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Mosses and Liverworts of the Mediterranean

Mosses & Liverworts of the Mediterranean

an illustrated field guide

2010

Title page: the liverwort Oxymitra palaeacea

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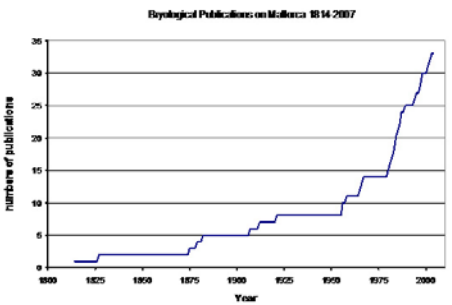
Preface

Sixty years ago, the mediterranean bryoflora was scarcely known. Many parts were difficult to reach, the coastal parts only by ship and the interior on bad roads. The interior of Cyprus could only be accessed by mules. The explosive increase of tourism and the enhanced infrastructure of the countries allowed fieldtrips to formerly remote regions. In addition, the different flora in the Mediterranean attracted many bryologists, who looked for interesting species which they had not seen before as a new challenge after having explored their home countries. The increased bryological activities especially in Italy and Spain lead to an improve of bryological knowledge and the discovery of many new species.



As an example, the number of bryological publications on Mallorca raised from five in the year 1900 to 34 in 2007 with a sudden increase in the Sixties and especially after 1980.
Because of the easy travel facilities, many parts of the Mediterranean got an attractive destination for bryologically interested tourists, especially during the winter time, when low temperatures and the seasonal rainfall favoured the bryophyte vegetation. The botanist is, however, faced with a complete new vegetation. Therefore numerous field guides for higher plants were published but not yet for bryophytes. Although mosses and liverworts are not in the main focus of general interest, they are a distinct and very characteristic part of the vegetation. However, there are only few books to identify mosses and liverworts, and these are usually designed for only experienced users. Therefore the author decided to publish a first photographic guide to the mosses and liverworts of the Mediterranean, similar to those for flowering plants. This book will give the interested botanist a first access to the mediterranean species, but due to the lack of illustrated field guides for the mediterranean species, it may also serve as nice picture book for the more advanced bryologist.
The photographs were taken by the author during the past five years during trips to Cyprus, Malta, Crete, Sardinia and Mallorca and cover all common species as well as local rarities.
I like to thank my friends Michael Lüth, Felix Schumm, Norbert Stapper and Huub van Melick who took part in these trips.

Summer 2010 Jan-Peter Frahm

Introduction

The mediterranean vegetation is determined by a seasonal climate with hot and dry summers and cold and rainy winters. These contrasting seasons determine much the bryopohyte flora by the way that part of the species are winter annual and show up only during the rainy seasons but diasappear over the summer. Therefore the best season for observing and collecting bryophytes are the months January to March or April. As a consequence, a high percentage of mosses and liverworts are winter ephemerals, finishing its live cycle within two months such as many acrocarpous mosses, or „oversummer“ the dry period in dry state almost not visible such as many thalloid liverworts. This counts for the true mediterranean vegetation, which is found in the coastal areas around the Mediterranean Sea up to some hundred meters altitude, which is focussed in this books. The mountain areas as well as the temperate forests show a more temperate flora. Therefore the bryoflora of the higher regions is similar to that of Central Europe is is not concerned.

Aim of this book is not to give an academic seminar on the ecology, altitudinal zonation, regional biodiversity or structural adaptation of mediterranean bryophytes nor to give bibliographies for regional or complete (there is only one for liverworts) checklists or books for identifications but an illustrated guide to the mosses and liverworts of the Mediterranean with some comments on the species.

The arrangement of the species is not consistent. Hornworts and liverworts are systemmatically arranged, because they are not too numerous and can relatively easily be differentiated. It would have made no sense to arrange the mosses, the largest bulk of species, in the same way. They are arranged by habitats instead.

Another problem is the scientific level, which is a balancing act. Therefore the book will not start with an introduction to the life cycle of bryophytes, the anatomical and morphological terms, but starts out from some general knowledge of this group of plants. It is nevertheless hoped that the pictures will be enjoyed also by the non-bryologist.

There are no exact numbers of species known occurring in the Mediterranean. A recent checklist of the liverworts and hornworts of the Mediterraneaan (Ros et al. 2007) lists 403 species. In this list are, however, all species from all countries surrounding the Mediterranean Sea included plus the Canary Islands and Madeira. By this ways all species from France are included, although no more than 10% of this country belongs to the Mediterranean. This concerns also for the alpine liverworts from Italy. The number of species will furthermore be much lower if the montane regions are excluded, which are inhabited by temperate vegetation types (e.g. beech forests) with temperate species.

Ros, R.M., Mazimpaka, V., Abou-Salama, U., Aleffi, M., Blockeel, T.L., Brugues, M, Cano,M.J., Cros, R.M., Dia, M.G., Dikse, G.M., El Saadawi, W., Erdag, A., Ganeva, A., Gonzalez-Mancebo, J.M., Herrnstadt, I., Khalil, K., Kürschner, H., Lanfanco, E., Losada-Lima, A., Refai, M.S., Rodriguez-Nunez, S., Sabovljevic, M., Sergio, C., Shabbara, H., Sim-Sim, M., Söderström, L. 2007. Hepatics and Anthocerotes of the Mediterranean, an annotated checklist. Cryptogamie, Bryologie 28: 351-437.

A Plants not differentiated into stems and leaves, thallose.

Anthocerotophyta

Thallus lobed, with usually present horn-like sporogones.
Hornworts (*Anthocerotophyta*) p. 10

Marchantiophyta

Thalli roundish, < 1 cm. sporogones always present, covered by a pear-shaped, inlated tube.
Balloonworts (Sphaerocarpidae) p. 13

Thallus unbranched or dichotomously branched, fleshy, without air chambers and pores. Rhizoids not vtuberculate.
Crystalworts (*Ricciales*) p. 14

Thallus surface areolate, with complex internal tissue, air chambers and pores. Rhizoids tuberculate .
Complex thalloid Liverworts (*Marchantiales*) p..19

Thallus divided into densely arranged leaf-like often fimbriate lobes. Spore cpasules positioned upon the midnerve.
Frillworts - (*Fossombroniaceae*) p. 32

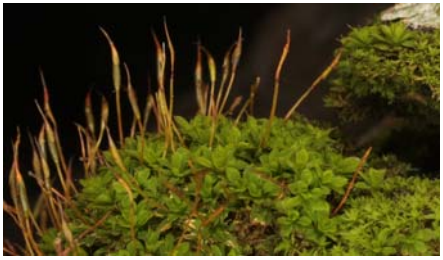
Thalli anders, bandförmig, gegabelt, geschlitzt. Sporogone nur kurzzeitig episodisch gebildet,lang gestielt, nicht dauernd von Hüllen umgeben.
Simple structured thallose liverworts (*Metzgeriidae)* p. 38

B Plants differentiated into stems and leaves, foliose.

Leaves in two rows (a third often on the venrtral side of the stem), wothout nerve.
Foliose liverworts (*Jungermanniidae*) p. 40

Bryophyta

Leaves spirally arranged (if in two or three rows with nerve). Mosses p. 48



Plants usually erect, in turfs or cushions. Spore capsules terminal. acrocarpous mosses

Plants usually prostrate in mats. Spore capsules lateral. pleurocarpous mosses

HORNWORTS

There are two genera of Hornworts in the Mediterranean as well as in the rest of Europe, Anthoceros with crispate lobes of the thalli and blackish spores and Phaeoceros with plane lobes and orange spores. The species can only be separated by the sex condition and the structure of the spore surface. They grow on soil, rarely rocks in wet places such as rocks and soil along streams, wet soil in ditches or along trail banks, also on loamy soil in cultivated land

Anthoceros (above) is represented by three species, Anthoceros agrestis, **Anthoceros caucasicus** (top), and Anthoceros punctatus. They lack in the drier parts of the Mediterranean and are confined to ravines or humid forests at higher elevations.

There are three species of Phaeoceros in the Mediterranean, **Phaeoceros bulbiculosus** (page right) , P. caucasicus and P. laevis (P. 12), of which P. laevis is the commonest and found in almost all countries. P. bulbiculosus (now in the genus Phymatoceros) is also widespread but not common, whereas P. carolinianus is a rare species. They grow in humid habitats such as seeping road banks like Anthoceros and decrease in frequency from West to East.


4x

Phaeoceros laevis, colonies on a roadside bank (top), plants with old and young sporophytes (middle, bottom left) and sterile plants (bottom right).

BALLOONWORTS

The balloonworts consist worldwide only of the genus Sphaerocarpus with twelve species. Systematically they are placed in the march-an-tealean liverworts because of the sterile cover of the spore capsule, although the plants are totally different in appearence. Three species occur in Europe, S. michelii S. stipitatus and S. texanus, which can only be identified by the microscopical structure of the spores. S. stipitatus is found only in Portugal, the others are more widespread. Both are ephemeral and show up on loamy soil in cultivated land, bare soil in lawns, orange groves only during the winter months until March/April. Sphaerocarpus michelii is more common than S. texanus. The male plants are much smaller (right).

Sphaerocarpus michelii, female plants with black spore capsules in the ballon-like involucrums (above) and a male plant (bottom right).

CRYSTALWORTS

Crystalworts (Ricciaceae) are found in damp places, even floating in water, but also as well as in dry habitats such as garigues in the Mediterranean, where they grow in winter and spring on bare soil amongst low grasses. During dry periods they fold their thalli as a protection against desiccation and are then hardly visible. Some strokes with a spray bottle will resurect them. Many of these species are found as rarities in the warmer parts of Central Europe, usually in regions with viniculture. Only Riccia crystallina is growing in damp places such as margins of ponds as many of their relatives in Central Europe.
Crystalworts are the small relatives of the big marchantealan liverworts. They produce their sex organs in the thallus, well protected against desiccation, where also the sporogons are developed. The spores will be released in the soil when the thallus is decaying. Spore dispersal happens by strong winds or feet of birds.

Riccia atromarginata

Riccia croszalsii

Riccia ciliata

Riccia ciliifera

Riccia crystallina

Riccia gougettiana

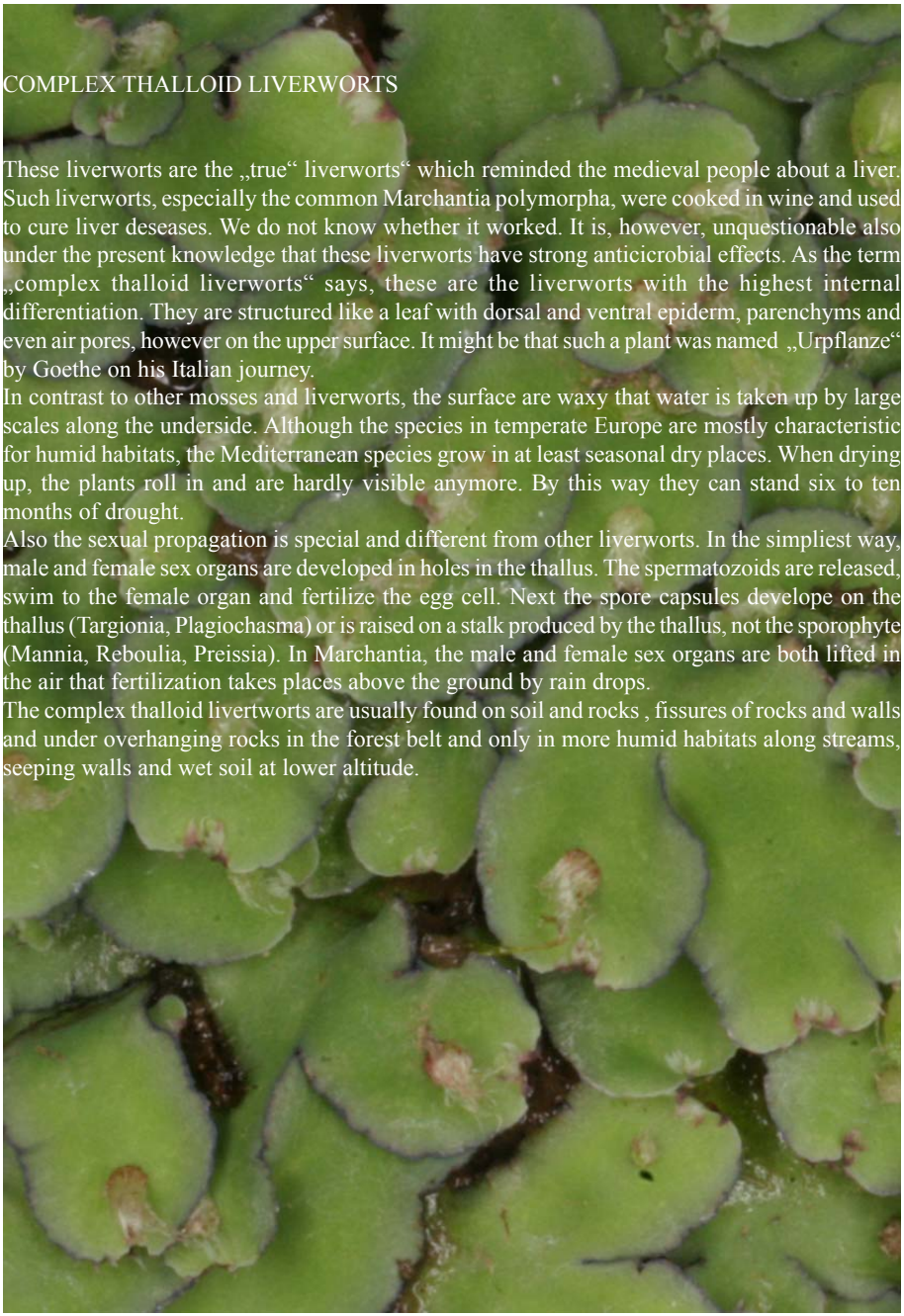
Riccia lamellosa

Riccia nigrella

Riccia sorocarpa

Riccia trabutiana

Oxymitra palaeacea looks almost like a marchantealean liverwort. It has conspicuous large white ventral scales, which project over the thallus margins. In dry state, the thallus folds in and only the white scales remain visible (bottom right). They are said to reflect the light but will also serve for a rapid water uptake when rain has started.



COMPLEX THALLOID LIVERWORTS

These liverworts are the „true“ liverworts“ which reminded the medieval people about a liver. Such liverworts, especially the common Marchantia polymorpha, were cooked in wine and used to cure liver deseases. We do not know whether it worked. It is, however, unquestionable also under the present knowledge that these liverworts have strong anticicrobial effects. As the term „complex thalloid liverworts“ says, these are the liverworts with the highest internal differentiation. They are structured like a leaf with dorsal and ventral epiderm, parenchyms and even air pores, however on the upper surface. It might be that such a plant was named „Urpflanze“ by Goethe on his Italian journey.

In contrast to other mosses and liverworts, the surface are waxy that water is taken up by large scales along the underside. Although the species in temperate Europe are mostly characteristic for humid habitats, the Mediterranean species grow in at least seasonal dry places. When drying up, the plants roll in and are hardly visible anymore. By this way they can stand six to ten months of drought.

Also the sexual propagation is special and different from other liverworts. In the simpliest way, male and female sex organs are developed in holes in the thallus. The spermatozoids are released, swim to the female organ and fertilize the egg cell. Next the spore capsules develope on the thallus (Targionia, Plagiochasma) or is raised on a stalk produced by the thallus, not the sporophyte (Mannia, Reboulia, Preissia). In Marchantia, the male and female sex organs are both lifted in the air that fertilization takes places above the ground by rain drops.

The complex thalloid livertworts are usually found on soil and rocks , fissures of rocks and walls and under overhanging rocks in the forest belt and only in more humid habitats along streams, seeping walls and wet soil at lower altitude.

Plagiochasma rupestre

This species is forming large mats of bluish green plants on seasonally wet, shadyvertical limestone rocks and below overhanging rocks. The bluish colour is caused by waxes on the surface. Therefore the plants cannot take up water with the surface but only with the underside, which explains their occurrence on rocks in niches, which are not reached by rain. Male and female sex organs are produced on the same plant. The male sex organs show hairy clusters along the midth of the thallus, which mark the opening above the male sex organs. The females produce low gametangiophors, which include few spore capsules which will be blackish when ripe.

A similar species, P. appendiculatum, has been found only on Mallorca. It is bright to yellowish green and has orbicular appendices (name!) on the ventral scales. The species is known from eastern Africa and SE-Asia.

Preissia quadrata has a thallus with reddish margins and whitish dots on the surface (the air pores). It can be confused with Reboulia hemisphaerica, but has a female gametangiophor (right) with four lobes (hence the name) and a hot taste. The species is found only in limestone areas on soil, in rock fissures, on wet rocks and calcareous tufa. It is also found in central and northern Europe but is more common in the Mediterranean.

