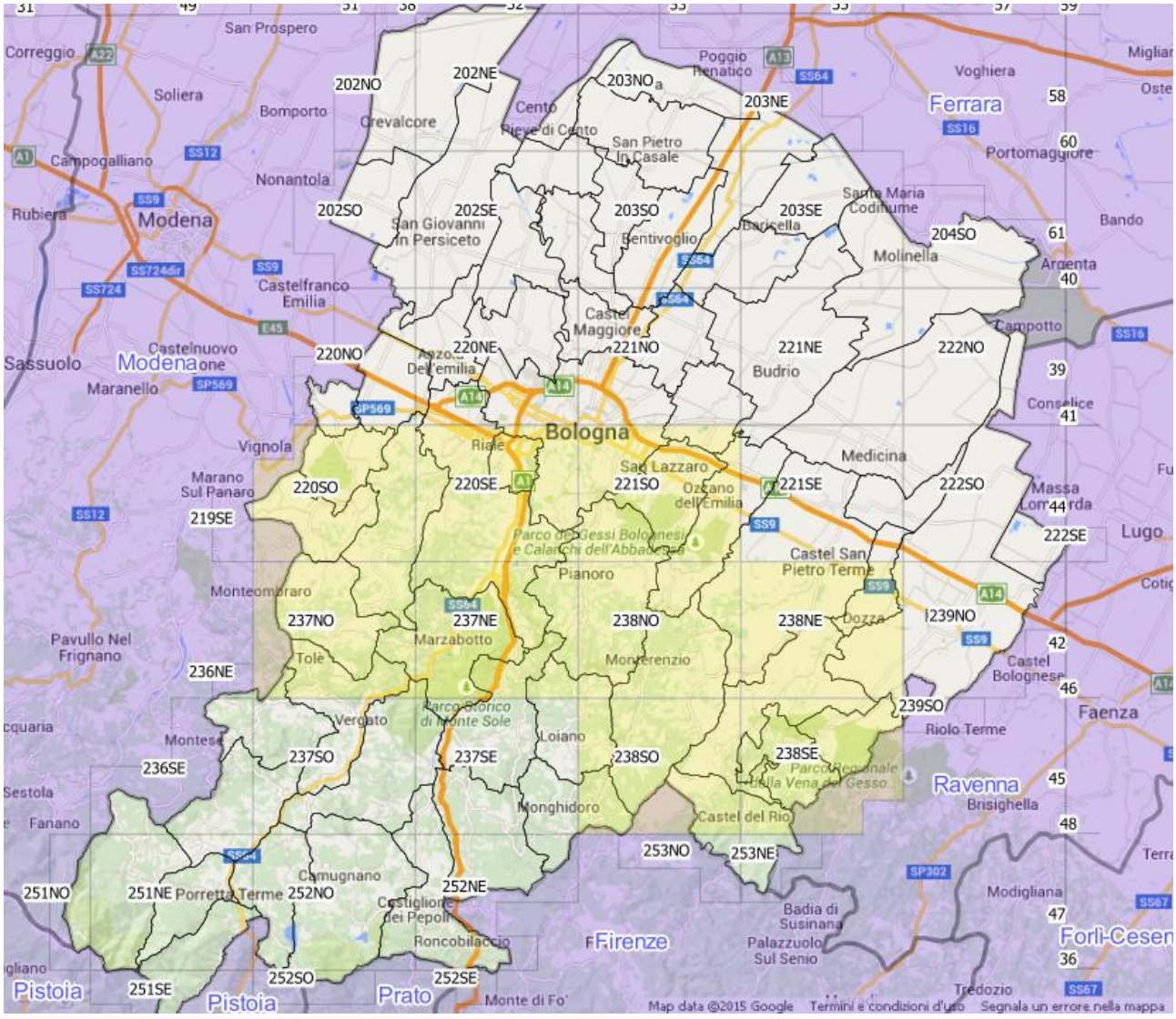

Fig. 1 – Hilly area subject of the investigation
Fig. 1- Territorio collinare oggetto dell'indagine

The data resulting from our surveys, most more recent than those of the Atlas, were sometimes, when of particular interest, published separately (CONSIGLIO et al. 2009; ILLICE et al. 2013; ILLICE & TODESCHINI 2009, 2013A, 2013B) or are in print (ILLICE et al. in print; ILLICE & TODESCHINI in print) or derive from our personal lists if they relate to the most common species.

