

Biodiversity Assignment: The Usage of the Tree Lichen *Evernia prunastri* as a Commercial Fragrance, Antifungal, and Antibacterial Agent

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Abstract:

The lichen species *Evernia prunastri*, otherwise known as its common name of oakmoss, has been recognized as a vital compound within the major perfume industry for numerous years. However, the species has gained infamy due to its allergenic tendencies provided by the presence of the chemical compounds atranol and chloroatranol. Within this report, the uses and eventual ban of oakmoss in the industry will be discussed; as well as other uses, the major features, and facts concerning this species of lichen.

Keywords: *Evernia prunastri*, oakmoss, perfume, antifungal, chloroatranol, atranol.

Features

Evernia prunastri, better known as the fruticose lichen oakmoss, is a species of lichen which specifically blooms on deciduous trees, hence the “oak” in the moniker “oakmoss.” The lichen forms as a symbiotic relationship between a green algal species and a fungus, allowing for both photosynthetic and saprophytic activity from the organism. Oakmoss typically forms with an outermost cortex of a pale green to mint colour. Its thallus, or fruiting body, is overall flat but erect, appearing to reach outward from its host tree. The thallus displays a branching pattern throughout, reminiscent of plant roots or animal veins. Said branching portions categorize the specimen as fruticose.



Figure 1. Graphical depictions of commonplace fruticose lichen. Images of *Evernia prunastri* cortexes can be observed under sections 9.a. and 9.b. (Culberson & Bolton, 1961).

In culture, oakmoss has been utilised for innumerable different items: ranging from dyes, to medicine, to a particularly vital component in perfumes and colognes. Regarding its use as the latter, extracts from the lichen’s thallus are selected to generate absolute extracts or ‘Absolutes,’ aromatic plant secretions which provide oakmoss with its distinctive ‘woody’ scent. According to Arctander (1960), these absolutes are attained by means of hydrocarbon extraction using an organic solvent such as petroleum ether. Such forms the crude *Evernia* extract, known as *Evernia* or Oakmoss Concrète, which may then be utilised in further olfactory development to create the desired Oakmoss Absolute. Specifically, the Concrètes must be “further treated with ethanol” (Joulain & Tabacchi, 2009) – indicating further extraction, utilising ethanol - to obtain the final Absolute form of the lichen.

The *Evernia* Absolute is the compound most sought after in perfuming due to its high aromaticity and olfactory content, producing the strongest overall scent of any product that may be attained from the lichen species. Being in its Absolute form also assures the fixative properties of the extract, indicative of a lingering fixation on the olfactory glands as well as on skin, as to provide a long-lasting scent which situates *E. prunastri* as a highly effective and desirable resource in perfumery. Seeing as such, multiple high-standard perfumes and colognes have been formed through this Absolute. Particularly notable examples are French fragrances Chanel no. 19 of Chanel fame and Drakkar Noir by Guy-Laroche.

However, recent controversy regarding the use of oakmoss in perfumes and scented products has arisen due to allergenic qualities of the extract. Specifically, the presence of the compounds atranol and chloroatranol has caused the ban of this species within the industry, as both molecules have been found to be skin irritants (Menné Bonefeld et al., 2014).

E. prunastri and many other lichen species have been utilised in medicinal practices for known centuries. Oakmoss in particular secretes the aforementioned compound usnic acid, which is used as an antifungal and antibacterial medium. Its use as a medicinal resource began in Ancient Greek civilizations, wherein the lichen was applied as an ointment or oil extract to areas on the skin to rid the body of general fungal diseases such as athlete's foot or vaginal yeast infections (Crawford, 2015). During modern times however, the antifungal uses of this substance are much more involved with oakmoss's usnic acid used in fending off the yeast species known as Candidiasis, which causes vaginal, skin, and internal infections in humans. Usnic acid inhibits the formation of the yeast's pseudohyphae, or buds, by preventing the creation of a biofilm layer around each cell (Millot et al., n.d.). The lack of this protective layer leaves the yeast susceptible to the antifungal properties of the acid, thereby allowing for the destruction of cells. In addition to this, oakmoss contains many antibacterial measures which have been used in modern medicine for preventing Gram-positive bacterial illnesses, such as *Streptococcus* spp. in the causing of throat infections (Shcherbakova et al., 2021).