Reboulia hemisphaerica is similar to Preissia quadrata with bluish green thallus, inconspicuous air pores and purplish margins, but has no hot taste. The female gametangiophor (right) is 4-7 lobed. It grows on somewhat basic substrates but not only on limestone.

In the genus Targionia, the spore capsules are situated beneath the tips of the thalli. The thalli are leathery with whitish dots (the air pores) and black underside. They roll in when the habitat dries up (left) and -like other complex thalloid liverworts such as Mannia and Plagiochasma), are hardly visible anymore.

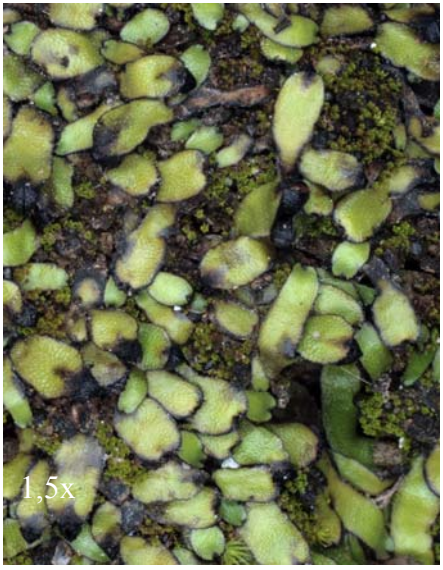
Targionia hypophylla is bluish green and grows in areas with siliceous rocks. It is rarely found also in Central Europe as several other mediterranean species.

Targionia lorbeeriana (next page) is a vicariant species growing in limestone areas. It differs by green not bluish green thalli and a conspicuous odor after fruit drops when scratching the surface with fingers.

Both species are growing on soil in niches of rocks and walls, soil covered rocks and also on vertical rocks in ahady sites.

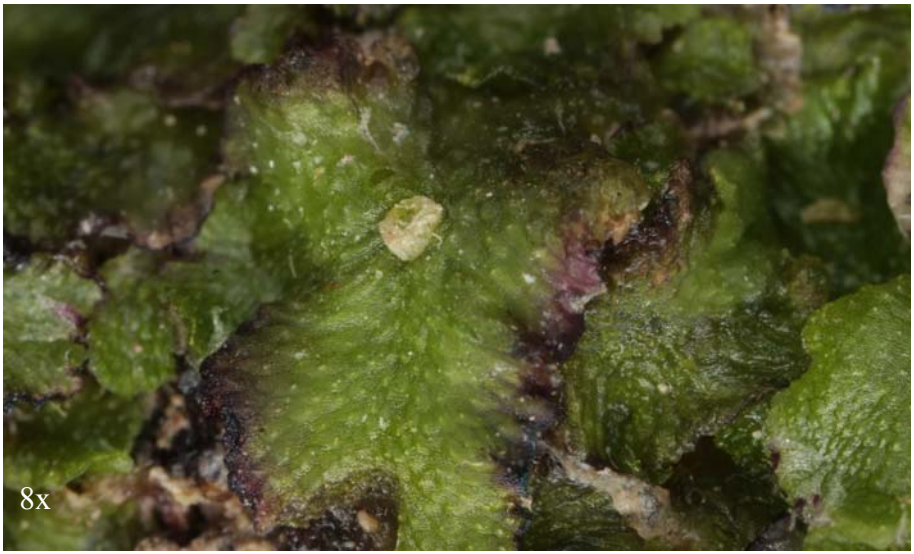

3x


15x


1,5x

Mannia androgyna is a good example for a resurrection plant. After the rainy seaason in spring or during longer dry seasons, theplants dry up (three pictures right) , roll in and are hardly visible anymore that they are no more found during the tourist season in summertime. The thallus is bluish green with white spotted air pores. The male sex argans are situated in holes along the midth of the thallus marked by blackish spots (bottom left), and the female gametangiophores are on low stalkes with 3-4 lobes. The species grows on relatively dry and sunny calcareous soil.

Athalamya hyalina (top) grows on humus over calcareous rocks. It is mainly found in the mountains of the arctic but paradoxically in xerothermic habitats scattered through Central Europe and the Mediterranean. The southern records are interpreted as relics from the glacial periods. This underlines that arctic species need no low temperatures but open habitats. In contrast **Athalamya spathysii (**bottom) is a purely mediterranean element.



Marchantia paleacea resembles the widespread M. polymorpha in the presence of gemmae cups, but has a bluish green thallus, usually with red margins, and red ventral scales. The female gametangiophors are different in having 5-9 broad lobes instead of 9 finger-like lobes. The species grows on humid rocks only in the western Mediterranean.

Corsinia coriandrina got its name from the coriander-like smell of the fresh thallus, which is conspiucously spongiose on the surface due to large air chambers, which walls break up in in age. The female sex organs as well as the spore capsules are formed in the middle of the thallus (bottom left). The plants have a pale undulate margin and a very light green colour. They grow on soil in limestone areas or basic volcanic rocks.

Lunularia cruciata is the most common thalloid liverwort in the Mediterranean. It grows in more humid habitats on soil and rock along streams in valleys and gorges, on shady trail banks, fissures of walls etc. The frequency is due to the vegetative propagation by lentil-shaped brood bodies (next page bottom), which are produced in half moon shaped gemmae cups. Plants without gemmae (next page top) are a bit difficult to address. Male plants produce wart-like structure upon their thalli. Femal plants produce their sex organs in cavities in the thallus, which are marked by pale dots. After fertilization a gametangiophor with a short lived weak stalk is produced which bears four spore capsules at its underside. Since male and female plants are separate, fertilization and thus production of spore capsules happens only rarely.
Lunularia cruciata was first recorded for Central Europe from the Botanical Garden of Karlsruhe in Germany in 1828, probably introduced with plant containers from the Mediterranean, and has spread from there in Botanical Gardens, parks and cemeteries. There it is usually sterile. Male or female sex organs have been found only as an exception. It was not frost tolerant but could survive winters in greenhouses. Since 50 years, it is also found in natural habitats, mainly along streams which are not frozen in winter time.

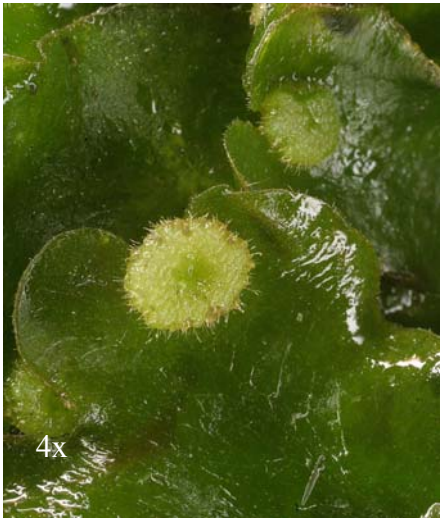

6x


5x


3x


3x

Although **Dumortiera hirsuta** belongs to the complex thalloid liverworts, it lacks many characters of this systematic group such as air pores, air chambers, and ventral scales. It forms large Pellia-like flaps in very moist and shady habitats. Therefore it is restricted to the Atlantic coast and Macaronesian Islands and is else in the Mediterranean only known from the Apuanian Alps in Italy, where more of such oceanic species are found. The male plants have pale disks at the end of the thalli (right), the females hairy capitula (left).



FRILLWORTS

There are ten species of frillworts in the Mediterranean in the genus Fossombronia and one species of Petalophyllum. They look intermediate between thalloid and leafy liverworts, having a creeping stem with more or less crispate lobes. The sex organs are formed along the stem. The male organs are small globose bodies with the appearence of snails eggs. The black round capsules are produced in involucrums on the stem and are lifted into the air by translucent setae. Most of the species are annual and show up in garigues at the end of the rainy season in early spring. They can be identified only by the spore ornamentation, but capsules are usually present. Only Fossombronia angulosa is perennial and can be recognized by the more leaf like lobes.

Fossombronia caespitiformis (top male plant, bottom left female plant with young spore capsules and bottom right with old spore capsules on translucent setae) is the most commen species on soil in garigues, where it is often abundant in spring. It dies after having produced sporophytes and survives the summer as spore.

Fossombronia echinata (top) is a small species similar to F. caespitiformis and differs by the spinose spores. It grows in similar habitats like the preceeding species.

Fossombronia husnotii is one of the larger species, which grows in contrast to the preceeding species on siliceous soil. The range extends along the west coast of Europe to the north.

Fossombronia pusilla forms small, usually single plants on siliceous soil. It extends from the Mediterranean to Central Europe.

As an perennial species, **Fossombronia angulosa** is confined to moister habitats such as soil and rock fissures in ravines. It is 1-3 cm long and 5-6 mm wide.

Petalophyllum ralfsii has a conspicuous appearence with parallel, leaf-like ridges which originate from both sides of a midrib. With 1,5 cm length it is bigger than most of the species of Fossombronia. It is the only representative of the genus in Europe, which includes worldwide four species in Bolivia, India and Australia, indicating a very ancient origin. Petalophyllum is found from Crete and Malta to southern England. It is said to grow on salty soil near the coast, which concerns the northwestern border of its range, but is also found on calcareous open soil amongst grasses in pastures.

SIMPLE THALLOID LIVERWORTS

These thalloid liverworts have - in contrast to the complex thalloid liverworts - a less structured thallus. It can be almost undifferentiated or have a midrib. The sporophytes are produced laterally, not terminally like the foliose liverworts.
The simple thalloid liverworts are inhabiting moist places and are therefore less common in the Mediterranean. Only **Pellia endiviifolia** is found more often on wet limestone rocks and tufa. It can be recognized in autumn and winter by the presence of small branches (see photograph).

The male plants of Pellia endiviifolia (left) show reddish brown wart like structures on the thallus surface, where the male sex organs are imbedded in the thallus. The female plants develope their spore capsules in a cover (involucrum, bottom left). In early spring, the capsule is rapidly exserted on a translucent seta.In contrast to other species of Pellia such as P. epiphylla (on siliceous substrate) and P. neesiana (in mountains), P. endiviifolia has a free standing involucrum which has a ciliate mouth.

LEAFY LIVERWORTS

Leafy or foliose liverworts are rare in the Mediterranean, because they are typical for humid climates. Thus the humidity of a region can be calculated by the ratio between liverworts and mosses. For example, in Germany are 280 species of liverworts and about 875 species of mosses, the ratio is about 1:3; on the Azores, there are only one and a half times more mosses than liverworts, the ratio is 1: 1,5, an d in the Chocó region of Columbia, one of the wettest r egions in the world, only ten percent of the bryophytes are mosses, the ratio is 9:1. For that reason liverworts are usually confined in the Mediterranean to mountain areas. These species are the same as in temperate Europe and not illustrated here. In the true mediterranean vegetation confined to altitudes up to 3-500 m are only some specialists found or they occur in deep gorges or moister regions such the Apuanian mountains.

The genera Gongylanthus and Southbya have dense opposite leaves. The plants are only a few millimetres long and grow on shaded soil in garigues, along roadside banks and on earth covered rocks.

Gongylanthus ericetorum (top) grows on acidic soil over siliceous rocks as expressed by the species name „ericetorum“, which means growing in Erica heaths. Therefore e.g. Erica arborea indicates the presence of Gongylanthus. The species is also found in South Africa, which exemplifies the large ranges of bryophyte species and the age of the species.

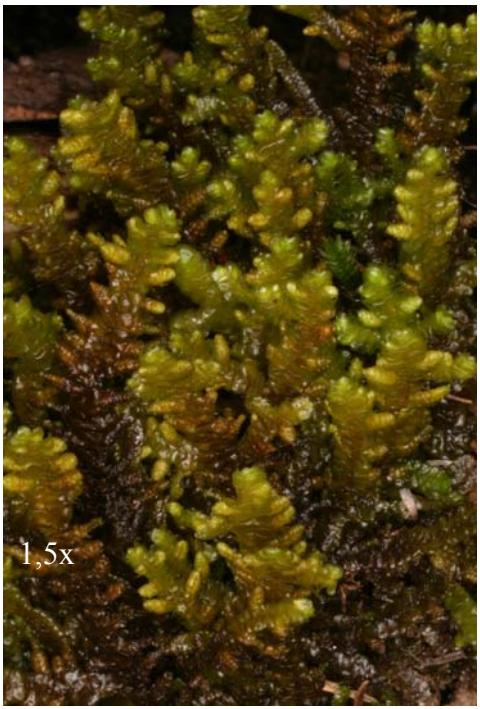
In contrast, the Southbya species grow over limestone (which is the most common geological substrate around the Mediterranean Sea). **Southbya nigrella** (next page top) is, as expressed by the name, blackish, **Southbya tophacea** (next page bottom) is „blond“. The latter grows in wetter habitats than the preceeding species such as seeping limestone rocks.

All species produce their sporophytes in deep pouches (marsupia), which are formed by the stem and penetrate the soil below the plant. By this way the development of the sporophyte is protected against desiccation.


10x

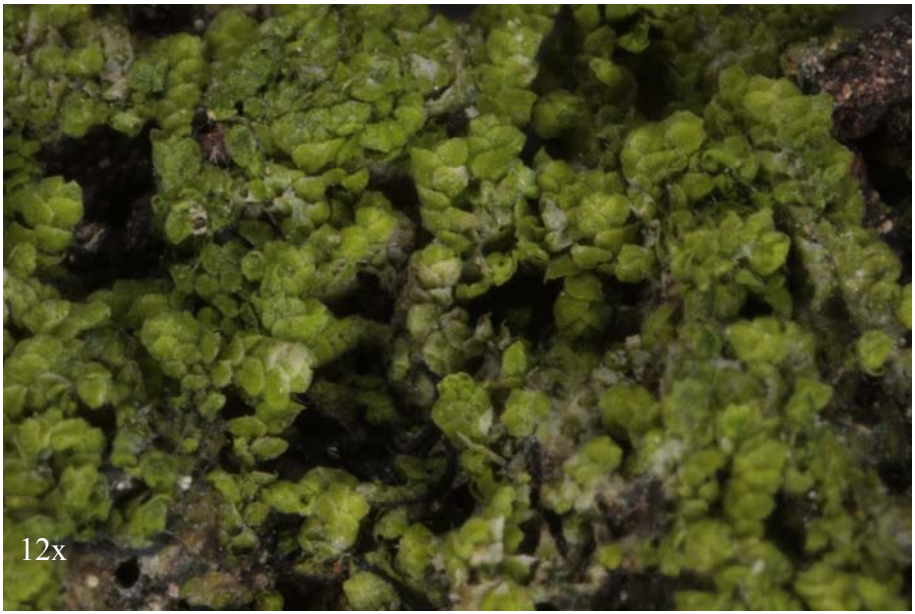

6x


50x



Saccogyna viticulosa (top) has opposite leaves as well but is in contrast to Gongylanthus and Southbya several centimetres long. It grows on soil, rocks and rotten wood and is an oceanic element with mediterranean-atlantic distribution on the atlantic islands (Azores, Canary Islands, Madeira), the atlantic coast of Europe (Ireland, Britain, Brittany) but also the western mediterranean region in Corsica, Sardinia and the west coast of northern Italy. Such distribution pattern is found in several other liverworts as well such as Dumortiera hirsuta, Marchesinia mackayii and others.

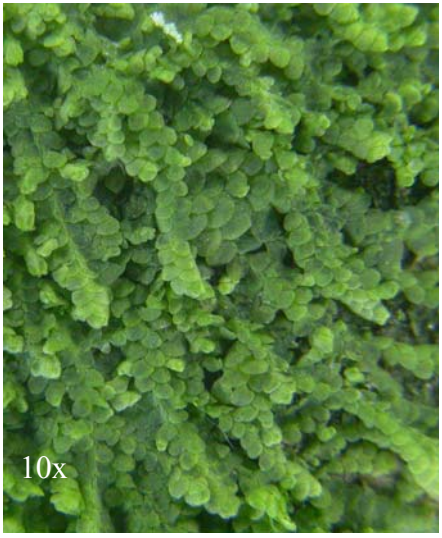
Porella obtusata (left) has a similar distribution as the preceeding species with the main range on the Macaronesian Islands and the west coast of Europe, but extends in the Mediterranean to the east to Croatia. It grows on bark in humid forests but towards the eastern limit of the range mainly on rocks.



Cololejeunea rossettiana is a minute liverwort, only half a millimetre wide, which grows creeping over calcareous rocks.

Leiocolea turbinata is amongst the smallest liverworts in the Mediterranean, but is often found in large pure mats. The plants are just 3-4 mm long and have bifid leaves with obtuse tips. They grow on wet calcareous rocks and tufa.

