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Lichens and lichenicolous fungi on *Taxus baccata* L. and *Ilex aquifolium* L. in Sardinia (Italy)

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INTRODUCTION

Ilex aquifolium L. and *Taxus baccata* L. are woody species which grow, often together, in humid and fresh mountain stations. In Sardinia, as in the rest of the Mediterranean area, their ecological value is particularly high because they represent residuals of primeval forest that is almost disappeared for causes linked also to human activities. The importance of *Taxus-Ilex* forest is underlined by the Directive 92/43/EEC which lists forests of *I.aquifolium* and Mediterranen woods of *Taxus baccata* in its first annex.

Lichens are a group of organisms which constitutes a big percentage of the biodiversity of a site and among them there are species particularly rare. They are very useful indicators of the ecological features of a site and they are used in numerous studies as bindicatior of pollution and as bioaccumulators of heavy metals and other elements. They are also indicators of the ecological continuity of forest and of man-made disturbance. Another aspect linked to them is the chromatic effect they give to the substrates where they grow. In particular the Sardinian landscape is so characterized by them that several nuraghes (megalithic monuments that were built between 1500 B.C. and 300 B.C.) are called Nuraghe Ruju (red nuraghe), for the orange-red colour linked to the genera *Xanthoria* and *Caloplaca*. They are, thus, a very interesting group which is sometimes ignored for the little dimensions, visibility and difficult identification of many species.

GENERALITIES ON LICHENS

Lichens are the product of the mutualistic symbiosis between fungal partners, mainly *Ascomycetes* but also *Basidiomycetes* and *Deuteromycetes*, and green algae or cyanobacteria (Nash, 1996). Each partner of the symbiosis benefits from this relationship: the algae receive minerals, water, nitrogen, mechanical protection and major resistance from desiccation thanks to the fungus; the latter obtains the carbohydrates produced by algal photosynthesis (Hale, 1974). One evidence of the benefits of the symbiosis is that lichenized fungi seem to have more longevity than the non-lichenized ones, although a slower rate of growth. Another evidence is that some photobionts, i.e. *Trebouxia,* are quite rare as free-living algae and seem to need the fungal partner to survive (Hale, 1974). Anyway the mutualistic nature of the relationship between mycobiont and photobiont is complex and some authors prefer to

consider it as a sort of controlled parasitism because the fungal partner appears to get more benefits from it. Occasionally also lichenicolous fungi such as parasitic and saprophytic ones are present in a thallus. Although at least two kind of partners and sometimes three different kingdoms are involved, in many studies the single thallus is considered as an individual organism (Nash, 1996).

Thallus structures

The **homeomerous** structure (fig. 1) is typical of gelatinous lichens. The thallus consists of a homogeneous interlacement of hyphae and algae. Lichens with this type of structure are in symbiosis with cyanobacteria and are usually dark coloured. The thallus is rigid and tough as in *Collema* or, as in *Leptogium*, can be fragile if dry and gelatinous if wet. This structure seems to be the most primitive one (Anpa, 2001; Nimis, 1987).

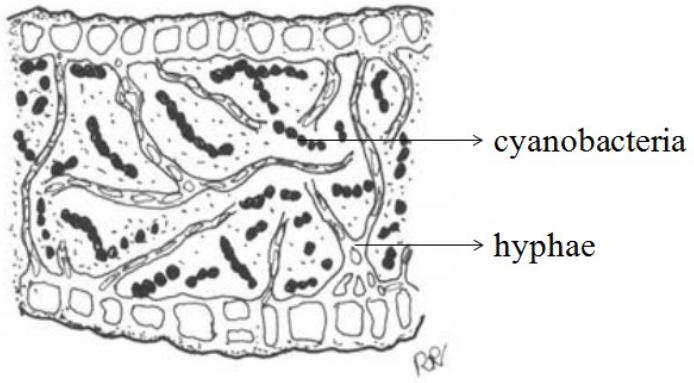


Fig. 1 - Drawing of a section of an homeomerous thallus (ANPA, 2001).

The **heteromerous** thallus (fig. 2) is divided in different strata: an upper and lower cortex, an algal layer and a medulla (Anpa, 2001; Nimis, 1987).

Cortex: is a layer with protective function made by fungal hyphae which are strongly cemented. The reproductive elements develop in the upper one, whereas in the lower cortex of foliose lichens there are the structures of attachment at the substratum. Crustose lichens lack the lower one and are attached only through the medulla. The upper cortex is usually 10-15 µm thick with several layers of cells but in some gelatinous lichens it is totally

indistinguishable or there are only one or two layers of cells (Hale, 1974; Nimis, 1987). There are 3 different types of cortex based on their structure:

Prosoplectenchymatous if it is made by elongated hyphae parallel to the surface i.e. *Anaptychia*.

Pseudoparenchymatous or paraplectenchymatous: if it has a cellular structure with isodiametric cells i.e. *Peltigera*.

Plectenchimatous if it is made by cylindrical cells that are perpendicular to the surface.

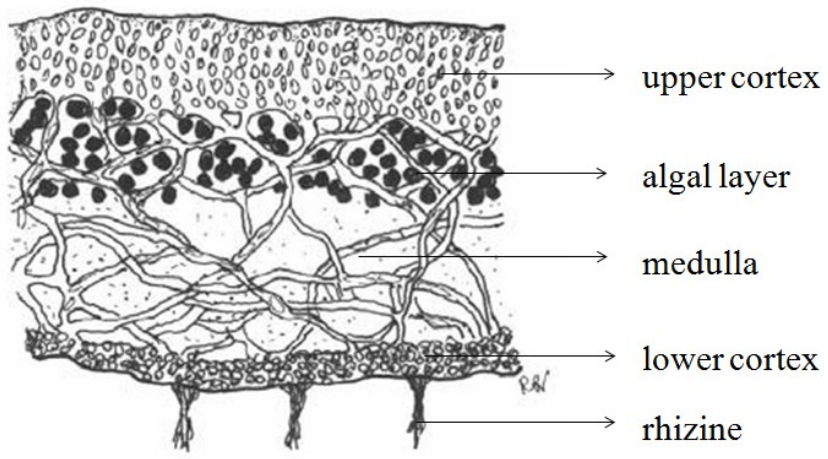


Fig. 2. - Drawing of a section of an heteromerous thallus (ANPA, 2001).

Algal layer: is placed between the upper cortex and the medulla and is usually 10-15 µm thick. The relation between fungus and algae could be different, in some cases fungal haustoria penetrate the algal cell, in others intramembranous haustoria envelop the cell without penetration. The first method appears to be typical of foliose and fruticose lichens whereas the second is mainly present in crustose ones. The shape of lichen thallus is determinate only by the mycobiont and many different species share the same type of photobiont. Sometimes the identification of algal species is difficult because of the changes made by fungus (Hale 1974; Zedda 2002).

More than 85% of lichens are in symbiosis with green algae and among them the most common is the genus *Trebouxia* (fig. 3), unicellular algae with a light green colour and usually not free living in nature. *Trentepohliaceae,* other green algae, are linked to warm-humid conditions, typical of tropical lichens and quite common in crustose forms. *Trentepohlia* can be found also in free-living colonies in nature, has a filamentous shape that

although modified in the thalli of lichens, is usually easily recognizable thanks to its yellowish colour, which is visible observing transversal section of the thallus under the microscope or scratching the upper cortex with a razor blade (Hale 1974, Zedda 2002).

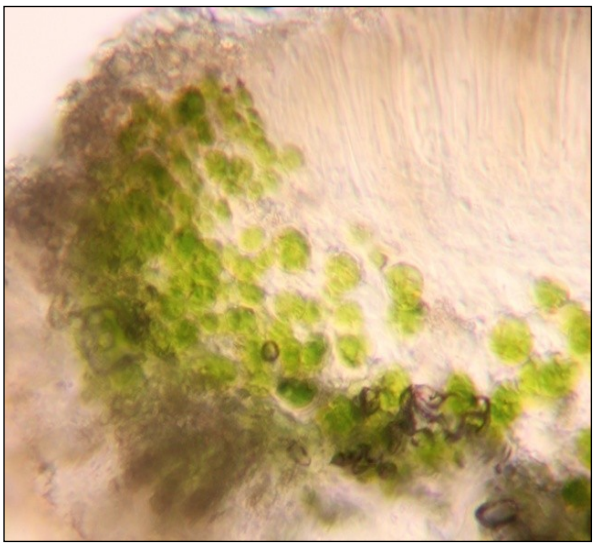


Fig. 3 – *Trebouxia* in the apothecium of *Lecanora* sp. (x1000)

The 10% of lichen species contain cyanobacteria which usually prefer oceanic conditions. *Nostoc*, *Scytonema* and *Stigonema* are the most common blue-green algae. They are present mainly in gelatinous lichens such as *Collema* and *Leptogium* but also in heteromerous thalli like *Peltigera* and *Nephroma*. Few lichens, ca. 3-4%, have both green algae and cyanobacteria. In these cases the latter are contained in cephalodia, wart-like structures present on the upper cortex, i.e. in *Lobaria pulmonaria* (fig. 8). Cyanobacteria are very useful for lichens because can use the nitrogen present in the air to synthesize organic substances (Hale 1974, Zedda 2002).

Medulla: is the thickest layer (ca. 500 µm). It is placed between the algal layer and the lower cortex, when it is present. It is a sort of fibrous or cottony stratum made by hyphae loosely interwoven. It has the greatest water-holding capacity, facilitates the gas exchanges and seems a useful place for food storage (Hale 1974).

Growth forms

Lichen thalli are quite different both in colour, size and shape. Their size can range between less than a couple of millimetres square to more than 2 m of length in some pendulous forms (Nash, 1996).

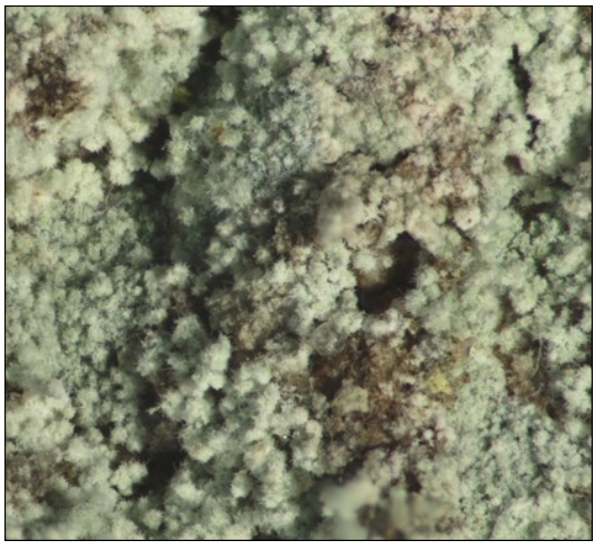
There are four principal growth forms:

Crustose: the thallus is tightly attached to the substratum through the medulla and can be continuous, areolate or verrucose. It is peltate if it consists of areoles attached with a central point and which have ascending margins. It is placodiomorph (fig. 4) if the margins are lobed. The leprose (fig. 5) ones are made by an undifferentiated mass of algae and hyphae and have a powdery aspect. The endolithic ones (fig. 6) can use the chemicals produced by the thalli to excavate the substratum and can, for instance, dissolve the carbonate rocks (Anpa, 2001; Nimis, 1987).

Squamulose: the thallus is made by descendant or sub-erect squamules or by convex warts grouped to form pillows (fig. 7). Rhizines are not present. This form is usually frequent in epigeous lichens.

Foliose: the thallus is flattened and grows parallel to the substratum, has a dorsiventral structure with different upper and lower cortex and is usually attached at the substratum through rizhines. They are divided in broad lobes (fig. 8) and narrow lobes (fig. 9) depending on lobe width. Whereas the umbilicate ones (fig. 10), less frequent, are linked only thanks to a central portion named umbilicus (Anpa, 2001; Nimis, 1987).

Fruticose: the thallus is made by elongated lobes named laciniae with a circular (fig. 11) or flattened (fig. 12) section and it is attached at the substratum only through the basal portion being therefore easily removable. The habit can be prostate or upright (Anpa, 2001; Nimis, 1987). Some fruticose lichens originate from the basal squamulose thallus after the formation of elongated structures similar to rods (fig. 13) or cups. These structures, called podetia, belong to the regenerative tissue of the apothecia, the organs of the sexual reproduction. In some case the squamulose thallus totally disappears and only the secondary structures remain (Anpa, 2001; Nimis, 1987).



Figs. 4, 5 - Placodiomorph thallus of *Diploicia canescens* (Dicks.) A. Massal; leprose thallus of *Lepraria jackii* Tønsberg.

Figs. 6, 7 - Endolithic thallus of *Verrucaria marmorea* (Scop.) Arnold, sample SS2525; *Normandina pulchella* (Borrer) Nyl., sample SS698.


Figs. 8, 9 – *Lobaria pulmonaria* (L.) Hoffm, foliose lichen with broad lobes; *Physcia semipinnata* (J.F. Gmel.) Moberg, foliose lichen with narrow lobes.


Figs. 10, 11 – Umbilicate thallus of *Umbilicaria* sp.; fruticose thallus of *Roccella phycopsis* (Ach.), the laciniae have a circular section.


Figs. 12, 13 –Fruticose thallus of *Ramalina fraxinea* (L.) Ach., the laciniae have a flattaned section; podetia of *Cladonia* sp.

Morphological features

(Hale 1974; Nimis, 1987)

Pruina: crystalline or organic deposits present on the upper cortex or on the fruiting bodies of some lichens. It is usually white and can hide the real colour of the thallus.

Tomentum: densely packed formations of single celled hyphae sometimes present in the upper cortex of some lichens i.e. *Anaptychia ciliaris* (fig. 14).

Cilia: are elongated structure made by interlaced hyphae present in the margin of lobes or laciniae in some foliose or fruticose lichens.

Rizhines: structures which originate in the lower cortex of foliose lichens. They anchor the thallus to the substrate and are made by many hyphae. They can be simple, squarrose or have a brush-shape.

Pseudocyphelles: perforations present in the upper or lower cortex maybe useful for gas exchanges and aeration of the thallus. They can have circular, elongated or reticular (fig. 15) shape.

Pycnidia: flask-shaped structures, immersed or superficial, similar to small perithecia, where asexual spores named conidia are produced.

Fig. 14 - Lobes with tomentum and cilia of *Anaptychia ciliaris* (L.) Körb. ex A. Massal.

Fig. 15 - Reticular pseudocyphelles on the thallus of *Parmelia sulcata* Taylor.

Reproduction

Lichens can have two reproductive strategies: sexual and vegetative. Many species can adopt both types but in others one type is rare or unknown.

Vegetative reproduction

Algae adopt only this type of strategy. In the lichen it occurs by thallus fragmentation or thanks to propagules such as: soredia and isidia which are also important elements for the identification of the species.

Soredia: are made by algae wrapped by fungal hyphae. They develop in the medulla and in the algal layer and come out from pores or cracks present in the upper cortex. Once free in the environment, after finding the suitable substrate, they form another lichen thallus which is genetically equal to the previous one. The leprose forms are totally made by a continuous layer of soredia.

The soredia are usually grouped in bigger structures named **soralia** which shape, position in the thallus and consistence are different among the species. They can be granular or farinose according to their thickness (Hale 1974; Nimis, 1987) and can be divided in:

Linear: if they have an elongated shape, for example if they developed along linear cracks in the thallus as in *Parmelia sulcata* or along the margins of the lobes as in *Parmotrema perlatum* (fig. 16).
Capitiform: if they surround an ascending lobe i.e. *Hypogymnia tubulosa.*
Labriform: if they are present in the lower face of a raised lobe i.e. *Physcia tenella.*
Helmet-like: if they develop inside an enlarged lobe which breaks freeing the soredia i.e. *Physcia adscendens.*
Maculiform: if they have a circular shape i.e. *Ramalina farinacea*.

Isidia: differ from soredia in being corticated. They are protuberances present in the upper cortex which contain both algal and fungal components. They are usually fragile, break out and disperse in the environment. The 25-30% of fruticose and foliose lichens have isidia but they are less common in the crustose ones. They can have different shapes: flattened, finger-like (fig. 17), coralloid or knob-like (Hale 1974; Nimis, 1987).

Fig. 16 – Visible soredia of *Parmotrema perlatum* (Huds.) M. Choisy.

Fig. 17 - Isidia in the thallus of *Lobaria pulmonaria* (L.) Hoffm.

Sexual reproduction

A small number of lichens where the mycobiont is a *Basidiomycetes* produce the basidiospores in ascocarps called basidia but most of the fungal partner in lichens are *Ascomycetes* which are characterized by the production of spores in sac-like structures named asci. The fruiting bodies contain a fertile layer named hymenium made by asci and sterile thread-like paraphyses which can be unbranched, branched or anastomozed (fig. 18). Each ascus can contain from one to several hundreds of spores depending on the species, but the most are 8-spored. The spores can be hyaline or coloured, straight or curved, simple, transversely septate, sub-muriform or muriform (with both longitudinal and trasversal septa). They also vary in sized, shape, type and thickness of walls. The polarilocular spores (fig. 17) are typical of the family *Teloschistaceae* and in particular of the genera *Caloplaca* and *Xanthoria*. They usually have two cells which are placed in the extremity of the spore and are linked by a thin istmus. In some cases, they have a single cell that is constricted in the middle part (Anpa, 2001; Hale 1974; Nimis, 1987).

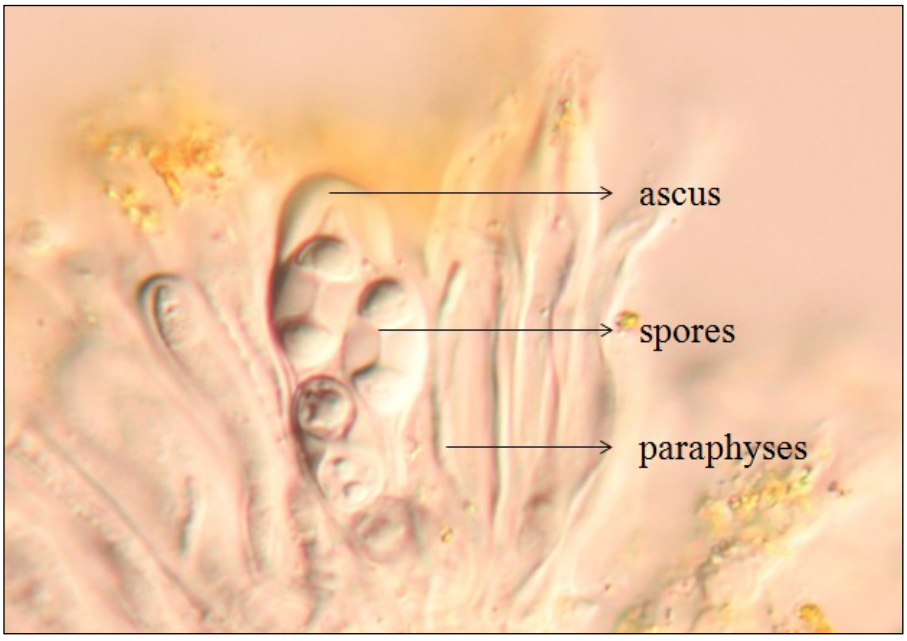


Fig. 18 – Ascus, paraphyses and polarilocular spores of *Caloplaca holocarpa* (Hoffm.) A.E. Wade (x3000).

There are 2 types of fruiting bodies: perithecia and apothecia.

Perithecium: is a flask-shape structure (fig. 19). The spores are ejected by an apical pore.

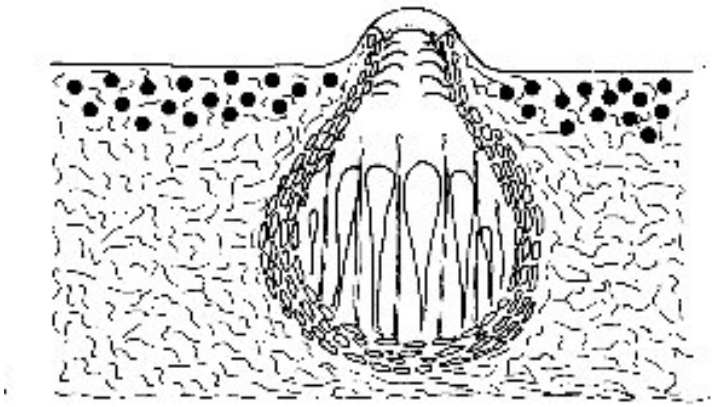


Fig. 19 – Drawing of a perithecium (Nimis, 1992).

Apothecium: has the shape of a disk or a cup and the hymenium is usually well exposed. In some cases, i.e. genus *Pertusaria*, the apothecia are inside warts and the only visible part is a pore like structure similar to perithecia. On the contrary the apothecia in *Cladonia* are in the upper part of elongated structure, cup or rod like, named podetia.

The apothecium is made by a disk and margins and can be lecanorin (fig. 20, 22) or lecidein, (fig. 21, 23). In the first the margins have usually the same colour of the thallus and contain algae, in the second the margins and the disk differ in the colour from thallus and algal cells are not present. The apothecia can have different size, colours and shape and can be flat, concave, convex or without margins (Anpa, 2001; Hale, 1974; Nimis, 1987).

Obviously to form a new lichen thallus the spores, after be freed in the environment, need to find a fungus. The majority of lichens are in symbiosis with *Trebouxia* and could be a challenge for the fungus to find a source of them in the environment. Sometimes algal cells are present in the ascocarp and the ascospores can pick them up before going out, in other cases the mites or other animals which feed on lichen thalli can promote the dispersal of both spores and algae. Also fragments of thallus or vegetative propagules of other lichens can be a source of algae (Anbg, 2010; Hale, 1974).

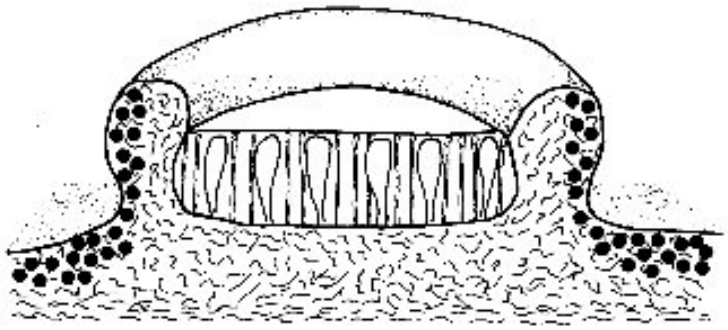


Fig. 20 - Lecanorin apothecium (Anpa, 2001).

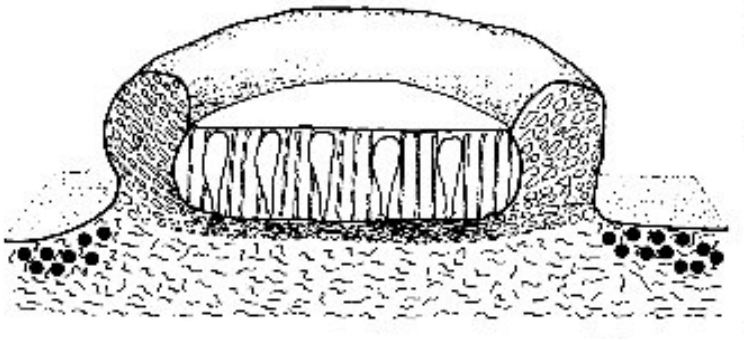


Fig. 21 - Lecidein apothecium (Anpa, 2001).

Figs. 22, 23 – Lecanorin apothecia of *Tephromela atra* (Huds.) Hafellner; lecidein apothecia of *Bacidia rosella* (Pers.) De Not.

Remarks on the two types of reproduction

Sexual reproduction has the advantage to create genetic diversity and so it is more likely to find, within a population, some individuals that can be more adapted to different environmental conditions. In fact the spores are small and are easily dispersed by wind or other agents for long distances and in different environments. In this cases the genetic diversity could be very important (Crespo & Pérez-Ortega, 2009; Anbg, 2010).

On the contrary, some propagules, such as isidia, are bigger than spores and are carried by wind or other agents for short distances. They are adapted to the environment conditions because they grow in the same environment of the original thallus to whom they are genetically equal. Moreover they do not need to find an algal partner and can easily develop in sterile landscape such as volcanic islands (Crespo & Pérez-Ortega, 2009; Anbg, 2010).

Pair species are another aspect linked to reproduction. They are species very similar morphologically but which adopt different reproduction strategies. The sorediate species is usually more widespread and widely distributed than the one forming ascospores. There are many theories. One is that the original species had both agamic and sexual reproduction, from it two different ones originated on the basis of the adaptation to the environmental conditions. When the symbiosis was optimal the species adopted the agamic reproduction, whereas when the conditions were sub-optimal the lichens started to reproduce sexually to increase the probability to find more suitable features.

However it has been discovered that also lichens with asexual reproduction are able to generate in some ways genetic diversity and to exchange photobionts, conditions that can promote the adaptation to the environment (Crespo & Pérez-Ortega, 2009; Anbg, 2010).

Metabolism

Lichens have no organs for the absorption and transpiration of water which are instead linked to physical processes. The rate of absorption is different. In some species it is a fast process, in others the thalli are covered by non-wettable substances and need quite a long time to be saturated because the water is taken by the steam present in the environment.

In a saturated thallus the water which is stored in the cytoplasm of the cells seems to be a small percentage of the total that is present in the whole thallus and it is mainly accumulated

in the walls and in the intercellular spaces. The quantity of water that can be held by a lichen differs among tissues and species. For example a study on water content in *Peltigera polydactyla* shows a major quantity of water in the medulla than in upper cortex or algal layer (Hale, 1974). A mechanism to prevent water loss does not exist and the lack of water can affect both photosynthesis and respiration. Anyway lichens are usually quite resistant to drought periods, especially the ones which live in warm and dry places than the ones in cool moist habitats (Hale, 1974).

Lichens absorb the nutrients which are dissolved in the water by the whole surface of the thallus and accumulate mineral and organic nutrients in intracellular and extracellular spaces. The rate of accumulation is linked to temperature and water content. Nitrogen, carbon and minerals are essential for lichens. Nitrogen is very important for the production of proteins. It can be dissolved in the rainwater in different forms and can be absorbed by the thallus. The dust on the trees near farms and the guano of birds in perches are rich sources of organic nitrogen. Blue-green algae as *Nostoc* can fix the nitrogen present in the air. Studies on bioaccumulation exploit the capacity of lichens to accumulate and tolerate big concentrations of elements, including radioactive ones, that can be lethal for plants (Hale, 1974).

There is a seasonal variation in the physiological activities maybe linked to the amount of chlorophyll and the rate of photosynthesis seems to decrease during summer (Hale, 1974).

Lichen metabolites

The lichens generate various secondary metabolites. They are produced by the mycobiont but surely the symbiosis plays an important role because the substances differ if they are produced by the same type of fungus but that has been isolated and cultivated in laboratory. The kind and the quantity of the produced chemicals are different and can depend on internal factors such as thallus age and on external ones like environmental conditions. In many cases, however, the chemicals are different among the species and the genera and their presence can help the identification of the specimens.

There are many theories on the functions of these substances: can have an anti-microbial action, for example against gram-positive bacteria or fungi; can inhibit the

germination and growth of seeds and spores of bryophytes and other lichens; can make the thallus uneatable to some arthropods; can be a screen against the excessive solar irradiation, in fact *Trebouxia* seems to tolerate less light then the free-living algae; can regulate the water uptake; can help the exchanges between mycobiont and photobionts; can help in the assumption of nutrients. Furthermore, endolithic lichens are able to excavate the rocky surface with the produced acids (Baruffo *et al*., 2001; Hale 1974).

The secondary metabolites are located in different parts of the thallus, usually the pigments are in the upper cortex and the colourless substances are in the medullar strain mainly on fungal hyphens. The chemicals are different if in vegetative or fruiting bodies and the substances which are present in the hymenium are usually different from the ones in the rest of the thallus. There are, however, a lot of exceptions and sometimes the same species has different chemotypes (Baruffo *et al*., 2001).

Ecology

Lichens can grow in every kind of substrate: rocks, ground, plants, metals, glass and even on animals and bones and they are usually pioneers in plant successions. They can be find everywhere from Arctic to Antarctic and thanks to their adaptations to the lack of water can also dominate xeric environment where plants are unable to live.

In the forests they are usually the major components of epiphytic communities, in competition with bryophytes and climbing plants. Many lichen species are tree specific link to the pH, porosity and texture of the bark which affect the water-holding capacity. For example, trees with a hard bark can give up the water faster than trees with soft bark. The presence of lichen species is also relate to the occurrence of nitrogen compounds and to the light conditions. They are sensitive to the atmospheric pollution and in particular to the presence of sulphur dioxide (Hale, 1974).

For these reasons lichen communities are good indicators of ecosystem functions in several contexts. Many region-wide ecological studies aim to monitoring the variation of lichen communities due to major factors such as air quality, climate and tree species composition and their interactions. Moreover the study on lichens growing in a particular forest type is useful to monitor the effects of forest management activities and other indirect

anthropic impacts on forest environments. The changes in the age and forest compositions and the fragmentation of forests, with the consequent edge effect, could be reflected by the great modifications in lichen communities (Will-Wolf *et al*., 2002).

LICHEN BIODIVERSITY IN SARDINIA AND WORKS

In 1829 in the *Stirpium Sardoarum elenchus*, Moris reported a list of 90 species collected in Sardinia, about a third of which on trunk or twigs. Except for *Lecanora rubra* Ach. collected on oak, he did not specify the kind of tree. In the period 1846-1852 De Notaris collected many lichen specimens and described new species, records which were included by Baglietto (1879) in the *Lichenes insulae Sardiniae*. This work present a list of 397 species of lichens and it was later incorporated by Barbey (1884) in his *Florae Sardoae compendium*. Terraciano (1914) in *Flora Sardoa* created a list of flowering plants, fungi and some Sardinian lichens. In 1917-1919 Colosi wrote a list of 115 lichen species, among them 10 collected on *Quercus,* and in 1920 Mameli published a list of Sardinian lichens. More recent publications on Sardinian lichens and in particular concerning also epiphytic ones are: the check list of Nimis and Poelt (1987) which contains 243 epiphytic species, the work of Nimis and Tretiach (1993) who reported other 19 epiphytic taxa, Tretiach (1997) with his Addition to the Italian lichen flora, Zedda & Sipman (2001) with their study on lichens and lichenicolous fungi on *Juniperus oxycedrus* L., Zedda (1999) who wrote on *Ramalina farinacea* (L) Ach complex and Zedda (2000) on genera *Lepraria* and *Leproloma* in Sardinia. Particolar revelant works are also the degree thesis of Luciana Zedda (1995) on epyphitic lichens in Marghine and Goceano and her work on lichens on *Quercus* in Sardinia and their value as ecological indicators. One of the most recent work on lichens in Sardinia was written by Rizzi *et al*. (2011), in it 390 taxa, both epilithic and epiphytic, collected in 17 localities in the western Sardinia are reported.

Hitherto according to Nimis and Martellos (2008) in Sardinia there are 1116 species of lichens, and in particular: 646 epilithic, 415 epiphytic, 78 lignicolous and 149 terricolous species.

GENERALITIES ON *ILEX AQUIFOLIUM* L. AND *TAXUS BACCATA* L.

Overview on *Ilex aquifolium* L.

The genus *Ilex* is distributed in the northern hemisphere and belongs on the family *Aquifoliaceae*, order *Aquifoliales*. *I.aquifolium* (fig. 24, 25, 26) is an evergreen shrub or tree that usually reaches the height of 10-15(-30) m. It has a dense crown. The twigs are glabrous and the trunk can have 1.5-2 m of circumference. The bark is thin and smooth. It is usually green in the beginning and then dark grey or brown. At maturity it tends to desquamate by rolling on itself. The leaves are coriaceous, dark green and glossy on the upper surface and matt and lighter on the underside. The leaf blade is around 3-5 x 4-10 cm. It has oval shape and usually has wavy, whitish margins fitted with 6-8 spines in each side. Anyway in the plants with big dimensions, the margins of the leaf tend to be not waved. The presence of spines in the leaves is probably a defence against the grazing animals but it is a feature which is usually absent in the upper twigs (Camarda & Valsecchi, 2008; Pignatti, 1982).

Fig. 24 – *Ilex aquifolium* L. in locality Arcu Ittase (Desulo).

I.aquifolium is a dioic plant with unisexual flowers, they are in groups of 2 or 3, and have 4 white petals and a short peduncle. Male flowers have red-edged petals, 4 stamina and sterile ovary. Female flowers have one style, superior ovary, 4 stigmas and sterile stamina. Flowers are rarely hermaphrodite. The fruit is a sub-spherical drupe, about 6-8 mm in diameter and contain 4 seeds (Camarda & Valsecchi, 2008; Pignatti, 1982).