The taxa identified as belonging to the fungal biota of the Bolognese hills in the manner described above were also compared with the national framework distribution for the region reported in the Italian checklist, limited, however, only to Basidiomycetes (ONOFRI 2005). As regards the nomenclature, we have chosen, for

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reasons of simplicity and easy of reference, to continue to refer to that used in the Atlas, as well described in Chapters 3.6, 4.1 and 4.2, except for a very few necessary exceptions.

Geological and vegetational characteristics of the investigated territory

A key feature of the previously defined territory consists of the gullies (“calanchi”), poorly covered with vegetation for reasons both geo-climatic and sociological-historical. The “calanchi” are forms of deep erosion determined by the flow of water on clay soils. The composite rocks that are randomly mixed in the scaly clays of the badlands, partly formed by the Ligurian Ocean of the Middle Jurassic (about 180 million years ago) and therefore called Ligurian Units, are made of limestone blocks, marl elements, brown sandstone and, less commonly, dark ophiolitic pieces.

The phenomenon of the gullies is present in large areas of the hills around Bologna and is often the dominant note of the landscape. Recently it underwent strong anthropogenic pressures such as deforestation, crop growth and pastoral activities that have been too intensive for the nature of the soil, thus amplifying its natural predisposition to erosion.

Another significant feature of the hilly territory of Bologna is the spectacular yellow sandstone of the Natural Reserve of the “Contrafforte Pliocenico”, a rugged rocky ridge originated from a small Pliocenic marine gulf (5 million to 2 million years ago). This formation is rich in marine fossils, where the cemented sand and gravel host numerous Mediterranean plants. The reserve is located in the municipalities of Sasso Marconi, Pianoro, and Monzuno and reaches its highest altitudes in Monte Adone (655 m) and Monte delle Formiche (638 m).

A third characteristic of the investigated area is the important gypsum outcrops found mainly in the municipalities of Bologna, San Lazzaro di Savena, Ozzano dell'Emilia, Pianoro, Borgo Tossignano, Casalfiumanese and Fontanelice; they are gathered in the two Regional Parks of "Gessi Bolognesi and Calanchi of Abbadessa” and “Vena del Gesso Romagnola” (the latter also overlapping the Province of Ravenna) at altitudes between 70 and 400 m. The gypsums of the Parks were formed by the intense evaporation which occurred in the Mediterranean sea during the Middle Messinian (6 million to 5.6 million years ago); later buried by clay and sand sediments, they subsequently rose up and partially reemerged during the Quaternary (less than 2.5 million years ago).

A major portion of the study area consists of the Regional Historical Park of “Monte Sole”, which extends from north to south between the Reno River and the Setta creek, in a part of the municipalities of Marzabotto, Monzuno and Grizzana Morandi, with an irregular alternation of wooded hills or sometimes rocky, intricate valleys, grassy highlands and gullies between 150 m a.s.l. at the northern boundaries and 668 m a.s.l. at Monte Sole. Geologically the Park is characterized by a diverse set of sedimentary rocks formed between the Middle Eocene (40 million years ago) and the Lower Middle Miocene (15 million years ago) in deep sea basins located in the Ligurian Units and for this reason called Epiliguri (formations of Montepiano, Antognola and Bismantova).

Another important part of the territory in question is that of the “La Martina” Provincial Park, located in the municipality of Monghidoro at altitudes between 400 and 796 m (Monte Gurlano). The area was originally grassland and fields, but has been densely reforested since 1920 with various conifers, which are poorly represented in the remaining part of the area under investigation.