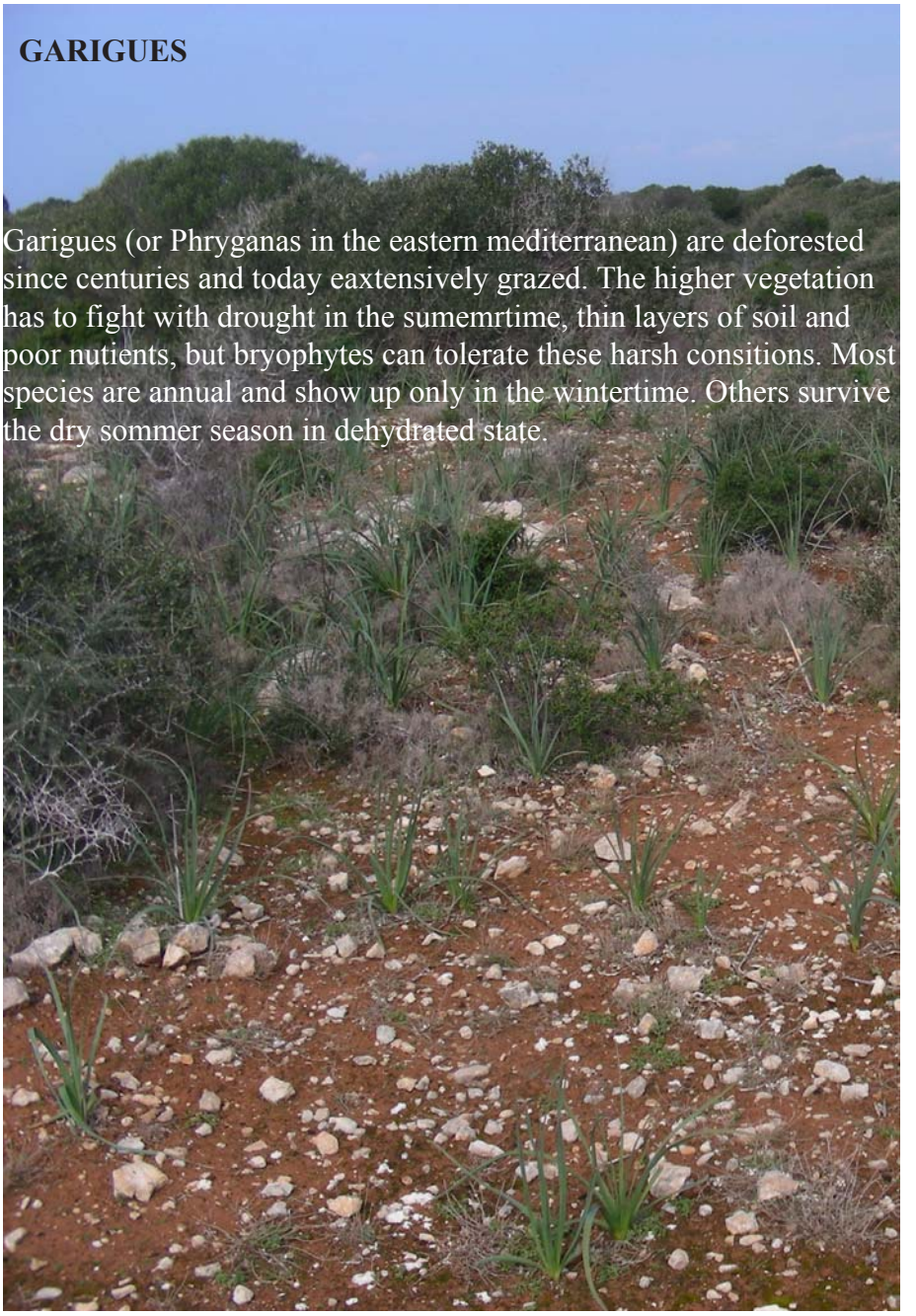
More foliose liverworts are found in the humid montane regions of the Mediterranean on rocks and tree trunks. Examples are the genera Radula (here **Radula complanata,** top left), Frullania (here **Frullania dilatata**, top right), Porella (here **Porella platyphylla**, bottom left). and Lejeunea (**Lejeunea cavifolia**, bottom right).



MOSSES

Mosses are by far the most numerous representatives of bryophytes in the Mediterranean, because they are better adapted to drought.

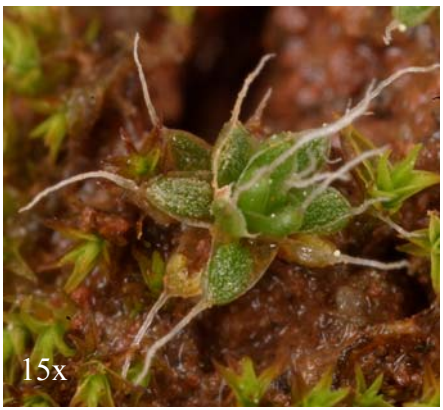
GARIGUES

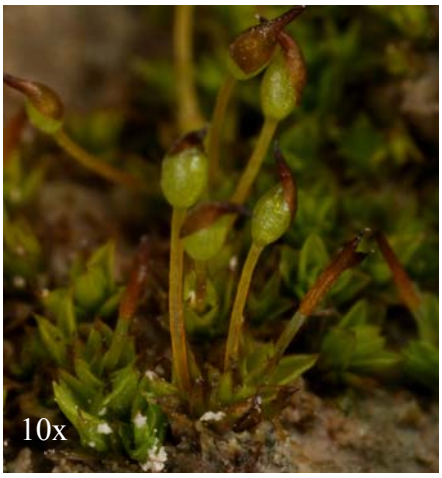


Garigues (or Phryganas in the eastern mediterranean) are deforested since centuries and today eaxtensively grazed. The higher vegetation has to fight with drought in the sumemrtime, thin layers of soil and poor nutients, but bryophytes can tolerate these harsh consitions. Most species are annual and show up only in the wintertime. Others survive the dry sommer season in dehydrated state.

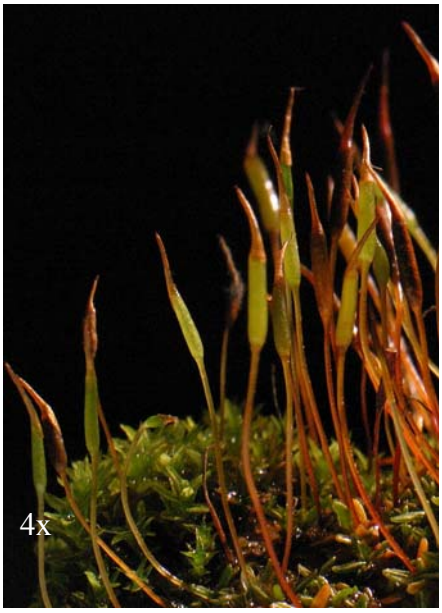
Most of the mosses in Garigues belong to the Pottiaceae. The family was named „mosses of harsh environments“. This is especially true for the Mediterranean, where this family represents most of the acrocarpous mosses. Reason ist that many species are drought adapted. They developed structures to reduce the insolation by longly excurrent nerves which are silvery for example in the genus Syntrichia. Others developed outgrowths along the upper side of the nerve, which can store water and function for assimilation. The genera Aloina, Crossidium and Pterygoneurum have filaments (the latter also lamellae) on the nerve, which store water during rain or humid nights like in a sponge. During the early morning hours, these structures photosynthesize. When the temperatures raise, the leaf margins fold in, keeping filaments and lamellae moist. By this way the photosynthetic phase can be much extended.

Crossidium squamiferum has longly excurrent nerves which are almost as long as the leaves. The filaments raised from the nerve cover almost the whole the leaf surface (right). The species grows on soil in garigues as well as limestone rocks and walls.
Under the hand lens, green spongy pads like from cotton wool can be seen on the surface of the leaves, which store water and function for photosynthesis.
In dry state, then plants form grey cushions (right page bottom left).and can hardly be recognized.





Crossidium crassinerve(top) has shorter excurrent nerves and grows on open calcareous soil. **Crossidium aberrans** (right) was described from Arizona and Baja California. It was recently found in several places in the Mediterranean as well as in southern France, southern Switzerland and southwest Germany . It is not known whether the species was so far overlookek or not. All Crossidium species mentioned here extend to loess regions in Central Europe.

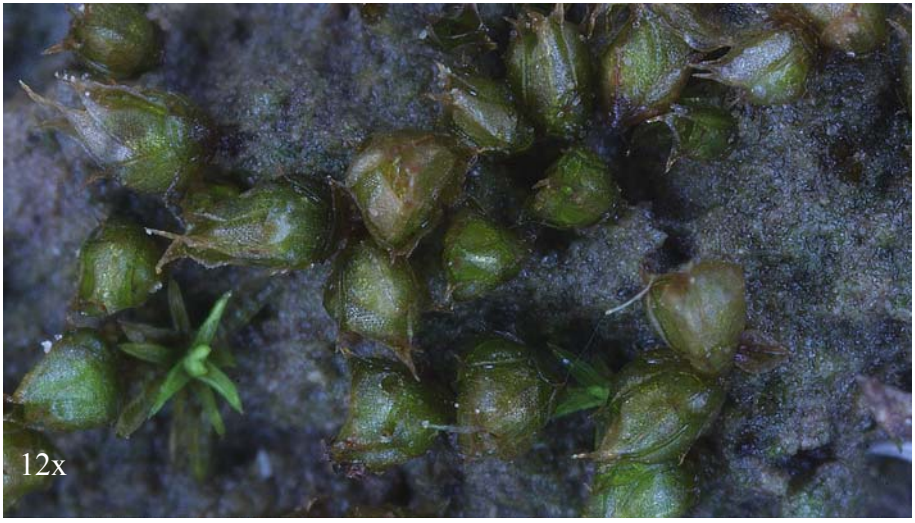


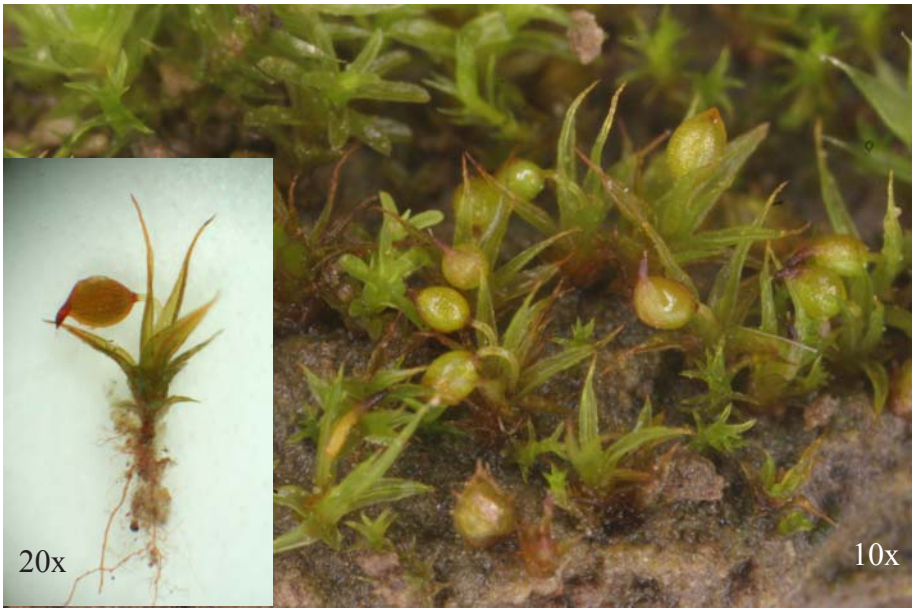
The species of Aloina have involute leaf margins, which cover the filaments growing on the nerve. The species can mainly be distinguished by microscopic characters. They grow on loamy calcareous soil. Only **Aloina aloides** (bottom right) grows on soil covered rocks. It can be recognized in the field by slightly curved capsules.

The species of Pterygoneurum bear lamellae on their nerves, which can sometimes be filamentose. They can be distinguished by the length of the seta. **Pterygoneurum subsessile** (top left) has - as expressed by the latin name - almost no seta, in **Pterygoneurum lamellatum** (top right), the seta is 1 cm long, and in **Pterygoneurum ovatum** (bottom), the seta is 5 mm long. All species grow on decomposed limestone and bare calcareous soil and are also found in the loess regions of Central Europe.

Some genera of Pottiaceae are highly reduced. the plants are bulbiform and have no stems. The capsules have no setae and are immersed in the leaves, where they can ripe protected against desiccation.

The species of Acaulon are bud like and only 2-3 mm tall. They grow gregarious on calcareous soil. **Acaulon muticum** (top) has round rosettes and only shortly excurrent nerves, **Acaulon triquetrum** (bottom) - as expressed by the latin name - is triangular in shape and has longly excurrent nerves. Three more very rare species have been described recently. They grow on bare loamy calcareous soil.

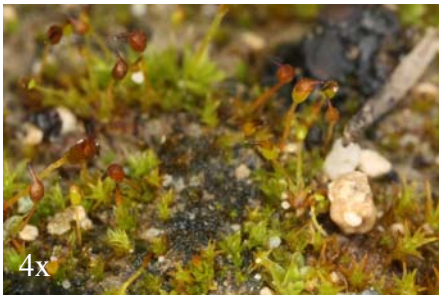


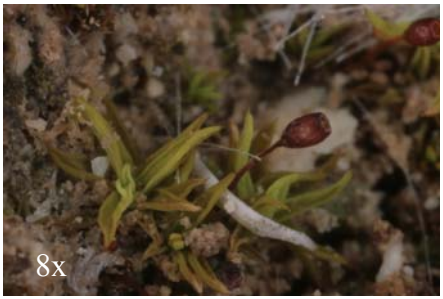


The genus Phascum differs from Acaulon by capsules with a short apiculus. As in Acaulon, the capsules do not open with a lid. Therefore the spores are released when the capsule wall decomposes. **Phascum curvicolle** (top) has characteristically curved setae, **Phascum piliferum** (cuspidatum var. piliferum) has longly excurrent nerves. Both grow in patches on open soil and extend to warm habitats in Central and western Europe.

Species of the genus Pottia look like the prototype of a moss, or an textbook example: all necessary organs are present but much reduced. The plants consists of a small rosette of lanceolate leaves with per- or excurrent nerve, roundish cells, a more or less short seta with a spore capsule in shape of an urn, which may have a peristome or not. The species are winter-annual and have no stress with the summer heat and drought but survive in the soil as spore. These spores germinate after the first rainfalls in autumn. The plants grow gregarious on thin layers of soil in garigues or salt marshes.

Pottia davalliana (top and bottom left) differs from the previous species by the lack of peristome teeth at the mouth of the capsule. In contrast, **Pottia recta** (bottom right) has neither a peristome nor even a capsule which opens with a lid, it is „cleistocarpous“. The spores are released when the capsule decays.



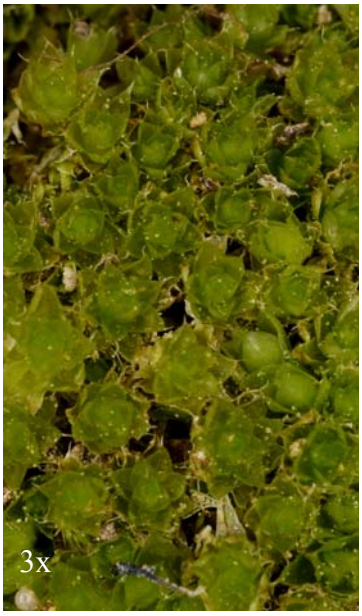


Pottia commutata (left) and **Pottia starckeana** (right are only a few millimetres tall. They differ only by the ultrastructure of the spores.

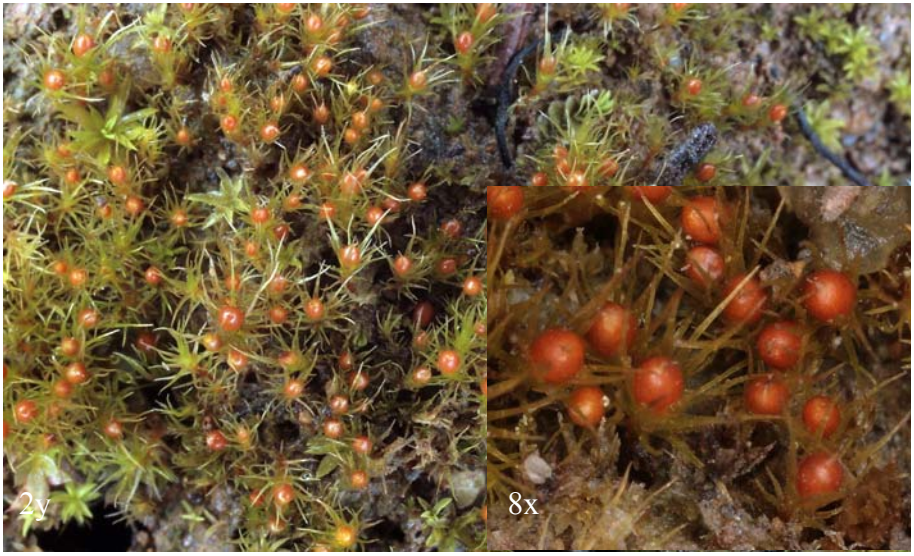
Grimmia pitardii was the only species of Grimmia growing on soil, not on rocks. Vegetatively it resembles a species of Didymodon but has Grimmia-like sporophytes. It is now transferred to the genus Campylostelium. The species was described from northern Africa but has subsequently been found all over the Mediterranean, although always very scattered. It grows on thin layers of humus over limestone or walls.