The holly can develop basal shoots after cuttings and the bark even if thin can regenerate after grazing but it is strongly affected by big fires. After them radical shoots develop and form colonies of unisexual plants. In the Mediterranean area the holly usually grows in mountain sites from 700-900 m to 1900 m a.s.l. In Sardinia it usually grows above 800 m, but it is rarely present at 250 m a.s.l., which is the lowest altitude it can reach. It forms mono-specific woods, mixed woods with *Taxus baccata* L. or it is present in mixed woods dominated by *Quercus ilex* L. or *Quercus pubescens* Willd. It grows on soils with high humidity and usually near springs (Brunu, 2011; Camarda & Valsecchi, 2008).

Fig. 25 - Particular of leaves and fruits of *I.aquifolium* L.

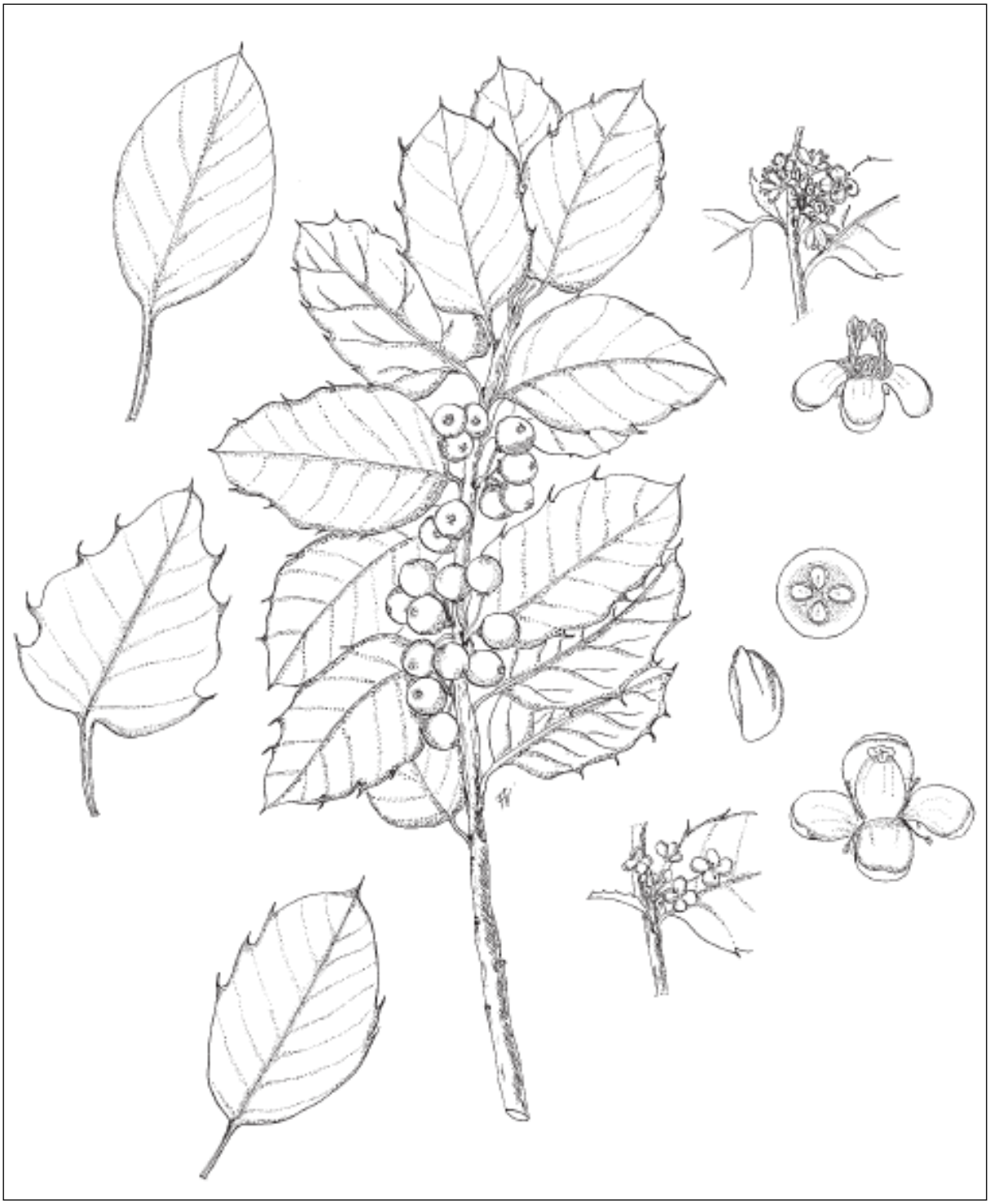


Fig. 26 – *Ilex aquifolium* L. Twig with fruits, leaves, inflorescence x0.5; male and female flowers x2; section of the fruit x1.3; seed x5 (Camarda & Valsecchi, 2008).

Overview on *Taxus baccata* L.

The genus *Taxus* is one of the 5 genera of the family *Taxaceae*, order *Taxales*, and like the genus *Ilex* is present only in the northern hemisphere. *T.baccata* (figs. 27, 29) is an evergreen tree or shrub. It can reach 3 m of diameter and 15-20 m of height (rarely 25 m as in Caucasus). It has a dark-green crown with conical shape. The bark is reddish-brown, thin and smooth, in the old trees it desquamates in elongate strips (fig. 28). The leaves are needle-shape, around 1-3 cm x 2-3 mm. They have a superior glossy, dark green surface and a clearer inferior surface (Camarda & Valsecchi, 2008; Pignatti, 1982).

Fig. 27 – *Taxus baccata* L.

The species is dioic but the same individual can change the sexuality several times or parts with different gender can develop in the same tree. It is a Gymnosperm so it has not fruits but the seeds are enveloped by a red fleshy aril (fig. 29) about 8 mm in diameter which is the only edible part of the plant and also it is quite important for the dispersion of the seeds

by birds. In fact the leaves are very poisonous for the presence of the alkaloid Taxine but birds and little mammalians eat the sweet arils and eject the seeds whose germination is helped by their scarification in the digestive tract (Camarda & Valsecchi, 2008).

Fig 28 – Particular of the bark of *Taxus baccata* L.

Yew seems to vegetate in different pedological conditions and sometimes also in rocky surfaces, apparently it can resist the aridity in region with oceanic conditions but it prefers wet and deep soils. In Sardinia it is present between 600 and 1800 m a.s.l.. It is present mainly in fresh and humid localities and form mixed formation with *Ilex aquifolium*, *Quercus pubescens* and *Acer monspessulanum*. It needs ecological conditions similar to the holly but being not sciaphilous as the latter, it is less widespread (Brunu, 2011; Camarda & Valsecchi, 2008).

Fig. 29 – *Taxus baccata* L. Twig, twig with seed and arils, seed and aril, twig with female flowers, twig with male flowers x0.65; male inflorescens with leaves x2.5; seeds x1.3 (Camarda & Valsecchi, 2008).

Directive 92/43/EEC

I. aquifolium and *T. baccata* are present several times in the Annex I of the Directive 92/43/EEC concerning "natural habitat types of community interest whose conservation requires the designation of special areas of conservation":

91. Forests of Temperate Europe

91A0 Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles.

9120 Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*).

91J0 * *Taxus baccata* woods of the British Isles.

92. Mediterranean deciduous forests

9210 * Apeninne beech forests with *Taxus* and *Ilex.*

93. Mediterranean sclerophyllous forests

9380 Forests of *Ilex aquifolium.*

95. Mediterranean and Macaronesian mountainous coniferous forests

9580 * Mediterranean *Taxus baccata* woods.

In Sardinia the forests of *I.aquifolium* (9380) and the woods of *Taxus baccata* (9580*) are rare residual parts of the primeval forest and for this reason have an high scientific interest.

OBIECTIVES

Specific studies on lichens growing on *Ilex aquifolium* and *Taxus baccata* both in Sardinia than abroad seem to lack and this kind of tree grow usually in type of habitats which are particularly relevant for conservation and ancient. Moreover the lichens are organisms that are easily overlooked and sometimes ignored because of the difficulties in their identification but they are a big component of the biodiversity of a site. For these reasons the objectives of the thesis are to increase the knowledge on Sardinian lichens through the study of the ones which grow on *Taxus* and *Ilex* in different sites.

MATERIALS AND METHODS

The work is divided in 4 parts: the bibliographic research; the field collections; the identification in laboratory and data elaboration.

Bibliographic research

The first part of the work was the research of bibliography about lichens that had been collected in Sardinia on holly and yew, studies on lichens growing on these kind of trees in other regions and countries and other works on epiphytic lichens to decide what kind of sampling methods use. The Ph.D. thesis of Antonello Brunu (2011) about the distribution of *I.aquifolium* and *T.baccata* in Sardinia and the work of Farris and Filigheddu (2008) on *Taxus baccata* L. were particularly useful to decide the sites where to collect. Climatic information referred to the period before 1961 were found in Arrigoni (1968) whereas the more recent were given by the Sardinian Regional Environmental Protection Agency (A.r.p.a.s.). The works of Camarda (1977), Zedda (2002) and Bacchetta *at al*. (2009) were used, as well, to obtain climatic and bioclimatic information concerning the nearest weather stations to the collecting sites.

Field work

In each site: name of the locality, coordinates, altitude, exposure, type of vegetation (i.e. closed or open wood), species of tree, percentage of canopy cover, presence and height of the understorey and the uses of the area (i.e. recreational) were annotated. The coordinates were

detected by a GPS Garmin eTrex Vista HCx. Lichens were collected only on holly and yew. The circumference of the tree trunks at 130 cm was measured. The presence of climbers, mosses or damages in the trunks like stripped bark was annotated. For each kind of tree all the different lichen species which were present were noted writing if collected on twigs or main trunk. A magnifying glass was useful for the little thalli which were not easily visible with bare eyes. When the identification was not possible in the field, samples to be analyzed in laboratory were collected. The removal was made using a knife and trying to damage the less possible the bark. Little samples of twigs were also collected to look for very small crustose lichens.

Identification in laboratory

Most of the specimens collected were identified in the laboratory of the Department of Nature and Land Sciences of the University of Sassari (DIPNET). Some of the specimens whose identification was particularly difficult or needed the use of HTPLC were identified with the help of Dr. Holger Thues in the laboratory of the Natural History Museum of London, thanks to the Erasmus placement grant. The specimens are kept in the lichenological herbarium of the university of Sassari, whereas a copy of the specimens identified in London was added to the NHM lichen collection (fig. 30).

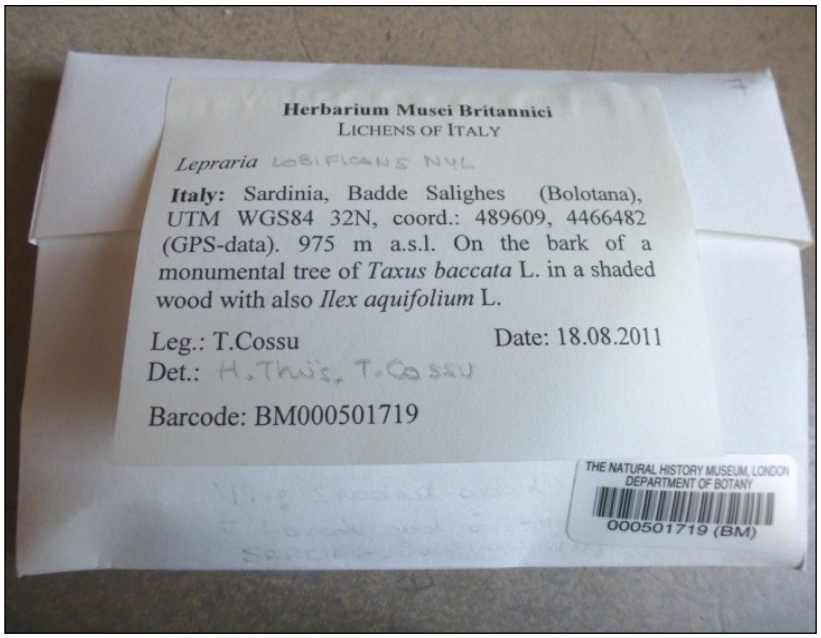


Fig. 30 – Specimens kept in the lichenological herbarium of the Natural History Museum of London.

A stereo microscope with magnification from 8 to 32x was used to examine and measure morphological parts such as rhizines, isidia, soredia and pseudocyphellae. It was also useful when thin sections of thallus and fruiting bodies were cut with a razor blade.

The slices were put inside a drop of water in a microscope slide and then covered with a cover lid and examined under a microscope with x10, x40, x100 objectives and x1000 magnification after immersion on oil. Thin sections of thallus, apothecia and perithecia were observed. Spores number, shape and dimensions, ascus shape and type of upper cortex were some of the features analysed for the identification. Polarized light was used to underline the presence, shape and dimensions of crystals in epithecium, margins of apothecium and medulla of *Lecanora* specimens.

Spot tests (fig. 31) were made to check the colour reactions of thallus, medulla or soralia. The tests were made with: 10 % solution of potassium hydroxide (K), pure bleach (C), the quick application of the first followed by the second (KC) and paraphenylenediamine (PD) in Steiner's stable solution or in ethanol. When necessary, a drop of K was put on a section of a fruiting body followed by a drop of Lugol's iodine, then the asci were examined under microscope to discriminate the type of them (i.e. *Lecanora* type, *Catillaria* type).

An UV lamp was used to check the presence of florescence in the specimens of the genus *Lepraria* and in the sterile thalli of the genera *Ochrolechia* and *Schismatomma*.

Fig. 31 – Reaction to potassium hydroxide (K) of *X.parietina* thallus.

High Performance Thin Layer Chromatography (HPTLC)

HTPLC analysis were carried out on some specimens of the genera *Cladonia*, *Lepraria*, *Ochrolechia*, *Pertusaria* and *Usnea*. They were made during the training period of 7 months in the Natural History Museum of London and with the help of the lichen curator Dr. Holger Thues. The HPTLC was made following a modified protocol based on Culberson & Ammann (1979), Culberson & Johnson (1982), Lumbsch (2002) and Orange *et al*. (2010).

Sample preparation: some small fragments of lichen thallus, for each specimen, were cut with a razor blade under the dissecting microscope and put in a phial. It was important to wear gloves and to be careful to avoid contaminations of mosses or other lichen thalli. Two or more controls were prepared, usually a mixture of thalli of *Pleurosticta acetabulum* and *Evernia prunastri*, to test atranorin and nordistic acid. Each phial was numerated with a code and a sheet with date, specimens number and used solvent system was prepared. One or two drops of acetone were put three times in each phial to extract lichen substances, allowing it to dry completely before adding more acetone.

Plate preparation: nano-TLC silica gel plates 10 x 10 cm were used. A line was drawn with a soft pencil 1 cm above the bottom of the plate. 12 tick-marks at 7 mm intervals leaving 1 cm from the margins were made. Each mark was numbered with the specimens code written in the phials. Another line was drawn above the first one to mark the end of the solvent front. In the right upper corner the date and the type of used solvent and the number of the plate were written. The extracts from each phial were spotted two times in the thick-mark above the corresponding number of the plate.

Solvents that were used:

A: toluene/ 1,4-dioxane/ acetic acid—90: 22.5: 2.5 ml

B: hexane/ methyl tert-butyl ether/ formic acid—70: 36: 9 ml

C: toluene/ acetic acid—100: 15 ml

Running plates: it was made under a fume hood. 10 ml of solvent was put into the conditioning tray of the developing chamber to achieve uniform vapour saturation throughout the chamber (only for A and B) and then each tank was filled with c. 2-5 ml of solvent system. The three prepared HPTLC plates were placed into each chamber with the silica-side facing downwards. The developing chamber was covered with a glass plate and 5 minutes were waited to pre-condition the plates. The chromatography started when pushing the rod at the side of the chamber the solvent started to rise in the capillary slit and entered the silica gel

layer of the plates. The plates were removed when the solvent front had almost reached the upper line, usually after 15-20 min depending on the solvent used. The front line was signed with the pencil and the plates were left under the fume hood until they were totally dried.

Examining the plates and acid treatment: each plate was placed and examined under the UV lamp. The visible spots were marked with the pencil putting an arrow in the upper part if visible under long-wave UV and an arrow in the lower part if visible under short wave ones. The colour of the spot was written near each mark with the first letter of the word: r for red, y for yellow, etc.

A 10% sulphuric acid solution was painted with a brush on each plate and then they were allowed to dry inside the fume hood. The opaque white spots, in correspondence of the aliphatic acids, were marked with a dotted line.

Charring the plates: the completely dried plates were placed in a pre-heated oven (110º C) and taken out after maximum 20-30 minutes. Several coloured spots appeared during the charring process (fig. 32).

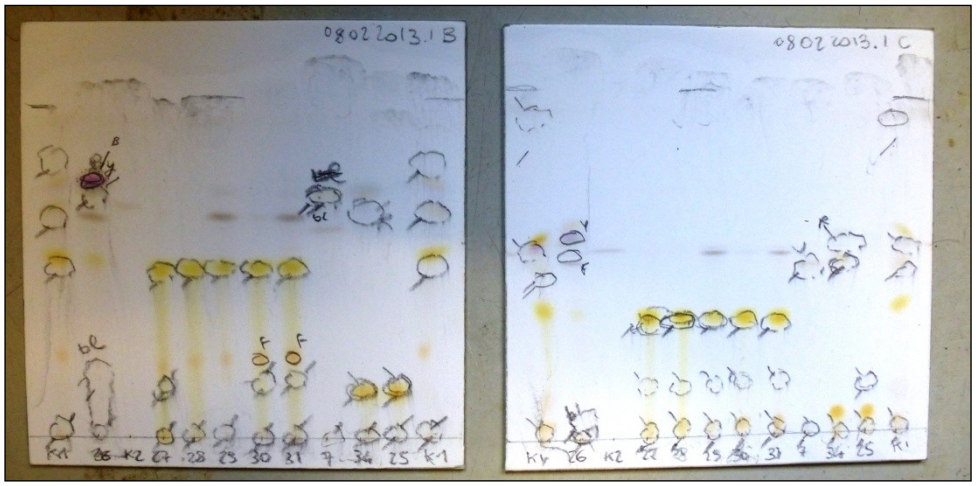


Fig. 32 – Plates for High Performance Thin Layer Chromatography after charring at 110°C in the oven.

Calculating Rf values and identifying the compounds: for each specimen the Rf classes in the different solvent systems were calculated using the method of Culberson (1972) or Orange *et al*. (2010). The position of each spot was compared to the position of control substances (usually atranorin and norstictic acid). The Rf values were then compared to published values to identify the compounds and the results were written on the sheet that had been prepared at the beginning of the HTPLC.

Identification keys

After the examination of macroscopic and microscopic features and the chemical compounds of the specimens, different dichotomous keys, sometimes specific for a particular genus, and online databases were used to identify the specimens:

Arup U., 2009. The *Caloplaca holocarpa* group in the Nordic countries, except Iceland. The lichenologist 41(2): 111-130.

Clauzade G., Roux C., 1985. Likenoj de Okcidenta Eüropo. Illustrita determinlibro. Bulletin de la Société Bolamque du Centre-Ouest, Nouvelle se'rie, Numero spécial 7.

Giralt M., 2001. The Lichen Genera *Rinodina* and *Rinodinella* (Lichenised *Ascomycetes*, *Physciaceae*) in the Iberian Peninsula. Bibliotheca Lichenologica 79.

Louwhoff S.H.J.J., 2009. *Peltigera.* Flora of Australia vol. 57.

Nimis P.L., 1986. I macrolicheni d'Italia: chiavi analitiche per la determinazione. Gortania, 8:101-220.

Nimis P.L., 1992. Chiavi analitiche al genere *Caloplaca* in Italia (Licheni, *Teloschistaceae*). Notiziario della Società Lichenologica Italiana. Vo. 5: 9-28.

Nimis P.L., Bolognini G., 1993. Chiavi analitiche del genere *Lecanora* Ach. in Italia. Notiziario della Società Lichenologica Italiana. Vol. 6: 29-46.

Nimis P.L., Martellos S., 2008. ITALIC. The Information System on Italian Lichens version 4.0 – 2008 [last visited: 2013-09-30] – www.dryades.eu/.

Ozenda P., Clauzade G., 1970. Les Lichens. Masson, Paris.

Rambold G., Elix J.A., Nash III T. H., Zedda L. (eds.), 2001 onwards [last visited: 2013-09-12]. LIAS light – A Database for Rapid Identification of Lichens. Translated by Ciurchea D. (Romanian), Cossu T. (Italian), Davydov E. A. (Russian), Gasparyan A. H. (Armenian), Gonzáles I. & Téllez, I. (Portuguese), Kis-Papo T. (Hebrew), Moske N. (Turkish), Muhambetalieva G.A. (Kyrgyz, Uzbek), Nöske N. (German), Osyczka P.J. (Polish), Roux C. (Esperanto, French), Şenkardeşler A. (Turkish), Sohrabi M. (Armenian, Farsi, Turkish), Vargas Castillo R. & Sanz V. (Spanish), Wei J. & Wei X. L. (Chinese). – liaslight.lias.net/.

Randlane T., Tõrra T., Saag A., Saag L., 2009. Key to European *Usnea* species. Bibliotheca Lichenologica 100: 419–462.

Smith C.W., Aptroot B.J., Coppins B.J., Fletcher A., Gilbert O.L., James P.W. & Wolseley P.A, 2009. The Lichens of Great Britain and Ireland. British Lichen Society.

Torrente P., Egea J.M., 1989. La familia *Opegraphaceae* en el Area Mediterránea de la Península Ibérica y Norte de Africa. Bibliotheca Lichenologica 32.

Zedda L., 2000. The lichen genera *Lepraria* and *Leproloma* in Sardinia (Italy). Cryptog. Mycol. 21: 249-267.

Creation of tables, maps and data analysis

Tables and graphs were created with Microsoft Office Excel 2007. Maps with the distribution of the sampling sites were created with the software Quantum GIS (QGIS) 1.8.0. using some informative layers that were downloaded from www.sardegnageoportale.it.

Graphs which divide the taxa for growth forms, type of photobiont and reproduction in each sites were created. The lists of the species were written checking the correct names in the database Cabi Bioscience Species Fungorum (2012). Ecological information and the rarity-commoness status of the species were taken by Nimis & Martellos (2008) and Zedda (2002). Statistical analysis were made with the software R.

RESULTS

The results combine the literature data with the ones obtained with the work in the field and laboratory.

STATE OF THE ART ON LICHENS ON *ILEX AQUIFOLIUM* L.

Lichens on *Ilex aquifolium* L. in Sardinia

Agonimia octospora Coppins & P. James: Mularza Noa – Bolotana (SS Herbarium Database).

Arthonia radiata (Pers.) Ach.: Mularza Noa – Bolotana (SS Herbarium Database).

Bacidia arceutina (Ach.) Rehm & Arnold.: Mularza Noa - Bolotana (Zedda, 2002).

Bacidia laurocerasi (Delise ex Duby) Zahlbr.: Mularza Noa - Bolotana (Zedda, 2002).

Caloplaca herbidella (Arnold) H. Magn.: N. Nunnaru - Anela (Zedda, 1995).

Collema nigrescens (Huds.) DC.: Western Sardinia (Rizzi *et al*., 2011).

Evernia prunastri (L.) Ach.: Nueradorzu (Nu); Sa Coa Scurosa - Anela (Zedda, 1995); Mularza Noa – Bolotana (SS Herbarium Database).

Lecanora chlarotera Nyl.: N. Nunnaru - Anela (Zedda, 1995).

Lecidella elaeochroma (Ach.) M. Choisy: N. Nunnaru - Anela (Zedda, 1995).

Lecidella euphorea (Flörke) Hertel.: Rio Aratu (Nu) (Nimis & Poelt, 1987); Mularza Noa - Bolotana (Zedda, 2002).

Lepraria lobificans Nyl.: Mularza Noa - Bolotana (Zedda, 2000).

Lepraria Ach. spp.: Nueradorzu (Nu); N. Nunnaru – Anela (Zedda, 1995).

Lobaria pulmonaria (L.) Hoffm.: Nueradorzu (Nu) (Zedda, 1995); Mularza Noa - Bolotana (Zedda, 2002).

Lobaria pulmonaria (L.) Hoffm. var. *meridionalis* (Vain.) Zahlbr.: Rio Aratu (Nu) (Nimis & Poelt, 1987).

Normandina pulchella (Borrer) Nyl.: Mularza Noa – Bolotana (SS Herbarium Database).

Ochrolechia szatalaënsis Verseghy: Mularza Noa – Bolotana (SS Herbarium Database).

Opegrapha varia Pers. = *Alyxoria varia* (Pers.) Ertz & Tehler.: Mularza Noa - Bolotana (Zedda, 2002).

Parmelia acetabulum (Neck.) Duby = *Pleurosticta acetabulum* (Neck.) Elix & Lumbsch: N. Nunnaru – Anela (Zedda, 1995).

Parmelia glabratula subsp. *glabratula* (Lamy) Nyl. = *Melanelixia fuliginosa* subsp. *glabratula* (Lamy) J.R. Laundon: Nueradorzu (Nu) (Zedda, 1995).

Parmelia saxatilis (L.) Ach.: N. Nunnaru – Anela (Zedda, 1995).

Parmelia sulcata Taylor.: Nueradorzu (Nu); N. Nunnaru - Anela (Zedda, 1995).

Parmelia tiliacea (Hoffm.) Ach. = *Parmelina tiliacea* (Hoffm.) Hale: Nueradorzu (Nu); Sa Coa Scurosa - Anela (Zedda, 1995).

Parmotrema perlatum (Huds.) M. Choisy: Mularza Noa – Bolotana (SS Herbarium Database).

Peltigera praetextata (Flörke ex Sommerf.) Zopf.: Mularza Noa – Bolotana (SS Herbarium Database).

Pertusaria albescens (Huds.) M. Choisy & Werner: Nueradorzu (Nu) (Zedda, 1995).

Pertusaria amara (Ach.) Nyl.: Nueradorzu (Nu) (Zedda, 1995).

Pertusaria pertusa (L.) Tuck.: Nueradorzu (Nu) (Zedda, 1995).

Phlyctis argena (Ach.) Flot.: Mularza Noa – Bolotana (SS Herbarium Database).

Phlyctis agelaea (Ach.) Flot.: Mularza Noa – Bolotana (SS Herbarium Database).

Physcia adscendens (Fr.) H. Olivier: N. Nunnaru – Anela (Zedda, 1995).

Physconia distorta (With.) J.R. Laundon: N. Nunnaru – Anela (Zedda, 1995).

Physconia venusta (Ach.) Poelt: N. Nunnaru – Anela (Zedda, 1995).

Porina aenea (Wallr.) Zahlbr.: Mularza Noa - Bolotana (Zedda, 2002)

Ramalina calicaris (L.) Röhl.: Nueradorzu (Nu); N. Nunnaru – Anela (Zedda, 1995).

Ramalina farinacea (L.) Ach. Nueradorzu (Nu); N. Nunnaru – Anela (Zedda, 1995).

Ramalina fastigiata (Pers.) Ach.: N. Nunnaru – Anela (Zedda, 1995).

Thelotrema lepadinum (Ach.) Ach.: Mularza Noa – Bolotana (SS Herbarium Database)

Usnea filipendula Stirt.: P.ta Palai (Nu). Zedda (2002) reported as collected by Nimis & Poelt on *Ilex*. In their book Nimis & Poelt indicate that the collection was made on a closed mixed wood with *I. aquifolium* but the kind of the tree where it was found is not specified.

Xanthoria parietina (L.) Beltr.: N. Nunnaru – Anela (Zedda, 1995).

STATE OF THE ART ON LICHENS ON *TAXUS BACCATA* L.

Lichens on *Taxus baccata* L. in Italy

Arthonia vinosa Leighton: Fonte Cardillo – Lungro (Calabria), 1228 m (Puntillo, 1996).

Calicium glaucellum Ach.: Fonte Cardillo – Lungro (Calabria), 1230 m (Puntillo, 1996).

Chaenotheca brunneola (Ach.) Müll. Arg: Fonte Cardillo – Lungro (Calabria), 1230 m, (Puntillo, 1996).

Chaenotheca trichialis (Ach.) Th. Fr.: Fonte Cardillo – Lungro (Calabria), 1230 m, (Puntillo, 1996).

Lichens on *Taxus baccata* L. in Sardinia

Bacidina phacodes (Körb.) Vězda = *Bacidia phacodes* Körb.: Mularza Noa - Bolotana (Zedda, 2002).

Calicium glaucellum Ach.*:* Mularza Noa - Bolotana (SS Herbarium Database).

Calicium salicinum Pers.: Mularza Noa - Bolotana (Zedda, 2002).

Caloplaca herbidella (Arnold) H. Magn.: Mularza Noa - Bolotana (Zedda, 2002).

Cladonia chlorophaea (Flörke ex Sommerf.) Spreng: Mularza Noa - Bolotana (SS Herbarium Database).

Candelariella xanthostigma (Pers. ex Ach.) Lettau.: Nuraghe Ortachis - Bolotana (Zedda, 2002).

Cladonia pyxidata (L.) Hoffm. - (Zedda, 2002).

Evernia prunastri (L.) Ach.: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Lecania naegelii (Hepp) Diederich & Van den Boom.: Mularza Noa - Bolotana (Zedda, 2002).

Lecanora carpinea (L.) Vain.: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Lecidella elaeochroma (Ach.) M. Choisy: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Lecidella euphorea (Flörke) Hertel.: Mularza Noa - Bolotana (Zedda, 2002).

Lepraria caesioalba (B. de Lesd.) J.R. Laundon.: Nuraghe Ortachis - Bolotana (Zedda, 2000).

Lepraria incana (L.) Ach.: Nuraghe Ortachis - Bolotana (Zedda, 2000).

Lepraria lobificans Nyl.: Nuraghe Ortachis - Bolotana (Zedda, 2000).

Lepraria nivalis J.R. Laundon.: Mularza Noa - Bolotana (Zedda, 2000).

Melanelia subaurifera (Nyl.) Essl.: Nuraghe Ortachis – Bolotana (SS Herbarium Database).

Opegrapha varia Pers. = *Alyxoria varia* (Pers.) Ertz & Tehler. Mularza Noa - Bolotana (Zedda, 2002).

Parmelia sulcata Taylor: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Parmelia tiliacea (Hoffm.) Ach.: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Pertusaria albescens var. *albescens* (Huds.) M. Choisy & Werner: Mularza Noa – Bolotana (SS Herbarium Database).

Pertusaria pertusa (L.) Tuck. : Mularza Noa – Bolotana; Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Phlyctis agelaea (Ach.) Flot.: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Phlyctis argena (Ach.) Flot.: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Physconia venusta (Ach.) Poelt: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Physcia adscendens (Fr.) H. Olivier: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Physconia venusta (Ach.) Poelt: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

Pleurosticta acetabulum (Neck.) Elix & Lumbsch: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

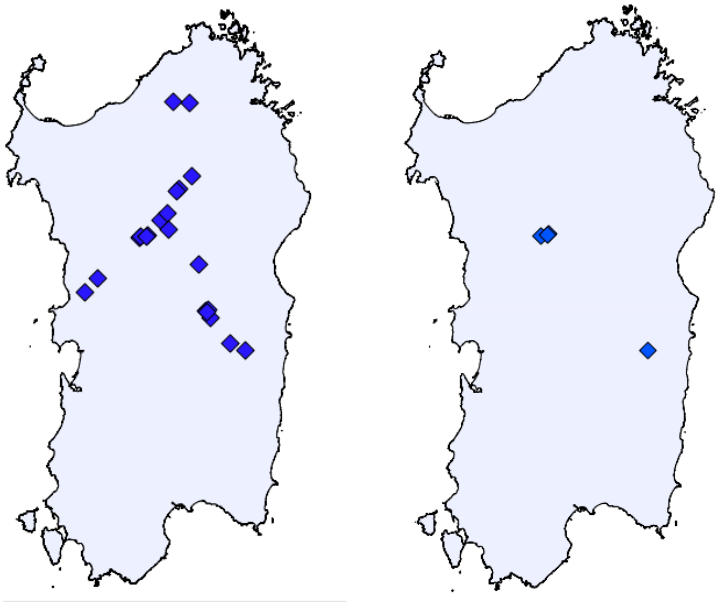
Porina aenea (Wallr.) Zahlbr.: Mularza Noa - Bolotana (Zedda, 2002).

Xanthoria parietina (L.) Beltr.: Nuraghe Ortachis - Bolotana (SS Herbarium Database).