From the point of view of vegetation, most of the hilly territory we considered, a potential home of "mixed oak" (oak, maple, manna ash, hornbeam, hop hornbeam and rowan), has been heavily modified over the centuries due to heavy deforestation, intensive agriculture and replanting with chestnuts. Many of the forests of this altitudinal band have the ecological characteristics of mesophilic vegetation, dominated almost everywhere by coppice. There are, in particular, two types of oak forest: the oak-hornbeam forest (consisting mainly of *Quercus pubescens*, *Ostrya carpinifolia*, *Fraxinus ornus*, *Corylus avellana*, *Cornus mas*, *C.*

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sanguinea and related vegetation) and the turkey oak forest (*Q. cerris*), the latter typical of the heavy clay soil. On the slopes with thin or rocky soil, these oaks tend to be replaced by ash-hornbeam forest (*O. carpinifolia* and *F. ornus*). The distribution of mesophilic oak has been greatly reduced up through the last century by the replacement of these forests with chestnut, which spread widely thanks to the lack of clay soils, for which the chestnut is a poor fit (FERRARI 1989).

Next to the mesophilic woods, xerophile vegetational complexes are frequently present in drier places, in the form both of sunny woodlands and shrubbery, mainly consisting of *Q. pubescens*, *Juniperus communis*, *C. monogyna* and *C. oxyacantha*. The herbaceous layer is often dominated by *Brachypodium rupestre* (FERRARI 1989).

Higher up in the hills, as in the "La Martina" Provincial Park, coniferous forests, formed mainly by *Pinus nigra*, but also by *P. sylvestris*, *Abies alba* and *Chamaecyparis lawsoniana*, were planted. Particularly interesting is the small population of native *P. sylvestris* present in the Regional Historical Park of "Monte Sole", for Italy the natural southern distribution limit.

In wetter areas, especially around creeks and streams, not infrequently mixed with chestnut, there are small populations of *Populus alba* and *P. tremula*, and usually more sporadically, *Alnus glutinosa*. Numerous groups of *Q. ilex* are clinging to the sunny sandstone rocks of the "Contrafforte Pliocenico" in the form of shrubs or small trees, accompanied by a flora with Mediterranean characteristics and probably, an equally peculiar, but still relatively little known mycoflora.

Results and discussion

Tables 2 and 3 show, respectively, the updated checklist and the taxonomic subdivision of the hilly macromycetes in the Province of Bologna. 1,110 taxa (1,058 species, 1 subspecies, 37 varieties, 14 forms) are listed in the present work, representing, with reference to the overall data of the Atlas, 39.7% of those found in the Region. They belong to 7 different classes (58% of the Region), 25 orders (68% of the Region), 107 families (73% of the Region) and 277 genera (55% of the Region). According to different phyla, 99 taxa belong to Ascomycota (31% of regional Ascomycota) and 1,011 to Basidiomycota (41% of regional Basidiomycota).

The fungal diversity is quite high, especially when taking into account that the Emilia-Romagna Region, in the present knowledge, is the richest in fungal species in Italy, according to the Basidiomycota (ONOFRI 2005). This can be demonstrated by comparing the number of macromycetes of the hills of Bologna with that of the Italian Regions; to underline that the data in ONOFRI (2005) are less than those of the Atlas (PADOVAN 2006) (Table 4). From this comparison it can be seen, among other things (and with all due caution), that the Basidiomycota of the Bologna hills make up about 24% of those known in Italy in 2005.

Taking into account the main ectomycorrhizal genera, of great ecological interest for their close relationship with the trees (Table 5), it is possible to see that the same percentage above is uniformly distributed, resulting in a "total" of 26% of the ectomycorrhizal entities in the area under consideration (332) with reference to Italian total entities (1,290). It seems that this is an indication both of a good overall knowledge framework regarding our territory, and well distributed and therefore still well preserved mycological diversity.

By analyzing the entities of Basidiomycota on our checklist in relation to their distribution in Italy, a list of 36 taxa reported, to date, only from the hills of Bologna, can be considered "**very rare**" in our country (Table 2: taxa with "*"). While in some cases this probably corresponds to reality (at least to the present state of knowledge), in other cases the reasoning is potentially distorted due to several factors, such as variations of the nomenclature over time, different interpretations of the taxa, poor knowledge of the taxa, etc. However, it is not our intention to analyze here these many and complex arguments, but we prefer instead to report, *sic et simpliciter*, this list of

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mushrooms, whose characteristics of supposed “great rarity” makes them, in our opinion, worthy of a future in-depth knowledge and, when and where appropriate, of protection.