Pleurochaete squarrosa is the most common perennial moss in Garigues. It grows preferably under bushes. In wet state it has squarrose leaves (top), in dry state the leaves are contorted (left). These mosses need no rain to get wetted. They are even moist in the early morning hours after a night with lolw temperatures. They raise the air humidity which allows the mosses to take up water vapour from the air by osmosis. Pleurochaete is one of the mediterranean species which are also found in the warmer parts of Central Europe, where they are said to be relics from the postglacial temperature optimum 8000 years b.p. This hypothesis is supported by the fact that this species is there always sterile and has no special ways for vegetative propagation. Only whole plants can be dispersed, for instance by sheep.

Bryum kunzei is a close relative or a variety of Bryum caespiticium. It has concave laeaves in rosettes and grows in dense tufts. **Bryum comense** (bottom right) is similar but has thick walled pitted laminal cells.



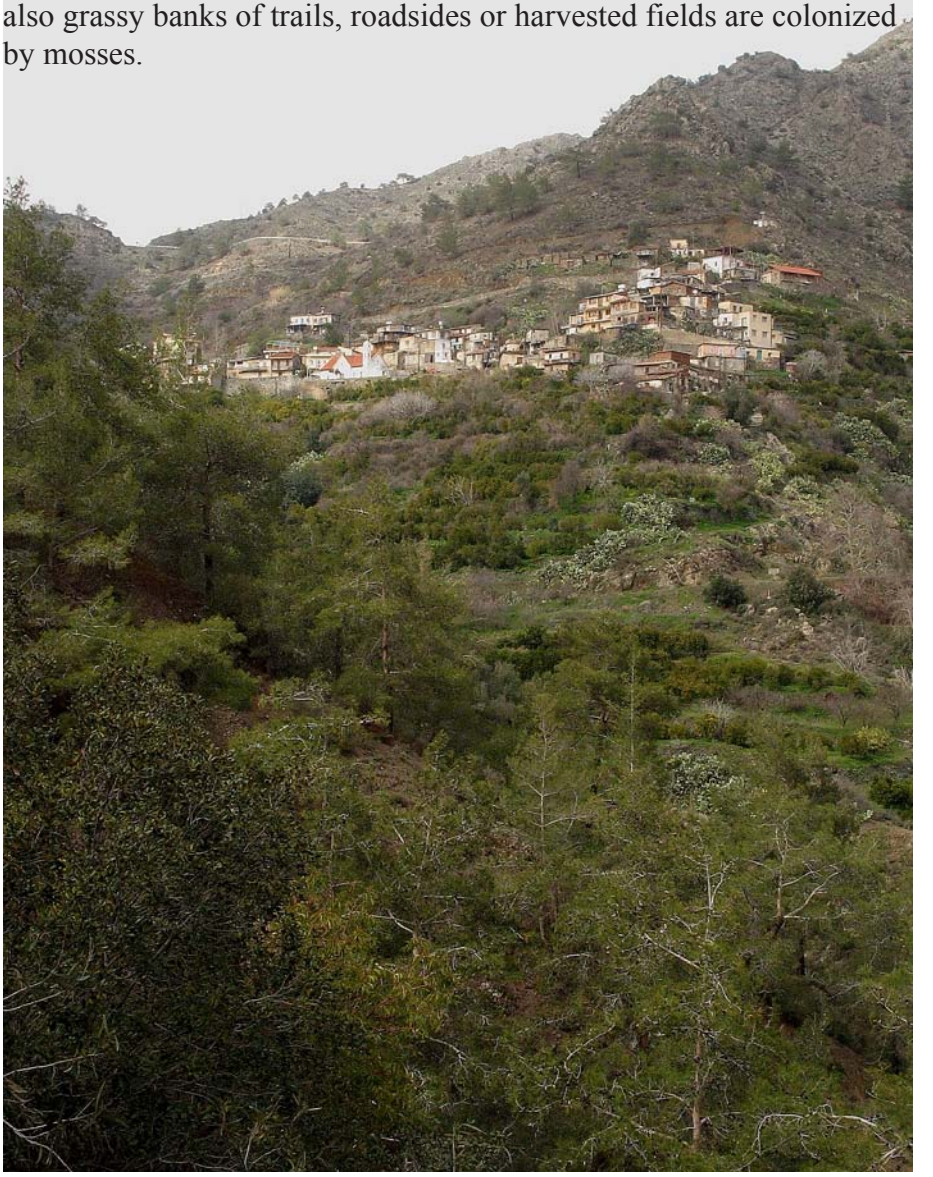
Bryum funckii has concave leaves with excurrent nerves in rosettes and is not too rare in calcareous habitats.



Pleuridium acuminatum (Ditrichaceae) is a few millimetres high species with capsules which are enclosed by the narrow lanceolate laves. The capsules do not open but the spores are released when the plants are decomposing. The species is found on non calcareous soils.

CULTIVATED LAND

Bare soil is common in waste land. It is an ideal ecological niche for mosses, which have not much competition by flowering plants. But also grassy banks of trails, roadsides or harvested fields are colonized by mosses.



The Funariaceae are nitrophilous. They grow on open bare soil but not just in garigues rather than in pastures, soil covered walls or on trailbanks. The genus Funaria has asymetric capsules, Funariella also, but the capsules lay on the ground, and Entosthodon has erect symetric ones. Shape of the capsule, position of the mouth of the capsule, position of the capsule (erect, inclined, pendant) has much to do with spore dispersal.

The species of Funaria (this double page) can almost only be distinguished by leaf characters under the microscope. **Funaria pulchella** (left) and **Funaria muehlenbergi**i (top) grow on calcareous soil and soil covered rocks.

Funaria hygrometrica (right page) is a cosmopolitan species which is characteristic for the fast colonization of old fire places. It is also found in the Mediterranean and is usually larger as the mediterranean species, but can remain quite small in dry habitats and then confused with the other species. It got its name by the setae, which perform hygroscopic movements when wetted or dried up.


5x


5x

Entosthodon pallescens (top left) and **Entosthodon attenuatus**have peristomes. They differ by microscopic characters of the leaves but E. pallescens has longer (5-8 mm) pale setae

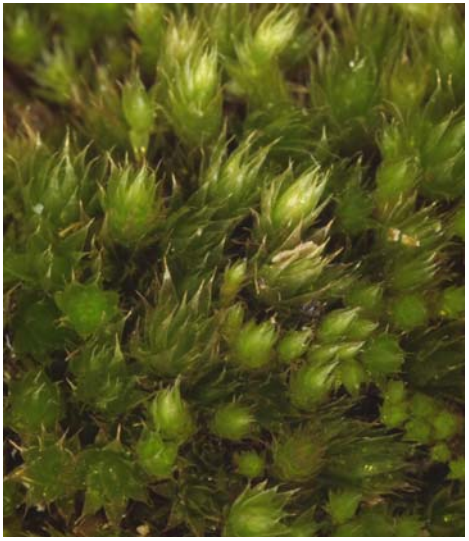
Entosthodon obtusus (this page) has no peristome and like E. attenuatus less than 5 mm tall. As in other so called atlantic-mediterranean species, the range extends from the Mediterranean north along the coast of the Atlantic Ocean, in this case to Iceland.
Entosthodon curvisetus (left page bottom) is now placed in a genus of its own, Funariella. It has curved decumbent setae. The plants are tiny, only up to 3 mm high.

The young capsules of **Entosthodon fascicularis** (top) are sheated by a large calyptra. Such plants can be confused with the rare Pyramidula tetragona..

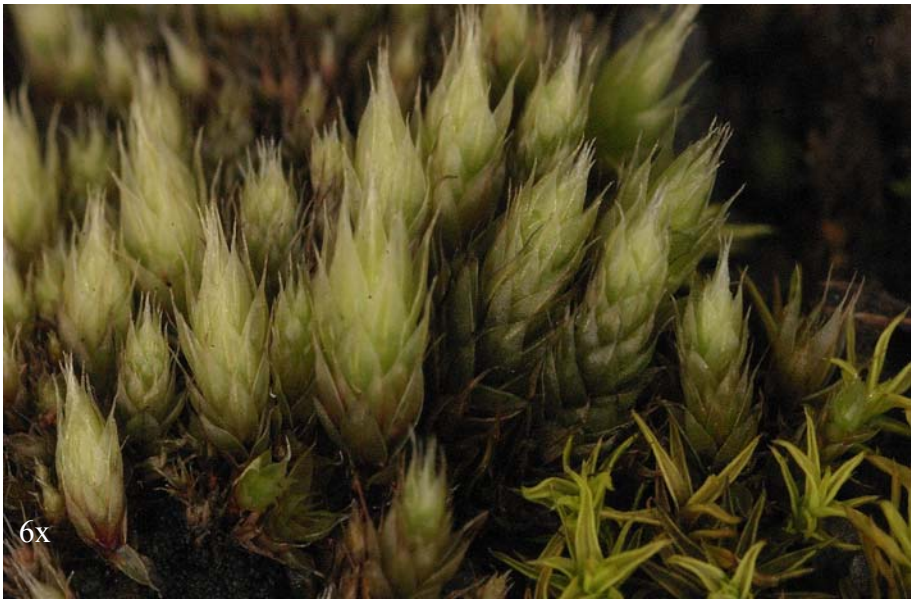
Bryum dunense is a species which was not too long ago newly described from dune valleys in Britain. It turned out to be a very common species on wasteland in the Mediterranean, where it was formerly included in Bryum bicolor, from which it differs by a longly excurrent costa (1/3 of leaf length, right page bottom right). The leaves in the picture belong to Aloina sp..
The mature capsules are crimson red (right page top left).

Pseudocrossidium hornschuchianum is also common on wasteland. It has acute but cucullate (hood shaped) leaf apices. and strongly incurved leaf margins. This functions as mechanical protection against cracking of the leaf margin.

Cheilothela chloropus is a common moss on wasteland. It resembles Ceratodon purpureus, which is very common else in Europe in the same habitat, but differs by papillose laminal cells. This is an adaptation to dry habitats because it facilitates a quick water uptake.



Bryum radiculosum grows on calcareous soil, rocks and in fissures of walls in villages. It is very similar to other species of the genus especially when sterile but has quadrate basal laminal cells.

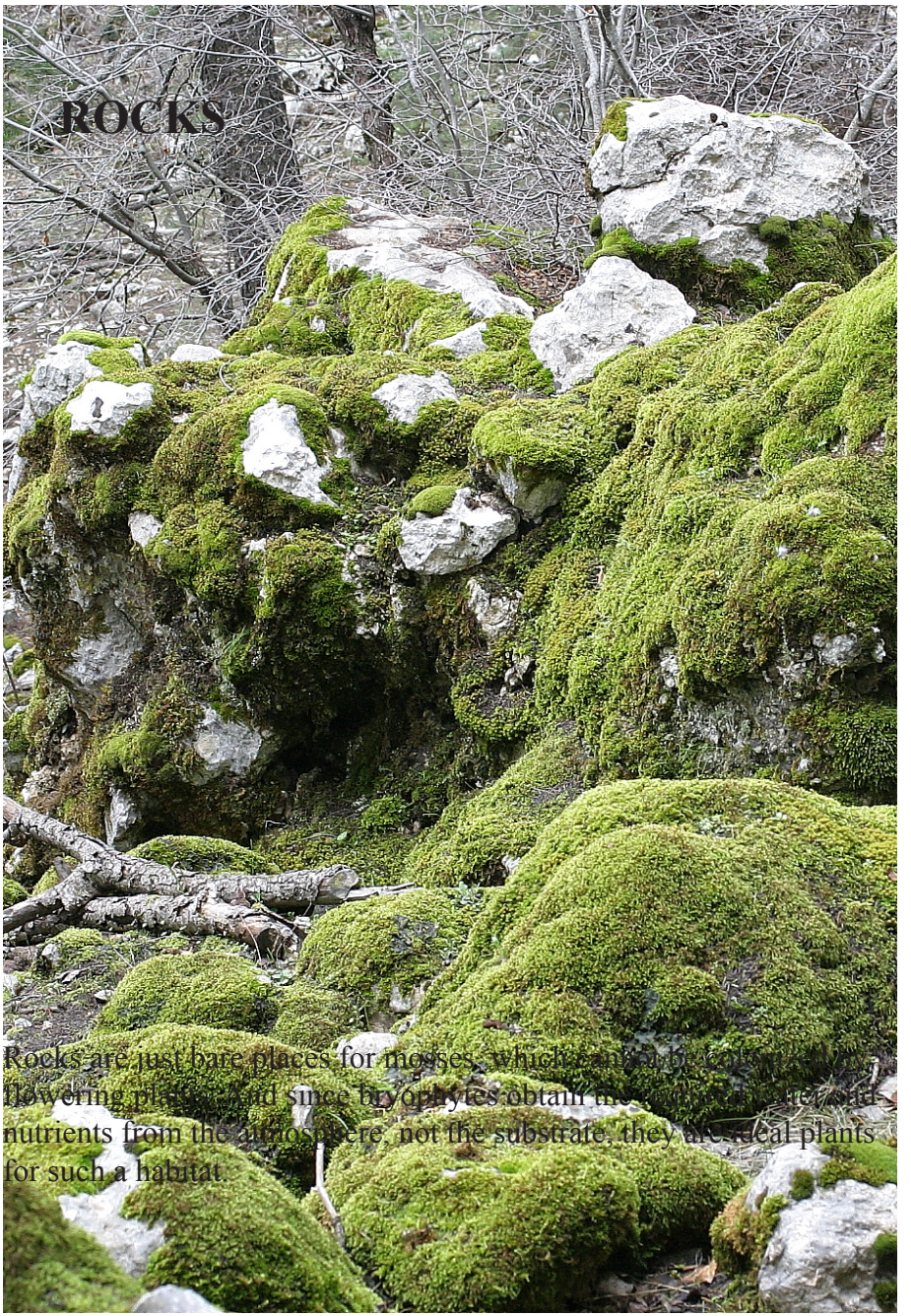


Bryum caespiticium is a common but very variable species on dry soil. It has lanceloate leaves with excurrent costas. In contrast to other species of Bryum, it the capsule has a short neck which is not much differentiated from the urn (green part of the capsule bottom right).

These pleurorapous mosses grow between grasses along trail banks. **Scleropodium tourettii** (top dry, bottom wet) has ovate, concave leaves with a short apiculus.

Rhynchostegium megapolitanum (top) is a very common moss between grasses. It looks somehow indifferent but has twisted leaf apices as seen under the handlens. **Eurhynchiummeridionale** (bottom) is anatomically similar to E. striatum or E. striatulum but has a distinct appearence with dense branches.

The genus Homalothecium has very narrow lanceolate leaves and erect capsules. **Homalothecium lutescens** (top) is very common in extensive pastures and chalk grassland. **Homalothecium aureum** (bottom) resesembles H. sericeum with regularly pinnate branches, which are curved in when dry, but grows on soil, not on rocks or walls.



Rocks are just bare places for mosses, which cannot be called [illegible] flowering plants. And since bryophytes obtain [illegible] nutrients from the atmosphere, not the substrate, they are ideal plants for such a habitat.

Scorpiurium circinatum is the commonest moss on limestone rocks. It differs much in appearence in wet (top) and dry (bottom) state. In dry state, the branches are all curved (which is expressed by the latin name) and pointing in one direction.

The name of **Bryum torquescens** means twisted pear moss. The genus name refers to the pear shaped, hanging capsule, and the species name refers to the leaves which are twisted in dry state, like in Bryum capillare, which is common in the rest of Europe. Bryum torquescens differs by the sex conditions but also often by a reddish tinge of the plants. It is rarely found also in the warmer part of Central and western Europe.

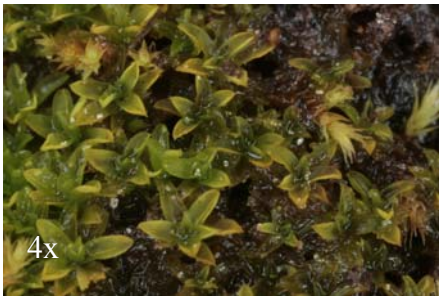
Homalia lusitanica grows on shady limestone rocks. It is closely related to Homalia trichomaoides in the rest of Europe and differs by longer nerves and shartply dentate leaf tips as well as the more lustrous shine of the plants.