LOCALITIES OF COLLECTION

The collections were made in the period 2011-2012 in 21 sites (maps 1 to 7; Annex 1). In reality the localities of collections were more, however if the sites were at a distance less than 1 km and shared the same ecological conditions (i.e. type of vegetation, canopy cover, use), they were considered as an unique site. Otherwise they were considered separately. For example the rows of *I.aquifolium* in proximity of Villa Piercy (Bolotana) and the shaded wood with *Taxus* and *Ilex* in Badde Salighes show different ecological conditions and vegetation type and were so considered 2 different localities.

Lichens were collected on *I.aquifolium* in 21 sites and on *T.baccata* in 4 sites (map. 1a,b).



Map. 1 - a. Collection sites of lichens on *Ilex aquifolium* L.; b. on *Taxus baccata* L.

The localities of collection belong to 7 macroareas (map.2):

- Marghine and Goceano
- Monte Lerno
- Limbara
- Monte Gonare
- Gennargentu
- Montarbu

- Montiferru

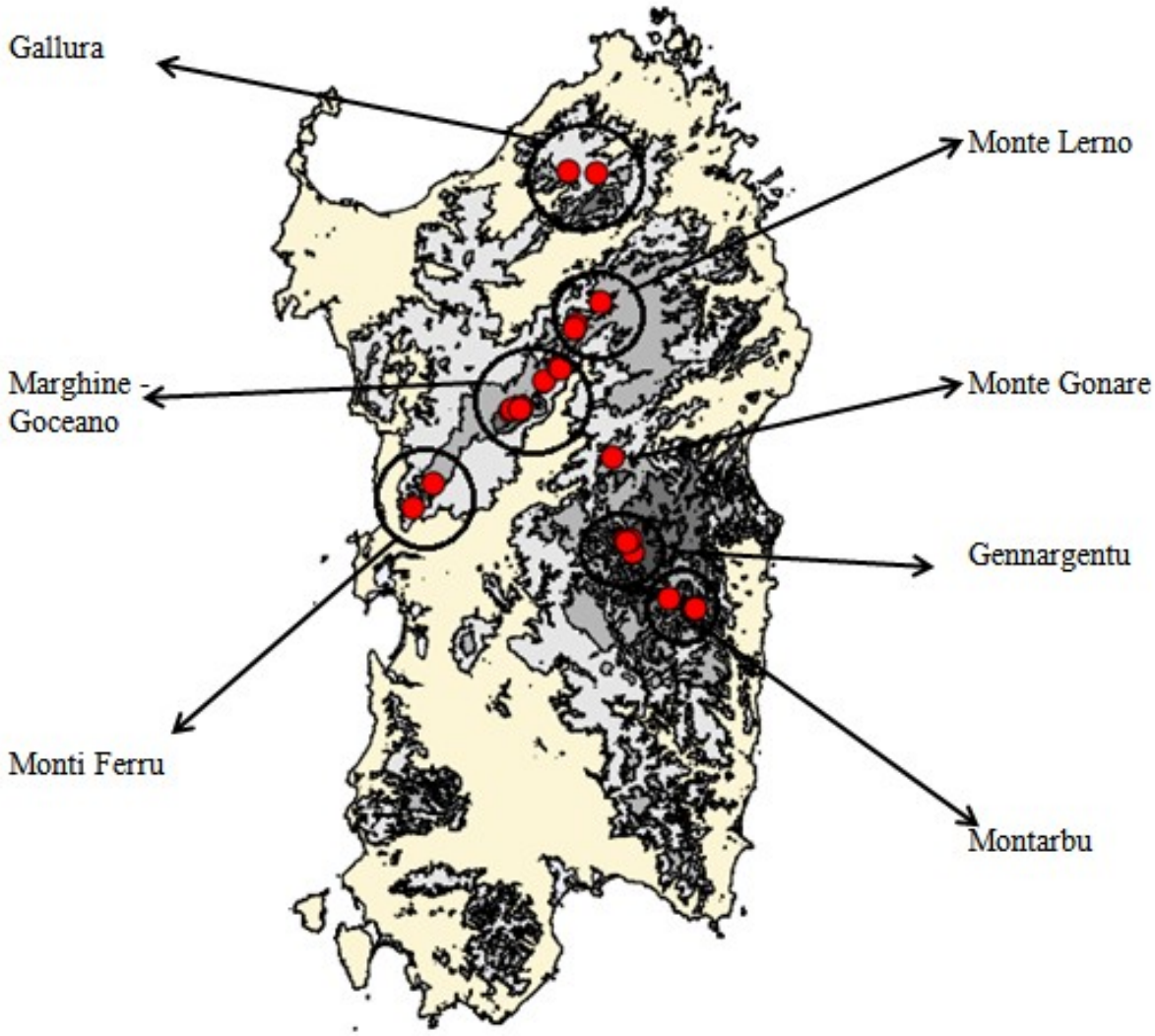
The sampling sites were overlapped to the 8 shapefiles of the areas subjected to fire in the period 2005-2012. The results show that none of them was crossed by fire during this period (map. 5). The shapefiles were downloaded from the website Sardegna Geoportale.

The sites in the Gennargentu are in Special Protection Area (ZPA) and in Site of Community Importance (SCI). Also the site in Monte Gonare and the ones (sites 1 to 6) in Marghine Goceano are located in Sites of Community Importance (maps 6 and 7).

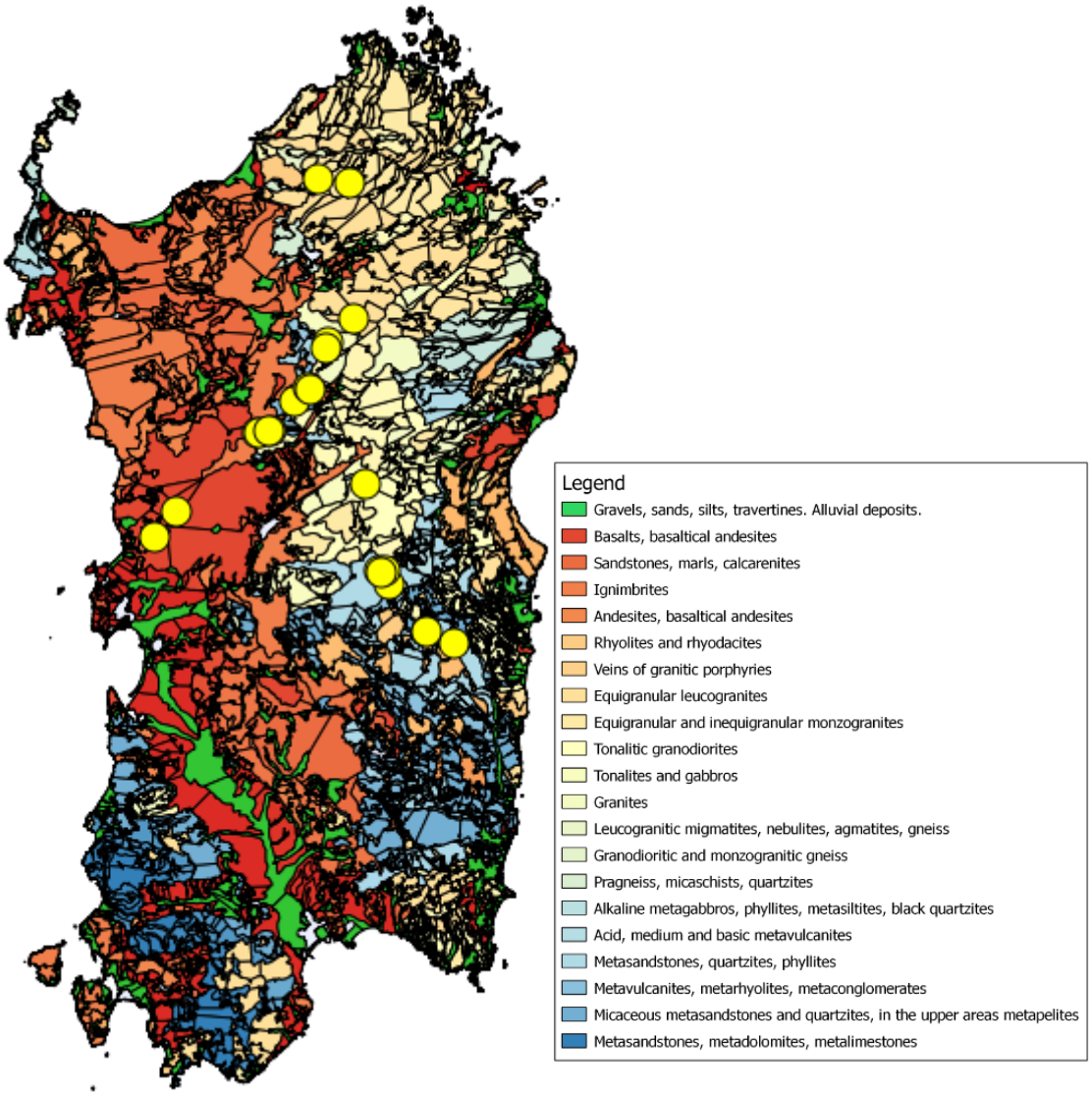
The altitude of the collecting sites is different and ranges from the lower ones (460 m a.s.l.) in the Limbata to the highest (1340 m a.s.l.) in the Gennargentu (map. 4).

The geology (map 3), the climatic features and the vegetation type of the collecting sites are different and are described in the following chapters. In particular the vegetation ranged from single trees of *I.aquifolium* to shaded wood. They can be pure wood of *I.aquifolium*, mixed wood of *I.aquifolium* and *T.baccata* or mixed wood where the dominant species are *Quercus pubescens* Willd. or *Quercus ilex* L. with also *I.aquifolium.* The uses of the areas are different, from the private area near Calangianus to areas that are used for recreational purposes (es. Pabude Park) or that are grazed by animals (es. Arcu Ittase).

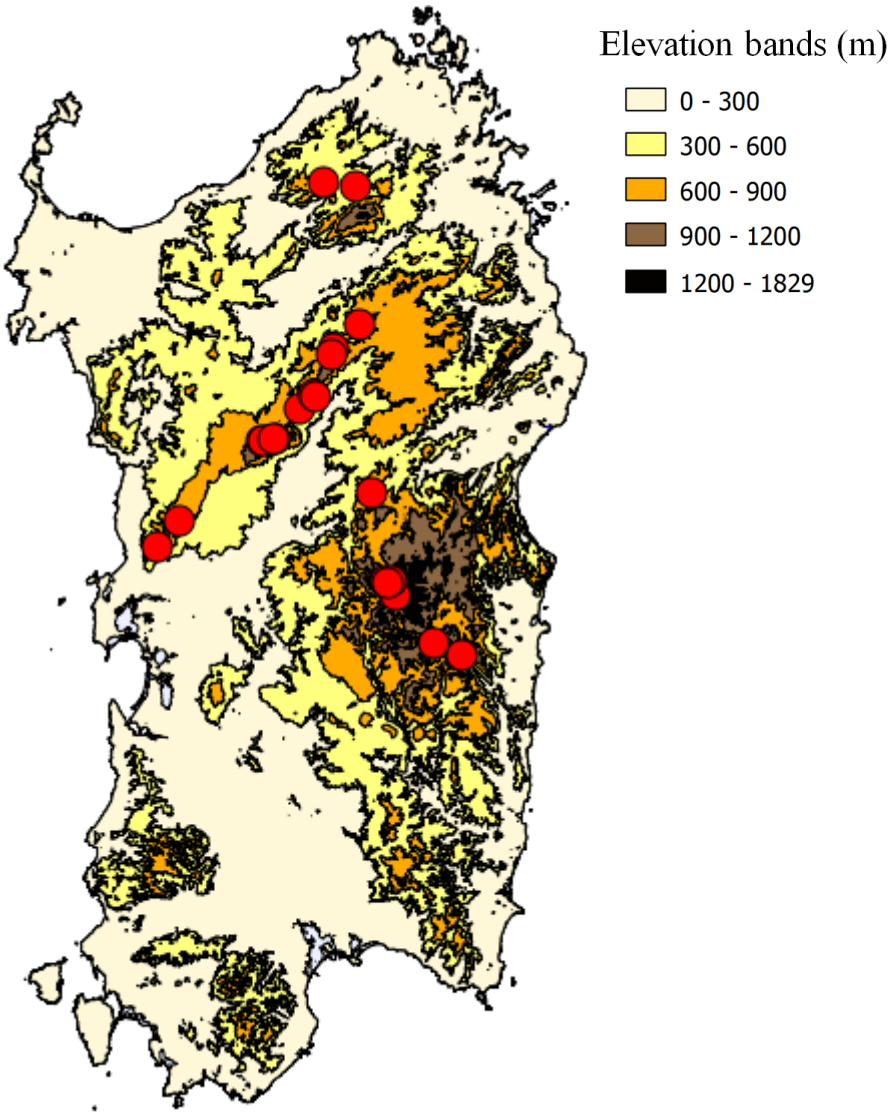
The circumference of the trunks of *I.aquifolium* ranges from young trees with 20 cm of circumference in Montarbu of Seui to monumental trees with more than 500 cm in Bruncu Sa Ruge (Gennargentu).



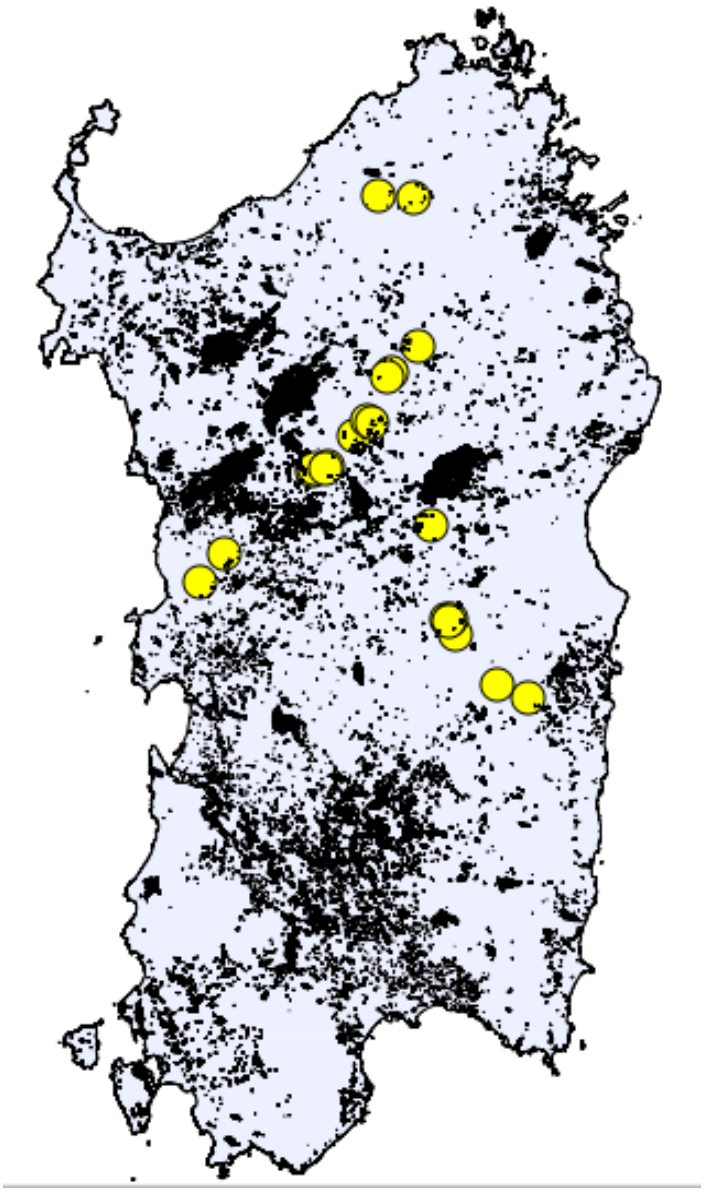
Map. 2 – The seven macro areas of collection.



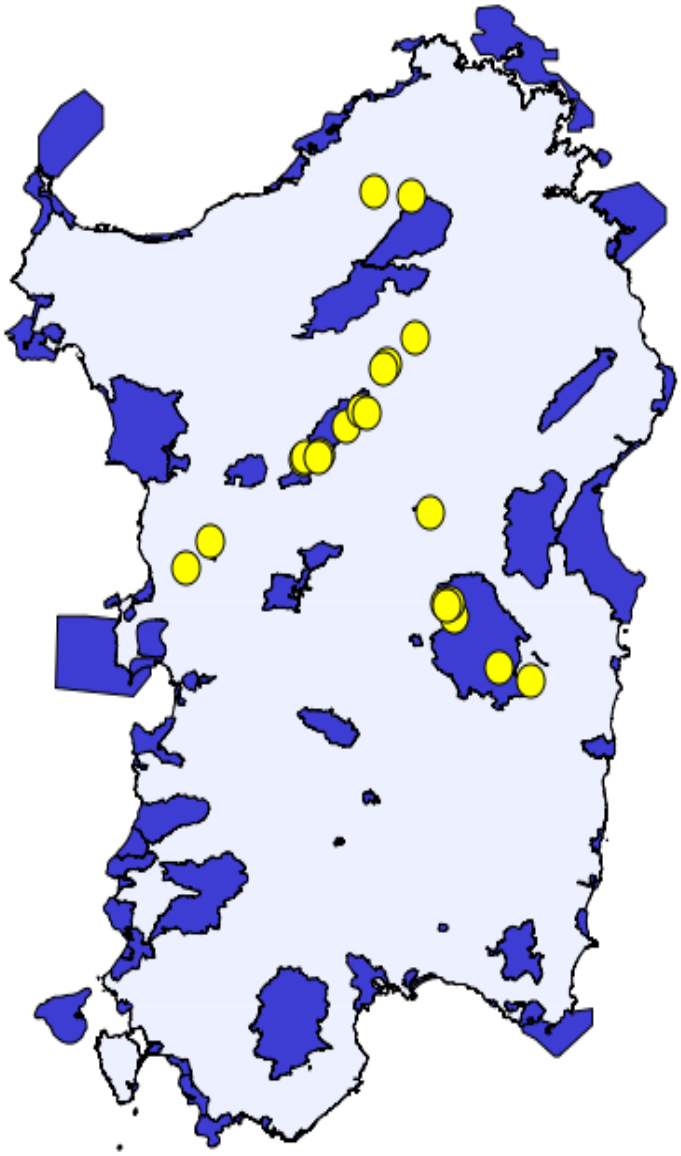
Map. 3 – Sampling sites (yellow circles) in the geological map.



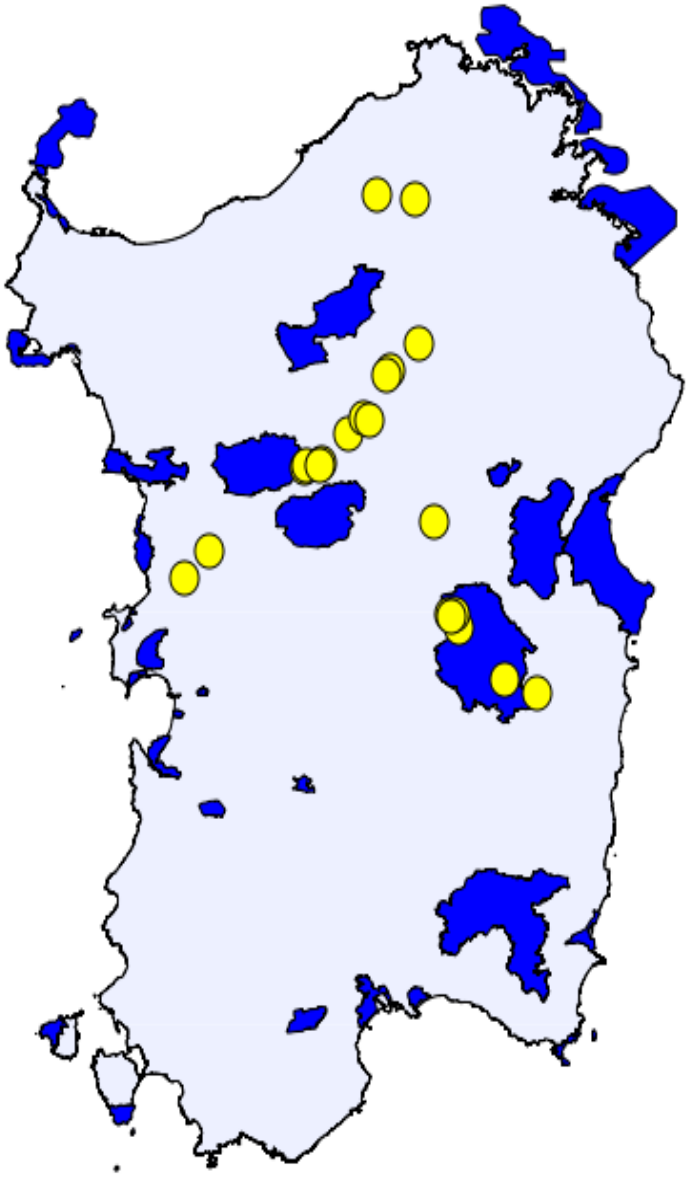
Map. 4 – Sampling sites (red circles) and elevation bands.



Map. 5 – Map with the areas subjected to fire (in black) during the period 2005-2012. The localities of collection are rapresented by yellow circles.



Map. 6 – Map with the Site of Community Importance in blue. The localities of collection are rapresented by yellow circles.



Map. 7 – Map with the Special Protection Area in blue. The localities of collection are rapresented by yellow circles.

MARGHINE – GOCEANO

Marghine-Goceano is an area in the centre of Sardinia, the highest altitudes reached are 1201 m a.s.l. in Punta Palai and 1259 m a.s.l. in Punta Manna. It is an area grazed by sheeps and cows (Camarda, 1977).

About the climatic features, the diagram of Walter and Lieth (fig. 33) referred to the period 1961-1990 indicates for the weather station of Macomer 15.02 °C of average annual temperature and 901 mm of average annual precipitation. Data which are similar if they are compared to the period before 1961 (Arrigoni, 1968; Arpas).

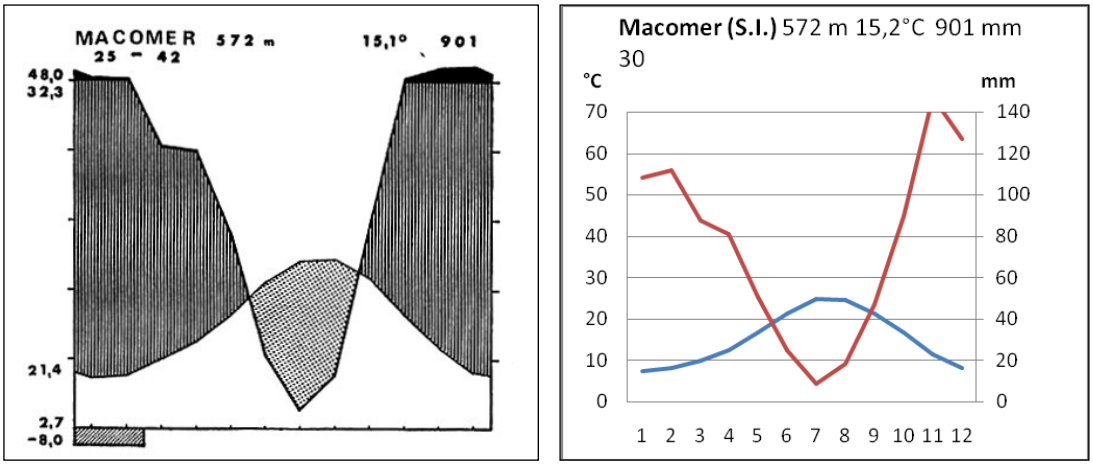


Fig. 33 – Climate diagrams of Walter and Lieth before 1961 (Arrigoni, 1968), in the period 1961-90 (Arpas)

In the weather station of Bolotana the average annual precipitation indicated in a period of 41 years, is 755 mm. The rainy days per year are 82 in Macomer and 72 in Bolotana. According to Camarda (1977) considering the thermal gradient and the higher altitude, the average annual temperature in Mularza Noa is few degrees lower than in Macomer and it is about 12°C. According to the bioclimatic classification of Emberger Macomer falls in the Mediterranean-subhumid (Arrigoni, 1968). Whereas according to the continentality index of Rivas-Martinez the station of Macomer belongs to the oceanic type, to the semicontinental subtype and to the meso-Mediterranean thermotype (Bacchetta *et al*., 2009).

The collections were made in 7 areas within the municipalities of Bolotana, Bono and Anela:

1. Badde Salighes (Bolotana), coord. 32 T 489609 44664802, 975 m a.s.l.

2. Villa Piercy (Bolotana), coord. 32 T 490059 4466758, 980 m a.s.l.

3. Parco Pabude (Bolotana), coord. 32 T 493114 4467467, 1007 m a.s.l.

4. Mularza Noa (Bolotana), coord 32 T 492752 4466993, 1003 m a.s.l.

5 Sos Nibberos (Bono), coord. 32 T 499132 4474514, 950 m a.s.l.

6. Foresta Demaniale Anela (Anela), coord. 32 T 502405 4477997, 990 m a.s.l.

7. Foresta Demaniale Anela (Anela), coord. 32 T 503303 4477453, 997 m a.s.l.

The lithology is different. Mainly basalts in the sites 1 and 2, rhyolites and rhyodacites in sites 3 and 4, metavulcanites in site 5 and tonalitic granodiorites in sites 6 and 7 (fig. 34).

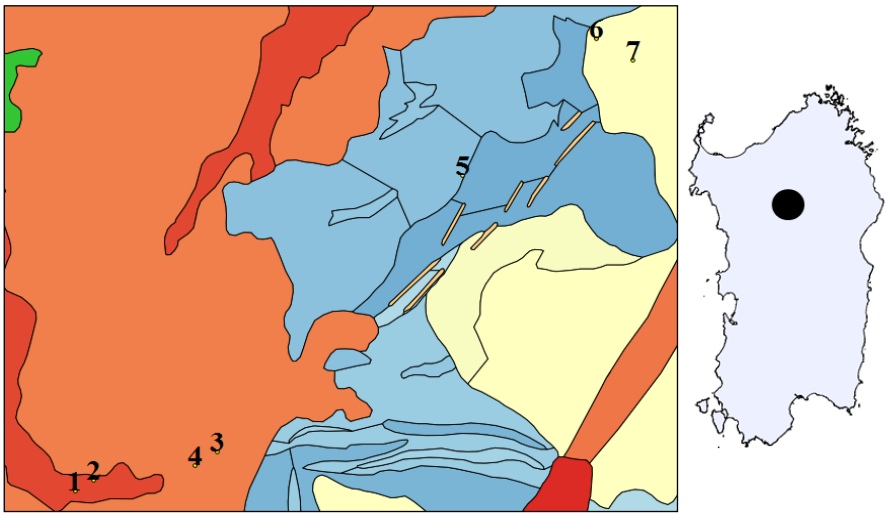


Fig. 34 – Particular of the geological map (map. 3).

The collecting sites from one to six belong to the Site of Community Importance named Catena Marghine e Goceano.

The vegetation type is different: from group of trees to open or shaded woods, from wood of *Ilex aquifolium* and *Taxus baccata* to ones dominated by holm oaks or pubescent oaks.

1. Badde Salighes – Bolotana

Coordinates: 32 T 489609 4466482, 975 m a.s.l.

The survey was made in a very shaded and old wood with mainly *Ilex aquifolium* and some monumental trees of *Taxus baccata* (fig. 35). The trees' canopy cover is almost 90%. The understorey is not present. Some individuals of *Hedera helix* L. are on tree trunks. The site is closed to grazing areas.

Lichens were collected both on holly and yew.

Holly trunks have around 70 cm of circumference. The trunks are covered mainly by crustose lichens and secondly by foliose ones both with narrow lobes such as *Phaeophyscia orbicularis* and broad lobes as *Parmelia sulcata* and *Melanelixia fuliginosa* subsp. *glabratula.* Twenty-nine species were found, among them 16 crustose, 10 foliose, 2 fruticose and only one leprose (annex 8). The species are mainly in symbiosis with *Trebouxia* and 4 with *Trentepohlia*, none with cyanobacteria (annex 6). The most adopt sexual reproduction with apothecia (19), only *Porina aenea* with perithecia. Six reproduce vegetatively with soredia and only two with isidia (annex 7).

Yew's trunks have circumferences superior to 4 metres. They show a low cover of lichens both on the twigs and on the main trunk. Leprose forms are the most common in the bark, followed by three crustose and small foliose thalli belonging to the genera *Xanthoria* and *Xanthoparmelia.* Specimens which belong to eight species were collected and among them the most are leprose forms (annex 8). Like holly the most numerous are the species in symbiosis with *Trebouxia* and only *Porina aenea* with *Trentepohlia* (annex 6). Sexual reproduction is adopted by 3 species, whereas 3 species reproduce vegetatively by soredia (annex 7).

Fig. 35 – a. *I.aquifolium*; b. *T.baccata*; c. and d. particulars of the bark of *T.baccata* with leprose lichens in loc. Badde Salighes (Bolotana).

2. Villa Piercy – Bolotana

Coordinates: 32 T 490059 4466758, 980 m a.s.l.

The collections were made on trees of *I. aquifolium* (fig. 36). The trees were maybe planted because they form a row on the left side of Villa Piercy. They are used for ornamental purposes. The site is inside the SCI of Catena Merghine e Goceano and it is close to grazing areas. The area is visited by the public and so the understorey is not present because it is constantly cutted.

The trees have the same dimensions. The circumference is around 30 – 40 cm and the bark in some parts of the trunks tends to rise and roll.

The trunks are exposed to sunlight and on the bark it is possible to find crustose, fruticose and foliose species (i.e. *Parmotrema perlatum* and *Parmelia sulcata*). The twigs are also well exposed to light and have a quite high presence of the fruticose species *Ramalina farinacea*, *R.fraxinea*, *R.farinacea* and *Evernia prunastri*. Also crustose and foliose lichens, for example several species of the genus *Physcia*, are present.

Forty taxa of lichens were found. The predominant forms are crustose (19) and foliose (16), in particular the ones with broad lobes. Also a leprose species and 4 fruticose were found (annex 8). The species with *Trebouxia* are the most numerous, followed by 4 species in symbiosis with *Trentepohlia*. None with cyanobactera was found (annex 6). The most of the taxa reproduce sexually by apothecia, only 1 by perithecia. Eighteen reproduce vegetatively, among them 13 by soredia and 5 by isidia (annex 7).

Fig. 36 – Trees of *I.aquifolium* near Villa Piercy (Bolotana).

3. Parco Pabude – Bolotana

Coordinates: 32 T 493114 4467467, 1007 m a.s.l.

Open wood dominated by *Quercus pubescens* Willd. and with also *I.aquifolium*, *Acer* sp. and some trees of *Taxus* mainly in the entrance of the park (fig. 37 a,b,c). The distance among the trees is more than 10 m and the canopy cover is less than 60%. The understorey is dominated by *Rubus* sp. and *Pteridium aquilinum* (L.) Kuhn. and its high is not superior than a meter. *Hedera helix* L. is sometimes present on the trunks of the trees. It is an area used for recreational purpose, there are in fact stone tables and benches, and for grazing. The collections were made both on holly and yew.

The trees of *I. aquifolium* examined have a trunk from 25 to 50 cm of circumference. Twenty-three taxa were collected. The crustose forms were the most numerous (11) followed by 9 foliose lichens and 3 fruticose (annex 7). No leprose species was found. Lichens were mainly in symbiosis with *Trebouxia* and only *Porina aenea* with *Trentepohlia* (annex 6).

Lichens were collected on a tree of *T.baccata* placed at the entrance of the park. Its circumference is 200 cm and there is no understorey around it. The trunk is exposed to the sunlight because the tree is isolated from the others. Twenty two taxa were collected. The most common forms were crustose ones (14) followed by 10 foliose, 3 fruticose and 3 leprose (annex 8). Lichens in symbiosis with *Trebouxia* were predominant, only *Alyxoria varia*, *Arthonia vinosa* and *Porina aenea* with *Trentepohlia*. None with cyanobacteria was found (annex 6).

Lichens collected in both holly and yew reproduce mainly sexually with apothecia, only *Porina aenea* with perithecia, and secondly asexually by soredia,. Two taxa collected on *I.aquifolium* and one collected on *T.baccata* reproduce by isidia (annex 7).

Fig. 37 – a. Wood; b. tree of *Taxus baccata* L.; c. tree of *Ilex aquifolium* L. Loc. Pabude Park (Bolotana).

4. Mularza Noa – Bolotana

Coordinates: 32 T 492752 4466993, 1003 m a.s.l.

It is an old shady wood (fig. 38a) with *Quercus ilex* L., I*lex aquifolium* and *Taxus baccata.* The canopy cover, that is not particularly high in the edges, increases penetrating inside up to 80%. The humidity is high and mosses cover rocks on the ground, the base and, in general, the trunks of the trees. There is no understorey. The collections were made on *I.aquifolium* and on *T.baccata*.