Tab. 4 Number of Basidiomycota for the Italian Regions (2005) and in the hills of Bologna (2014)
Tab. 4 Numero di Basidiomycota per Regione (2005) e nelle colline di Bologna (2014)

Piemonte	Valle d’Aosta	Liguria	Lombardia	Trentino-Alto Adige	Veneto	Friuli-Venezia Giulia	Emilia-Romagna	Toscana	Umbria
1,408	198	1,351	1,952	2,091	1,724	584	2,186	2,090	305
Marche	Lazio	Abruzzo	Molise	Campania	Puglia	Basilicata	Calabria	Sicilia	Sardegna
245	1,238	880	225	643	800	398	1,169	1,197	1,198
Italia	Hills of Bologna								
4,198	1,011								

Enlarging the area from the hills of Bologna Province to other provinces, similar arguments can be made for a list of 20 taxa reported in Italy, to date, only in the Emilia-Romagna Region. Being less localized that the previous, we might call them "**rare**", but to consider equally worthy of further study and protection (Table 2: taxa with “**”). In both “very rare” and “rare” lists, Ascomycota are excluded, as their national checklist is not yet available, thus precluding a proper comparison.

Another analysis, which was mainly what we set out to do with the present work, is that of macromycetes only reported in the literature before 1993 and never encountered again either by us (2000 to 2014) or during the investigations carried out in the field for the drafting of the Atlas (1993-2005). Their listing, presented in Table 6, includes 86 entities that could be considered potentially "**vulnerable**", as they had been observed in the past and yet have no longer been reported, as far as we know, in the last 22 years. A small number of them are also included in the lists of "very rare" or "rare" fungi.

As we have suggested in a previous work (ILLICE & TODESCHINI 2013a), some of these entities, in truth, may have been interpreted differently in the past and have never really been in the hilly area of Bologna. However, this should not rule out the possibility that environmental modifications, induced in particular by the significant climatic changes of the last twenty years, may have recently had a negative role in the fungal growth. For these reasons, the fungi on this list have to be considered for more extensive research and protection, especially when rarely reported in other Italian regions and provinces of Emilia-Romagna (see Table 6 for the national and regional distribution).

Another small group of extremely interesting macromycetes, not included in the lists of "very rare", "rare" or "vulnerable" fungi, is made up of 6 species listed in Table 7, for which the European Council for Conservation of Fungi has proposed inclusion in Appendix I of the Bern Convention as "**threatened**" species at the European level (COUNCIL OF EUROPE 2003; DAHLBERG & CRONEBORG 2006). These species, though certainly not common, do not seem in truth very rare in Italy, but they are in other countries in central and northern Europe. Their choice also stems from the possibility of easy monitoring (being all big enough and fairly easy to determine) and the association of their specific habitat that is equally deserving of protection.

Finally, in relation to the habitat of the hills around Bologna, we were able to describe it for almost half of the species here listed (Tables 2 and 8). Current data show that the in macromycetes richest ecosystem is the meso-thermophilic oak (mainly consisting of *Quercus pubescens* and *Q. cerris*, variously interspersed with

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Ostrya carpinifolia and *Fraxinus ornus*), followed by the chestnut (*Castanea sativa*). In third place one can possibly place the "forest" of *Pinus sylvestris*, unfortunately only comprised of a small residual population, dispersed between *C. sativa* plants in the protected area of the Historical Park of “Monte Sole” where we carried out our main research.
Investigations on plant communities should certainly continue.

Conclusions

The hilly territory of the Province of Bologna is very rich in fungal species, numbering nearly a quarter of known macromycetes in Italy. To underline that thanks to the present work, 56 species results "rare" or "very rare" entities because they are known only to Emilia-Romagna or even just to the hills of Bologna, while 86 other entities can be considered "vulnerable" as no more examples have been reported for over 20 years and are then in a phase of potential regression. There are also 6 species proposed by European Council for Conservation of Fungi for inclusion in Appendix I of the Bern Convention for the purpose of protection at the European level.
In our opinion all these entities should be further researched and studied for multiple reasons: to reevaluate their taxonomic terms, to confirm their presence or absence, to carefully take a census of the locations and habitats and to protect the natural environment in which they grow.

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