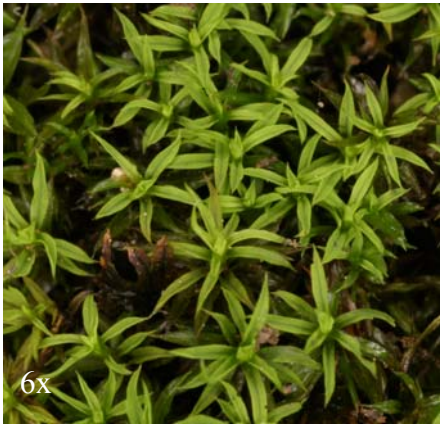
Metaneckera menziesii resembles very much the common Neckera crispa and grows as well on limestone rocks, but differs from the latter by the presence of a costa in the leaves.

Orthotrichum cupulatum is the most common species of the bristle mosses on limestone rocks. The capsules are inserted between the leaves and the calyptras have long hairs. The variety nudum has naked calyptras and occurs on rocks along streams.

Pterogonium gracile resembles somehow Scorpiurium circinatum. It has also overhanging branches but is more dendroid. The species has the leaves appressed when dry but spreading when wet. The species is also found in warmer parts of Central Europe, whether als relic of warmer climatic periods 8000 years b.p. or by spore dispersal is not known.

Timmiella barbuloides (top) is a relatively large, very common species on rocks and soil. **Pseudocrossidium revolutum** (bottom) is much smaller and has not incurved laef margins like many other species but recurved margins.





Trichostomum brachydontium is a very variable species, as expressed by the older name „mutabile“. The leaves can be acute or obtuse, with or without excurrent costa, and accordingly many varieties and forms have been described. The German bryologist Theodor Herzog devoted a special book on the variability of this species. It often grows in masses along trail banks, on forest floor and on open soil in macchias and garigues. In dry state, the leaves are characteristically curled.
Trichostomum crispulum (right) differs from T. brachydontium by red setae and cucullate leaf apices (like a hood). It grows in similar habitats like the preceeding species. Both species are also found in the warmer parts of western and central Europe, because the microclimate for example on exposed rocks resembles the mesoclimate in the Mediterranean.


3x


12x


3x

Bryum donianum is a frequent species with apical rosettes of leaves which are ovate in shape and have an excurrent costa. It is similar to the common B. torquescens. but differs by its leaves which are not contorted when dry. Bryum species have pear shaped capsules which are usually pendant. This facilitates the spore release.

The following species of Tortula on this page have no excurrent nerves Although such hairpoints are said to be an adaptation to exposed habitats, the presence of species without hairpoints -often in the same habitat - demonstrates that this adaptation is not necessary.

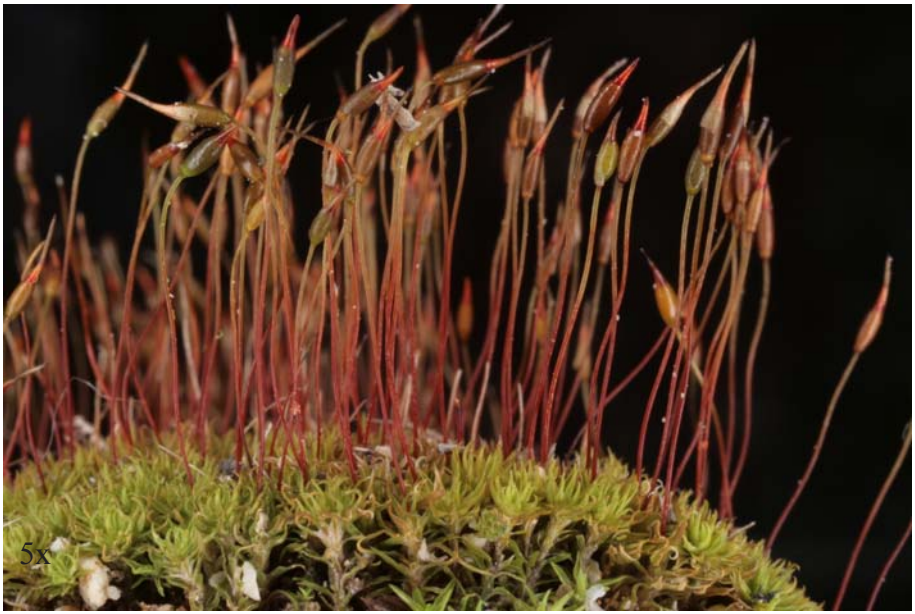
Tortula atrovirens (left) has a costa which is widened in the upper part to store water.

Tortula revolvens (centre right) has lingulate leaves with revolute leaf margins.

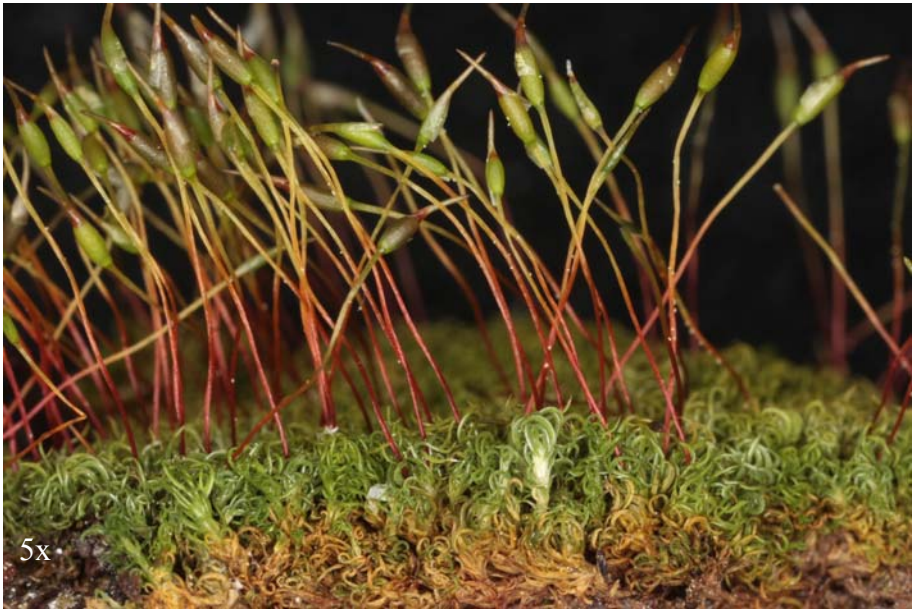
Tortula cuneifolia (bottom) has bud like plants with concave leaves.

Other species of Tortula have shortly excurrent costas, which are hyaline or greenish. **Tortula solmsii** has a short excurrent hyaline hairpoint. In contrast, **Tortula vahliana** (bottom) has greenish excurrent costas.

Tortula marginata (left) replaces Tortula muralis in the Mediterranean and looks quite similar from a distance but has shorter hairpoints and a yellowish border of elongate cells along the margins of the leaves as expressed by the Latin name. Like the latter it is also found in towns. **Tortula canescens** looks also like some forms of the common T. muralis but has acuminate leaf tips, not lingulate. **Leptobarbula berica** is common on limestone blocks in shrubs and pastures. It has tiny very narrow leaves.



Tortella species are characteristic for limestone areas. Except for T. tortuosa and T. inclinata, which area also commonly found outside the Medeiterranean, **Tortella humilis** (top) und **Tortella nitida** (bottom) are typical southern species in Europe.



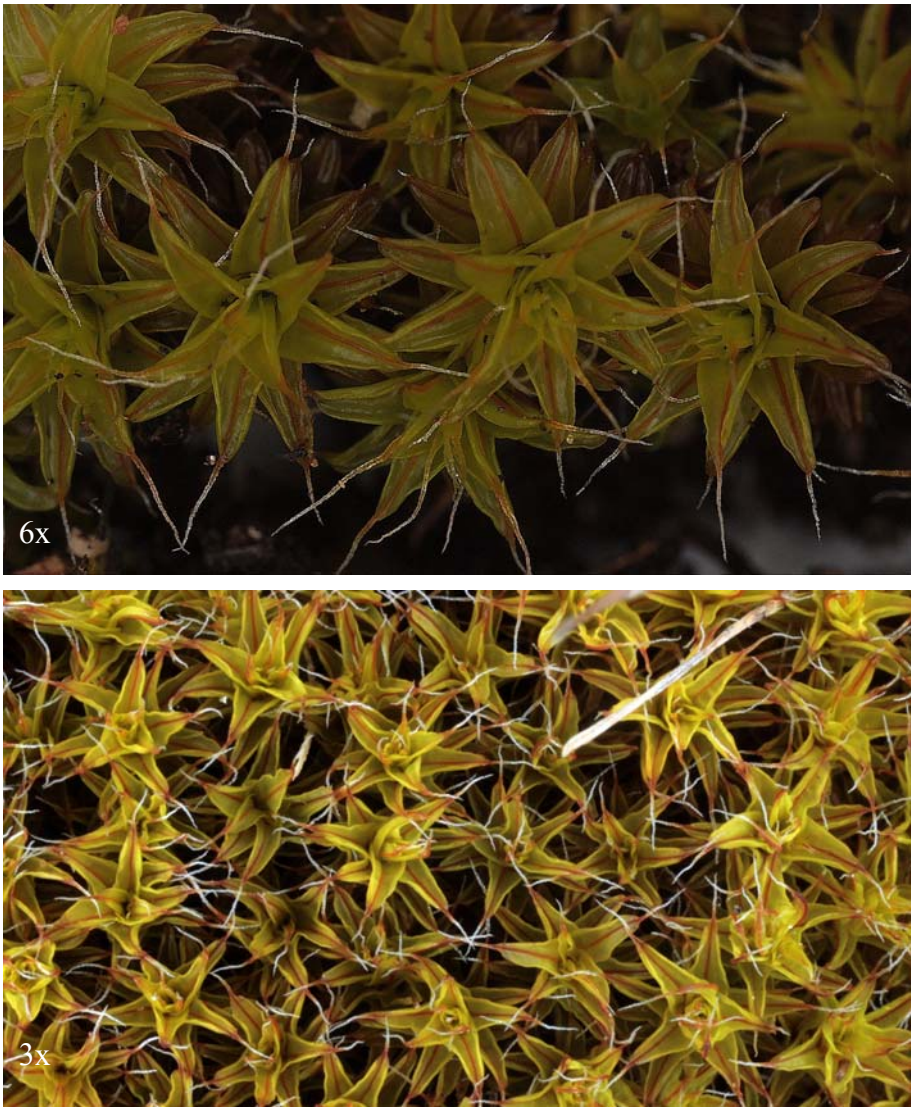
The big Tortula species, today again comprised in the genus Syntrichia, are characteristic for higher altitudes where theys are found on limestone rocks and walls. They possess lingulate leaves with an excurrent costa which is translucent. The plants are shrunken in dry state, but recover within seconds when they are wetted. This is the life strategy of a resurrection plant.

Syntrichia echinata (top left) has similar stellate papillae on the leaf surface like T. papillossissima. It bgrows on calcareous rocks and is confined to the Mediterranean. This species is similar to the common Syntrichia ruralis, which is widespread on calcareous rocks and soil.

Syntrichia montana (S. intermedia, Tortula crinita, top right and right)) is common on limestone rocks. It can be recognized by the leaf shape which resembles a violin, the smaller size and the glaucous green colour when dry.

Syntrichia ruralis and S. montana are also common in central and northern Europe, the latter confined to warmer habitats.

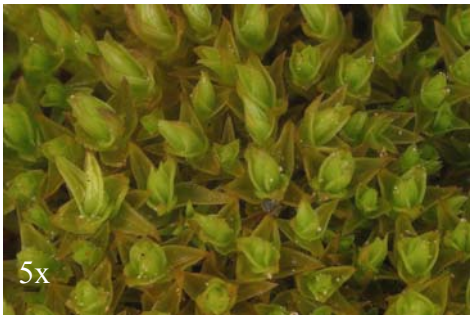
Previous page: The largest Syntrichia species is **Syntrichia papillossissima** (top), which gets up to 10 cm tall. The name refers to the single papillae on the leaf surface, which are star-like branched. A common representative of the genus and typical mediterranean in distribution is **Syntrichia princeps** (bottom). It is similar to the widespread S. ruralis but is monoiceous, which means that male and female sex organs are on the same plant (on different plants in S. ruralis). As a consequence, S. princeps produces regularly sporophytes (bottom right), whereas S. ruralis is found rarely with capsules.



Syntrichia ruraliformis (top) and **Syntrichia subpapillosissima** (bottom) can be recognized by narrowed leaf tips, which are not broadly obtuse as in the other species of the genus. They differ (as echinata from ruralis) by the papillae on the laminal cells, which are horse shoe shaped in S. ruraliformis but simple and branched at tips in S. subpapillosissima. Both species are found on open sunny rocks and gravelly soil in exposed, warm habitats in calcareous districts.

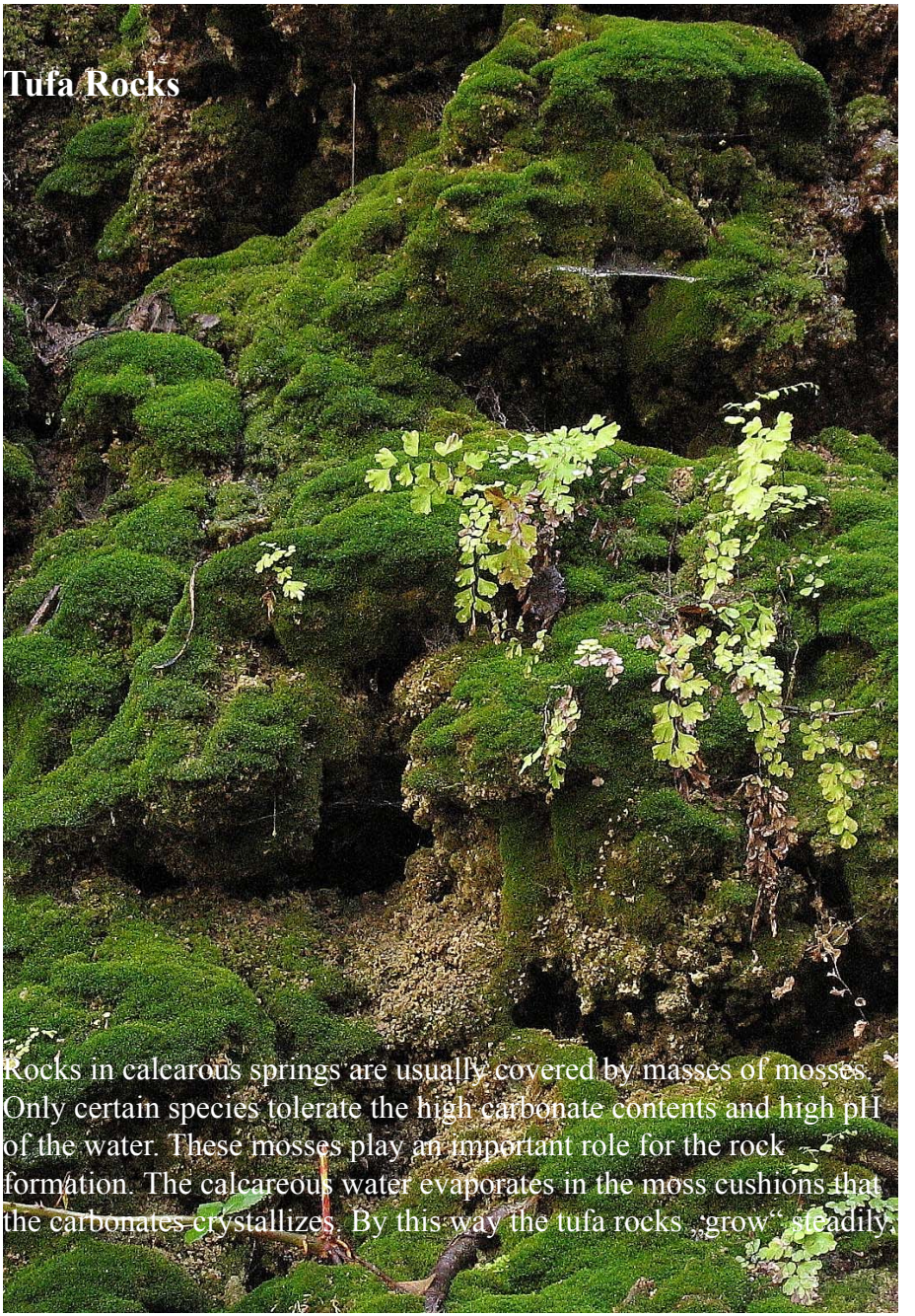
Some species of Syntrichia such as **Syntrichia inermis** (top left) and **Syntrichia subulata** (top right) lack long, whitish excurrent costas („hairpoints“). They grow, however, in the same hot habitats, which corroborates the explanation that the hairpoints function as protection against sunlight. All plants of the genus are shrunken in dry condition (as shown by Syntrichia inermis, bottom left in wet state, bottom right in dry state). The curling of the leaves is caused by asymmetric thickened cell walls in the costa.