The circumference of the trunks of *I.aquifolium* (figs. 37b,c,) ranges from ca. 50 to 200 cm. The trunks show the presence of numerous foliose lichens and among them big thalli of *Pleurosticta acetabulum* and *Parmelina tiliacea* and some exemplars of *Lobaria pulmonaria*. There are also fruticose lichens such as *Evernia prunastri* and *Ramalina* spp. and crustose lichens, among them species of the genera *Pertusaria*, *Lecanora* and *Arthonia*. On the twigs crustose, foliose and fruticose lichens are well represented.

Fifty-seven taxa were collected during the Ph.D work, to whom other 8 reported and collected by Zedda (2002) or only collected by her (Database SS Herbarium) must be added. The most are in symbiosis with *Trebouxia*, 6 with *Trentepohlia* and *Collema furfuraceum* and *Nephroma laevigatum* with cyanobacteria (annex 6). The crustose forms are the most numerous (32) followed by 23 foliose and 6 fruticose. Among them there are also the granulose *Agonimia octospora,* the squamulose *Normandina pulchella* and 2 leprose species (annex 8). Forty species reproduce sexually and among them only *Porina aenea* with perithecia. Seventeen reproduce asexually by soredia and 8 by isidia (annex 7).

Samples of lichens were collected also on a monumental tree of *T.baccata*. The most numerous taxa were collected on twigs exposed to sunlight where also *Xanthotia parietina* was found. The total number of taxa is 22 but Zedda (2002; Database SS Herbarium) collected other 7 in the same kind of tree. The most common forms on *T.baccata* are crustose (18), then 6 foliose, 3 fruticose and only 2 leprose (annex 8). Lichens in symbiosis with *Trebouxia* are predominant, only *Alyxoria varia* and *Porina aenea* are in symbiosis with *Trentepohlia* and none with cyanobacteria (annex 6). The most of the lichens reproduce sexually, 18 with apothecia and 1 with perithecia. Eight reproduce asexually with soredia and 1 with isidia (annex 7).

Fig. 38 – a. Wood; b. tree of *I.aquifolium*; c. trunk of *I.aquifolium*. In loc. Mularza Noa.

5. Sos Nibberos – Bono

Coordinates: 32 T 499132 4474514, 950 m a.s.l.

It is a mixed wood with mainly *Quercus pubescens* Willd. and secondly *Ilex aquifolium* (fig. 40a,b). The canopy coverage (90%) is quite high unless near paths where the tree trunks are exposed to sunlight. The area examined had an inclination ranging from 30 to few grades and with NW exposition. The understorey is quite high with mainly ferns. *Hedera helix* L. and mosses are present on tree trunks. The circumference of the examined trees of *I. aquifolium* ranges from 20 to 45 cm. The diameters of the tree trunks in general are quite similar and they are maybe coetaneous. The use of the area is recreational and mainly it is used also for the collection of the wood. Mainly crustose lichens are visible on the trunks (fig. 39c), among them *Phlyctis argena* and *Lecidella elaeochroma* are the most numerous. Few thalli of foliose lichens such as *Pleurosticta acetabulum* and *Parmotrema perlatum* and fruticose thalli of *Evernia prunastri* are also present. On *I.aquifolium* 30 taxa were collected, which are mainly in symbiosis with *Trebouxia,* only *Arthonia atra* and *A.didyma* with *Trentepohlia* (annex 6). The crustose forms (15) are the most numerous followed by 12 foliose, two fruticose and 1 leprose (annex 8). Eight taxa reproduce asexually by soredia and 3 by isidia, 18 sexually with apothecia (annex 7).

Lichens were checked also on *Taxus baccata,* the trunk (fig. 39) and the ramifications apparently have few lichens, only the crustose *Porina aenea*, which is in symbiosis with *Trentepohlia*, was found. Maybe further observations are needed.

Fig. 39 – Particular of the trunk of *T.baccata* in loc. Sos Nibberos (Bono)

Fig. 40 – a. Wood; b. tree of *I.aquifolium*; c. trunk of *I.aquifolium*. In loc. Sos Nibberos (Bono).

6. Foresta Demaniale - Anela

32 T 502405 4477997, 990 m a.s.l.

Mixed wood near a suburban road with mainly *Quercus pubescens* Willd. and also *Castanea sativa* Miller, *Quercus ilex* L. and *Ilex aquifolium* L (fig. 41a). The tree canopy cover is 50%. There is almost no understorey except some seedlings of *I.aquifolium* and *Q.ilex*. Mosses cover the rocks in the ground and are present on the trunks of trees.

The collections were made on *I.aquifolium* (fig.41b) whose circumference of the trunk ranged between 30 to 90 cm. Some trees have predominantly crustose lichens as *Pertusaria amara*, *P.pertusa* and *Lecidella elaeochroma* but the most show an high coverage of fruticose lichens such as. *Evernia prunastri* (fig.41c), *Ramalina* ssp. and *Pseudevernia furfuracea* and of foliose lichens with broad lobes, as *Parmelia submontana* and *Pleurosticta acetabulum*. The twigs are rich of lichens, although less than the near oaks.

Thirty-six taxa were collected, all of them are in symbiosis with *Trebouxia* (annex 6). The most have a crustose form (16) and secondly foliose (13). Only 5 taxa are fruticose and 2 leprose (annex 8). Eighteen taxa adopt vegetative reproduction, 14 by soredia and 4 by isidia. Eighteen species reproduce sexually with apothecia (annex 7).

Fig. 41 – a. Wood; b. tree of *I.aquifolium*; c. trunk of *I.aquifolium*. In loc. Forest'Anela (loc. 6).

7. Foresta Demaniale - Anela

Coordinates: 32 T 503303 4477453, 997 m a.s.l.

Mixed wood (fig. 42a) with mainly *Quercus pubescens* Willd. and secondly *Ilex aquifolium* L. Also some trees of *Crataegus monogyna* Jacq. are present. The inclination of the area is different and reaches 30° with North exposure. The tree canopy was ca. 60%. The rocks emerging from the ground are covered by mosses. The understorey is infrequent and it is mainly dominated by ferns and some seedlings of *I.aquifolium*. In some parts the understorey is almost totally absent. Lichen coverage is not high both on *Ilex aquifolium* (fig. 42c) and oaks.

Collections were made on hollys whose circumference of the trunks ranges from 20 to 40 cm. The boles have mainly crustose lichens (fig. 42b) which are typically pioneer species such as *Phlyctis argena* and *Lecidella elaeochroma* and few fruticose thalli of *Evernia prunastri* and *Ramalina* spp. The situation is similar in the twigs in shaded conditions. Whereas the ramifications exposed to sun light, such as the ones in the wood edges or near paths have a bigger amount of fruticose lichens and there are also few little thalli of the foliose *Xanthoria parietina.*

Eighteen taxa were found on *Ilex aquifolium*, among them 11 crustose, 3 foliose with broad lobes, 3 fruticose and 1 leprose (annex 8). The most are in symbiosis with *Trebouxia* and only *Porina aenea* with *Trentepohlia* (annex 6). Eleven taxa reproduce sexually with apothecia and only 1 with perithecia. Four taxa adopt vegetative reproduction with soredia, none with isidia (annex 7).

Fig. 42 - a. Wood; b. trunk of *I.aquifolium*; c. tree of *I.aquifolium*. In Foresta Anela (loc. 7).

MONTE LERNO

Monte Lerno is an area placed in central North Sardinia in the territories of the municipality of Pattada. The maximum height reached is 1094 m. The diagram of Walter and Lieth referred to the period 1991-2007 indicates in the locality of Alà dei Sardi 14.04 °C of average annual temperature and 793 mm of average annual precipitation (fig. 43). According to Emberger the station of Alà dei Sardi falls within the higher horizon of the Mediterranean-humid bioclimate (Arrigoni, 1968). According to the continentality index of Rivas-Martinez the station of Alà dei Sardi falls within the oceanic type, euoceanic subtype and meso-Mediterranean thermotype (Bacchetta *et al*., 2009).

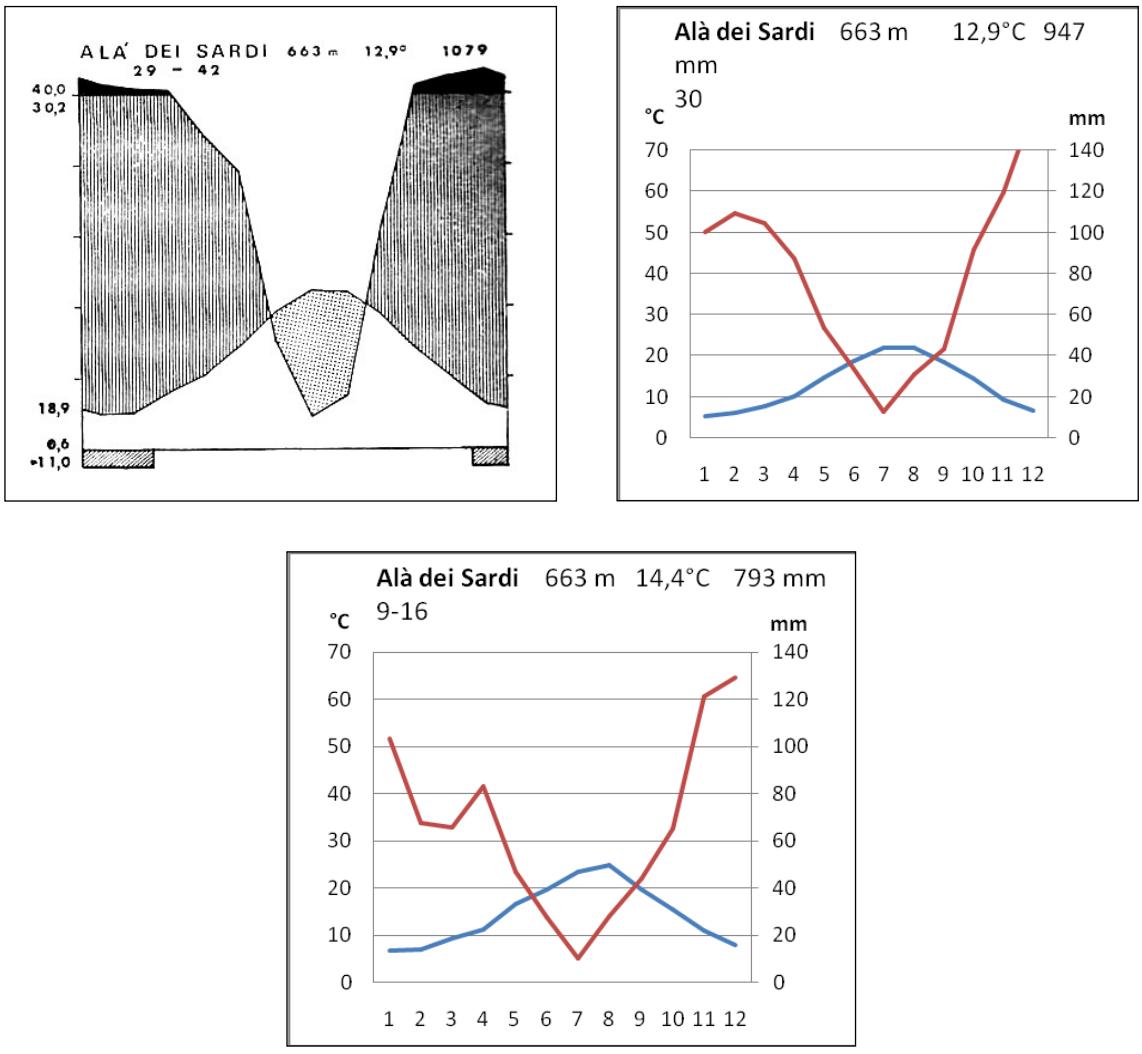


Fig. 43 - Climate diagrams of Walter and Lieth before 1961 (Arrigoni, 1968), in the periods 1961-90 and 1991-2007 (Arpas).

The collections were made in 3 sites:

8. Sa Pala de sa ‘e Tulippu (Pattada), coord. 32 T 507754 4489369, 875 m a.s.l.

9. Sololche (Pattada), coord. 32 T 506890 4488219, 855 m a.s.l

10. Funtana Rodè (Pattada), coord. 32 T 513829 4495640, 950 m a.s.l.

The geology (fig. 44) is linked to the intrusive process of the Hercynian orogeny and ranges from gabbros (sites 8 and 9) to leucogranites (site 10)

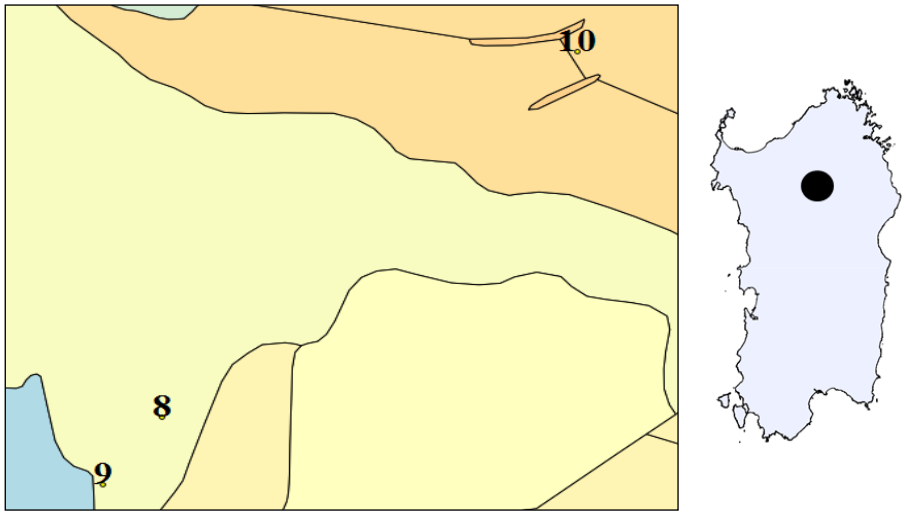


Fig. 44- Particular of the geological map (legend map. 3).

The three localities differ in the vegetation type. The first is a shaded wood dominated by *Quercus pubescens* and the third is a shaded wood dominated by *Quercus ilex*. Whereas in locality Sololche the collections were made on a group of trees of *Ilex aquifolium* in the roadside and so well exposed to sunlight.

8. Sa Pala de sa 'e Tulippu - Pattada

Coordinates: 32 T 507754 4489369, 875 m a.s.l.

It is a shaded wood (fig. 45a). The upper stratum is dominated by *Quercus pubescens* Willd., whereas the lower stratum is dominated by *Ilex aquifolium* L. (fig. 45b). The canopy coverage is 80-90% unless some little areas with clearings which are more exposed to the sunlight. The area has an inclination up to 30° with North exposure. The understorey is not thick with an height of 50-70 cm. It is made by seedlings of pubescent oak and holly, by ferns, *Rubus* sp., *Ruscus aculeatus* and by shrubs or little trees of *Crataegus monogyna*.

The circunference of the trunks of *I.aquifolium* is around 35-40 cm. The most common lichens in the trunk are the crustose forms and mainly *Phlyctis argena* and *P.agelaea* (fig. 45c). Some thalli of *Evernia prunastri* and few little ones of *Physconia* sp. are also present. In the twigs there are are few lichens. Mainly *Lecanora chlarotera* and *Lecidella elaeochroma* are visible.

Thirteen taxa were collected in this area on *I.aquifolium*, among them 11 crustose, only 1 foliose with narrow lobes and 1 fruticose (annex 8). The most of them is in symbiosis with *Trebouxia* and only *Porina aenea* and *Arthonia didyma* with *Trentepohlia* (annex 6). Eight taxa reproduce sexually with apothecia and one with perithecia. Two species adopt vegetative reproduction by soredia. No isidiate species was found (annex 7).

Fig. 45 – a. Wood; b. tree of *I.aquifolium*; c. trunk of *I.aquifolium*. Loc. Sa Pala de sa ‘e Tulippu (Pattada).

9. Sololche - Pattada

Coordinates: 32 T 506890 4488219, 855 m a.s.l.

Group of few trees of *Ilex aquifolium* near the roadside (fig. 46a). A fountain is present few meters far. It is a grazing area. The trees are exposed to sunlight and the understorey is not present. The circumference of the trunks ranges from 60 to 95 cm.

Lichen coverage on trunks (figs. 46b,c) is high with thalli of foliose lichens with broad lobes like *Xanthoria parietina* and *Pleurosticta acetabulum* and narrow lobes like *Physconia enteroxhanta* and *Physcia adscendens.* The fruticose species in the trunk are rapresented mainly by *Ramalina farinacea, R.fraxinea* and *R.fastigiata*. The twigs which are not exposed to the sunlight have mainly crustose species whereas the ones which are exposed have *Ramalina* ssp., *X. parietina* and *Physcia adscendens*.

On *I.aquifolium* were collected 17 taxa all in symbiosis with *Trebouxia* (annex 6). Among them the most numerous are the crustose (8) and the foliose ones (6). Only 3 fruticose and none leprose were found (annex 8). The most reproduce sexually with apothecia, 6 reproduce asesually with soredia and only *Parmelina tiliacea* with isidia (annex 7).

Fig. 46– a. Group of *I.aquifolium* trees of ; b.c. particulars of the trunk of hollies. Loc. Sololche (Pattada).

10. Funtana Rodè - Pattada

Coordinates: 32 T 513829 4495640, 950 a.s.l.

Shaded wood (figs. 47a,b) with *Quercus ilex*, *Ilex aquifolium* and few trees of *Taxus baccata*. The trees canopy is 90%. The understorey is almost not present with mainly seedlings of *I.aquifolium* and *Q.ilex*.

The collections were made on *I.aquifolium*. The circumference of tree trunks ranges from 40 to 90 cm. The ramifications show mainly crustose lichens such as *Phlyctis argena* and *P.agelaea*, *Lecidella elaeochroma* and *Lecanora chlarotera*, some thalli of *Physcia adscendens* and fruticose thalli of *Evernia prunastri* and *Ramalina fastigiata*. In the trunks (fig. 46c) mainly crustose lichens are present, among them *Pertusaria amara*, *P.leioplaca* and *P.pertusa*. In the bark of some trees big thalli of *Parmotrema perlatum*, some thalli of *Parmelia sulcata* and *Physcia adscendens* and few thalli of *Evernia prunastri* are present.

Twenty-three taxa were collected. The most are in symbiosis with *Trebouxia* and only *Arthonia radiata* and *Porina aenea* with *Trentepohlia* (annex 6). Twelve taxa are crustose, 6 foliose, 3 fruticose, one leprose and one squamulose (annex 8). Ten reproduce sexually with apothecia, one with perithecia. Ten adopt vegetative reproduction by soredia and 1 by isidia (annex 7).

Fig. 47 - a.b. Wood, c. trunk of *I.aquifolium*. Loc. Funtana Rodè (Pattada).

LIMBARA

Limbara is a rocky massif in North-Eastern Sardinia which is located in the geographic region of Gallura. It belongs to the municipalities of Berchidda, Calangianus, Oschiri and Tempio Pausania. The maximum elevation reached by the area is 1359 m a.s.l. in Punta Balestrieri.

The diagram of Walter and Lieth referred to the period 1991-2007 indicates 14.07 °C of average annual temperature and 836 mm of average annual precipitation in the weather station of Tempio (fig. 48). The yearly mean of the relative air humidity, calculated in the period 1940-65 is 74% with 13 days at year with fog calculated on the period 1969-77 (Zedda, 2002).

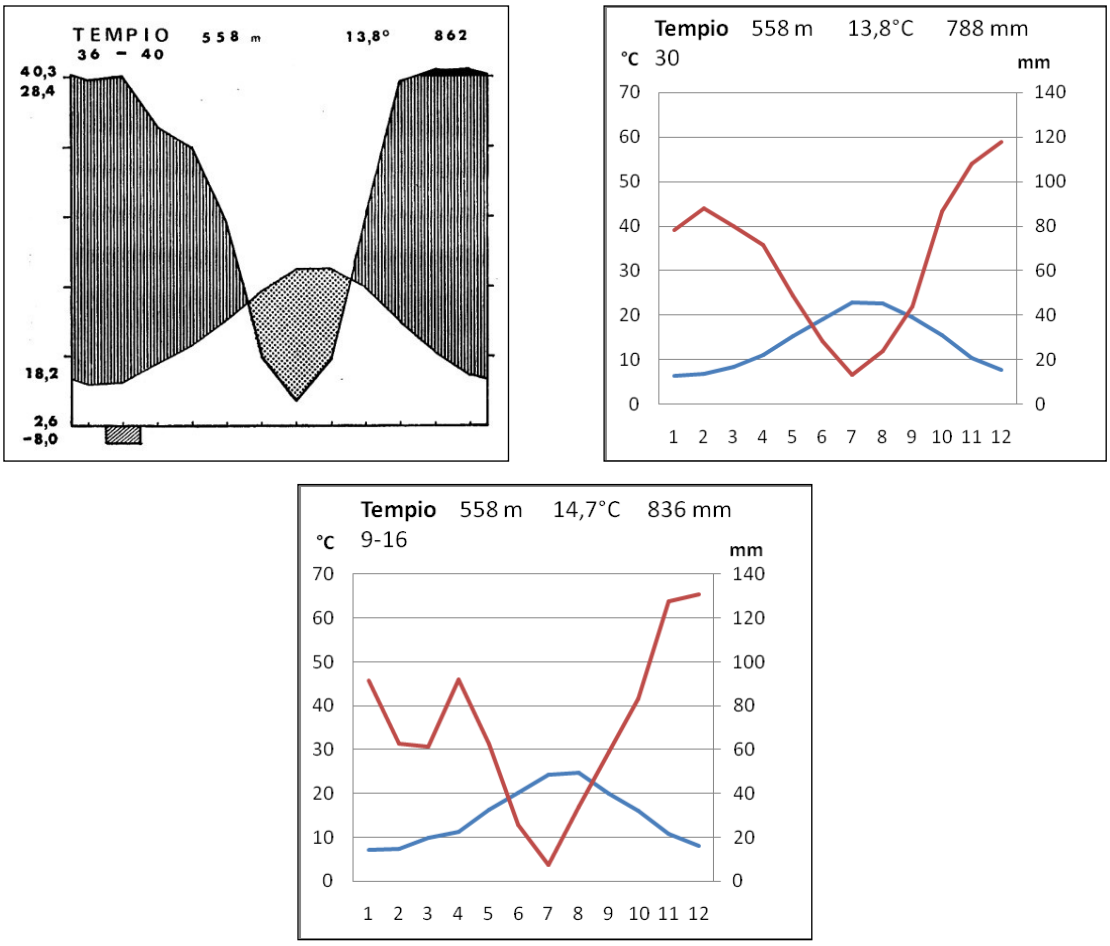


Fig. 48- Climate diagrams of Walter and Lieth before 1961 (Arrigoni, 1968), in the periods 1961-90 and 1991 (Arpas).

According to Emberger the station of Tempio belongs to the lower horizon of the Mediterranean-humid bioclimate (Arrigoni, 1968). According to the continentality index of Rivas-Martinez the station of Alà dei Sardi falls within the oceanic type, euoceanic subtype and superior meso-Mediterranean thermotype (Bacchetta *et al*., 2009).

The collections were made in 2 areas both close to Tempio Pausania:

11. Rio Mannu (Aggius), coord. 32T 505141 4530556, 510 m a.s.l.
12. Exit to Calangianus (Nuchis), coord. 32 T 513073 4529684, 460 m a.s.l.

The first area is situated near a river and the vegetation ranges from a shaded wood of *Quercus pubescens* with young trees of *Ilex aquifolium* to the typical riparian vegetation. It is an area that is open to the public and there are several paths. The second is a private area with few trees of *Ilex aquifolium* close to each other in a grazing area with decorticated trees of *Quercus suber*.

The geology (fig. 49) is linked to the intrusive process of the Hercynian orogeny and the litology is characterized by monzogranites.

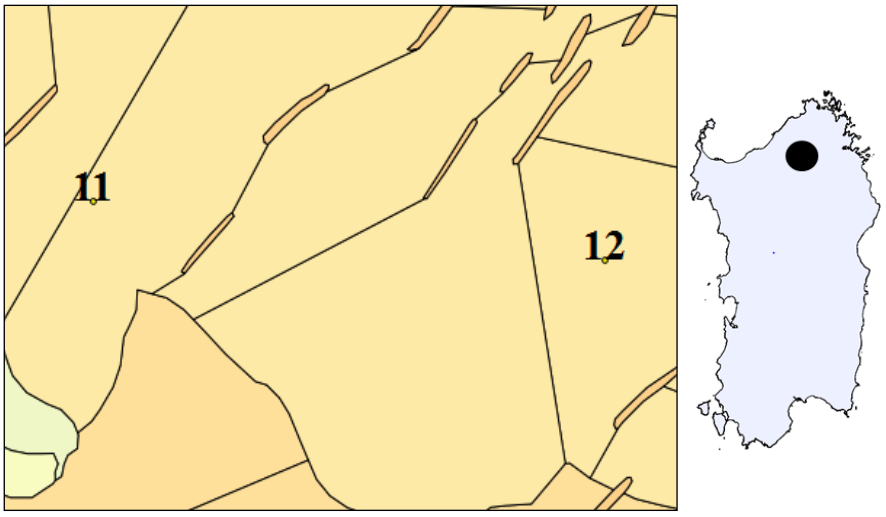


Fig. 49 - Particular of the geological map (map. 3).

11. Rio Mannu – Aggius

Coordinates: 32T 505141 4530556, 510 m a.s.l.

Wood, close to a river, dominated by tall trees of *Quercus pubescens* and also with trees of *I.aquifolium* (fig. 50b). Closer to the river there is a typical riparian vegetation with predominantly *Alnus glutinosa* (L.) Gaertner. The tree canopy of the wood is high (in some part 80% of coverage) so the holly are mainly in shaded conditions. Some trees are present along a path and are quite exposed to sunlight (fig. 50a). The understorey is tall and in some parts reaches 1.60 m. It is made by *Rubus* sp., *Ruscus aculeatus* L. and seedlings or shrubs of *I.aquifolium*. *Hedera helix* is present on the bark of some trees.

The trees of *I.aquifolium* are in general young ones with small bark circumference (11 – 20 cm) in few cases 70 cm. Lichen coverage is not high with mainly crustose lichens (fig. 50c). The foliose ones are mainly *Parmotrema perlatum* and *Physcia adscendens*. There are also some little thalli of the fruticose *Evernia prunastri*. The trunks of the trees near paths are exposed to the light and in the bark it is possible to find also some small thalli of *Xanthoria parietina*. The twigs have not a big coverage of lichens. The thalli of *Phlyctis argena*, *Lecidella elaeochroma* and *Lecanora chlarotera* are the most common. In some twigs it is possible to find also well developed thalli of the fruticose *Ramalina farinacea* and *fastigiata*. The predominance of the pioneer taxa (*P.argena*, *L.elaeochroma*, *L.chlarotera*) seem linked to the young age of most of the trees and to the small circumference of the trunk.

Eighteen species were collected: 11 crustose, 4 foliose, 2 fruticose and 1 leprose (annex 8). The most are in symbiosis with *Trebouxia* and only *Porina aenea* and *Schismatomma decolorans* with *Trentepohlia*, none with cyanobacteria (annex 6). The most reproduce sexually, 10 with apothecia and 1 with perithecia. Six adopt vegetative reproduction through soredia and one through isidia (annex 7).

Fig. 50 – a. A path in the wood; b. trees of *I.aquifolium*; c. trunks of *I.aquifolium.* Locality Rio Mannu.

12. Exit to Calangianus - Nuchis

Coordinates: 32T 513073 4529684, 460 m a.s.l.

Fig. 51 – Tree of *I.aquifolium* in Nuchis.

Few close trees of *I.aquifolium* (fig. 51) in a private country with some trees of decorticated *Quercus suber* L. It is a grazing area. The trees' trunk circumference is around 120 cm. The understorey is quite tall and dense, with *Rubus* sp. and *Asparagus* sp. The tree trunk is covered in many parts by *Hedera helix*. The trunks and the ramifications are not exposed to sunlight because of the high understorey and the tree canopy. Lichen coverage is quite low with mainly crustose thalli. The twigs show few foliose lichens and mainly crustose ones, in particular sorediate. On *Ilex aquifolium* 36 taxa were found: 23 crustose, 1 crustose placodiomorph, 1 minutely squamulose, 9 foliose and 1 fruticose taxa (annex 8). The most are in symbiosis with *Trebouxia*, 4 with *Trentepohlia* and none with cyanobacteria (annex 6). The species adopt mainly sexual reproduction with apothecia (23), 1 with perithecia. Ten taxa reproduce sexually through soredia and only one through isidia (annex 7).

MONTE GONARE

It is a mountainous area in the centre of Sardinia with three peaks: Gonare (1.083 m a.s.l.), Gonareddu (1.045 m a.s.l.) and Punta Lotzori (976 m a.s.l.). The southern slope is mainly calcareous with marbles and metamorphic rocks whereas the northern one is predominantly siliceous with granites and granodiorites (Camarda, 1986). The survey was made only in a site whose litology is charaterized by metasandstones and phyllites (map. 3).

For the climatic features the data of the weather station of Fonni were used. The diagram of Walter and Lieth referred to the period 1991-2007 indicates 12.04 °C of average annual temperature and 817 mm of average annual precipitation (fig. 52). The yearly mean of the relative air humidity, calculated in the period 1940-65 was 65% (Zedda, 2002).

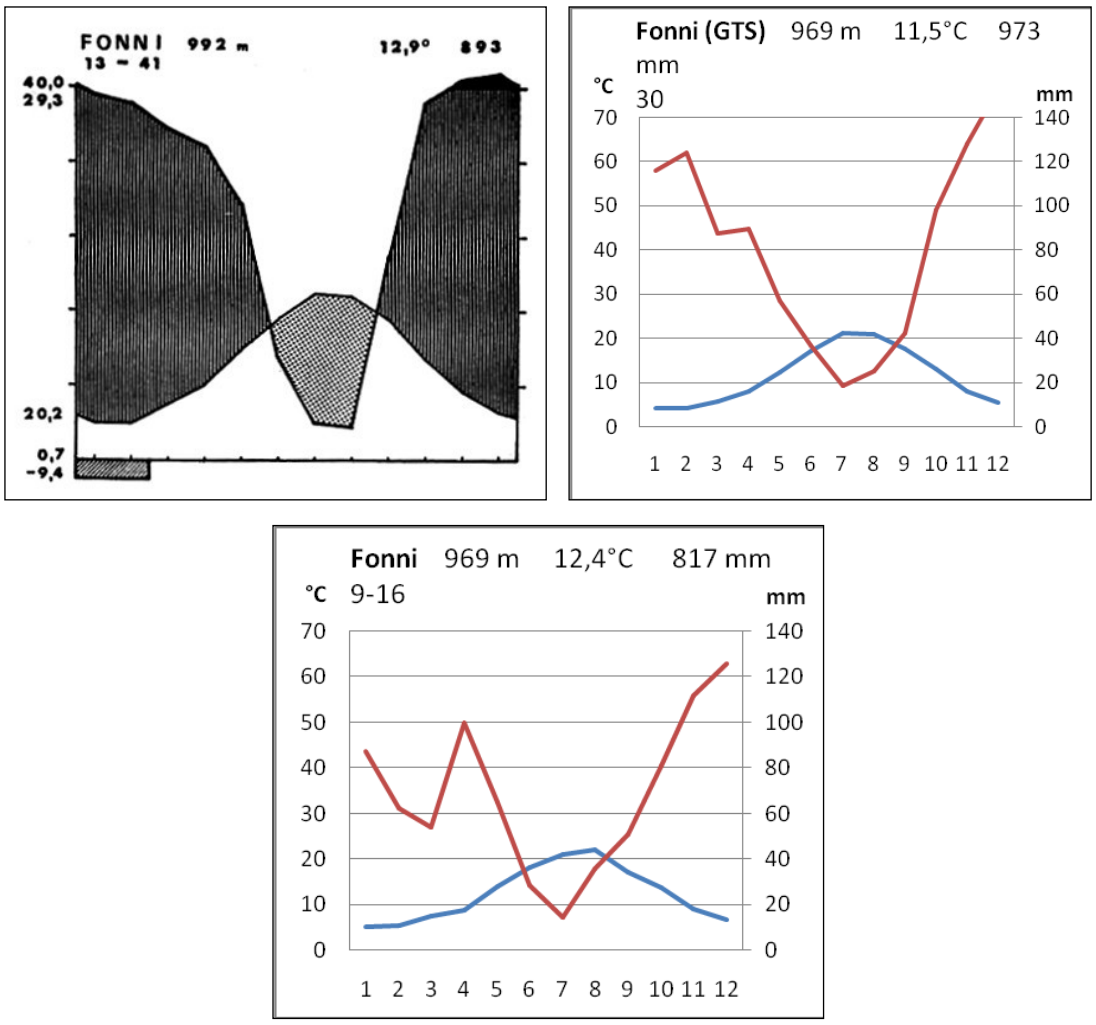


Fig. 52 - Climate diagrams of Walter and Lieth before 1961 (Arrigoni, 1968), in the periods 1961-90 and 1991-2007 (Arpas).

According to Emberger the station of Fonni (992 m a.s.l.) falls within the higher horizon of the Mediterranean-humid bioclimate whereas the nearer station of Nuoro (545 m a.s.l.) falls within the Mediterranean-subhumid bioclimate (Arrigoni, 1968). According to the continentality index of Rivas-Martinez the station of Nuoro belongs to the oceanic type, semicontinental subtype and inferior meso-Mediterranean thermotype (Bacchetta *et al*., 2009).

13. Monte Gonare - Orani

Coordinates: 32T 517185 4453835, 875 m a.s.l.

It is a quite shaded wood dominated by *Quercus pubescens* Willd. and *Quercus ilex* L. with also *Ilex aquifolium* L.(fig. 53a). The trees are close to each others and the canopy cover is around 80%. The understorey is present with only few herbaceous and some seedlings of *Ilex aquifolium* and oaks. It is a recreational area with stone tables and benches.

The collections were made on of *Ilex aquifolium* trees, whose circumference is between 30 and 40 cm. In the trunks (fig. 53b) the most common are the crustuse lichens such as *Phlyctis argena*, *Lecidella elaeochroma* and *Lecanora chlarotera*. There are also foliose thalli such as *Parmotrema perlatum* and *Physconia distorta* and some fruticose as *Evernia prunastri* and *Ramalina fastigiata*. Also *Lobaria pulmonaria* was found on some trunks. In the twigs the crustose forms are the predominant.

Thirty taxa were found on *Ilex aquifolium*: 14 crustose, 12 foliose and 4 fruticose (annex 8). Almost all are in symbiosis with *Trebouxia* and only *Arthonia radiata* is in symbiosis with *Trentepohlia*, none with cyanobacteria (annex 6). Seventeen reproduce sexually with apothecia, 9 adopt vegetative reproduction through soredia and 4 through isidia (annex 7).

Fig. 53 – a. Wood; b. trunks of *Ilex aquifolium*. In Monte Gonare (Orani).

GENNARGENTU

Gennargentu is a mountain area located in the central eastern Sardinia. The highest peak is Punta La Marmora which reaches 1.834 m a.s.l. It is an area grazed by sheeps, cows, goats and porcine, which can have strong impacts either on the vegetation that on the soil (Camarda, 1977).

The diagram of Walter and Lieth referred to the period 1991-2007 indicates 13.04 °C of average annual temperature in the locality of Desulo and 12.04 °C in the locality of Fonni. They indicate 1079 mm of average annual precipitation in Desulo and 817 mm in Fonni (fig. 56). The average annual temperature calculated in the period 1930-80 in the station of Genna Silana is 11.70 °C, whereas the average annual precipitation related to the period 1921-80 is 1147 mm (Zedda, 2002).

According to Emberger the stations of Desulo, Fonni and Genna Silana belong to the higher horizon of the Mediterranean-humid bioclimate (Arrigoni, 1968). According to the continentality index of Rivas-Martinez the stations of Desulo and Genna Silana fall within the oceanic type. Desulo belongs to the semicontinental subtype whereas Genna Silana to the euoceanic one. About the thermotype Desulo belongs to the superior meso-Mediterranean and Genna Silana to the lower supra-Mediterranean one (Bacchetta *et al*., 2009).

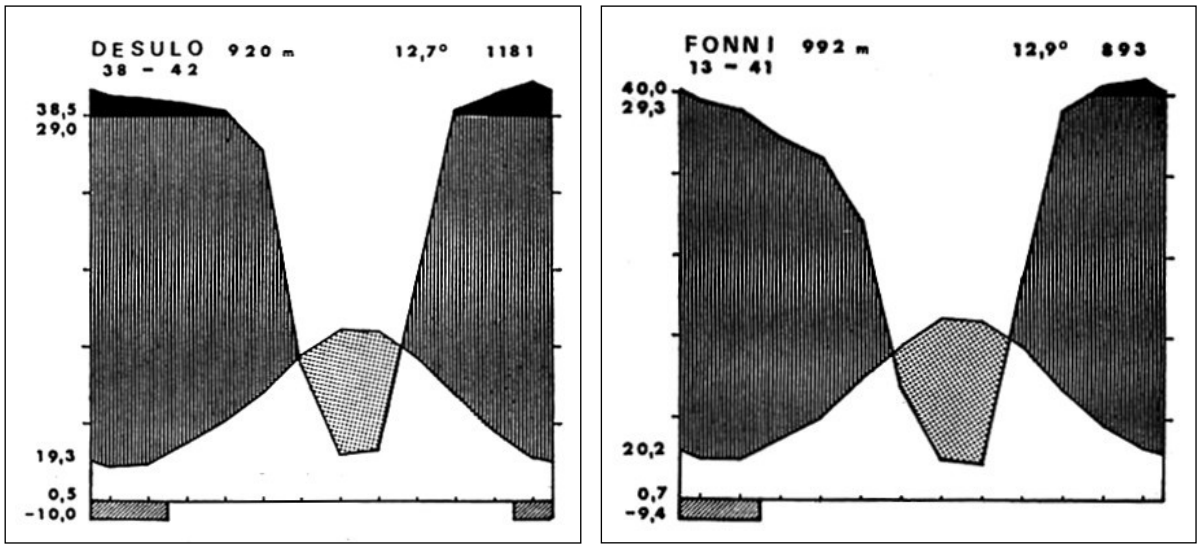


Fig. 54 - Climate diagrams of Walter and Lieth before 1961 (Arrigoni, 1968).

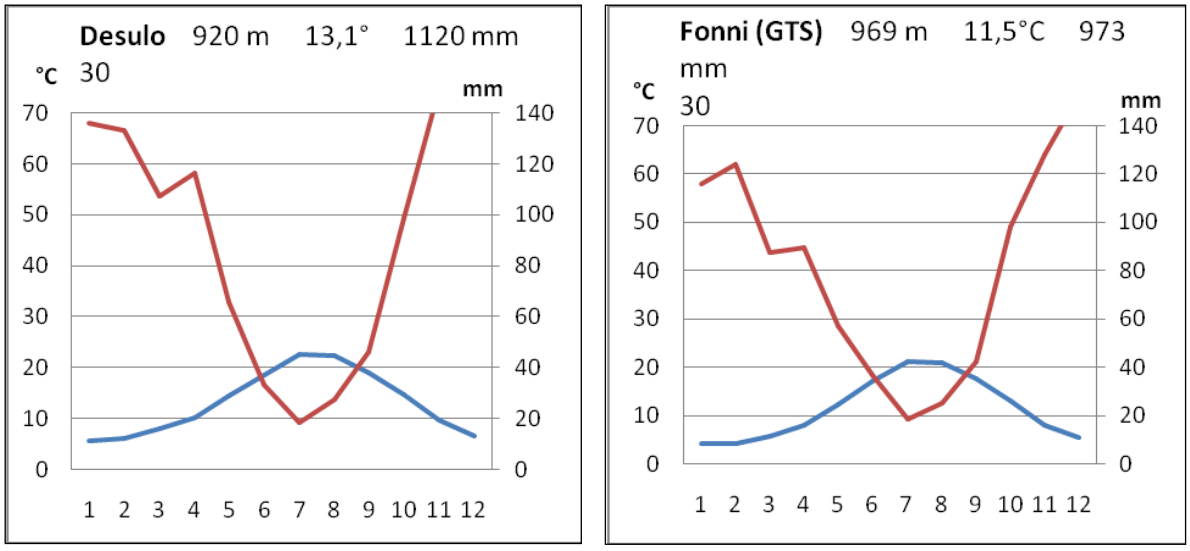


Fig. 55 - Climate diagrams of Walter and Lieth in the period 1961-90 (Arpas).

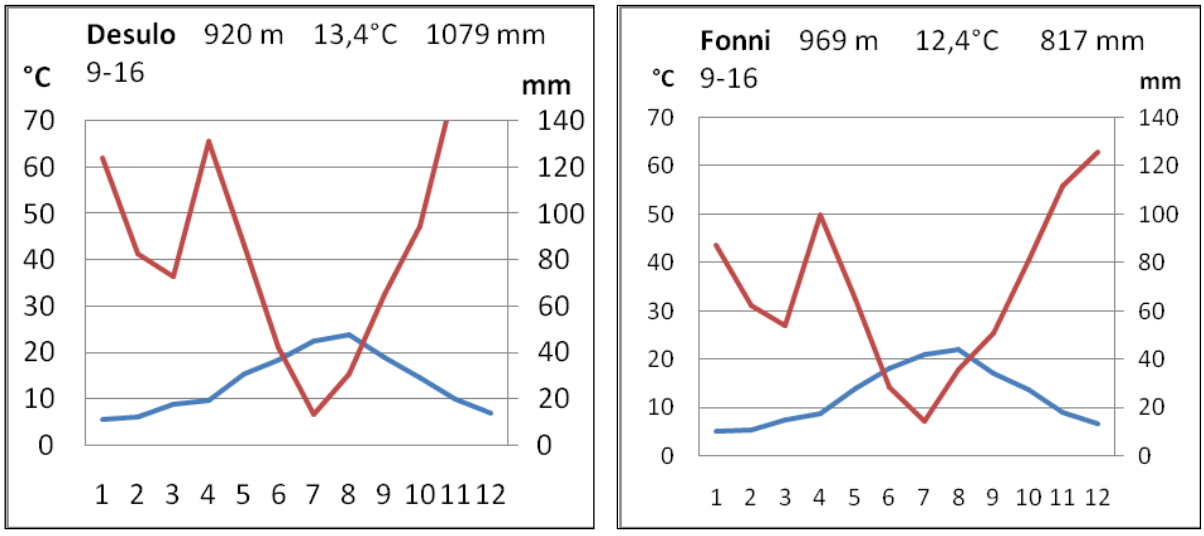


Fig. 56 - Climate diagrams of Walter and Lieth 1991-2007 (Arpas).

The collections were made in 4 sites on *Ilex aquifolium* L.:

14. Funt.na Fritta (Arcu Ittase) - Desulo, coordinates 32T 520523 4432055, 1260 m a.s.l.

15. Bruncu Sa Ruge - Desulo, coordinates 32T 521138 4431373, 1340 m a.s.l.

16. Rio Carrada - Desulo, coordinates 32T 522725 4428542, 900 m a.s.l.

17. Rio Aratu - Desulo, coordinates 32T 521796 4432194, 925 m a.s.l.

The site of Bruncu Sa Ruge is located at an higher altitude and it is more continental, than the localities of Fonni, Desulo and Genna Silana. For this reason the period of aridity is shorter.

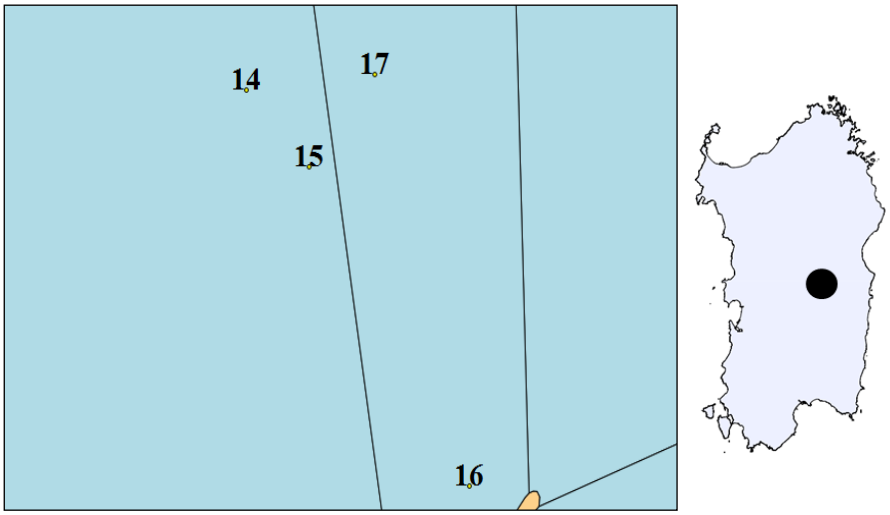


Fig. 57- Particular of the geological map (map. 3).

The geological substrate is characterized by terrigenous successions which date back to the Cambrian - lower Ordovician with alternation of metasandstones, quartzites and phyllites (fig. 57).

14. Funt.na Fritta (Arcu Ittase) – Desulo

Coordinates: 32 T 520523 4432055, 1260 m a.s.l.

Open wood with *Quercus pubescens* Willd. and *Ilex aquifolium* L. (fig. 58a). In proximity of the road there are mainly holly trees, inside the wood their number decrease and the pubescent oaks become the dominant trees. The area is used mainly for grazing (fig. 58). Some trees show damages on the bark made by goats.

Fig. 58 – Goats grazing in loc. Arcu Ittase.

Collections were made on holly. The circumference of the trunks ranged between 35 and 140 cm. Lichen coverage is high either in the tree trunk that on twigs (fig. 59b,c). The trees were divided in two groups according to their circunference: the small ones (around 35-40 cm) and the big ones (between 90 and 140 cm) to show possible differences.

The results in both groups are quite similar: 49 taxa were collected in the first and 44 in the second. The most common lichens are the crustose forms followed by fruticose. One leprose and two different lichenicolous species, one in a group and one in the other, were found (annex 8, fig. 60). The most are in symbiosis with *Trebouxia*, only *Arthonia radiata* with *Trentepohlia*. *Collema flaccidum* and C.*furfuraceum* in symbiosis with cyanobacteria were found only in the biggest trees (annex 6, fig. 62). About the reproduction there are no differences among the groups: the majority of the lichens (65%) reproduce sexually with apothecia, the 18% asexually by soredia and the 16% by isidia (annex 7, fig. 61).

Fig. 59 – a. *Ilex aquifolium* L.; b. trunk of *I.aquifolium;* c. lichens on a twig of *I.aquifolium*. Loc. Arcu Ittase (Desulo).

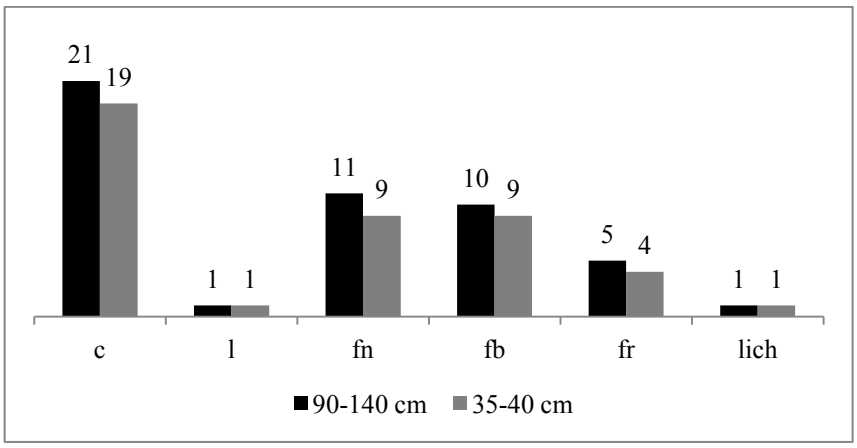


Fig. 60 - Number of taxa on *I.aquifolium* for each growth form, loc. 14.

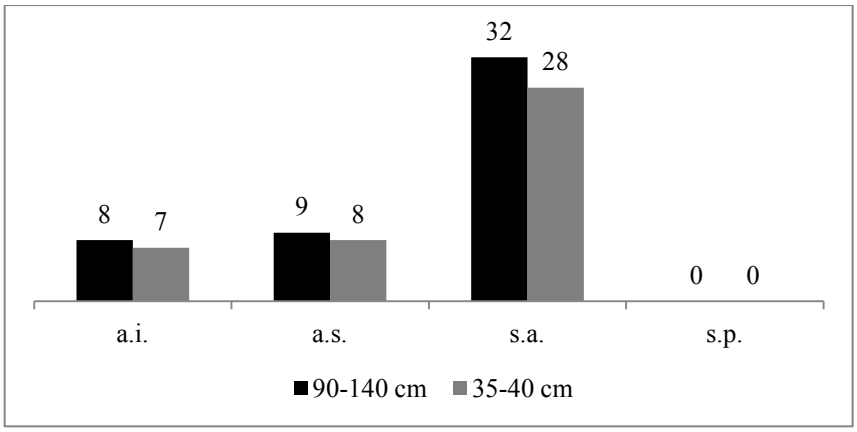


Fig. 61 - Number of taxa for reproduction strategy on *I.aquifolium,* in loc. 14.

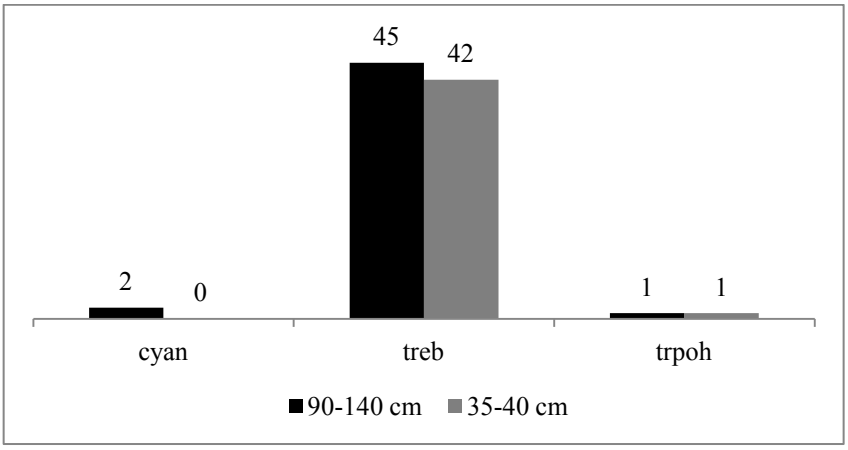


Fig. 62 - Number of taxa on *I.aquifolium* for each type of photobiont, in loc. 14.

15. Bruncu Sa Ruge – Desulo

Coordinates: 32 T 521138 4431373, 1340 m a.s.l.

Group of trees of *Ilex aquifolium* L. (fig. 63a). The area is particularly relevant for conservation purposes because it is characterized by the presence of monumental trees of holly whose circumference of the trunks ranges from 85 to 518 cm (Brunu, 2011). The area has low inclination with South exposure. It is an area used for grazing. The bark of the trunks shows damages caused by goats (fig. 63b). The coverage of lichens is high either on trunks (fig. 64), main branches and twigs (fig. 65).

Some of the most visible lichens on the trunks are big crustose thalli of *Pertusaria* ssp., foliose lichens with broad lobes, such as *Pleurosticta acetabulum* and *Xanthoria parietina,* foliose with narrow lobes of the genus *Physconia* and *Physcia* and the fruticose lichen *Anaptychia ciliaris*. On the twigs the most numerous are the crustose genera *Lecanora* and *Caloplaca,* the foliose of the genus *Physcia* and the fruticose *Ramalina*. On the lower part of the trunks big thalli of *Parmelina tiliacea* are present and in the exposed roots *Candelariella xanthostigma* and *C.vitellina.*

The most of the lichens collected were in symbiosis with *Trentepohlia*, *Collema subflaccidum* with cyanobacteria and *Alyxoria varia* and *Arthonia radiata* with *Trentepohlia* (annex 6). The most are crustose forms (31). One leprose, 15 foliose and 4 fruticose taxa were found (annex 8). Thirty-six taxa reproduce sexually with apothecia, 8 asexually by soredia and 6 by isidia (annex 7)

Fig. 63 – a. Trees of *I.aquifolium*; b. trunk of *I.aquifolium* damaged by goats. Loc. Bruncu Sa Ruge (Desulo).

Fig. 64 – Lichens on the main trunk of *Ilex aquifolium* Loc. Bruncu Sa Ruge (Desulo).

Fig. 65 –Lichens on main branches and twigs of *Ilex aquifolium* in loc. Bruncu Sa Ruge (Desulo).

16. Rio Carrada – Desulo

Coordinates: 32 T 522725 4428542, 900 m a.s.l.

Few trees of *Ilex aquifolium* near a spring (fig. 66). Lichens were collected only in the trunk of one tree which has a circunference of 70 cm. The base of the trunk is covered by mosses and on them there is the leprose species *Lepraria jackii*. On the bark mainly crustose species such as *Pertusaria leioplaca*, *Lecanora chlarotera* and *Lecidella elaeochroma* and also some thalli of *Melanelixia fuliginosa* subsp. *glabratula* (annex 8) are present. The most of the species are in symbiosis with *Trebouxia* and only 2 with *Trentepohlia* (annex 6). The main reproduction strategy is sexual with apothecia. Two species reproduce asexually by soredia and 1 by isidia (annex 7).

Fig. 66 – Locality Riu Carrada (Desulo).

17. Rio Aratu – Desulo

Coordinates: 32 T 521796 4432194, 925 m a.s.l.

The collections were made on two trees of *Ilex aquifolium* in the roadside (fig. 67). The circumference of the trunk is around 40 cm. In the bark only crustose lichens and few small foliose thalli of *Parmelina tiliacea*, *Physcia adscendens*, *Physconia distorta*, *Pleurosticta acetabulum* and *Xanthoria parietina* are present. The most were found on twigs which are well exposed to the sunlight. The collected species are 11 crustose, 9 foliose and 1 fruticose (annex 8). All the lichens identified are in symbiosis with *Trebouxia* (annex 6). Sixteen taxa reproduce sexually with apothecia, 2 asexually by soredia and 2 by isidia (annex 7).

Fig. 67 – Tree of *Ilex aquifolium* L. in locality Rio Aratu (Desulo).

MONTARBU – SEUI

Montarbu (Seui) is a mountain area located in South-East Sardina. The maximum altitude reached is 1324 m a.s.l. in the peak Margiani Pubusa.

The diagram of Walter and Lieth referred to the period 1991-2007 indicates 14.04 °C of average annual temperature and 707 mm of average annual precipitation (fig.68) in the weather station of Villanovatulo.

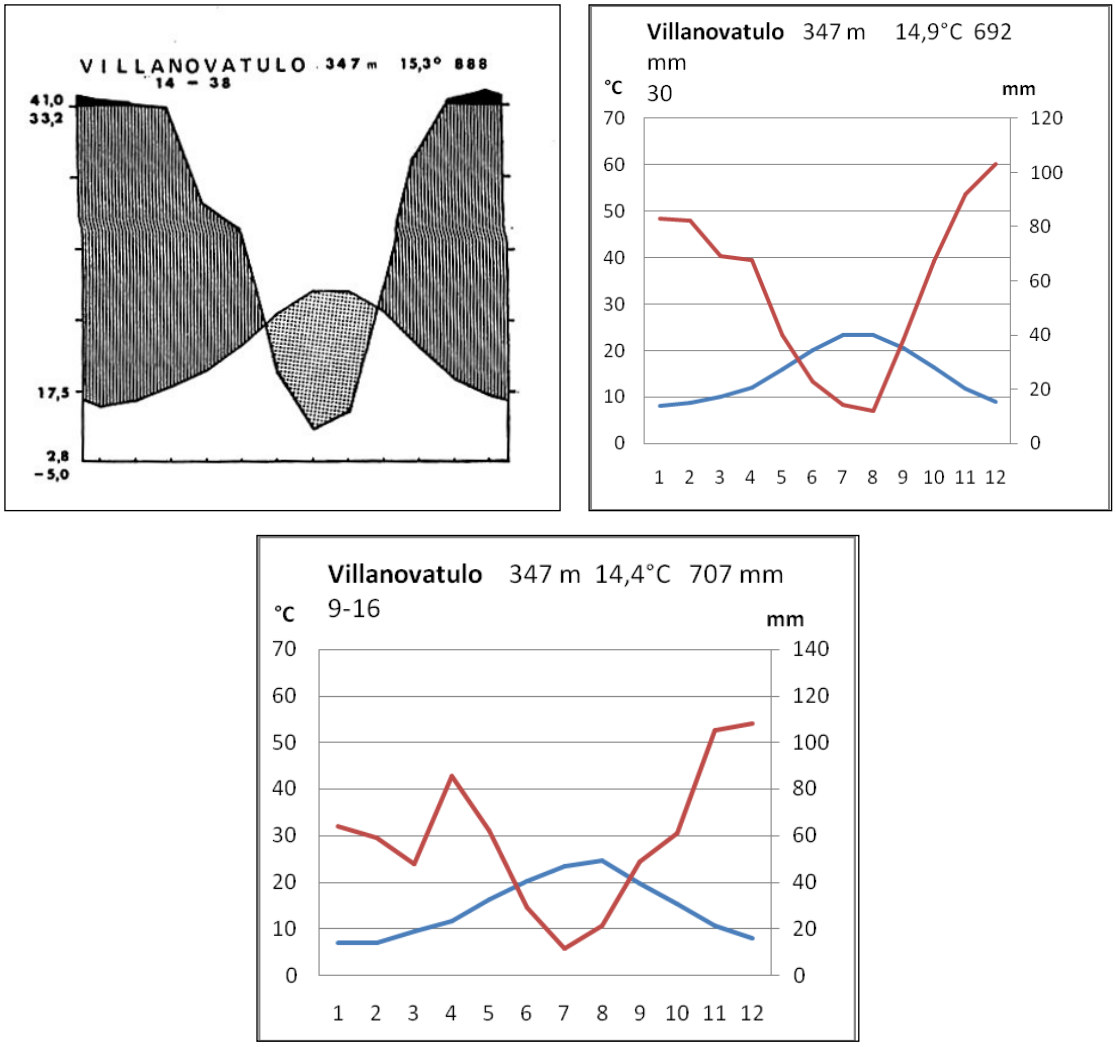


Fig. 68 - Climate diagrams of Walter and Lieth before 1961 (Arrigoni, 1968), in the periods 1961-90 and 1991-2007 (Arpas).

According to Emberger the station of Villanovatulo belongs to the Mediterranean-subhumid bioclimate (Arrigoni, 1968). According to the continentality index of Rivas-Martinez, the nearest weather station of Arzana (674 m a.s.l.) falls within the oceanic type, euoceanic subtype and belongs to the lower meso-Mediterranean thermotype (Bacchetta *et al*., 2009).

The collections were made in 2 localities which belong to the municipality of Seui:

18. Montarbu-Seui, coordinates: 32S 539276 4413534, 920 m a.s.l.
19. Montarbu-Seui, coordinates: 32S 532341 4416641, 905 m a.s.l.

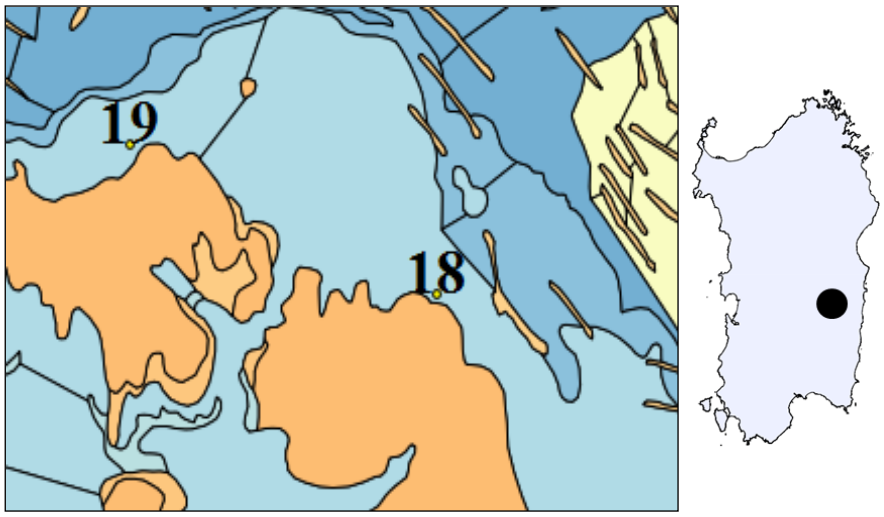


Fig. 69 - Particular of the geological map (legend map. 3).

The geological substrate is characterized by terrigenous successions which date back to the Cambrian - lower Ordovician with alternation of metasandstones, quartzites and phyllites (fig. 69).

18. Montarbu – Seui

coordinates 32 S 539276 4413534, 920 m a.s.l.

Shaded holm-oak wood (fig. 70) with also *Ilex aquifolium* L. and some trees of *Taxus baccata* L. The area has an exposure of 30 degree North-West and a canopy cover of 80%. The understorey, when present, is mainly made by ferns.

The circumference of holly trees ranged from 20 to 40 cm The lichen coverage on the trunk was made mainly by crustose lichens such as *Lecanora spp* and *Bacidia rosella.* Among them *Arthonia radiata* is one of the most numerous. The fruticose lichens *Evernia prunastri*, *Ramalina farinacea*, *R.fastigiata* and the foliose *Hypogymnia tubulosa* are the most visible lichens in the ramifications followed by crustose ones. On *I.aquifolium* 27 taxa were collected, the most in symbiosis with *Trebouxia* and only *Arthonia radiata* (fig. 70c) and *Arthonia punctiformis* with *Trentepohlia* (annex 6). Sixteen crustose, 6 foliose, 4 fruticose and 1 leprose lichens were found (annex 8). Sixteen reproduce sexually with apothecia and only one with perithecia. Seven reproduce asexually with soredia and one with isidia (annex 7).

Seven taxa were collected on *Taxus baccata* whose circumference of the trunk is 81 cm. Trunk, main branches and twigs have a low coverage of lichens, the most are crustose (5). Only few and little thalli of the foliose *Xanthoria parietina* and *Physcia adscendens* where found (annex 8). Four taxa are in symbiosis with *Trebouxia* and three with *Trentepohlia* (annex 6). Five lichens reproduce sexually with apothecia, only *Porina aenea* with perithecia, one reproduce asexually by soredia, none by isidia (annex 7).

Fig. 70 – a. Wood; b. branches of *Ilex aquifolium* L.; c. *Arthonia radiata* on the trunk of *I.aquifolium*. In Montarbu (Seui).

19. Montarbu – Seui

coordinates 32 S 532341 4416641, 905 m a.s.l.

Mixed wood with mainly *Quercus ilex* L. and secondly *Ilex aquifolium* L. (fig. 71a). The understorey is not present or is low. The starting point of ramifications is high because the inferior twigs have been cut.

Collections were made on *I.aquifolium*. Its circumference of the trunk ranges between less than 40 to 60 cm. Some mosses are present in the trunks. There is not a big coverage of lichens and in the main trunks there are mainly crustose lichens such as *Bacidia rosella* and *Arthonia radiata* and some big foliose thalli of *Parmelina tiliacea, Melanohalea exasperata* and *Melanelixia fuliginosa* subsp. *glabratula* (figs. 71b,c).

On *I.aquifolium* 22 species, among them 13 crustose, 7 foliose and only one fruticose and leprose were collected (annex 8). The most of the lichens are in symbiosis with *Trebouxia* and only *Arthonia radiata* and *Porina aenea* with *Trentepohlia* (annex 6). Thirteen taxa reproduce sexually with apothecia and one with perithecia. Five taxa reproduce asexually with soredia and three with isidia (annex 7).

Fig. 71 – a. Wood; b. trunks of *I.aquifolium*; c. lichens on the trunk of *I.aquifolium*. In Montarbu (Seui).

MONTIFERRU

Montiferru is a mountainous area in the centre-West Sardinia and has volcanic origins. It includes the mounts of Seneghe and Santulussurgiu. The maximum elevation reached by the area is 1050 m a.s.l. in Monte Urtigu. The diagram of Walter and Lieth referred to the period 1991-2007 indicates 15.08 °C of average annual temperature and 734 mm of average annual precipitation in the weather station of Cuglieri (fig. 72).