The following Barbula- and Didymodon speacies are also found in other parts of Europe but are especially frquent in the Mediterranean. **Barbula commutata** was originally dyescribed as Barbula sardoa, which means from Sardinia. It has undulate leaf margins and grows on humid limestone or concrete.



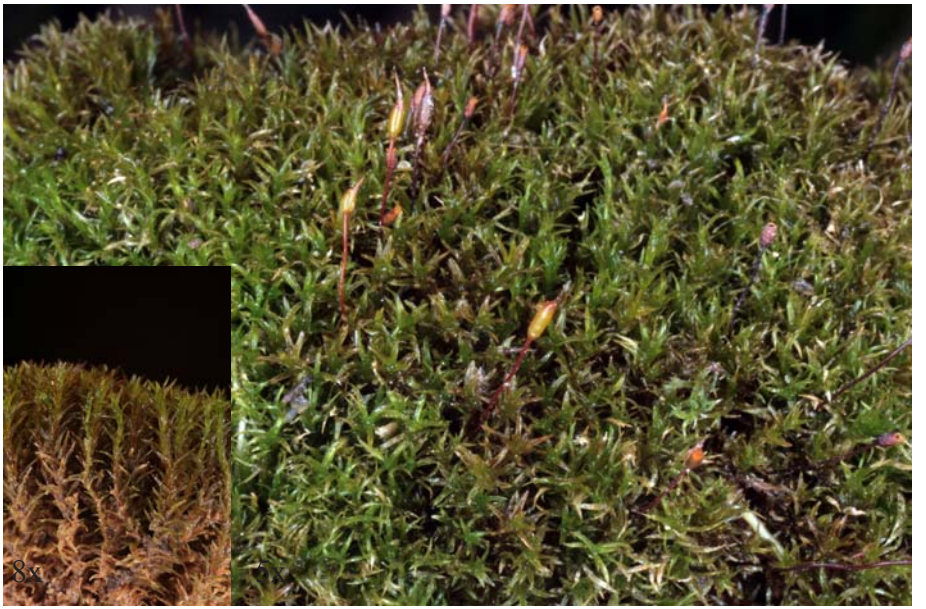
Didymodon luridus grows on dry calcareous rocks and walls. It has lanceolate leaves with recurved leaf margins. Therefore the leaveas do not curl when drying up as in other species of Didymodon.

Grimmia orbicularis is just one representative of the genus with numerous species growing on rocks. This species ha a more southern distribution in Europe. It looks like the common Grimmia pulvinata and iks groweing on limestone rocks as well bus as a blunt lid of the capsule.



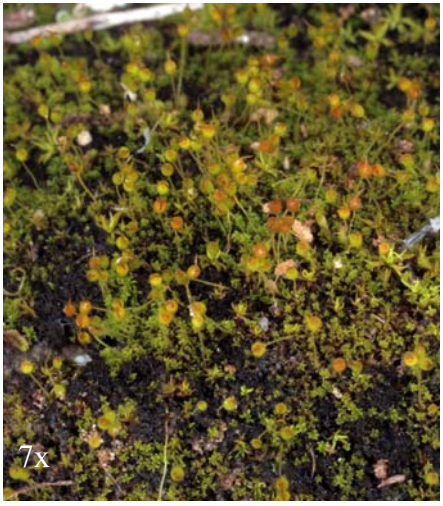
Tufa Rocks

Rocks in calcarous springs are usually covered by masses of mosses. Only certain species tolerate the high carbonate contents and high pH of the water. These mosses play an important role for the rock formation. The calcareous water evaporates in the moss cushions that the carbonates crystallizes. By this way the tufa rocks „grow“ steadily.



Eucladium verticillatum is the most common moss on wet tufa rocks, where it grows usually in masses (see photograph on previous page). **Gymnostomum calcareum** is smaller than G. aeruginosum (right page) and can be differentiated from small forms of the latter only under the microscope.

Gymnostomum aeruginosum (top and left) is growing in similar habitats as Eucladium but bis rarer. **Gymnostomum viridulum (**bottom) differs by its shiny colour and short, obtuse leaaves. It is not forming tufa but growing in rock fissures with seeping water.

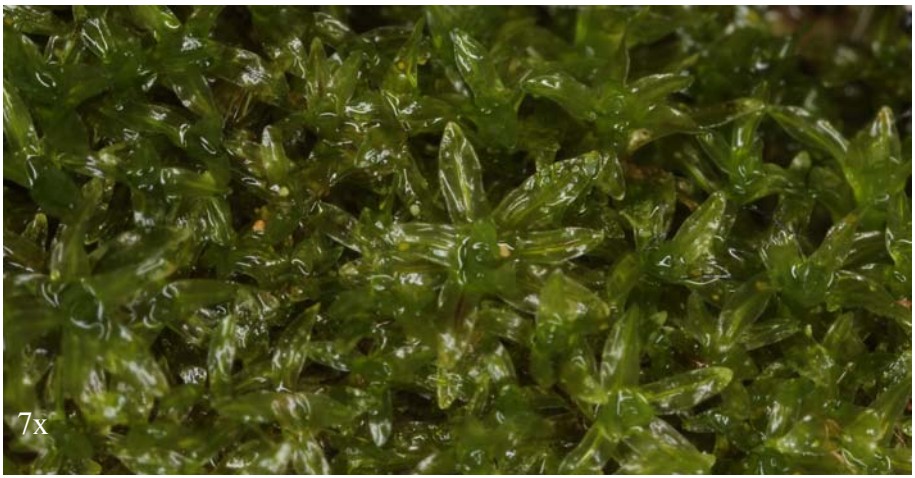


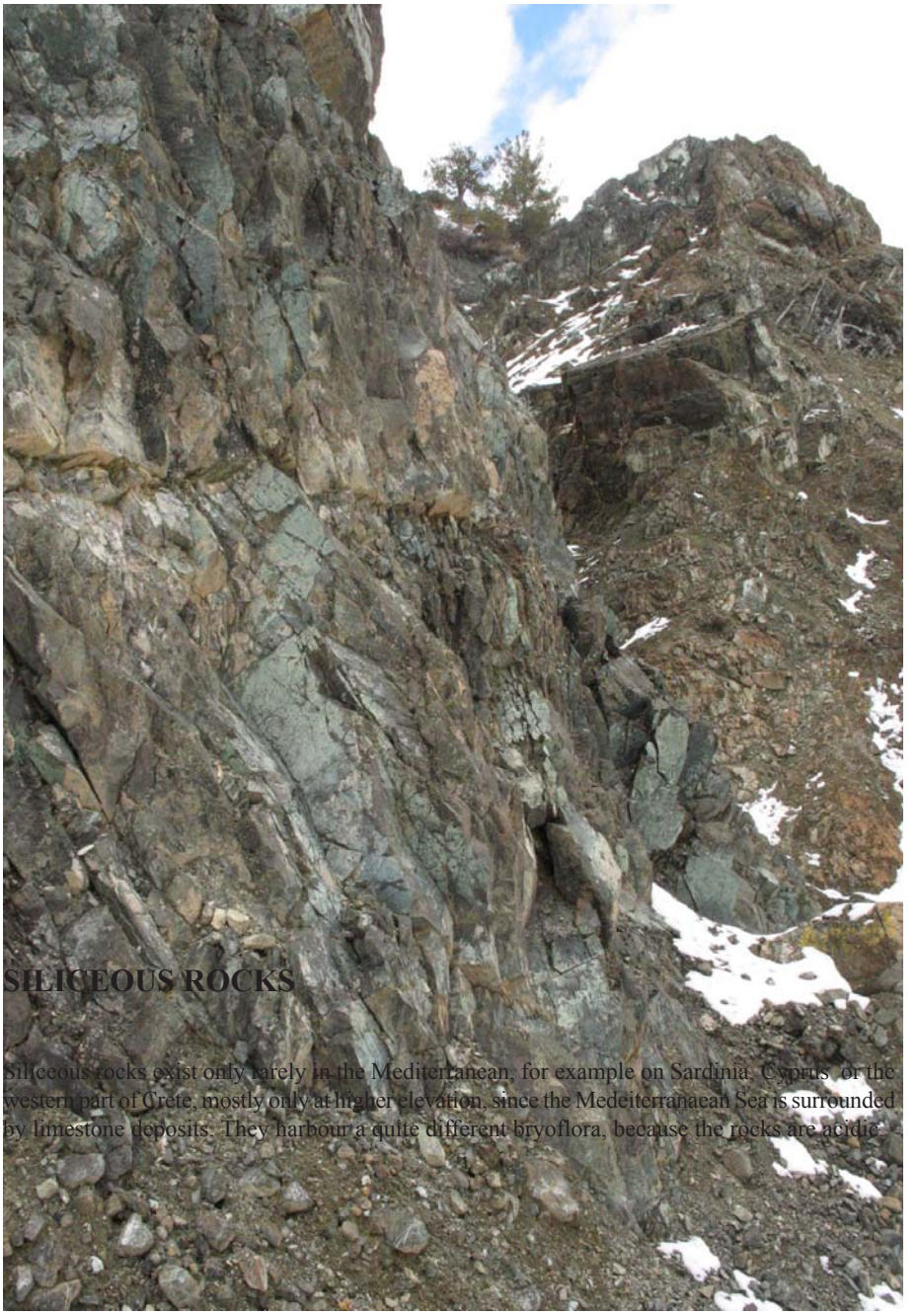
Gyroweisia tenuis is a minute species, which grows on wet mortar or on wet limestone rocks. It has conspicuously lingulate leaves with obtuse apex and is usually sterile.

Didymodon tophaceus is recognized by its blunt leaf apices. It occurs on all kind of wet calcareous ground and can also form tufa.

Cratoneurum commutatum (Palustriella commutata) is the common moss around limestone springs. It has conspicously curved leaves. The dripping calcareous water evaporates in the plants, that the lime discharges. Therefore the bottom of the plants is incrusted with chalk, but the plants continue growing at the tips. By this way the tufa rock is growing which is called biological rock formation.

Hydrogonium ehrenbergii (Barbula ehrenbergii, Barbula bolleana, Hyophila ehrenbergii) has broadly lingulate leaaves with stalked gemmae in the leaf axils. It grows on wet limestone rocks, along streams or, as here, in the inlet of a well. It was described by a German botanist fxrom the St. Catherine´s monastery in Sinai.





SILICEOUS ROCKS

Siliceous rocks exist only rarely in the Mediterranean, for example on Sardinia, Cyprus, or the western part of Crete, mostly only at higher elevation, since the Medeiterranaean Sea is surrounded by limestone deposits. They harbour a quite different bryoflora, because the rocks are acidic.

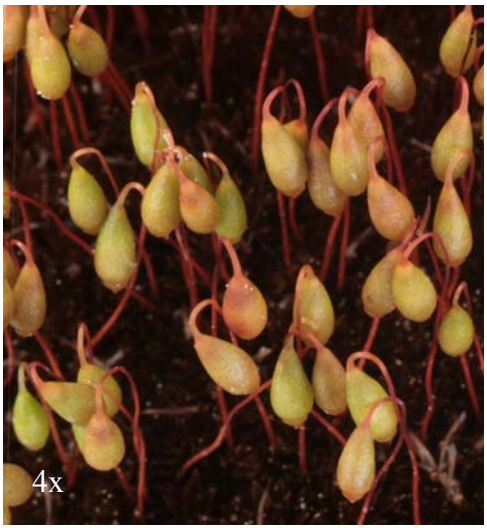
The apple mosses (Bartramiaceae), named after their globose capsules, are such characteristic species which are almost all confined to acidic rocks - worldwide. They grow on rocks, earth covered rocks, rock fissures and soil.

Bartramia stricta has straight leaves as indicated by the name, whereas the species in Central and northern Europe have leaves which are contorted when dry. The species grows on rocky slopes in Erica heathland and other acidic vegetation types.
Sterile populations along the Mosel valley in Germany were named as B. stricta and regarded as mediterranean element in Central Europe such as Targionia hypophylla and others. They have only superficial resemblance with B. stricta because of the erect leaves but turned out to be Anacolia laevisphaera, a species from ovearseas, fors example the Andes. It is not known how this species came to Europe, perhaps by long distance dispersal (with ash from volcanic eruptions).

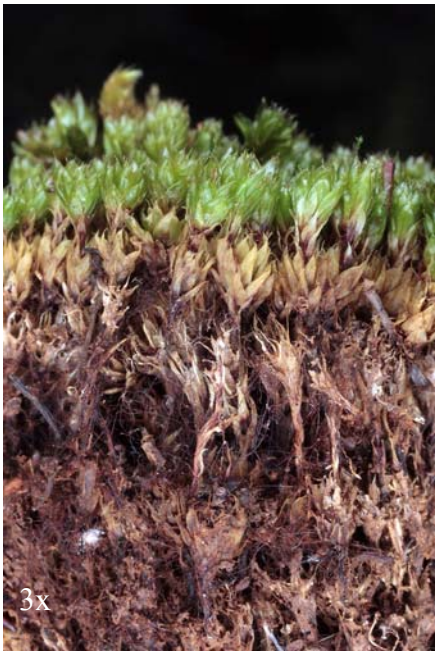
The genus Anacolia is represented by two species, Anacolia webbi (bottom) and Anacolia menziesii (next page). **Anacolia webbii** was so far the only species known in the Mediterranean. It is occasionally found on cliffs with slightly seeping water.

Anacolia menziesii was known from California before (Menzies was a Californian Botanist) and has been found only recently very scattered in the Mediterranean. These records underline the close relationships between the Mediterranean vegetation and that in Western North America. It is still an open question whether these disjunctions are the result of a former continuous range. In this case the species must have an age of 50 million years, the time, when North America and Eurasia started to split. Both species, Anacolia webbii (named after an Italian botanist) and A. menziesii can be distinguished only under the microscope, which shows their close relationsship. It could be that both species developed from a common ancestor after the breakup of Laurasia and A. menziesii was later distributed by spores.

Campylopus pilifer is - like all 160 species of the genus - indicating acidic substrates. It grows on siliceous rocks in South America and tropical Africa and also in the Mediterranean. The costa is ending in hyaline hairpoints which is said to reduce the light intensity but may also have a function for water uptake by condensation of water from humid air.



Bryum mildeanum (left) and **Bryum alpinum** (right) are not specificly mediterranean species but are found there on seeping rocks.

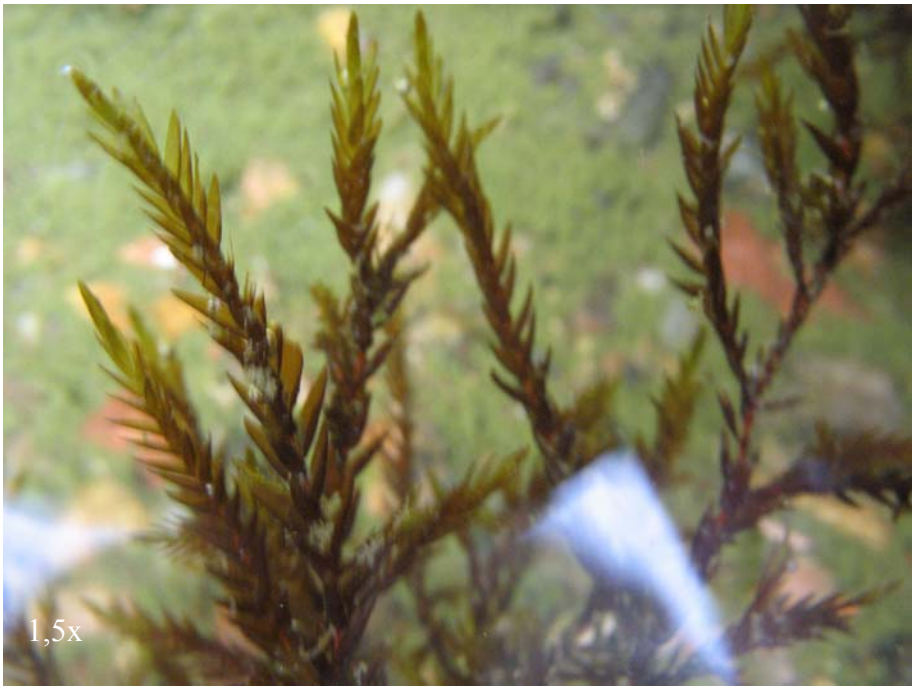


Bryum canariense (= B. provinciale left) and **Bryum platyloma** (right) are species of the Bryum capillare group. The first has successive comal tufts, the latter is variegated reddish. **Grimmia meridionalis** (bottom) is just one example of the many species of Grimmia on acidic rock, of which most are not specificly mediterranean in distribution.