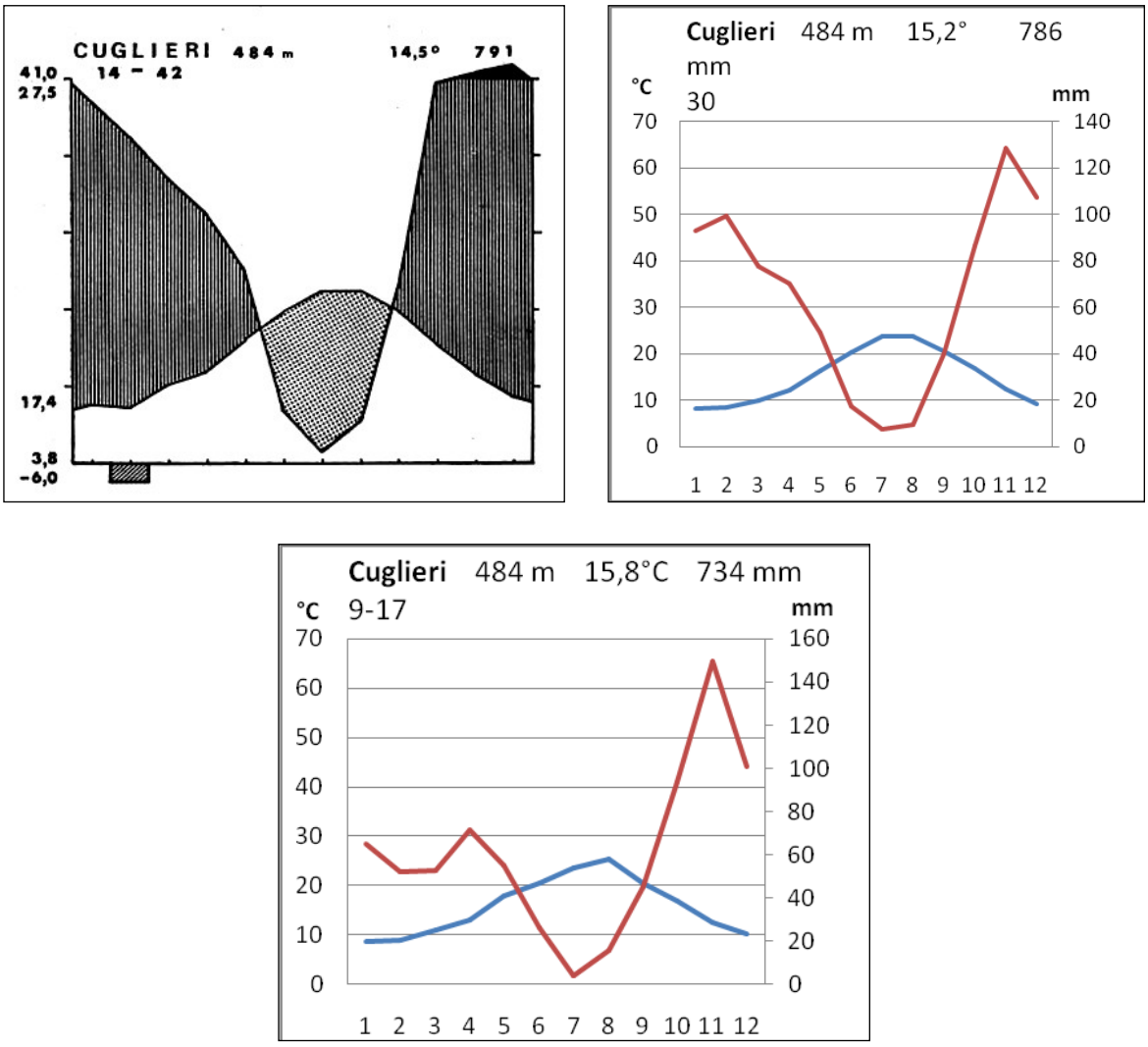


Fig. 72 - Climate diagrams of Walter and Lieth before 1961 (Arrigoni, 1968), in the periods 1961-90 and 1991-2007 (Arpas).

According to Emberger the station of Cuglieri belongs to the higher horizon of the Mediterranean-humid bioclimate (Arrigoni, 1968). According to the continentality index of Rivas-Martinez the stations of Cuglieri falls within the oceanic type, euoceanic subtype and belongs to the lower meso-Mediterranean thermotype (Bacchetta *et al*., 2009).

The collections were made in 2 localities which belong to the municipalities of Seneghe and Cuglieri:

20. Funtana e S'Elighe – Cuglieri, coordinates: 32T 469416 4447011, 800 m a.s.l.

21. Nuraghe Ruju – Seneghe, coordinates: 32T 463869 4440483, 735 m a.s.l.

The litology of both sites is characterized by alkaline basalts, basanites, hawaites and trachybasalts which date back to the Pliocen (fig. 73).

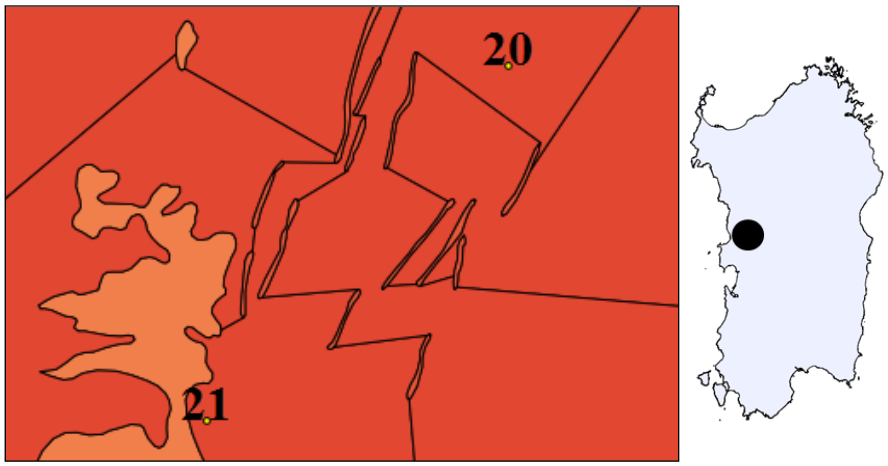


Fig. 73 - Particular of the geological map (map. 3).

The vegetation is different. In both localities there is a shaded wood but the species composition is different. In Funtana e S'Elighe there are mainly trees of *Ilex aquifolium* whereas in Nuraghe Ruju the dominant tree is *Quercus ilex* and secondly there are some young trees or shrubs of holly.

20. Funtana e S'Elighe & Badde Urbana – Cuglieri

Coordinates: 32 T 469416 4447011 - 32 T 469159 4446988, 800 m a.s.l.

It is a shaded wood made mainly by *Ilex aquifolium* L. (fig. 74a). The canopy cover is ca. 80-90%. Main trunks' circumference ranges between 30 and 80 cm. There is no understorey. The area is used for grazing and recreational purposes. A fountain, stone tables and benches are present.

The trees which are not exposed to the sunlight are poor of lichens and mainly crustose forms are present. Whereas the ones in the edge and well exposed to the light show a good coverage of lichens in the bark (74b) and twigs (fig. 74c), among them there are fruticose forms such as *Evernia prunastri* and *Ramalina* spp. and foliose forms as *Physconia distorta* and *Xanthoria parietina*.

On *I.aquifolium* 31 taxa were collected. Most of them are in symbiosis with *Trebouxia* and 6 with *Trentepohlia* (annex 6). The predominant forms are the crustose and then the foliose, only 4 taxa were fruticose and 3 leprose (annex 8). Twenty taxa reproduce sexually with apothecia, one with perithecia. Eight taxa reproduce asexually by soredia and only three by isidia (annex 7).

Fig. 74 – a. Wood; b. c. particular of the bark and twigs of *Ilex aquifolium*. Funtana e S'Elighe (Cuglieri).

21. Nuraghe Ruju – Seneghe

Coordinates: 32 T 463869 4440483, 735 m a.s.l.

The name of the locality is linked to the presence of a Nuraghe. As it is written in the introduction, the name "ruju", which means red, belongs to the colour that the lichens of the genera *Xanthoria* and *Caloplaca* give to the megalithic monument.

The collections were made in a Shaded holm-oak wood (fig. 75a) with some young trees of *Ilex aquifolium* (fig. 75b). The canopy cover is 80-90% and there is no understorey unless some little shrubs of *Crataegus monogyna* Jacq. It is a recreational area with fountains and stone tables.

The trees of holly are young with low circumference of the trunks, less than 20 cm. In general the trees are poor of lichens both on trunks (fig. 75c) and twigs. Few crustose species and few little thalli of the foliose *Parmotrema perlatum* are present but their coverage is low.

Only six species were found on *I.aquifolium*, 4 are in symbiosis with *Trebouxia*, 1 with *Trentepohlia* and none with cyanobacteria (annex 6). Among the 5 species, 3 are crustose, 1 foliose with broad lobes and 1 leprose (annex 8). Three taxa adopt vegetative reproduction with soredia. One reproduce sexually with apothecia and one with perithecia (annex 7).

Fig. 75 - a. Holm-oak wood; b. tree of *Ilex aquifolium* L.; c. trunk of *I.aquifolium*. In Nuraghe Ruju (Seneghe).

List of taxa on *Taxus baccata* L. in Sardinia

(Field data and bibliography)

Alyxoria varia (Pers.) Ertz & Tehler
Arthonia vinosa Leight.
Bacidia phacodes Körb.
Calicium glaucellum Ach.
Calicium salicinum Pers.
Caloplaca cerinella (Nyl.) Flagey
Caloplaca herbidella (Arnold) H. Magn.
Candelariella xanthostigma (Pers. ex Ach.) Lettau
Chaenothecopsis cf. *vainioana* (Nádv.) Tibell
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.
Cladonia coniocraea (Flörke) Spreng.
Cladonia pyxidata (L.) Hoffm.
Diploicia canescens (Dicks.) A.Massal.
Evernia prunastri (L.) Ach.
Hyperphyscia adglutinata (Flörke) H.Mayrhofer & Poelt
Lecania cyrtellina (Nyl.) Sandst
Lecania naegelii (Hepp) Diederich & Van den Boom
Lecanora carpinea (L.) Vain.
Lecanora chlarotera Ach.
Lecanora dispersa (Pers.) Röhl. s.l.
Lecidella elaeochroma f. *elaeochroma* (Ach.) M. Choisy
Lecidella euphorea (Flörke) Hertel
Lepraria caesioalba (B. de Lesd.) J.R. Laundon.
Lepraria incana (L.) Ach.
Lepraria jackii Tønsberg
Lepraria lobificans Nyl.
Lepraria nivalis J.R. Laundon
Melanelia subaurifera (Nyl.) Essl.
Melanohalea exasperata (De Not.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch
Melaspilea sp.
Ochrolechia balcanica Verseghy
Parmelia sulcata Taylor
Parmelia tiliacea (Hoffm.) Ach.
Pertusaria albescens var. *albescens* (Huds.) M. Choisy & Werner
Pertusaria pertusa (L.) Tuck.
Phlyctis agelaea (Ach.) Flot.
Phlyctis argena (Ach.) Flot.
Physcia adscendens (Fr.) H. Olivier
Physcia aipolia (Humb.) Fürnrh.
Physcia tenella (Scop.) DC.
Physconia distorta (With.) J.R. Laundon
Physconia enteroxantha (Nyl.) Poelt
Physconia venusta (Ach.) Poelt

Pleurosticta acetabulum (Neck.) Elix & Lumbsch
Porina aenea (Wallr.) Zahlbr.
Ramalina fraxinea (L.) Ach.
Rinodina exigua (Ach.) Gray
Rinodina sophodes (Ach.) A. Massal.
Xanthoria parietina (L.) Beltr.
Xanthoria polycarpa (Hoffm.) Rieber

List of taxa on *Ilex aquifolium* L. in Sardinia

(Field data and bibliography)

Agonimia octospora Coppins & P. James
Alyxoria varia (Pers.) Ertz & Tehler
Amandinea punctata (Hoffm.) Coppins & Scheid.
Anaptychia ciliaris (L.) Körb. subsp. *ciliaris*
Arthonia atra (Pers.) A. Schneid.
Arthonia didyma Körb
Arthonia dispersa Dufour
Arthonia leucopellaea (Ach.) Almq. (*)
Arthonia punctiformis Ach.
Arthonia radiata (Pers.) Ach.
Bacidia arceutina (Ach.) Rehm & Arnold
Bacidia laurocerasi (Delise ex Duby) Zahlbr.
Bacidia naegelii (Hepp) Zahlbr.
Bacidia rosella (Pers.) De Not.
Biatora cf. *helvola* Körb. ex Hellb. (*)
Buellia griseovirens (Turner & Borrer ex Sm.) Almb.
Caloplaca alnetorum Giralt, Nimis & Poelt
Caloplaca cerina (Hedw.) Th. Fr.
Caloplaca cerinella (Nyl.) Flagey
Caloplaca cerinelloides (Erichsen) Poelt
Caloplaca ferruginea (Huds.) Th. Fr.
Caloplaca haematites (Chaub. ex St.-Amans) Zwackh
Caloplaca herbidella (Arnold) H. Magn.
Caloplaca holocarpa (Hoffm.) A.E. Wade
Caloplaca hungarica H. Magn.
Caloplaca luteoalba (Turner) Th. Fr. (*)
Caloplaca pyracea (Ach.) Zwackh
Candelaria concolor (Dicks.) Arnold
Candelariella vitellina (Ehrh.) Müll. Arg.
Candelariella xanthostigma (Pers. ex Ach.) Lettau
Catillaria nigroclavata (Nyl.) J. Steiner
Catinaria atropurpurea (Schaer.) Vězda & Poelt
Cladonia cf. *coniocraea* (Flörke) Spreng.
Cliostomum griffithii (Sm.) Coppins
Collema flaccidum (Ach.) Ach.
Collema furfuraceum Du Rietz
Collema nigrescens (Huds.) DC.
Collema subflaccidum Degel.
Dactylospora parasitica (Flörke) Arnold
Diploicia canescens (Dicks.) A.Massal.
Diploschistes muscorum (Scop.) R. Sant.
Diplotomma alboatrum (Hoffm.) Flot.
Evernia prunastri (L.) Ach.
Flavoparmelia caperata (L.) Hale

Gyalecta derivata (Nyl.) H. Olivier (*)
Hypogymnia tubulosa (Schaer.) Hav.
Lecania cyrtellina (Nyl.) Sandst.
Lecania naegelii (Hepp) Diederich & Van den Boom
Lecanora argentata (Ach.) Malme
Lecanora carpinea (L.) Vain.
Lecanora chlarotera Nyl.
Lecanora dispersa (Pers.) Röhl. s.l.
Lecanora expallens Ach.
Lecanora intumescens (Rebent.) Rabenh.
Lecanora leptyrodes G.B.F. Nilsson
Lecanora pulicaris (Pers.) Ach.
Lecanora rugosella Zahlbr.
Lecanora symmicta (Ach.) Ach.
Lecidea erythrophaea Florke ex Sommerf
Lecidella elaeochroma f. *elaeochroma* (Ach.) M. Choisy
Lecidella elaeochroma f. *soralifera* (Erichsen) D. Hawksw
Lecidella euphorea (Flörke) Hertel.
Lepraria jackii Tønsberg
Lepraria jackii Tønsberg s.l.
Lepraria lobificans Nyl.
Lepraria vouauxii (Hue) R.C. Harris
Lobaria pulmonaria (L.) Hoffm.
Megalaria laureri (Hepp ex Th. Fr.) Hafellner (*)
Melanelia subaurifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Melanelixia fuliginosa subsp. *glabratula* (Lamy) J.R. Laundon
Melanohalea exasperata (De Not.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch
Melanohalea exasperatula (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Melanohalea laciniatula (Flagey ex H. Olivier) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Micarea prasina Fr.
Nephroma laevigatum Ach.
Normandina pulchella (Borrer) Nyl.
Ochrolechia balcanica Verseghy
Ochrolechia sp.
Ochrolechia szatalaënsis Verseghy
Opegrapha cf. *vulgata* (Ach.) Ach.
Pachyphiale carneola (Ach.) Arnold
Parmelia pastillifera (Harm.) R. Schub. & Klem.
Parmelia saxatilis (L.) Ach.
Parmelia submontana Hale
Parmelia sulcata Taylor
Parmelina tiliacea (Hoffm.) Hale
Parmotrema perlatum (Huds.) M.Choisy
Peltigera praetextata (Flörke ex Sommerf.) Vain.
Pertusaria albescens var. *albescens* (Huds.) M. Choisy & Werner

Pertusaria albescens var. *corallina* (Zahlbr.) J.R. Laundon
Pertusaria amara f. *amara* (Ach.) Nyl.
Pertusaria amara f. *slesvicensis* (Erichsen) Almb.
Pertusaria cf *hymenea* (Ach.) Schaer.
Pertusaria coccodes (Ach.) Nyl.
Pertusaria leioplaca DC.
Pertusaria pertusa (L.) Tuck.
Phaeophyscia orbicularis (Neck.) Moberg
Phlyctis agelaea (Ach.) Flot.
Phlyctis argena (Spreng.) Flot.
Physcia adscendens (Fr.) H.Olivier
Physcia aipolia (Ehrh. ex Humb.) Fürnr.
Physcia biziana (A. Massal.) Zahlbr.
Physcia leptalea (Ach.) DC.
Physcia stellaris (L.) Nyl.
Physcia tenella (Scop.) DC.
Physconia distorta (With.) J.R. Laundon
Physconia enteroxantha (Nyl.) Poelt
Physconia grisea (Lam.) Poelt
Physconia servitii (Nádv.) Poelt
Physconia subpulverulenta (Szatala) Poelt
Physconia venusta (Ach.) Poelt
Platismatia glauca (L.) W.L. Culb. & C.F. Culb.
Pleurosticta acetabulum (Neck.) Elix & Lumbsch
Porina aenea (Wallr.) Zahlbr.
Pseudevernia furfuracea (L.) Zopf
Ramalina calicaris (L.) Röhl.
Ramalina farinacea (L.) Ach.
Ramalina fastigiata (Pers.) Ach
Ramalina fraxinea (L.) Ach.
Ramalina fraxinea f. *tuberculata* Ach. (*)
Rinodina exigua (Ach.) Gray
Rinodina gennarii Bagl.
Rinodina pyrina (Ach.) Arnold
Rinodina sophodes (Ach.) A. Massal.
Schismatomma cretaceum (Hue) J.R. Laundon
Schismatomma decolorans (Turner & Borrer ex Sm.) Clauzade & Vězda
Scoliciosporum umbrinum (Ach.) Arnold
Sphinctrina turbinata (Pers.) De Not.
Tephromela atra (Huds.) Hafellner
Thelotrema lepadinum (Ach.) Ach.
Usnea filipendula Stirt.
Usnea glabrescens (Nyl. ex Vain.) Vain.
Xanthoria parietina (L.) Beltr
Xanthoria polycarpa (Hoffm.) Rieber (*) new segnalations for Sardinia, to be confirmed

Table with species presence

Specie	1A	1T	1AT	2	3A	3T	3AT	4A	4T	4AT	5	6	7	8	9	10
Agonimia octospora Coppins & P. James	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Alyxoria varia (Pers.) Ertz & Tehler	1	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0
Amandinea punctata (Hoffm.) Coppins & Scheid.	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Anaptychia ciliaris (L.) Körb. subsp. ciliaris	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Arthonia atra (Pers.) A. Schneid.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Arthonia didyma Körb	1	0	1	1	0	0	0	1	0	1	1	0	0	1	0	0
Arthonia dispersa Dufour	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Arthonia leucopellaea (Ach.) Almq.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthonia punctiformis Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthonia radiata (Pers.) Ach.	1	0	1	1	0	0	0	1	0	1	0	0	0	0	0	1
Arthonia vinosa Leight.	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Bacidia arceutina (Ach.) Rehm & Arnold	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Bacidia laurocerasi (Delise ex Duby) Zahlbr.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Bacidia rosella (Pers.) De Not.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biatora cf. helvola Körb. ex Hellb.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bacidia phacodes Körb.	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Buellia griseovirens (Turner & Borrer ex Sm.) Almb.	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1
Calicium glaucellum Ach.	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Calicium salicinum Pers.	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Caloplaca alnetorum Giralt, Nimis & Poelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caloplaca cerina (Hedw.) Th. Fr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caloplaca cerinella (Nyl.) Flagey	1	0	1	1	0	1	1	1	0	1	0	0	0	0	0	0
Caloplaca cerinelloides (Erichsen) Poelt	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Caloplaca ferruginea (Huds.) Th. Fr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caloplaca haematites (Chaub. ex St.-Amans) Zwackh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caloplaca herbidella (Arnold) H. Magn.	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Caloplaca holocarpa (Hoffm.) A.E. Wade	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1
Caloplaca hungarica H. Magn.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caloplaca luteoalba (Turner) Th. Fr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caloplaca pyracea (Ach.) Zwackh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candelaria concolor (Dicks.) Arnold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Specie	1A	1T	1AT	2	3A	3T	3AT	4A	4T	4AT	5	6	7	8	9	10
Candelariella vitellina (Ehrh.) Müll. Arg.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candelariella xanthostigma (Pers. ex Ach.) Lettau	0	1	1	0	0	0	0	0	1	1	0	1	0	0	0	0
Catillaria nigroclavata (Nyl.) J. Steiner	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Catinaria atropurpurea (Schaer.) Vězda & Poelt	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaenothecopsis cf. vainioana (Nádv.) Tibell	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Cladonia cf. coniocraea (Flörke) Spreng.	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0
Cladonia pyxidata (L.) Hoffm. (Zedda, 2002).	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cliostomum griffithii (Sm.) Coppins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Collema flaccidum (Ach.) Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collema furfuraceum Du Rietz	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Collema subflaccidum Degel.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dactylospora parasitica (Flörke) Arnold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diploicia canescens (Dicks.) A.Massal.	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0
Diploschistes muscorum (Scop.) R. Sant.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diplotomma alboatrum (Hoffm.) Flot.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Evernia prunastri (L.) Ach.	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Flavoparmelia caperata (L.) Hale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyalecta derivata (Nyl.) H. Olivier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyperphyscia adglutinata (Flörke) H.Mayrhofer & Poelt	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Hypogymnia tubulosa (Schaer.) Hav.	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0
Lecania cyrtellina (Nyl.) Sandst.	0	1	1	1	1	1	1	0	1	1	1	0	1	0	1	0
Lecania naegelii (Hepp) Diederich & Van den Boom	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Lecanora argentata (Ach.) Malme	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Lecanora carpinea (L.) Vain.	1	0	1	0	0	0	0	1	0	1	0	1	1	1	0	0
Lecanora chlarotera Nyl.	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Lecanora dispersa (Pers.) Röhl. s.l.	1	0	1	1	0	1	1	1	1	1	0	1	1	0	0	0
Lecanora expallens Ach.	0	0	0	1	1	0	1	0	0	0	0	1	0	0	1	0
Lecanora intumescens (Rebent.) Rabenh.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lecanora leptyrodes G.B.F. Nilsson	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Lecanora pulicaris (Pers.) Ach.	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
Lecanora rugosella Zahlbr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Specie	1A	1T	1AT	2	3A	3T	3AT	4A	4T	4AT	5	6	7	8	9	10
Lecanora symmicta (Ach.) Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Lecanora sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lecidea erythrophaea Flörke ex Sommerf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lecidella elaeochroma f. elaeochroma (Ach.) M. Choisy	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lecidella elaeochroma f. soralifera (Erichsen) D. Hawksw	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0
Lecidella euphorea (Flörke) Hertel	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
Lepraria caesioalba (B. de Lesd.) J.R. Laundon.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepraria incana (L.) Ach.	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
Lepraria jackii Tønsberg	1	1	1	1	0	1	1	1	0	1	0	0	0	0	0	1
Lepraria jackii Tønsberg s.l.	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Lepraria lobificans Nyl.	0	1	1	0	0	1	1	1	0	1	0	0	0	0	0	0
Lepraria nivalis J.R. Laundon	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Lepraria vouauxii (Hue) R.C. Harris	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Lepraria sp.	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Lobaria pulmonaria (L.) Hoffm.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Megalaria laureri (Hepp ex Th. Fr.) Hafellner	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Melanelia subaurifera (Nyl.) Essl.	0	0	0	1	1	0	1	1	0	1	1	1	0	0	0	0
Melanelixia fuliginosa subsp. glabratula (Lamy) J.R. Laundon	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0
Melanohalea exasperata (De Not.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch	1	0	1	1	0	1	1	1	0	1	1	1	0	0	0	0
Melanohalea exasperatula (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Melanohalea laciniatula (Flagey ex H. Olivier) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Melaspilea sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melanoparmelia sp.	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Micarea prasina Fr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nephroma laevigatum Ach.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Normandina pulchella (Borrer) Nyl.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1
Ochrolechia balcanica Verseghy	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
Ochrolechia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ochrolechia szatalaënsis Verseghy	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Opegrapha cf. vulgata (Ach.) Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pachyphiale carneola (Ach.) Arnold	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Parmelia pastillifera (Harm.) R. Schub. & Klem.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parmelia saxatilis (L.) Ach.	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0

Specie	1A	1T	1AT	2	3A	3T	3AT	4A	4T	4AT	5	6	7	8	9	10
Parmelia submontana Hale	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0
Parmelia sulcata Taylor	1	0	1	1	1	0	1	1	0	1	1	0	0	0	0	1
Parmelina tiliacea (Hoffm.) Hale	0	0	0	1	0	1	1	1	0	1	0	1	0	0	1	0
Parmotrema perlatum (Huds.) M.Choisy	0	0	0	1	1	0	1	1	0	1	1	1	0	0	0	1
Peltigera praetextata (Flörke ex Sommerf.) Vain.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Pertusaria albescens var. albescens (Huds.) M. Choisy & Werner	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0
Pertusaria albescens var. corallina (Zahlbr.) J.R. Laundon	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pertusaria amara f. amara (Ach.) Nyl.	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	1
Pertusaria amara f. slesvicensis (Erichsen) Almb.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Pertusaria hemisphaerica (Flörke) Erichsen	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pertusaria cf hymenea (Ach.) Schaer.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pertusaria coccodes (Ach.) Nyl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pertusaria leioplaca DC.	1	0	1	1	1	0	1	1	0	1	1	1	0	0	0	1
Pertusaria pertusa (L.) Tuck.	0	0	0	1	0	1	1	1	1	1	1	1	0	0	0	1
Pertusaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Phaeophyscia orbicularis (Neck.) Moberg	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Phlyctis agelaea (Ach.) Flot.	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Phlyctis argena (Spreng.) Flot.	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Physcia adscendens (Fr.) H.Olivier	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1
Physcia aipolia (Ehrh. ex Humb.) Fürnr.	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0
Physcia biziana (A. Massal.) Zahlbr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physcia leptalea (Ach.) DC.	1	0	1	1	1	0	1	1	0	1	0	0	0	0	0	0
Physcia stellaris (L.) Nyl.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Physcia tenella (Scop.) DC.	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1
Physcia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Physconia distorta (With.) J.R. Laundon	0	0	0	1	1	1	1	1	0	1	1	1	0	0	0	0
Physconia enteroxantha (Nyl.) Poelt	0	0	0	0	0	1	1	1	0	1	1	0	0	0	1	0
Physconia grisea (Lam.) Poelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physconia servitii (Nádv.) Poelt	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Physconia sp.	1	0	1	0	0	0	0	0	1	1	0	0	1	1	0	0
Physconia subpulverulenta (Szatala) Poelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physconia venusta (Ach.) Poelt	0	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0
Platismatia glauca (L.) W.L. Culb. & C.F. Culb.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Pleurosticta acetabulum (Neck.) Elix & Lumbsch	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Porina aenea (Wallr.) Zahlbr.	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1

Specie	1A	1T	1AT	2	3A	3T	3AT	4A	4T	4AT	5	6	7	8	9	10
Pseudevernia furfuracea (L.) Zopf	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ramalina calicaris (L.) Röhl.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Ramalina farinacea (L.) Ach.	1	0	1	1	1	0	1	1	0	1	0	1	0	0	1	1
Ramalina fastigiata (Pers.) Ach	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	1
Ramalina fraxinea (L.) Ach.	0	0	0	1	0	0	0	1	1	1	0	1	1	0	1	0
Ramalina fraxinea f. tuberculata Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramalina sp.	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
Rinodina exigua (Ach.) Gray	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0
Rinodina gennarii Bagl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rinodina pyrina (Ach.) Arnold	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
Rinodina sophodes (Ach.) A. Massal.	1	0	1	0	0	0	0	1	1	1	0	1	0	0	0	0
Rinodina sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schismatomma cretaceum (Hue) J.R. Laundon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schismatomma decolorans (Turner & Borrer ex Sm.) Clauzade & Vězda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scoliciosporum umbrinum (Ach.) Arnold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphinctrina turbinata (Pers.) De Not.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tephromela atra (Huds.) Hafellner	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Thelotrema lepadinum (Ach.) Ach.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Usnea glabrescens (Nyl. ex Vain.) Vain.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Xanthoria parietina (L.) Beltr.	1	0	1	1	1	1	1	1	1	1	0	1	1	0	1	0
Xanthoria polycarpa (Hoffm.) Rieber	1	0	1	0	1	1	1	1	0	1	1	0	0	0	1	0
Xanthoria sp.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

A = collected only on *Ilex aquifolim* L.

T= collected only on *Taxus baccata* L.

AT = collected both on *I.aquifolium* and *T.baccata*

Where it is not specified the collections were made only on *I.aquifolium*.

Specie	11	12	13	14	15	16	17	18_A	18_T	18_AT	19	20	21
Agonimia octospora Coppins & P. James	0	0	0	0	0	0	0	0	0	0	0	0	0
Alyxoria varia (Pers.) Ertz & Tehler	0	1	0	0	1	1	0	0	1	1	0	1	0
Amandinea punctata (Hoffm.) Coppins & Scheid.	0	0	0	0	0	0	0	0	0	0	0	0	0
Anaptychia ciliaris (L.) Körb. subsp. ciliaris	0	0	0	1	1	0	0	0	0	0	0	0	0
Arthonia atra (Pers.) A. Schneid.	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthonia didyma Körb	0	0	0	0	0	0	0	0	0	0	0	1	0
Arthonia dispersa Dufour	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthonia leucopellaea (Ach.) Almq.	0	1	0	0	0	0	0	0	0	0	0	0	0
Arthonia punctiformis Ach.	0	0	0	0	0	0	0	1	0	1	0	1	0
Arthonia radiata (Pers.) Ach.	0	1	1	1	1	1	0	1	0	1	1	1	0
Arthonia vinosa Leight.	0	0	0	0	0	0	0	0	0	1	0	0	0
Bacidia arceutina (Ach.) Rehm & Arnold	0	0	1	0	0	0	0	0	0	0	0	0	0
Bacidia laurocerasi (Delise ex Duby) Zahlbr.	1	0	0	0	0	0	0	0	0	0	0	0	1
Bacidia rosella (Pers.) De Not.	0	0	0	0	1	0	0	1	0	1	1	0	0
Biatora cf. helvola Körb. ex Hellb.	0	0	0	0	0	0	0	0	0	0	0	1	0
Bacidia phacodes Körb.	0	0	0	0	0	0	0	0	0	0	0	0	0
Buellia griseovirens (Turner & Borrer ex Sm.) Almb.	0	0	1	1	0	0	0	0	0	0	0	0	0
Calicium glaucellum Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0
Calicium salicinum Pers.	0	0	0	0	0	0	0	0	0	1	0	0	0
Caloplaca alnetorum Giralt, Nimis & Poelt	0	0	0	0	1	0	0	0	0	1	0	0	0
Caloplaca cerina (Hedw.) Th. Fr.	0	0	0	1	1	0	0	0	0	1	0	0	0
Caloplaca cerinella (Nyl.) Flagey	0	1	0	1	0	0	1	0	0	0	0	0	0
Caloplaca cerinelloides (Erichsen) Poelt	0	0	0	0	0	0	0	0	0	0	0	0	0
Caloplaca ferruginea (Huds.) Th. Fr.	1	1	0	1	0	0	0	0	0	1	0	0	0
Caloplaca haematites (Chaub. ex St.-Amans) Zwackh	0	0	0	1	1	0	0	0	0	0	0	0	0
Caloplaca herbidella (Arnold) H. Magn.	0	0	0	1	1	0	0	0	0	0	0	0	0
Caloplaca holocarpa (Hoffm.) A.E. Wade	0	1	1	0	0	0	1	1	0	0	1	1	0
Caloplaca hungarica H. Magn.	0	0	0	0	1	0	0	0	0	0	0	0	0
Caloplaca luteoalba (Turner) Th. Fr.	0	0	0	0	1	0	0	0	0	0	0	0	0
Caloplaca pyracea (Ach.) Zwackh	0	0	0	1	1	0	0	0	0	0	0	0	0
Candelaria concolor (Dicks.) Arnold	0	1	0	0	0	0	0	0	0	0	0	0	0
Candelariella vitellina (Ehrh.) Müll. Arg.	0	0	0	0	1	0	0	0	0	0	0	0	0
Candelariella xanthostigma (Pers. ex Ach.) Lettau	0	1	0	1	1	0	1	0	0	0	0	0	0
Catillaria nigroclavata (Nyl.) J. Steiner	0	1	0	0	0	0	0	0	0	0	0	0	0

Specie	11	12	13	14	15	16	17	18_A	18_T	18_AT	19	20	21
Catinaria atropurpurea (Schaer.) Vězda & Poelt	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaenothecopsis cf. vainioana (Nádv.) Tibell	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia cf. coniocraea (Flörke) Spreng.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia pyxidata (L.) Hoffm. (Zedda, 2002).	0	0	0	0	0	0	0	0	0	0	0	0	0
Cliostomum griffithii (Sm.) Coppins	0	0	0	0	0	0	0	0	0	0	0	0	0
Collema flaccidum (Ach.) Ach.	0	0	0	1	0	0	0	0	0	0	0	0	0
Collema furfuraceum Du Rietz	0	0	0	1	0	0	0	0	0	0	0	0	0
Collema subflaccidum Degel.	0	0	0	0	1	0	0	0	0	0	0	0	0
Dactylospora parasitica (Flörke Arnold	0	0	0	1	0	0	0	0	0	0	0	0	0
Diploicia canescens (Dicks.) A.Massal.	0	1	0	0	0	0	0	0	0	0	0	0	0
Diploschistes muscorum (Scop.) R. Sant.	0	0	0	1	0	0	0	0	0	0	0	0	0
Diplotomma alboatrum (Hoffm.) Flot.	0	0	0	0	1	0	0	0	0	0	0	0	0
Evernia prunastri (L.) Ach.	0	1	1	1	0	0	0	1	0	1	1	1	0
Flavoparmelia caperata (L.) Hale	0	0	1	0	0	0	0	0	0	0	0	0	0
Gyalecta derivata (Nyl.) H. Olivier	0	1	0	0	0	0	0	0	0	0	0	0	0
Hyperphyscia adglutinata (Flörke) H.Mayrhofer & Poelt	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypogymnia tubulosa (Schaer.) Hav.	0	0	0	1	0	0	0	1	0	1	0	0	0
Lecania cyrtellina (Nyl.) Sandst.	0	0	1	0	1	0	0	0	0	0	0	0	0
Lecania naegelii (Hepp) Diederich & Van den Boom	0	1	0	1	1	0	0	1	1	1	1	1	0
Lecanora argentata (Ach.) Malme	0	0	0	0	0	0	0	0	0	0	0	0	0
Lecanora carpinea (L.) Vain.	0	0	1	1	0	1	1	0	0	0	1	1	0
Lecanora chlarotera Nyl.	1	1	1	1	1	1	1	1	0	1	1	1	0
Lecanora dispersa (Pers.) Röhl. s.l.	0	0	1	1	0	0	1	0	1	1	0	0	0
Lecanora expallens Ach.	0	0	1	1	0	0	0	1	0	1	0	0	0
Lecanora intumescens (Rebent.) Rabenh.	0	0	0	1	1	0	0	0	0	0	0	0	0
Lecanora leptyrodes G.B.F. Nilsson	0	0	0	0	1	0	0	0	0	0	0	0	0
Lecanora pulicaris (Pers.) Ach.	0	1	0	1	0	0	0	0	0	0	1	0	0
Lecanora rugosella Zahlbr.	0	0	0	1	0	0	0	0	0	0	0	0	0
Lecanora symmicta (Ach.) Ach.	0	0	0	0	1	0	1	1	0	1	0	0	0
Lecanora sp.	0	0	0	0	0	1	0	0	0	0	0	0	0
Lecidea erythrophaea Flörke ex Sommerf.	0	1	0	0	0	0	0	0	0	0	0	0	0
Lecidella elaeochroma f. elaeochroma (Ach.) M. Choisy	1	1	1	1	1	1	1	1	0	1	1	1	0
Lecidella elaeochroma f. soralifera (Erichsen) D. Hawksw	0	0	0	0	0	0	0	0	0	0	0	0	0

Specie	11	12	13	14	15	16	17	18_A	18_T	18_AT	19	20	21
Lecidella euphorea (Flörke) Hertel	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepraria caesioalba (B. de Lesd.) J.R. Laundon.	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepraria incana (L.) Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepraria jackii Tønsberg	0	0	0	0	0	1	0	0	0	0	0	0	0
Lepraria jackii Tønsberg s.l.	0	0	0	1	1	0	0	0	0	0	0	1	0
Lepraria lobificans Nyl.	0	0	0	0	0	0	0	0	0	0	0	1	0
Lepraria nivalis J.R. Laundon	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepraria vouauxii (Hue) R.C. Harris	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepraria sp.	1	0	0	0	0	0	0	1	0	1	1	0	1
Lobaria pulmonaria (L.) Hoffm.	0	0	1	0	0	0	0	0	0	0	0	0	0
Megalaria laureri (Hepp ex Th. Fr.) Hafellner	0	0	0	0	0	0	0	0	0	0	0	0	0
Melanelia subaurifera (Nyl.) Essl.	0	1	1	1	0	0	0	0	0	0	0	0	0
Melanelixia fuliginosa subsp. glabratula (Lamy) J.R. Laundon	1	0	1	0	1	1	0	0	0	0	1	1	0
Melanohalea exasperata (De Not.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch	0	1	0	1	0	0	1	1	0	1	1	1	0
Melanohalea exasperatula (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	0	1	1	0	0	0	0	0	0	0	0
Melanohalea laciniatula (Flagey ex H. Olivier) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	0	0	0	1	0	0	0	0	0	0	0	0	0
Melaspilea sp.	0	0	0	0	0	0	0	0	1	1	0	0	0
Melanoparmelia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Micarea prasina Fr.	1	1	0	0	0	0	0	0	0	0	0	0	0
Nephroma laevigatum Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0
Normandina pulchella (Borrer) Nyl.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ochrolechia balcanica Verseghy	0	0	0	0	0	0	0	0	0	0	0	0	0
Ochrolechia sp.	0	0	0	0	0	0	0	1	0	0	0	0	0
Ochrolechia szatalaënsis Verseghy	0	0	0	0	0	0	0	0	0	0	0	1	0
Opegrapha cf. vulgata (Ach.) Ach.	0	0	0	0	0	0	0	0	0	0	0	1	0
Pachyphiale carneola (Ach.) Arnold	0	0	0	0	0	0	0	0	0	0	0	0	0
Parmelia pastillifera (Harm.) R. Schub. & Klem.	0	0	0	1	1	0	0	0	0	0	0	0	0
Parmelia saxatilis (L.) Ach.	0	0	0	1	0	0	0	0	0	0	0	0	0
Parmelia submontana Hale	0	0	0	1	0	0	0	0	0	0	0	0	0
Parmelia sulcata Taylor	0	1	0	0	0	0	0	0	0	0	0	1	0
Parmelina tiliacea (Hoffm.) Hale	0	0	1	1	1	0	1	0	0	0	1	1	0
Parmotrema perlatum (Huds.) M.Choisy	1	0	1	0	0	0	0	0	0	0	0	1	1
Peltigera praetextata (Flörke ex Sommerf.) Vain.	0	0	0	0	0	0	0	0	0	0	0	0	0

Specie	11	12	13	14	15	16	17	18_A	18_T	18_AT	19	20	21
Pertusaria albescens var. albescens (Huds.) M. Choisy & Werner	0	0	0	1	1	0	0	0	0	0	0	0	0
Pertusaria albescens var. corallina (Zahlbr.) J.R. Laundon	0	0	0	0	1	0	0	0	0	0	0	0	0
Pertusaria amara f. amara (Ach.) Nyl.	0	0	0	1	1	0	0	0	0	0	0	0	0
Pertusaria amara f. slesvicensis (Erichsen) Almb.	0	0	0	0	0	0	0	0	0	0	0	0	0
Pertusaria hemisphaerica (Flörke) Erichsen	0	0	0	0	0	0	0	0	0	0	0	0	0
Pertusaria cf hymenea (Ach.) Schaer.	0	0	0	1	0	0	0	0	0	0	0	0	0
Pertusaria coccodes (Ach.) Nyl.	0	0	0	1	1	0	0	0	0	0	0	0	0
Pertusaria leioplaca DC.	1	1	1	0	1	1	0	1	0	1	0	0	0
Pertusaria pertusa (L.) Tuck.	0	0	0	1	1	1	0	0	0	0	0	1	0
Pertusaria sp.	0	0	0	0	0	0	0	0	0	0	1	0	0
Phaeophyscia orbicularis (Neck.) Moberg	0	1	1	1	1	0	0	0	0	0	0	0	0
Phlyctis agelaea (Ach.) Flot.	1	1	1	1	1	0	0	1	0	1	1	1	0
Phlyctis argena (Spreng.) Flot.	1	1	1	1	1	1	1	1	0	1	1	1	1
Physcia adscendens (Fr.) H.Olivier	0	1	1	1	1	0	1	1	1	1	1	1	0
Physcia aipolia (Ehrh. ex Humb.) Fürnr.	0	0	0	1	0	0	1	0	0	0	0	0	0
Physcia biziana (A. Massal.) Zahlbr.	0	1	0	1	0	0	0	0	0	0	0	0	0
Physcia leptalea (Ach.) DC.	0	1	0	1	1	0	1	0	0	0	0	0	0
Physcia stellaris (L.) Nyl.	0	0	0	1	1	0	1	0	0	1	0	0	0
Physcia tenella (Scop.) DC.	0	1	0	1	1	0	0	0	0	0	0	0	0
Physcia sp.	0	0	0	0	0	0	0	1	0	0	0	0	0
Physconia distorta (With.) J.R. Laundon	0	0	1	1	0	0	1	0	0	0	0	1	0
Physconia enteroxantha (Nyl.) Poelt	0	0	0	0	0	0	0	0	0	1	0	0	0
Physconia grisea (Lam.) Poelt	1	0	0	0	0	0	0	0	0	1	0	0	0
Physconia servitii (Nádv.) Poelt	0	0	0	0	0	0	0	0	0	1	0	0	0
Physconia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Physconia subpulverulenta (Szatala) Poelt	0	0	1	1	1	0	0	0	0	0	0	0	0
Physconia venusta (Ach.) Poelt	0	0	0	1	1	0	0	0	0	0	0	0	0
Platismatia glauca (L.) W.L. Culb. & C.F. Culb.	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleurosticta acetabulum (Neck.) Elix & Lumbsch	0	0	1	1	1	0	1	0	0	0	0	0	0
Porina aenea (Wallr.) Zahlbr.	1	1	0	0	0	0	0	1	1	0	1	1	1
Pseudevernia furfuracea (L.) Zopf	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramalina calicaris (L.) Röhl.	0	0	0	1	0	0	0	0	0	0	0	0	0
Ramalina farinacea (L.) Ach.	1	0	1	0	0	0	0	1	0	1	1	1	0

Specie	11	12	13	14	15	16	17	18_A	18_T	18_AT	19	20	21
Ramalina fastigiata (Pers.) Ach	1	0	1	1	1	0	0	1	0	1	1	1	0
Ramalina fraxinea (L.) Ach.	0	0	1	1	1	0	0	0	0	0	0	1	0
Ramalina fraxinea f. tuberculata Ach.	0	0	0	0	1	0	0	0	0	0	0	0	0
Ramalina sp.	0	1	0	0	1	0	1	1	0	1	0	0	0
Rinodina exigua (Ach.) Gray	0	1	1	0	0	0	0	1	0	1	0	0	0
Rinodina gennarii Bagl.	0	1	0	0	0	0	0	0	0	0	0	0	0
Rinodina pyrina (Ach.) Arnold	0	0	0	0	0	0	1	0	0	0	0	0	0
Rinodina sophodes (Ach.) A. Massal.	0	1	0	1	0	0	1	1	0	1	1	0	0
Rinodina sp.	1	0	0	0	0	0	0	0	0	0	0	0	0
Schismatomma cretaceum (Hue) J.R. Laundon	0	1	0	0	0	0	0	0	0	0	0	0	0
Schismatomma decolorans (Turner & Borrer ex Sm.) Clauzade & Vězda	1	0	0	0	0	0	0	0	0	0	0	0	0
Scoliciosporum umbrinum (Ach.) Arnold	0	0	0	1	1	0	0	0	0	0	0	1	0
Sphinctrina turbinata (Pers.) De Not.	0	0	0	1	0	0	0	0	0	0	0	0	0
Tephromela atra (Huds.) Hafellner	0	0	0	0	1	0	0	0	0	0	0	0	0
Thelotrema lepadinum (Ach.) Ach.	0	0	0	0	0	0	0	0	0	0	0	0	0
Usnea glabrescens (Nyl. ex Vain.) Vain.	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthoria parietina (L.) Beltr.	1	1	1	1	1	0	1	1	1	0	1	1	0
Xanthoria polycarpa (Hoffm.) Rieber	0	0	0	1	1	0	0	0	0	0	0	0	0
Xanthoria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0

A = collected only on *Ilex aquifolim* L.

T= collected only on *Taxus baccata* L.

AT = collected both on *I.aquifolium* and *T.baccata*

Where it is not specified the collections were made only on *I.aquifolium*.

LICHEN FLORA ON *ILEX AQUIFOLIUM* AND *TAXUS BACCATA*

The number of taxa collected on *Ilex aquifolium* L. is 140, on *Taxus baccata* L. is 55. Fourty-two species were found on both, 98 only on *I.aquifolium* and 13 only on *T.baccata* (fig. 76).

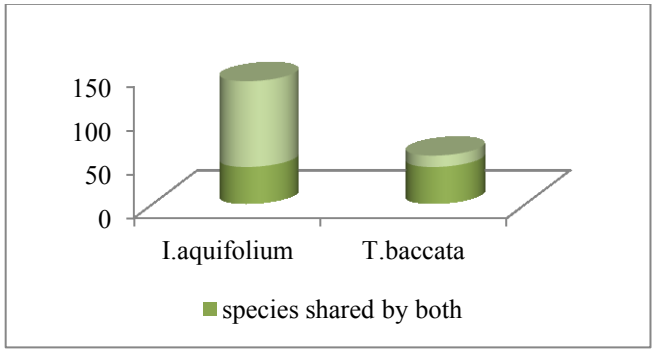


Fig. 76 - Number of taxa collected on *I.aquifolium* and *T.baccata*.

The number of taxa collected on the main trunk (56) of *Ilex aquifolium* is almost equal to the number of taxa collected both on trunk and twigs (55), whereas the number of taxa present only on twigs is quite lower (27).

Most of the taxa collected on *Taxus baccata* were found only on twigs (29) and their number is about the duble of the one of taxa found only on the trunk. Only 3 species grow both on main trunk and twigs. The most common forms in the trunks of *Taxus* are crustose and leprose, other two belong to the genus *Cladonia,* one is the narrow-lobed foliose lichen *Physconia venusta* and one a foliose lichen with broad lobes identificated only at genus level. The scarsity of foliose lichens can be due to the characteristic desquamating bark (fig. 77).

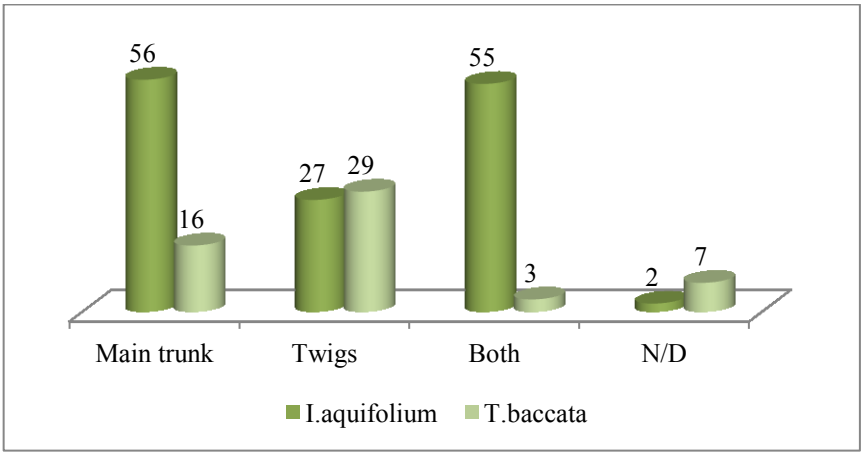


Fig. 77 – Number of taxa collected on main trunk, twigs or both.

Phytogeographic affinities

The taxa have been divided on the base of phytogeographic affinities (tab. 1; fig. 78).

Table 1. Percentage occurrence of chorotypes

Chorotypes %	***I.aquifolium***	***T.baccata***
Temp	46,4	60,0
nTemp	7,1	9,1
sTemp	2,9	1,8
Oc	1,4	1,8
Suboc	23,6	9,1
Subcon	0,7	0,0
North	3,6	1,8
Med	1,4	1,8
Med-mo	0,7	1,8
Med-Atl	4,3	1,8
n/d	7,9	10,9

Among the taxa collected on *I.aquifolium* the temperate are the most common (more than 46%) followed by suboceanic (23.6%), then North temperate (7.1%), Mediterranean atlantic species (4.3%), northem (3.6%), Mediterranean and oceanic (1.4%) and subcontinental and Mediterranean montane 0.7%.

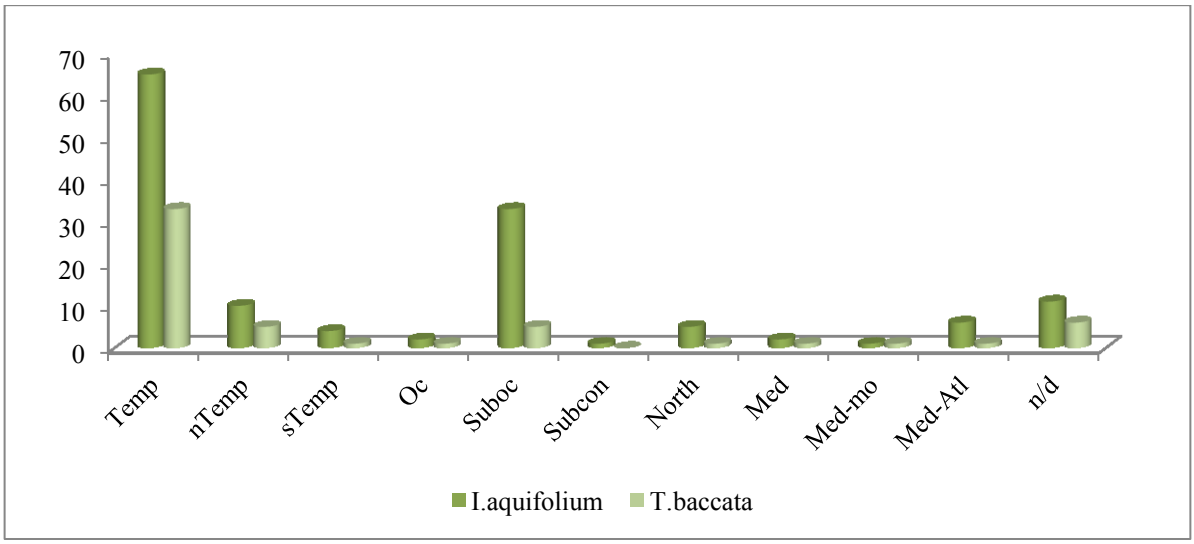


Fig. 78 - Chorotypes distribuition (number of species) on the lichen flora of *I.aquifolium* and *T.baccata* in Sardinia.

The most common taxa on *Taxus baccata* are the ones with temperate affinities, which are present with a bigger percentage than in *I.aquifolium* (60%), followed by suboceanic and northem temperate (9.1%). The remaining groups have the same percentage of presence (1.8%), except subcontinental taxa that are not present (tab.1, fig. 78).

Photobionts

The species collected both on *T.baccata* and *I.aquifoium* are mainly in symbiosis with *Trebouxia.* The 11.4% on *Ilex* and the 7.3% on *Taxus* are in symbiosis with *Trentepohlia.* No species with cyanobacteria was found on *Taxus* and only the 5 on *Ilex* (tab. 2, fig. 79).

Table 2. Percentage occurrence of photobionts

Photobionts %	***I.aquifolium***	***T.baccata***
Ch	83,6	90,9
Cy.f	3,6	0,0
Tr	11,4	7,3
None	1,4	1,8

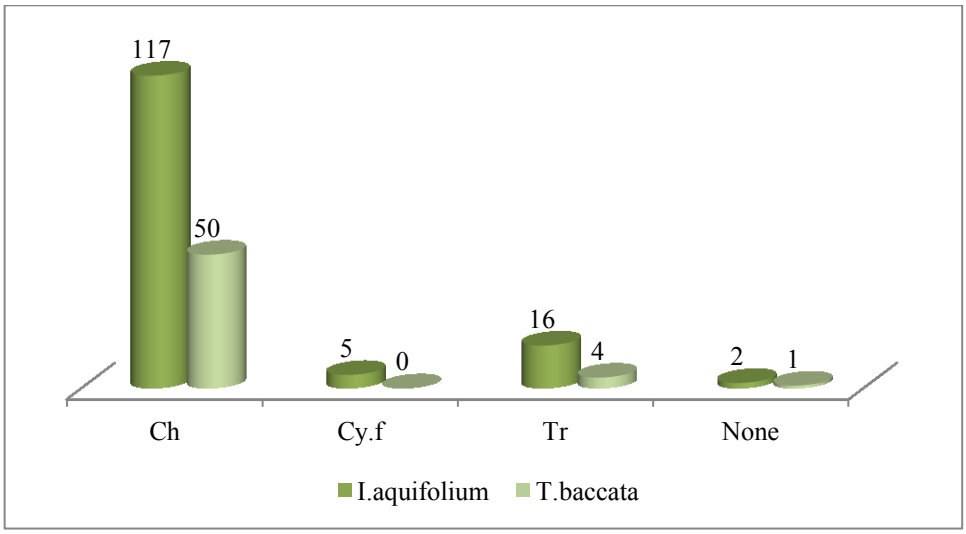


Fig. 79 - Number of species divided for type pf photobionts on *I.aquifolium* and *T.baccata* in Sardinia.

Growth form

The most common form on *I.aquifolium* is the crustose (80) followed by foliose with broad lobes (24) and foliose with narrow lobes (16), then fruticose (8), leprose (5) and minutely squamulose (4). Only one species fruticose filamentous, one crustose placodiomorph and one squamulose were found (tab.3, fig. 80).

Similarly to *I. aquifolium*, on *T.baccata* the most common forms are the crustose (24), but the foliose with narrow lobes (9) are slightly more than the ones with broad lobes (8). The percentage of fruticose and leprose species are higher than *Ilex* with 10.9% each. Only one crustose placodiomorph species and one minutely squamulose were found (tab.3, fig. 80).

Table 3. Percentage occurrence of growth forms

Growth form %	***I.aquifolium***	***T.baccata***
Cr	57,1	43,6
Cr.pl	0,7	1,8
Fol.b	17,1	14,5
Fol.n	11,4	16,4
Fr	5,7	10,9
Fr.f	0,7	0,0
Gr	2,9	1,8
Lep	3,6	10,9
Sq	0,7	0,0

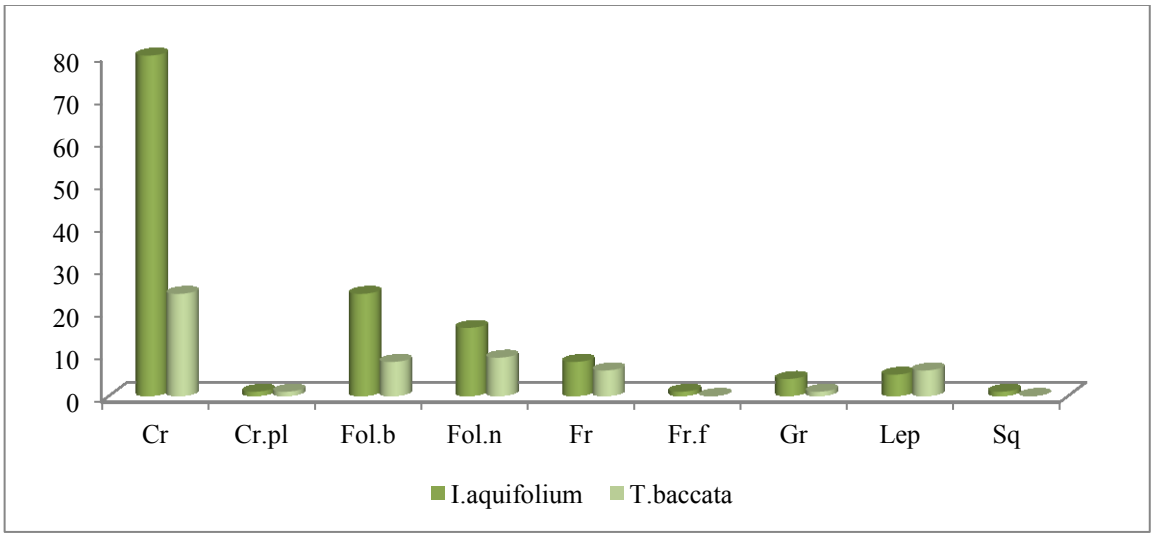


Fig. 80 - Number of species divided for growth form on *I.aquifolium* and *T.baccata* in Sardinia.

Commoness/rarity status in Sardinia

The work of Zedda (2002) was used to assign the value of commonness or rarity status in Sardinia. The value n/d means that only the genus level was attribuited to the specimens or that the taxa were not listed in Zedda's work. So the percentage of rare species could be higher.

Table 4. Rarity status in Sardinia

Rarity status n	*I.aquifolium*	*T.baccata*
ER	4	2
VR	6	0
R	4	0
RR	4	3
RC	3	3
C	32	11
VC	28	9
EC	29	18
n/d	30	9

On *Ilex aquifolium* common, very common and estremely common taxa occur with the higher percentage (respectively 23, 20 and 21%). Three taxa are considered rather common in Sardinia, 4 rare, 6 very rare and 4 extremely rare (tab. 4, fig. 81).

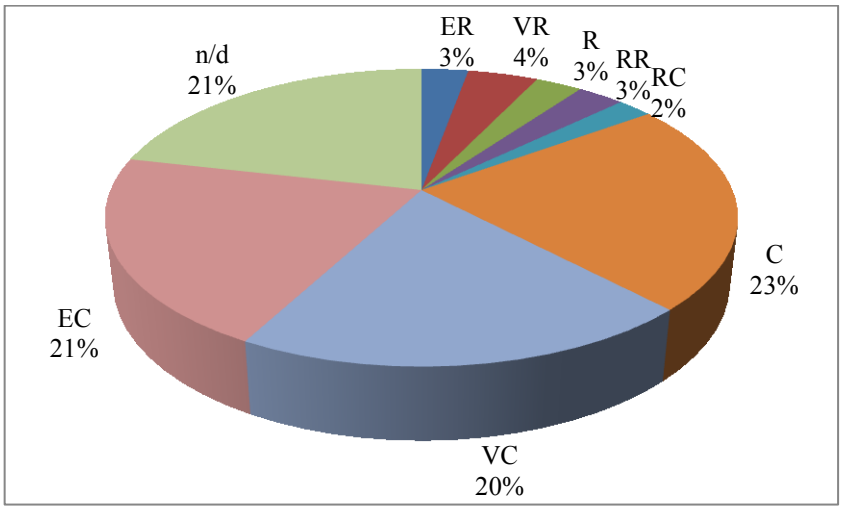


Fig. 81 - Commoness/rarity status of species on *Ilex aquifolium* in Sardinia.

On *Taxus baccata* similarly to *I.aquifolium* the common (20%), very common (16%) and extremely common (33%) taxa occur with the higher percentage. Also 3 rather common, 3 rather rare and 2 extremely rare species were found (tab. 4, fig. 82).

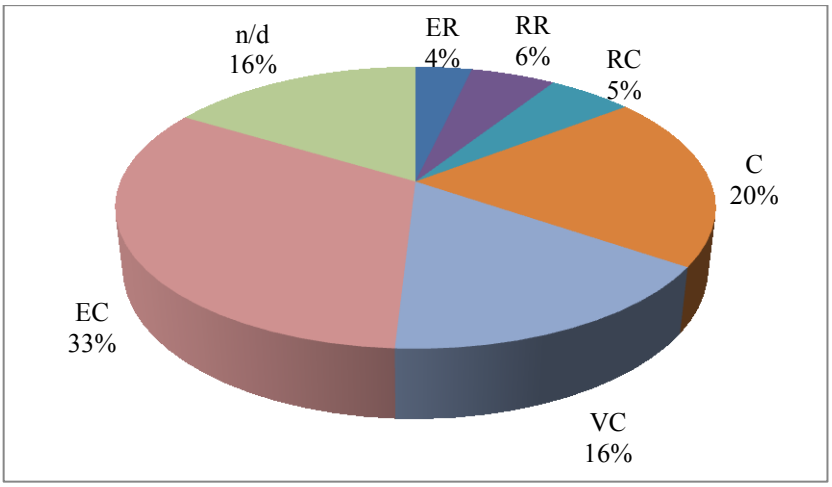


Fig. 82 - Commoness/rarity status of species on *Taxus baccata* in Sardinia.

Commoness/rarity status in Italy

The online databes of Nimis and Martellos (2008) was used to assign the value of commonness or rarity status for Italy. The value n/d means that only the genus level was attribuited to the specimens or that the values are not indicated in the database of Nimis and Martellos.

Table 5. Rarity status in Italy

Rarity status n.	***I.aquifolium***	***T.baccata***
ER	4	3
VR	14	4
R	9	1
RR	14	5
RC	24	6
C	20	8
VC	22	11
EC	15	9
n/d	19	8

The most of the taxa collected on *Ilex aquifolium* belong to the categories rather common (17%), common (14%), very common (16%) and secondly extremely common (11%). Fourteen taxa are considered rather rare for Italy, 9 rare, 14 very rare and 4 extremely rare (tab. 5, fig. 83).

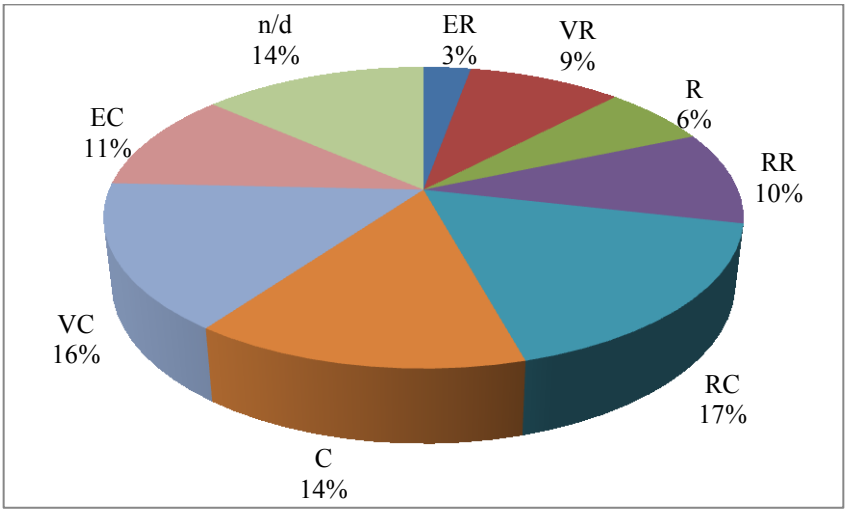


Fig. 83 - Commoness/rarity status of species on *Ilex aquifolium* L. in Italy.

On *T.baccata* the categories very common (20%), common (15%), and extremely common (16%) are the most represented. They are followed by rather common (11%) and rather rare (9%) taxa. One species is rare, 4 are very rare and 3 are considered extremely rare in Italy (tab. 5, fig. 84).

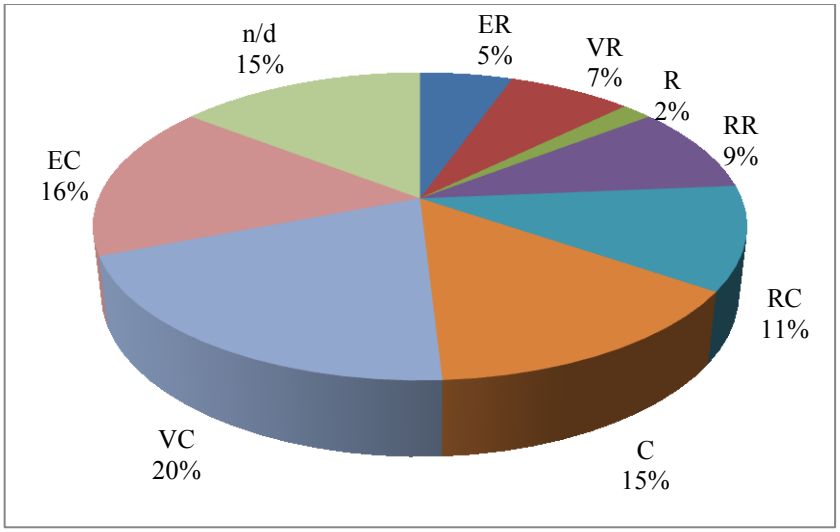


Fig. 84 - Commoness/rarity status of species on *Taxus baccata* in Italy.