STREAMS

Streams seem to be an ideal habitat for bryophytes. They can exist there attached to rocks in the water. However, streams in the Mediterranean are different. They can dry up in summertime. In wintertime, they can carry hugh masses of water. In this case the water is not the problem as shown by cascades but the amount of pebbles in the water, which sand the bryophytes down. Therefore some small rivers show no bryophytes at al or only in sheltered places.

Some mosses grow totally submerged. Example is the genus Fontinalis. **Fontinalis antipyretica** (top, an underwater picture) occurs everywhere in Europe. It has keeled leaves. **Fontinalis duriaei** (right page), however, is mediterranean in distribution. It has concave leaves. Both produce spores only when they are dried up but propagate else by fragments of plants which are washed away.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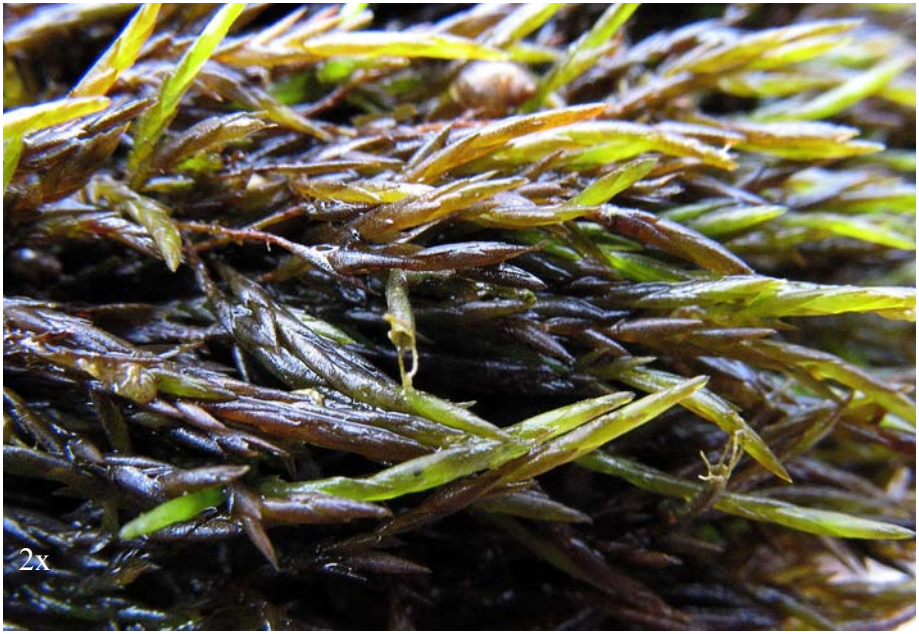
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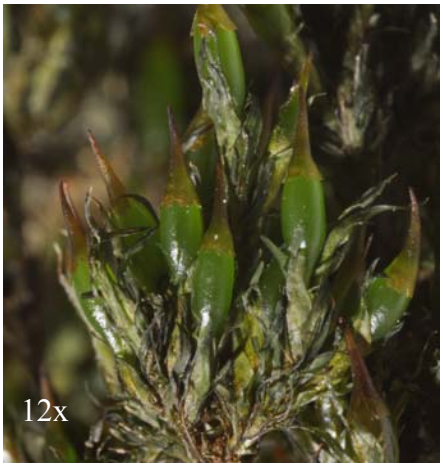


Species of Cinclidotus grow in the water spray zone of streams and rivers with basic water or basic rocks. The genus is endemic to Europe, very unusual for bryophytes which have usually larger ranges. The center of diversity is in the Eastern Mediterranean, where species such as C. bistratosus, C. confertus, C. pachylomoides and C. nyholmiae occur. The other species extend more or less to Central Europe. **Cinclidotus fontinaloides** (top) has curled leaves in dry state. It can produce abundant sporophytes in dry seasons, which are inserted in the upper leaves. **Cinclidotus aquaticus** (bottom) is recognized by its hooked leaves.

Cinclidotus mucronatus (Dialytrichia mucronata, top) differs by all other species of Cinclidotus by growing in compact tufts and by papillose laminal cells. It grows in the highest parts above the water level, also epiphytic in riverine forests. It is also found in Central Europe but only without sporophytes, which are produced only in the Mediterranean (bottom right).The similar **Dialytrichia fragilifolia** (bottom left) differs by erose leaves.

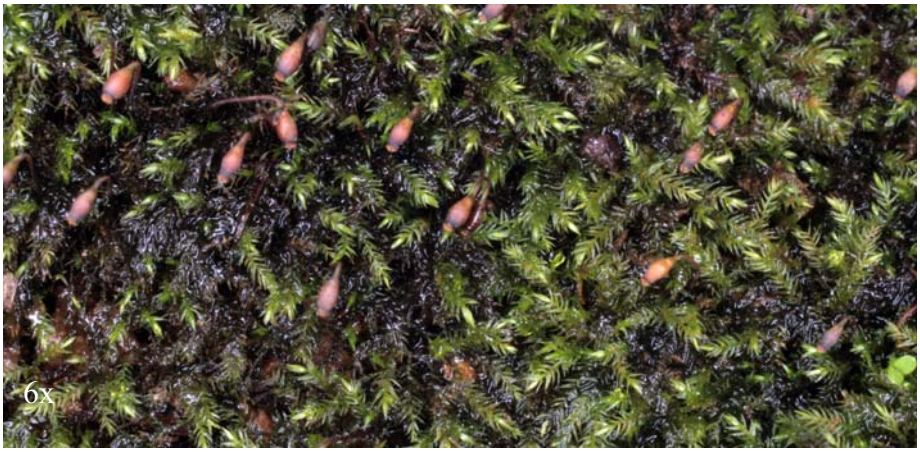
Cinclidotus riparius (left wet, right dry, the plants are blackish, hence the synony m nigricans) is smaller and not as branched as C. fontinaloides but grows in similar habitats along streams.

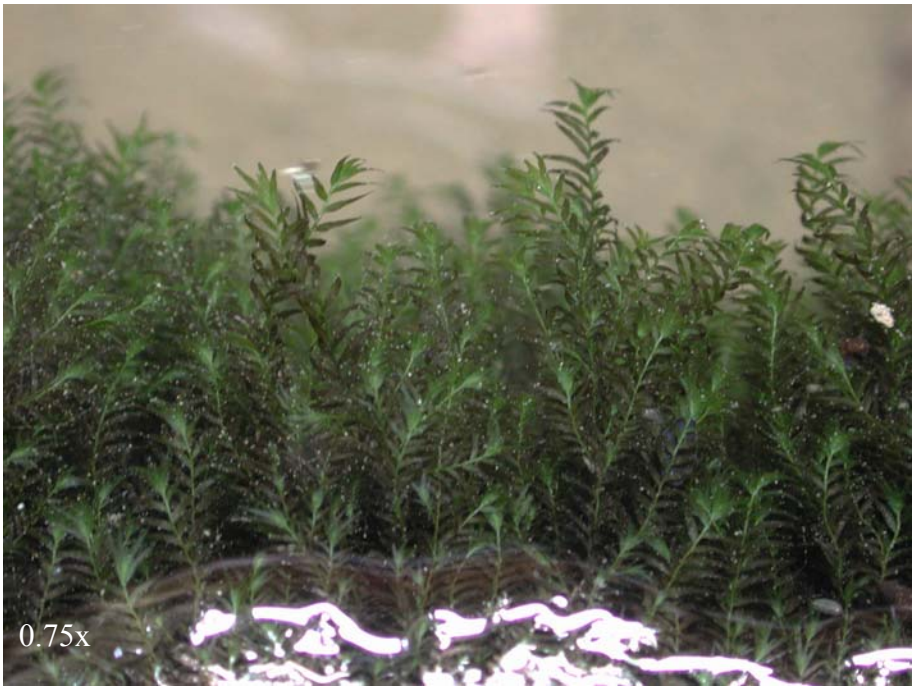
Bryum gemmiparum grows on rocks beside streams, also on seeping rocks. It has a conspicuous lustrous shine. The species propagates, as indicated by the name, by bulbiferous gemmae, which are produced in the axils of the leaves.

Fissidens crassipes (top) as well as **Rhynchostegiella curviseta** (bottom), and also R. teneriffae are found on wet shaded limestone or sandstone rocks along streams and by waterfalls.

Scorpiurium deflexifolium is often regarded as a variety of S. circinatum but is much larger and grows on seasonally flooded rocks in streams. **Rhynchostegiella teneriffae** (bottom) occurs as well as R. curviseta in wet shaded sandstone and limestone rocks along streams and waterfalls.

Scleropodium cespitans differs from the common Scleropodium tourettii by leaves which are gradually narrowed and not ending in a short apiculus. It grows on bases of trees and rocks especially along streams and rivers in the western Mediterranean and goes up to Britain





Octodiceras fontanus (Fissidens fontanus, Octodiceras julianus) grows always submerged in springs, rivers and often in water bassins, as shown in this picture. It is sterile and nobody knows how it disperses from one stretch of water to the other.

Fissidens crispus (= F. limbatus) and Fissidens kosaninii (right) are two of the small species growing on damp soil in shade along streams.

The pocket mosses (Fissidens spp.) are very much unlike the other mosses by having only two rows of leaves and growing prostrate (like the liverworts, from which they differ by a nerve in the leaf). The common name refers to the fact that they have a „pocket“ in one side of the lower part of the leaf., in which the dorsal wing of the next leaf is stuck.
Fissidens species can be as small as 3-4 mm or reach 10 cm. Some species grow on rocks in or by streams, other on damp soil.

Fissidens grandifrons (Pachyfissidens g.) is perfectly adapted to fast running water by multistratose leaves. They feel hard when touched. The species is distributed almost worldwide but is always rare, possibly because it is always sterile.

Fissidens polyphyllus (top), **Fissidens rivularis** (top right) and **Fissidens serrulatus** (bottom right) are western mediteranean species which are found north to Britain.

EPIPHYTES

Epiphytic mosses and liverworts require not as much rainfall rather than high humidity. This humidity is provided during night, when the temperatures go down and the dew point is reached. By this way, we find epiphytes (also lichens) even in habitats which look quite dry, for instance on olive trees. Nevertheless the phytomass of epiphytic bryophytes generally increases with elevation.

One of the most common epiphytic mosses is **Leucodon sciuroides.** The German name means „squirreltail moss“, which circumscribes precisely the appearence in dry state. In wet state, however, it looks totally different. Leucodon sciuroides occurs also in other parts of Europe, however, the mediterranean population has a larger size and is named var. morensis.

Leptodon smithii is even more different in wet and dry state as compared with Leucodon. The plants from fern-like fronds, which are rolled in in dry state like a snail but unfold in wet state. This hygroscopic movement is due to the stem, which has less incrassate outer cell walls on the ventral side than on the dorsal side. Leptodon is found on bark as well on rocks in oak forests, in the Mediterranean and north along the atlantic coast to Brittany. Recently it was found in the Netherlands and Germany, perhaps as a result of the climate change.

Habrodon perpusillus is - as expressed by the name - a tiny moss growing on bark of deciduous trees, along the atlantic coast at sea level but at higher altitudes in the Mediterranean.

Species of Fabronia are minute plants which form spider net like covers on rocks and bark. Under the microscope, the longly apiculate leaves are dentate. As shown by fossils in Baltic amber, the genus was already present in Scandinavia in Tertiary and has possibly survived here for 45 mio years.
There are two species of Fabronia in the Mediterranean, **Fabronia pusilla** (bottom) and **Fabronia ciliaris** (top). The latter has long cilia along the leaf margins, hence the name.

Scorpiurium sendtneri is an eastern mediterranean element and grows in riverine forests on bark e.g. of Platanus and Liquidambar. It is usually treated as a variety of the common Scorpiurium circinatum, but bis distinct in the small size, the occurrence on bark and its range.

Species of Orthotrichum are most common mosses on tree trunks. Many species occurring at higher altitudes in the mediterranean are also distributed in western and Central Europe. Because they are sensitive to air pollution, these species got extinct there. By this way some species were no more found for more than hundred years, others were rarely found only in not so much polluted regions. Since the decrease of the sulphurdioxide emissions at the end of the 20th. century, these species returned and it could be that the Mediterranean functioned as a refugium for those species.

On the next page only species are shown, which are not found in other parts of Europe. Additional species were described recently by Spanish bryologists such as Orthotrichum vittii, O. ibericum, O. tortidontium,, O. hispanicum, O. casasianum and others, which are not illustrated here. The determination is not possible by photopgraphs but requires detailed studies under the microscope and also much esperience.

Orthotrichum acuminatum (top left) has long elliptical capsules which are almost smooth when dry. **Orthotrichum macrocephalum** (top right) has rounded leaf apices. **Orthotrichum philibertii** (bottom left) has a pale calyptra with papillose hairs. **Orthotrichum vittii** (bottom right) has hyaline hairtips like O. diaphanum but the peristome teeth united into 8 pairs.

Orthotrichum diaphanum is recognized by its hyaline leaf apices. The species is a strong nitrophyte in middle Europe and grows especially in urban areas and regions with intensive agriculture. In the Mediterranean, the species grows in unpolluted areas. Reason is presumambly, that the species is drought adapted and has high osmotic values to absorb water also at low levels of air humidity. High osmotic values help, however, to tolerate wet nitrogen emissions, which are in fact salt solutions.

Orthotrichum tenellum (left) is also found in Central Europe but very common in the Mediterranean. It has a pale, naked calyptra. **Orthotrichum rupestre** (right) means that the species is growing on rocks. In the Mediterranean it prefers bark of oaks. The stems are curved upwards as in Leucodon sciuroides and the moist leaves tend to be squarrose.

Syntrichia laevipila is a common epiphyte. It resembles much other species of Syntrichia with lingulate leaves but is relatively smaller and has a non serrate excurrent nerve. It produces frequently sporophytes. The species is also found in western and central Europe, where it seems to expand perhaps due to the climate change.

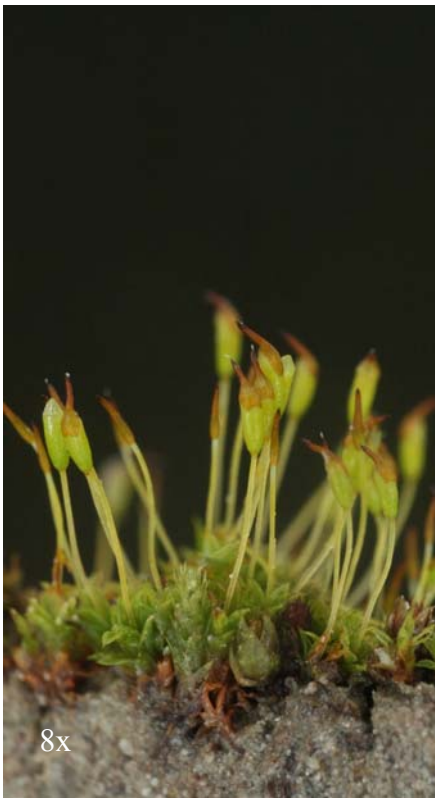
Syntrichia pagorum is similar to Syntrichia laevipila (and therefore synonymized with the latter by Spanish bryologists) but has even smaller leaves and the brood leaves which are produced in clusters in the leaf rosette have no costa. The species is also found on humid rocks as in the type locality, the Küchelberg in Merano, northern Italy. Syntrichia pagorum is probably not native in Europe. Although described from Merano already in 1862, we have only male plants in Europe. In North A merica, only female plants are found but in Australia, both sexes are present. This could indicate that the species was introduced from there to Europe and North A merica. And although the population in Europe is sterile. the species is spreading also over longer distances, which can only be possible by the brood bodies, which are 1/10 of a millimetre large.

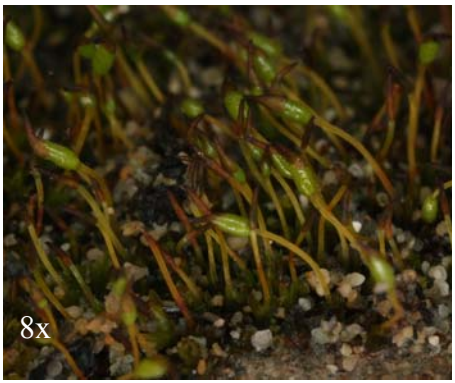
Syntrichia virescens can also grow on rocks. In contrast to Syntrichia laevipila, it is dark green, and has a serrate excurrent costa.