New segnalations for Sardinia

Five species and one form are new records for Sardinia:

Arthonia leucopellaea (Ach.) Almq.
Biatora cf. *helvola* Körb. ex Hellb.
Caloplaca luteoalba (Turner) Th. Fr.
Gyalecta derivata (Nyl.) H. Olivier
Megalaria laureri (Hepp ex Th. Fr.) Hafellner
Ramalina fraxinea f. *tuberculata* Ach.

The number of the new taxa for Sardinia can grow with further investigations in other localities of Sardinia. Many species, in fact, have crustose forms and a barely visible thallus which can be difficulty observed in the field. This consideration is valid also for the Red List taxa.

Red list taxa

Nimis and Martellos (2008) list some species among the potential ones to be added to a future Red List, among them the following species, collected on *Ilex aquifolium* and *Taxus baccata*, are indicated for Italy:

Agonimia octospora Coppins & P. James
Arthonia leucopellaea (Ach.) Almq.
Arthonia vinosa Leight.
Caloplaca luteoalba (Turner) Th. Fr.
Chaenothecopsis cf. *vainioana* (Nádv.) Tibell
Cliostomum griffithii (Sm.) Coppins
Schismatomma cretaceum (Hue) J.R. Laundon.

COMPARISON AMONG SITES

The sampling sites have different vegetation types, they were divided in 3 levels:

1 = group of trees

2 = open wood – tree canopy less than 60%

3 = shaded wood – tree canopy more than 60 %

In the site 12 near Nuchis there is a group of trees of *Ilex aquifolium* but, because of the high canopy, the level 3 has been assigned to it. Figure 85 shows the distribuition of the sampling sites, previously divided for vegetation type, on respect of altitude of the area and maximum circumference reached by hollies. The most of them are placed at an altitude between 800 and 1000 m and in the majority the circumference of the trunks of *I.aquifolium* is less than 100 cm.

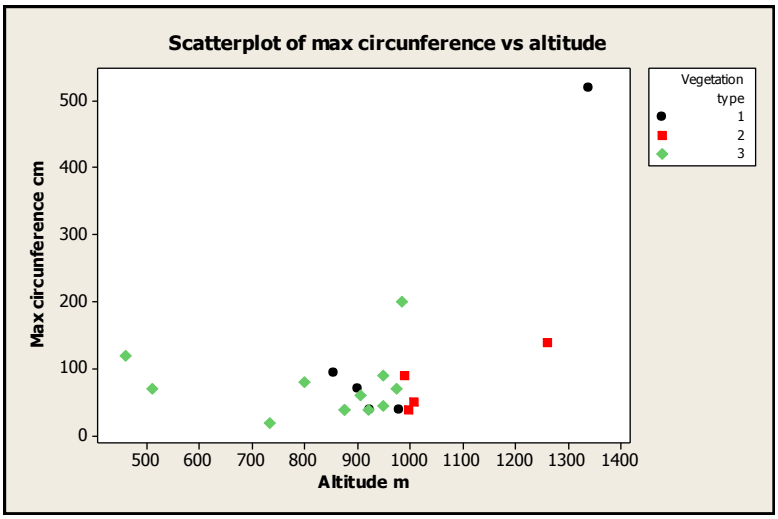


Fig 85 – Sites distribution according to altitude and maximum circumference of hollies.

The number of taxa collected among the sites is highly variable. On *Ilex aquifolium* it ranges from 5 in Seui to 65 in Mularza Noa. On *Taxus baccata* it ranges from 7 in Badde Salighes to 30 in Pabude Park and Mularza Noa (fig. 86a). Moreover the higher richness of lichen species, on regard of *T.baccata* and *I.aquifolium*, seem to be concentrated in two areas of Sardinia placed in the macroareas of Marghine-Goceano and Gennargentu (fig. 86b).

In three of the four areas, where the collections were made also on *Taxus*, the number of species found on *Ilex aquifolium* were highly superior to the ones on *Taxus*, whereas in Pabude Park species found on yew are more than species on holly. The numbers of species

found on *Taxus* in areas with similar lighting conditions is almost equal. Thirty taxa were found in Pabude Park and twenty-nine in Mularza Noa where the trees are isolated and the twigs are exposed to light. Whereas 8 and 7 taxa were collected respectively in the shaded wood of Badde Salighes and Montarbu-Seui (fig. 86).

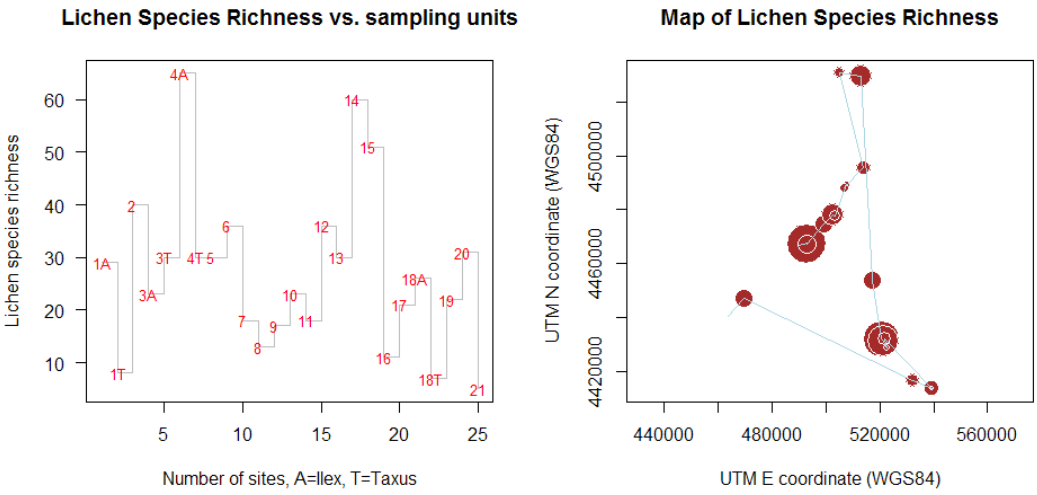


Fig. 86. a Lichen species richness in each sampling unit; b. map of lichen species richness.

The model of quantile regression was tested to check the relationships between altitude, circumference and number of days with fog with the number of taxa found on *Ilex aquifolium*.

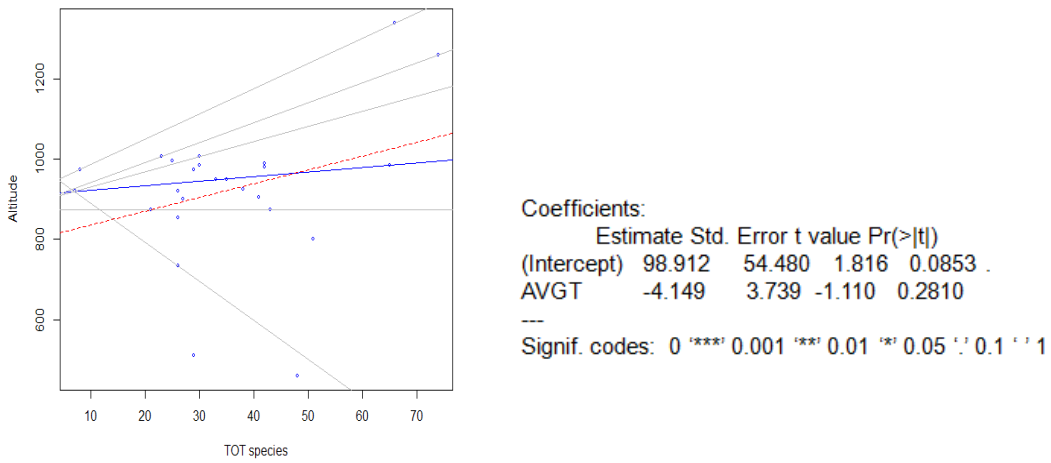
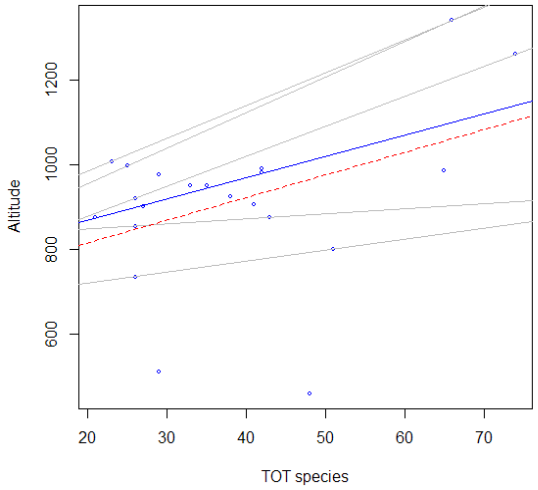


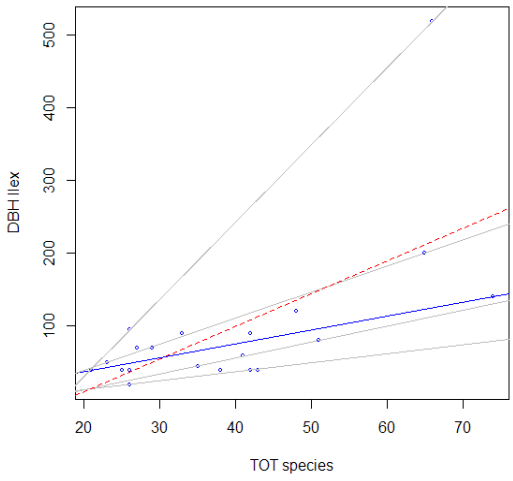
Fig. 87 - Quantile Regression Model between altitude and the species collected in the 25 sampling units.

According to the results there is not a statistically significant relationship between altitude and the number of species collected both on *Taxus* and *Ilex* (fig. 87). The same kind of relationship was tasted excluding the taxa collected on yew. The results, in this case are statistically significant, despite the low value (fig. 88).




```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   3.0227     7.9568    0.38   0.7082
x             0.4278     0.1927    2.22   0.0388 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 88 - Quantile Regression Model between altitude and the species collected on holly in the 21 sampling units.

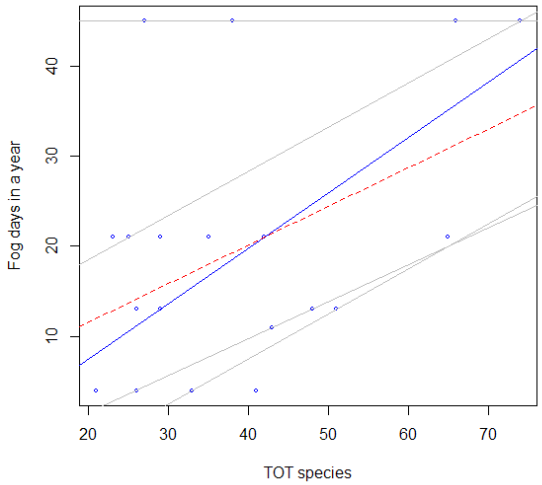



```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -80.156     50.897  -1.575  0.13179
x             4.495      1.233   3.647  0.00171 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 89 – Quantile Regression Model between diameter of the trunk and the species collected on holly in the 21 sampling units.

The model of quantile regression between diameter of the trunks and number of taxa collected on *I.aquifolium* in the 21 sampling units shows a significant relationship among them (fig. 89).

The same happens testing the yearly number of days with fog in each locality with the number of taxa collected on *Ilex aquifolium*, in this case the relationship is also highly significant (fig. 90). On the contrary there are not statistically significant relationships between number of taxa and yearly average temperature, number of taxa and humidity and number of taxa and type of litological substrate of the sites.




```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  706.747    111.035   6.365 4.17e-06 ***
x              5.373      2.689   1.998   0.0602 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 90 – Quantile Regression Model between yearly days with fog and the species collected on holly in the 21 sampling units.

The 25 sampling units were also compared on the base of the table of presence/absence of the species. The dendrogram (fig. 91) created with the software R shows that the sites are quite different from this point of view. The most similar are the sites 18A and 19 which are close to each others in the area of Montarbu and the collections were made in both localities in shaded woods. Also the site 14 and 15 seem similar for the presence of species, in this cases the type of vegetation is different: an open wood in loc. 14 and a group of monumental trees of *I.aquifolium* in loc. 15. The two areas are quite close to each others and are both grazed by animals. The sites 2 and 4A are close in the dendrogram and very close geographically, the vegetation is totally dissimilar, in the first a group of trees of holly and in the second a shaded wood with *Ilex* and *Taxus*. The site 11 and 21 are not close spatially but in both of them the collections were made on shaded wood. Their similarity is linked to the poor number of taxa collected on site 21. In fact they share 4 of the 5 species found in it. The site 1T is the most different from the others, it is maybe linked to the poor numbers of taxa, only 8, and also that among them almost the 30% is rapresented by leprose ones.

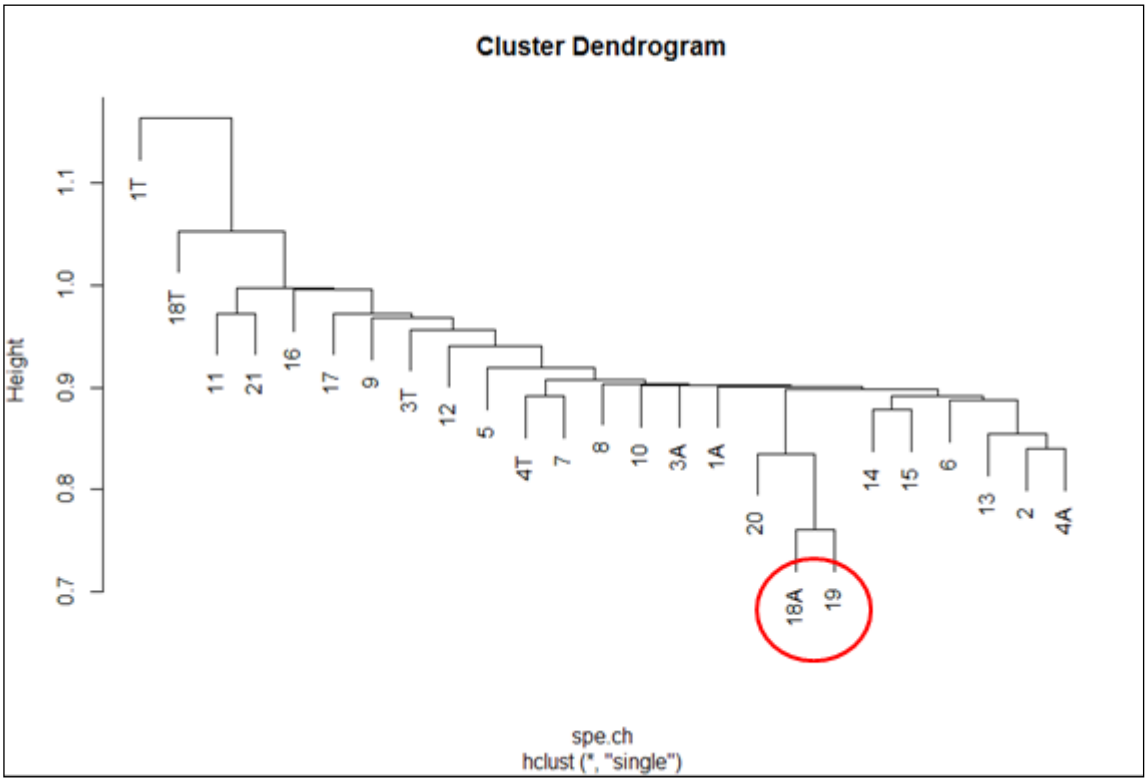


Fig. 91 – Cluster dendrogram according to the table of presence and absence of the species.

CONCLUSION

The total number of taxa (140) collected on *Ilex aquifolium* is not particularly high if compared with the number of lichens collected by Zedda (2002) on *Quercus ilex* and *Quercus pubescens* in Sardinia, respectively 256 and 207. Whereas it is more or less close to the number of species collected on *Quercus suber* by the same author: 168. Field surveys show clearly the difference among the epiphytic lichens present on holly and the near oaks, which have usually an high coverage of lichens both on main trunk and twigs. Instead hollies have usually a low coverage of lichens with mainly crustose species on the main trunk and on the lower twigs. Because of the thick dome made by leaves, the upper twigs are usually poorly colonized by lichens both on shaded wood than in open ones. Whereas the number of lichen thalli and the number of species tend to increase where the trunks or the lower twigs are exposed to sunlight. Another aspect that can be linked to the lower presence of lichens on this kind of tree can be the smooth bark which can interfere with the attachment of thalli. In fact

the trees with the biggest coverage of lichens are the monumental ones in Bruncu Sa Ruge which have a thicker and less smooth bark. Moreover in some of the collecting sites there are only young hollies with small diameters and thus lichens thalli are few and there are tipically pioneer species.

The situation of *Taxus baccata* seems different but only trees which are present in 4 sites were analyzed. The individuals of yew that were observed are big old trees. The main trunk in all of them has few species and mainly crustose and leprose ones. It is surely due to the characteristic desquamating bark which makes impossible a long attachment of bigger species such as broad-lobed foliose and fruticose ones. The twigs in shaded conditions show a very low coverage with mainly crustose species, whereas the ones exposed to light have a good coverage of species with crustose, foliose and some fruticose thalli.

As written previously, 4 estremely rare, 6 very rare, 4 rare and 4 rather rare species in Sardinia were collected on *I.aquifolium*; 2 estremely rare and 3 rather rare in Sardinia were collected on *T.baccata*; 4 extremely rare, 14 very rare, 9 rare and 14 rather rare species in Italy were collected on *I.aquifolium*; 3 extremely rare, 4 very rare, 1 rare and 5 rather rare species in Italy were collected on *T.baccata*; 7 species according to Nimis and Martellos (2008) should be added to a future Red List and 5 species and a form are new records for Sardinia. The results show a very interesting flora of lichens.

As underlined by Zedda (2002) the conservation of lichens is linked to their habitat conservation. Habitat can mean a single tree, a group of trees or a wood with particular ecological features. This confirms the importance of the preservation of Holly and Yew not only for their intrinsic value but also for the safeguard of the biodiversity which grows on them.

ANNEXES

1. Table of the localities of collections

2. Legend of the abbreviations

3. Taxa divided for reproduction type in each site of collection

4. Taxa divided for photobiont type in each site of collection

5.Taxa divided for growth form in each site of collection

ANNEX 1

Table of localities of collection:

N	Date	Locality	Municipality	FUTM	ZUTM	UTMEWGS84	UTMNWGS84	Altitude a.s.l.	*I.aquifolium*	*T.baccata*
1	18,08,2011	Badde Salighes	Bolotana	32	T	489609	4466482	975 m	Yes	Yes
2	18,08,2011	Villa Piercy	Bolotana	32	T	490059	4466758	980 m	Yes	No
3	18,08,2011	Parco Pabude	Bolotana	32	T	493114	4467467	1007 m	Yes	Yes
4	22,04,2012	Mularza Noa	Bolotana	32	T	492752	4466993	1003 m	Yes	Yes
5	22,08,2011	Sos Nibberos	Bono	32	T	499132	4474514	950 m	Yes	No
6	01,09,2012	Foresta Demaniale Anela	Anela	32	T	502405	4477997	990 m	Yes	No
7	01,09,2012	Foresta Demaniale Anela	Anela	32	T	503303	4477453	997 m	Yes	No
8	06,08,2012	Sa Pala de sa ‘e Tulippu	Pattada	32	T	507754	4489369	875 m	Yes	No
9	06,08,2012	Sololche	Pattada	32	T	506890	4488219	855 m	Yes	No
10	11,08,2012	Funtana Rodè-M.Lerno	Pattada	32	T	513829	4495640	950 m	Yes	No
11	15,08,2012	Riu Mannu	Aggius	32	T	505141	4530556	510 m	Yes	No
12	27,11,2011	Exit to Calangianus	Nuchis	32	T	513073	4529684	460 m	Yes	No
13	02,06,2012	Monte Gonare	Orani	32	T	517185	4453835	875 m	Yes	No
14	29,10,2011	Funt.na Fritta (Arcu Ittase)	Desulo	32	T	520523	4432055	1260 m	Yes	No
15	14,07,2012	Bruncu Sa Ruge	Desulo	32	T	521138	4431373	1340 m	Yes	No
16	15,03,2012	Rio Carrada	Desulo	32	T	522725	4428542	900 m	Yes	No
17	15,03,2012	Rio Aratu	Desulo	32	T	521796	4432194	925 m	Yes	No
18	08,09,2012	Montarbu	Seui	32	S	539276	4413534	920 m	Yes	Yes
19	08,09,2012	Montarbu	Seui	32	S	532341	4416641	905 m	Yes	No
20	20,07,2012	Funtana e S'Elighe	Cuglieri	32	T	469416	4447011	800 m	Yes	No
21	20,07,2012	Nuraghe Ruju	Seneghe	32	T	463869	4440483	735 m	Yes	No

ANNEX 2

Legend of the abbreviations:

The ecological information and the abbreviations have been extract by Nimis & Martellos (2008) and Zedda (2002)

Growth forms:

Cr: crustose

Lep: leprose

Cr.pl: crustose placodiomorph

Gr: minutely squamulose to coarsely granular

Sq: squamulose

Fol.b: foliose with broad lobes

Fol n: foliose with narrow lobes

Fr : fruticose

Fr.f: fruticose filamentous

Photobionts:

Ch: green algae, other than *Trentepohlia*

Tr: *Trentepohlia*

Cy.f : cyanobacteria, filamentous forms

Reproduction:

A.i: mainly asexual by isidia

A.s.: mainly asexual by soredia

S : mainly sexual

n/d : non detectable

Phytogeographical patterns:

Temp: mainly temperate element

nTemp: northern temperate element

sTemp: southern temperate element

Oc: oceanic element

Suboc: sub-Atlantic species

North: northen element limited to the highest mountains

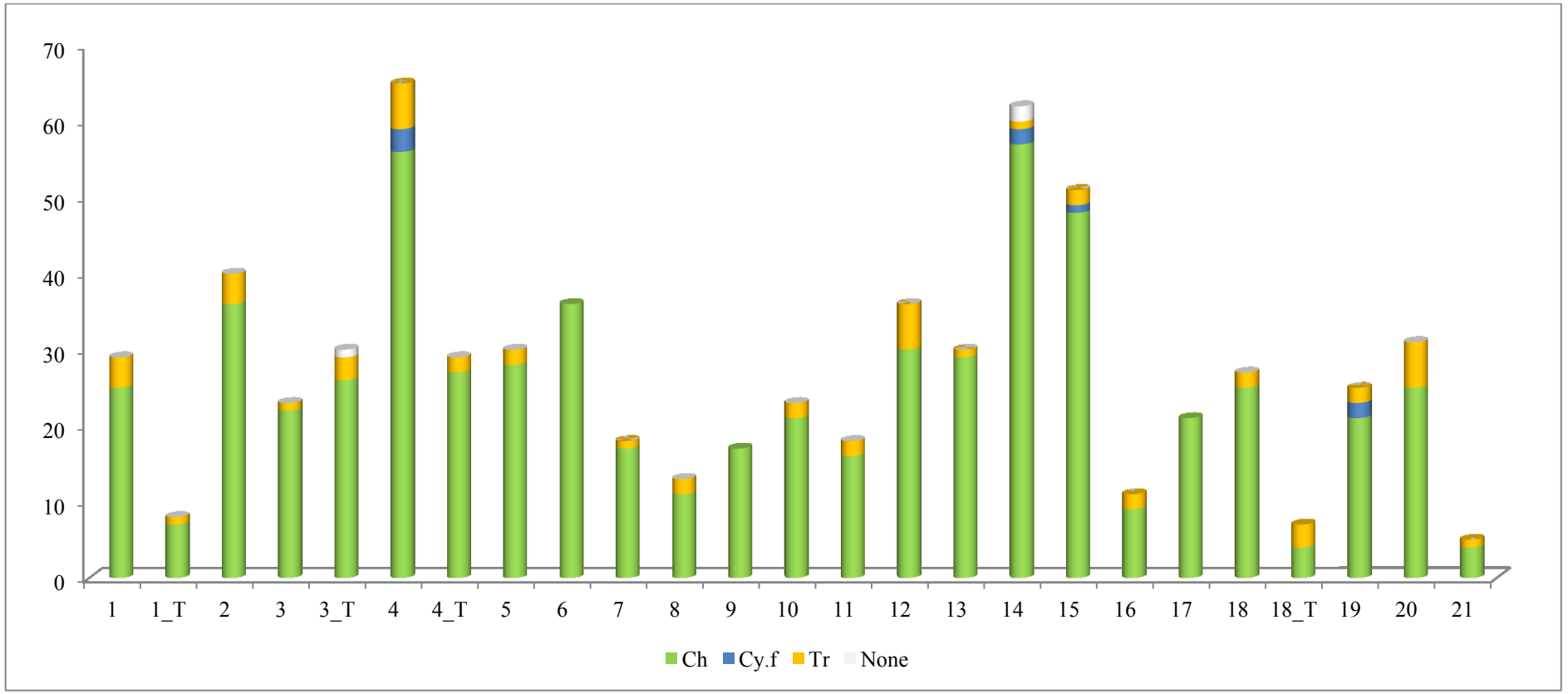
Med: Mediterranean species

Med-mo: species limited to the humid belt of the Mediterranean mountains

Med-Atl: species widespread in the Mediterranean region and in the western Europe

ANNEX 3

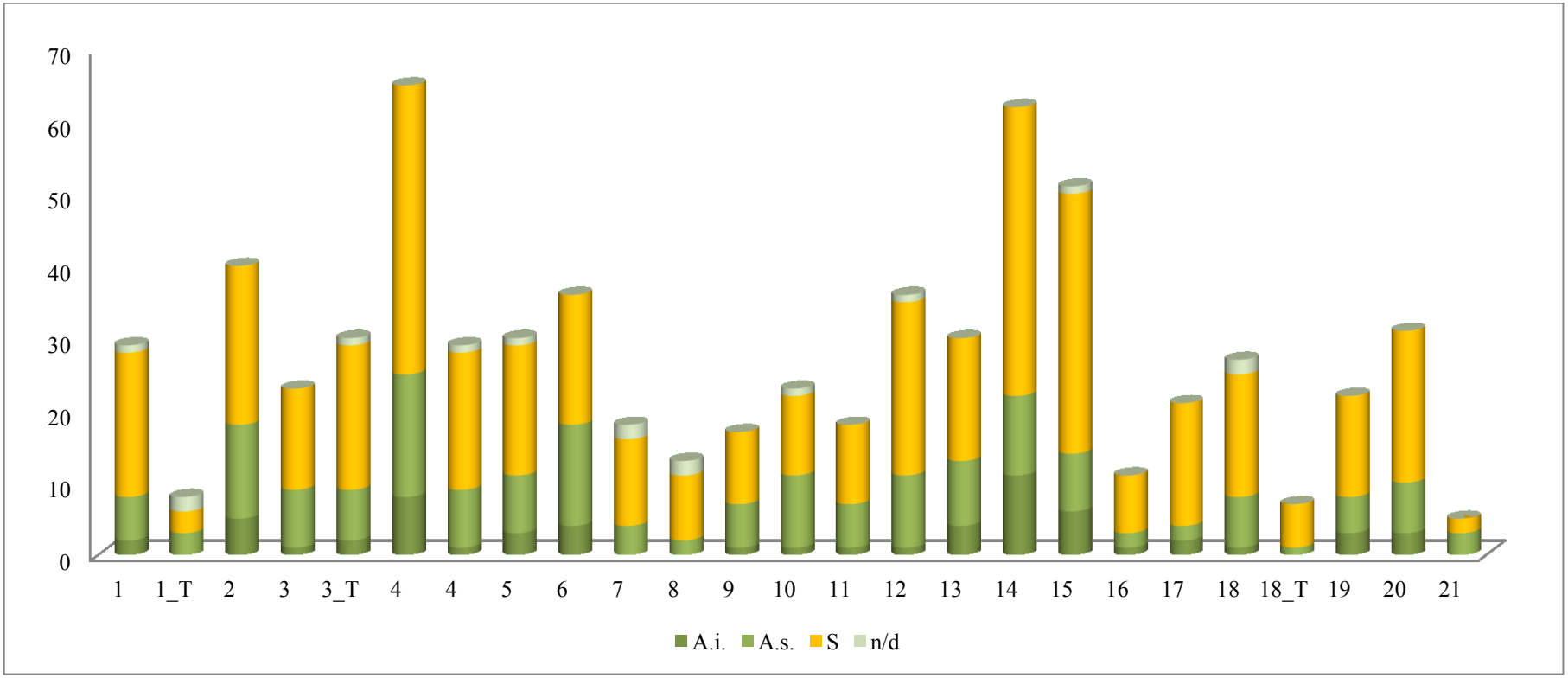
Photobiont type



Number of taxa divided on the base of photobiont type in each locality. T means collected on *Taxus baccata.* If it is not specified the data are referred to *Ilex aquifolium*.

ANNEX 4

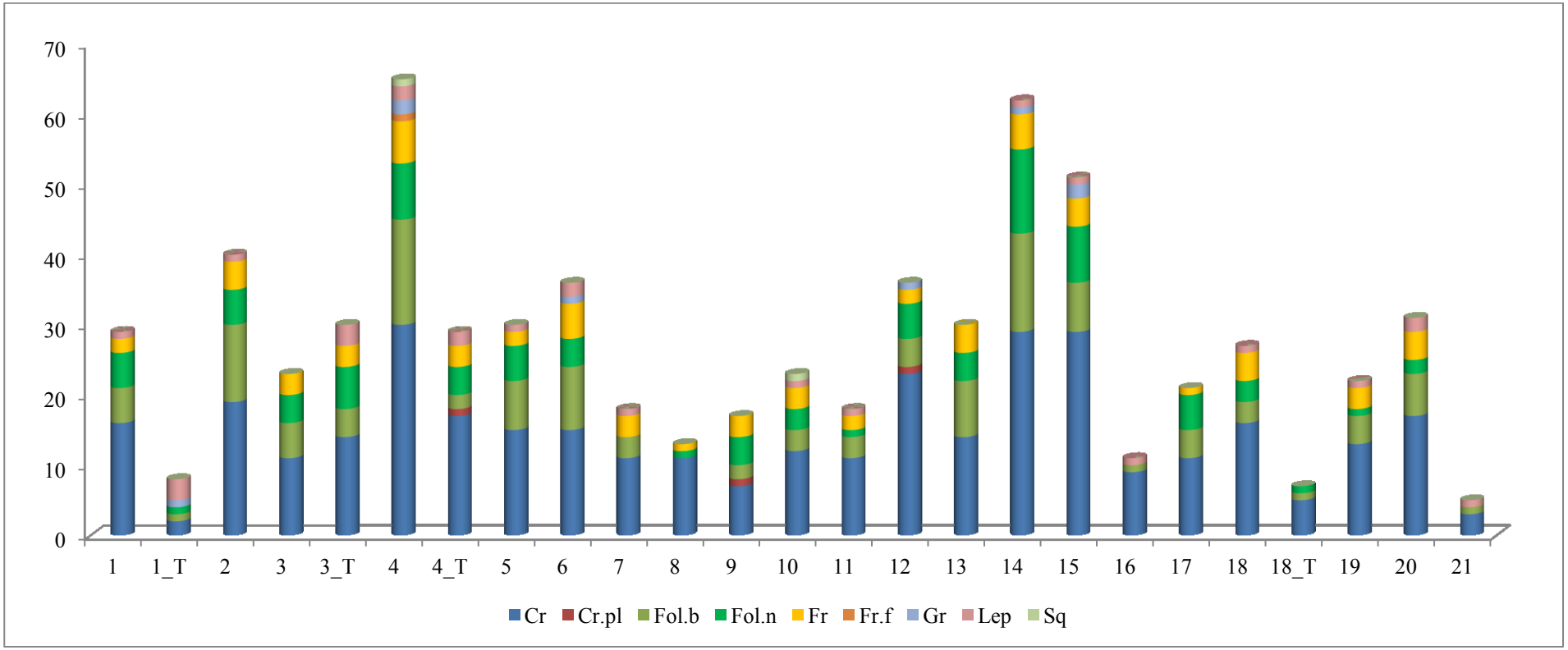
Reproduction type



Number of taxa divided on the base of the reproduction type in each locality. T means collected on *Taxus baccata.* If it is not specified the data are referred to *Ilex aquifolium*.

ANNEX 5

Growth form



Number of taxa divided on the base of the growth form in each locality. T means collected on *Taxus baccata*. If it is not specified the data are referred to *Ilex aquifolium*.

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