SALT MARSHES

Bryophytes usually do not tolerate salt water, with very few exceptions. Beside the liverwort genus Riella, which lives submerged in ponds with brackish water and can eaasily taken for an algae, only few species of the moss genus Pottia are found at the edges of Salicornia marsches.

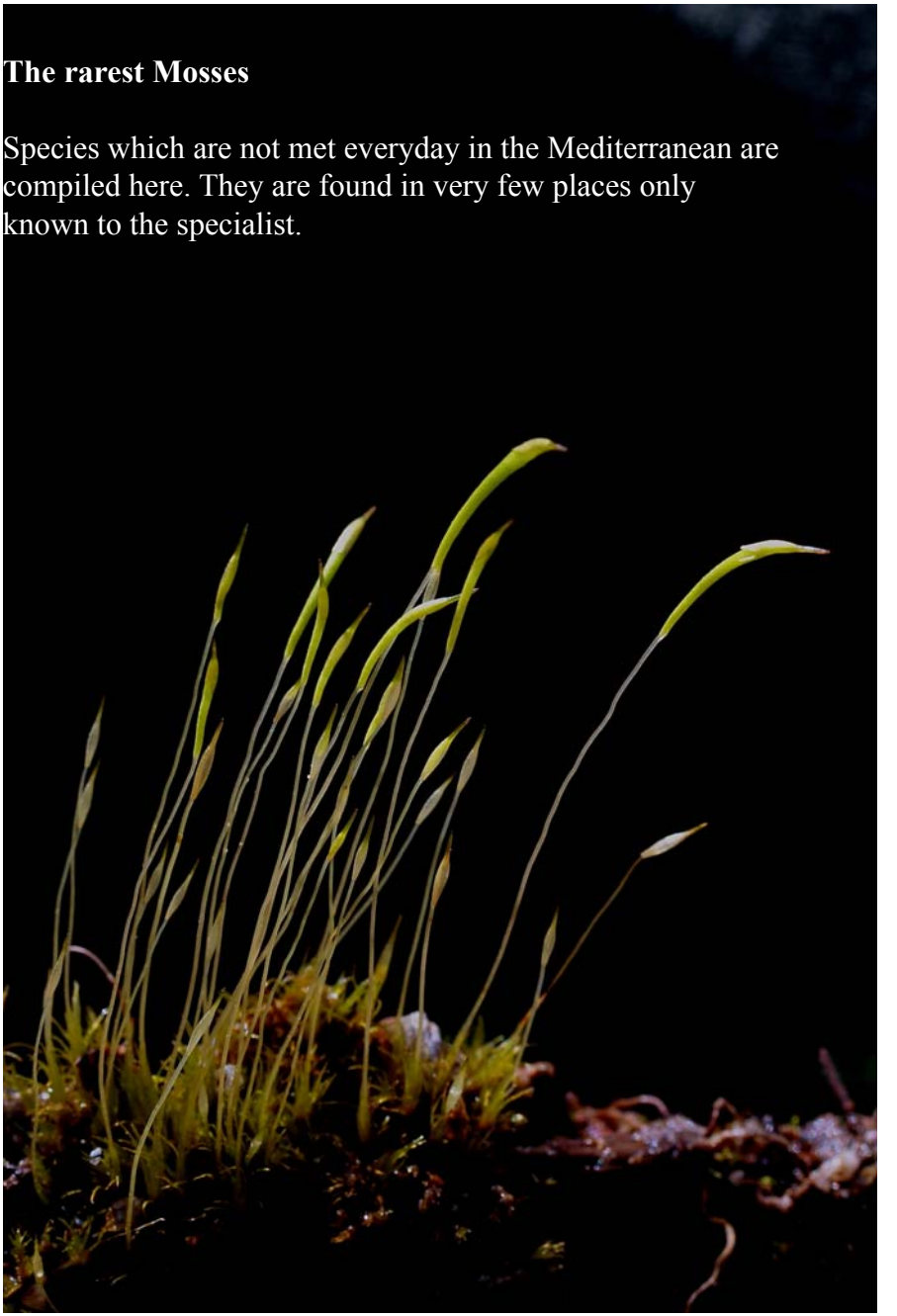
The salt tolerant species are **Pottia crinita** (middle left), **Pottia pallida** with conspicuous pale capsules (middle right) or **Pottia wilsonii** (bottom). The latter both pictures show the species with young spore capsules (left) and some weeks later with emptied spore capsules. At this stage, the plants start to decompose and are hardly visible.

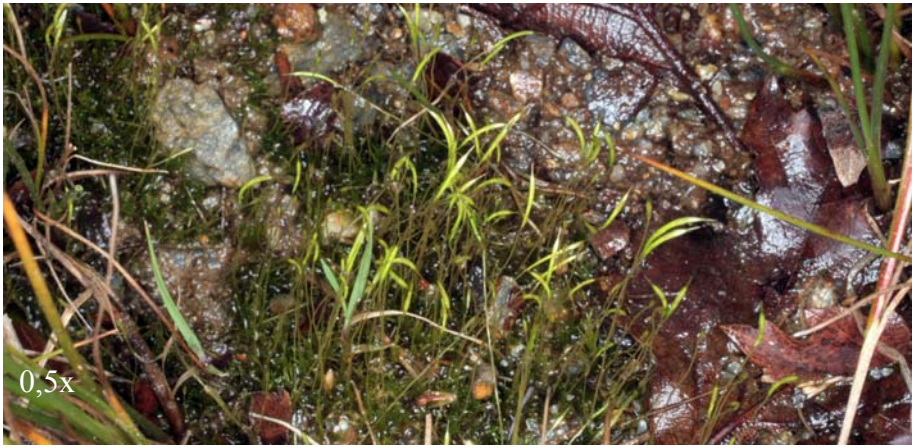




The rarest Mosses

Species which are not met everyday in the Mediterranean are compiled here. They are found in very few places only known to the specialist.

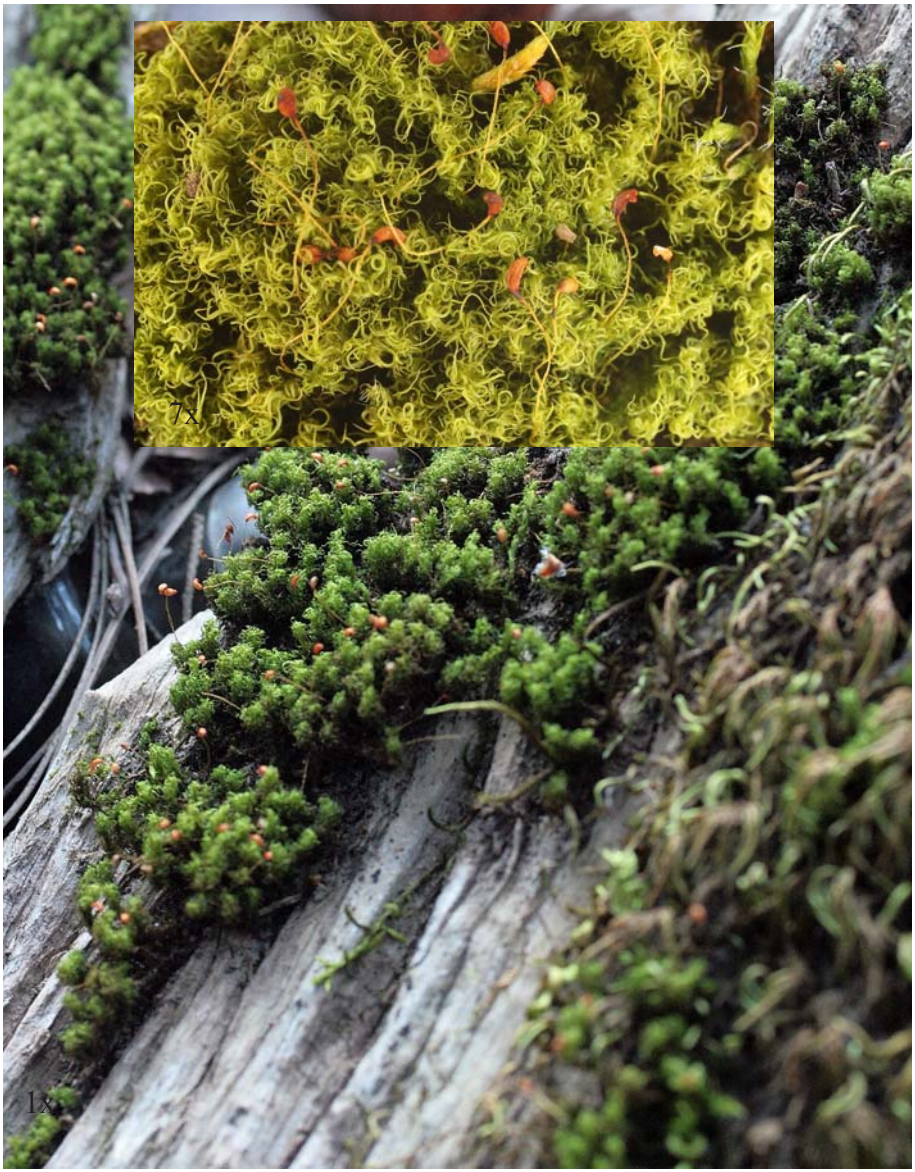




Trematodon longicollis (see also the page before) is a tropical species, which is only found in one place in Crete and (still?) around solfataras of Ischia, Pantelleria and Pozzuoli. The name refers to the extremely long neck of the capsule. which is about 3 times longer than the urn in which the spores are produced. Whereas the habitat of the Italian localities comprise warm soil, which seems to fit a tropical species, the species grows in Crete along a wet trailbank. The origin of the species is doubtful. The nearest guess maybe that it has been dispersed by spores, however, the occurrence in Crete is associated with the liverwort Jungermannia handelii and the fern Woodwardia radicans, which are said to be relics from the Tertiary.

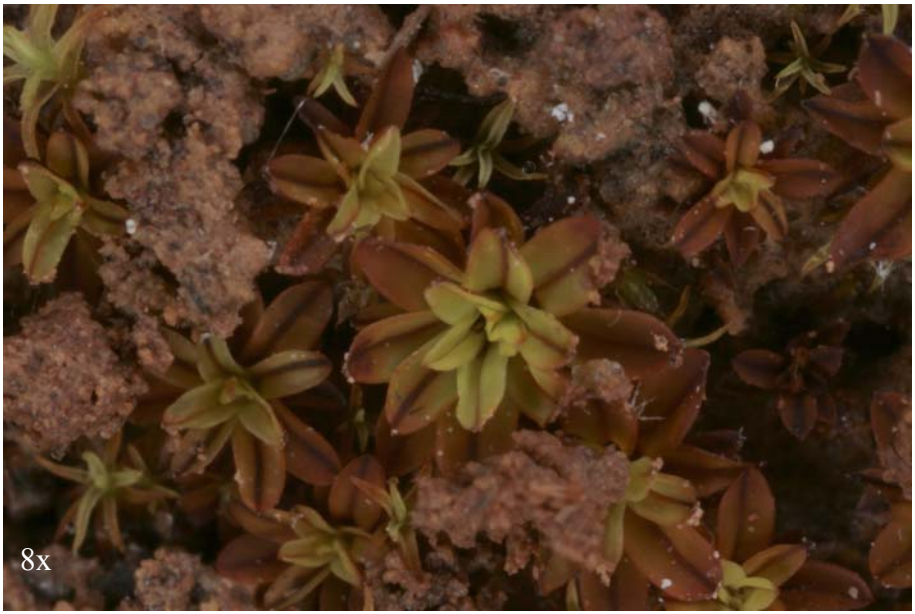
Jungermannia handelii is one of the rarest liverworts in the Mediterranean and even worldwide. It has been found on only a few nearby places in the western parts of Crete, next in one locality at the Black Sea coast in Turkey and furthermore in Japan. This suggests a relic from a more widespread range in the Tertiary. On Crete, the occurrence of this species is associated with the hugh fern Woodwardia radicans, which is else found in southern Spain and the Macaronesian Islands. Both regions are also known for relictic species from the Tertiary.
The species is named after Heinrich Freiherr von Handel-Mazzetti, an Austrian botanist, who made numerous collecting trips at the begin of the 20th. century and collected the species first during a journey to the Near East.

Claopodium whippleanum (Thuidiaceae) is another species which is mainly found in western North A merica. In 1866 it was discovered in one locality in southern Portugal and 1911 in more places. Recently it has been found in Sardinia. Molecular studies on populations of this species revealed that the European population are not congruent with any of those in North America. They differ, however, not so strongly from the latter, which would support a separation of more than 20 million years.



One of the rarest mosses in the Mediterranean is **Oncophorus dendrophilus.** In spite of the name „dendrophilus“ it is also found on rocks. The species was not described before 2006 and is only known from small areas in Crete and Cyprus. Remarkably, the genus includes two more species in Europe, which are boreal in distribution. Another species, O. sardous was once found in Sardinia in only one place but remains dubious.

Gigaspermum mourettii is one of the few species within the Gigaspermaceae. The genus is only known from South Africa, Australia and New Zealand (indicating a Gondwana element), but Gigaspermumn mourettii was also known from Morocco and southern Spain, which is a strange disjunction, indicating an ancient origin. During the past twenty years, the species has been found more often all over the Mediterranean on open soil in Garigues. It can be assumed that it has been overlooked so far due to the similarity with certain species of Bryum, from which it differs by the lack of a costa in the leaves and the presence of subterraneous stolons. The capsules, if present, are inserted in the comal leaves and have „giant" spores to 70 µm in diameter as expressed by the Latin name.



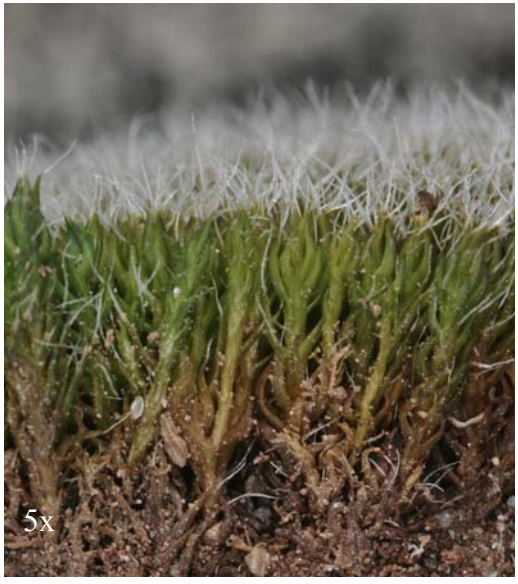
Syntrichia bolanderi was named after a North American botanist and was so far known from California (with a similar climate and vegetation as in the Mediterranean). It has recently be found in southern France, Sartdinia and Sicily.

Bryum minii grows in fissures of granite rocks. It has been described from Portugal and has additionally found twice in Sardinia.

The following Grimmia species are endemic in the Mediterranean and inhabit siliceous rocks at higher elevations.

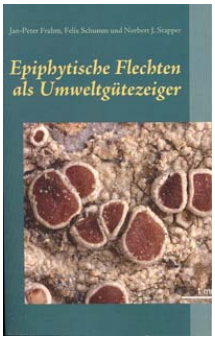
Grimmia nutans has conspicuous glaucous (waxy) leaves which are slow to adsorb water, and a long curved seta. It is only known from southern France, northern Greece (monastry of Meteora, from where ist was described as G. meteorae) and Cyprus.

Grimmia ungeri was described from Cyprus and is said to be endemic there, although other authors report the species also from other parts of the Mediterranean.



Grimmia pilosissima was described from higher elevations in Sardinia and has additionally olnly found in Corsica and Portugal. It has reflexed hairpoints and cushions which are yellowish internally.

Register



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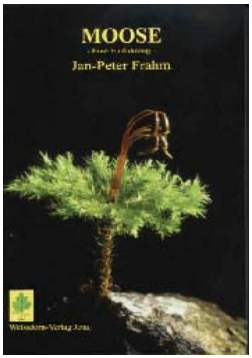

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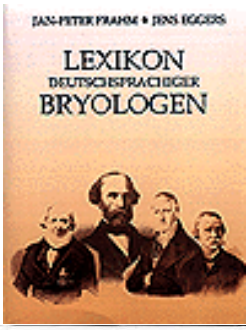

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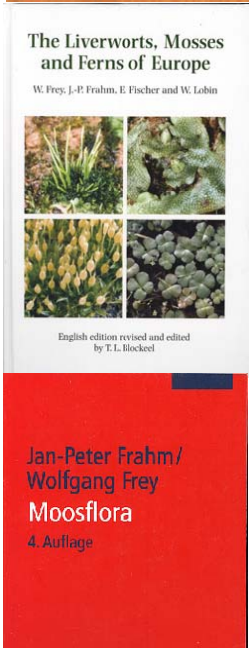

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