Samples	Minimum inhibitory concentration (MIC), µg/ml [‡]			
	<i>Staphylococcus aureus</i>	<i>Pseudomonas aeruginosa</i>	<i>Escherichia coli</i>	<i>Candida albicans</i>
<i>E. prunastri</i> (Hexane)	21 ± 9 ^(0.9)	150 ± 41 ^(0.8)	> 500	150 ± 50 ^(0.2)
<i>E. prunastri</i> (DCM)	4 ± 1*	167 ± 33 ^(0.5)	500 ± 1*	150 ± 50 ^(0.2)
<i>E. prunastri</i> (60% ACN)	14 ± 3 ^(0.1)	133 ± 33 ^(1.0)	250 ± 1 ^(0.3)	38 ± 13*
Usnic acid	21 ± 9	133 ± 33	225 ± 25	100 ± 1

[‡]Data expressed as a mean ± SD (n = 3 for each experiment)

*p < 0.01 vs. usnic acid

Table 1. Analysis of usnic acid, as well as alternate *E. prunastri* extracts, in their effectiveness in inhibiting Gram-positive (*S. aureus*, etc.) and Gram-negative (*E. coli*, etc.) bacteria (Shcherbakova et al., 2021)

Taxonomic Affiliation

Evernia prunastri can be specifically identified as *Evernia prunastri* (L.) Ach. var. *prunastri* and belongs to the phylum Ascomycota under the Parmeliaceae family and the genus of *Evernia*. According to Thell et al. (2012), the family is characterized by its thin, shield-like apothecia or reproductive structure, which in *Evernia prunastri* takes the form of cups. Additional members of this familial group include *Usnea*, *Parmelia*, and *Cetraria*.



Figure 2. Comparative images of Pedaliaceae species: A) *Usnea dasypoga* (Valero Risoto, n.d.); B) *Cetraria muricata* (Bouffinier, n.d.-a); C) *Parmelia ernstiae* (Haine, n.d.-b); and D) *Evernia prunastri* (Bouffinier, n.d.-b).

E. prunastri and its associated *Evernia* species are specified as fruticose lichen due to their flat, outbranching thallus and central core, which is used to attach the specimen to its selected substrate. As is common in fruticose lichens, *E. prunastri*'s preferred substrates are deciduous trees such as maples or oaks; the latter of which has earned it the name oakmoss.

Oakmoss, as mentioned previously, consists of a symbiosis between a fungal species and a green alga. Such can be clearly observed in the morphological form of this specimen, with the fungal medulla consisting of the internal portion and branching out into distinctive hyphae. Overtop of this fungal medulla exists the symbiotic algae in a covering layer known as a lichen

cortex, whose photosynthetic abilities and retention of chlorophyll *a* provide the distinctive mint-green colouration observed in *E. prunastri*.

Life Cycle

Oakmoss reproduces both sexually and more commonly asexually, involving a vegetative use of fragmentation via soredia, a lichen structure consisting of small “dust-like or granular balls of hyphae along with a few intertwined algal cells” (*LICHEN BIOLOGY – Ohio Plants*, n.d.). Said soredia allow for fragmentation of the fruiting thallus, as the granules bud out from the main body and may therefore disconnect. These new fragments of the oakmoss undergo mitosis and grow into new daughter lichens.



Figure 3. Asexual fragmentation structures, or soredia, of *Evernia prunastri* (Uebel, 2007).

The sexual reproduction of oakmoss oversees the formation of an apothecium from the thallus body: a brown cup-like structure which hosts the lichen’s spores along the fungal hyphae, as seen in Fig.4. These apothecia disperse the sexual spores to allow for germination, which is followed by mitotic divisions into newly formed daughter hyphae and thalli.

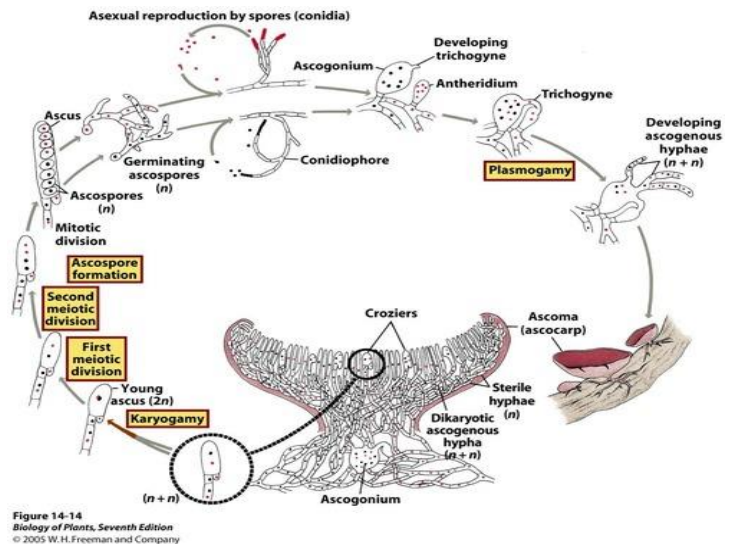


Figure 4. Apothecia (left) (Haine, n.d.-a) and sexual life cycle diagram of *Evernia prunastri* (Raven et al., 2005).

Habitat

As has been stated previously, the main substrate for *Evernia prunastri* is that of deciduous tree branches. These growths can be observed in commonly humid areas of temperate regions, in areas such as Central to Western Canada, Central Europe, and in Northern parts of Japan and Africa as reported by both the Global Biodiversity Information Facility (2021) and Nash et al. (2002).

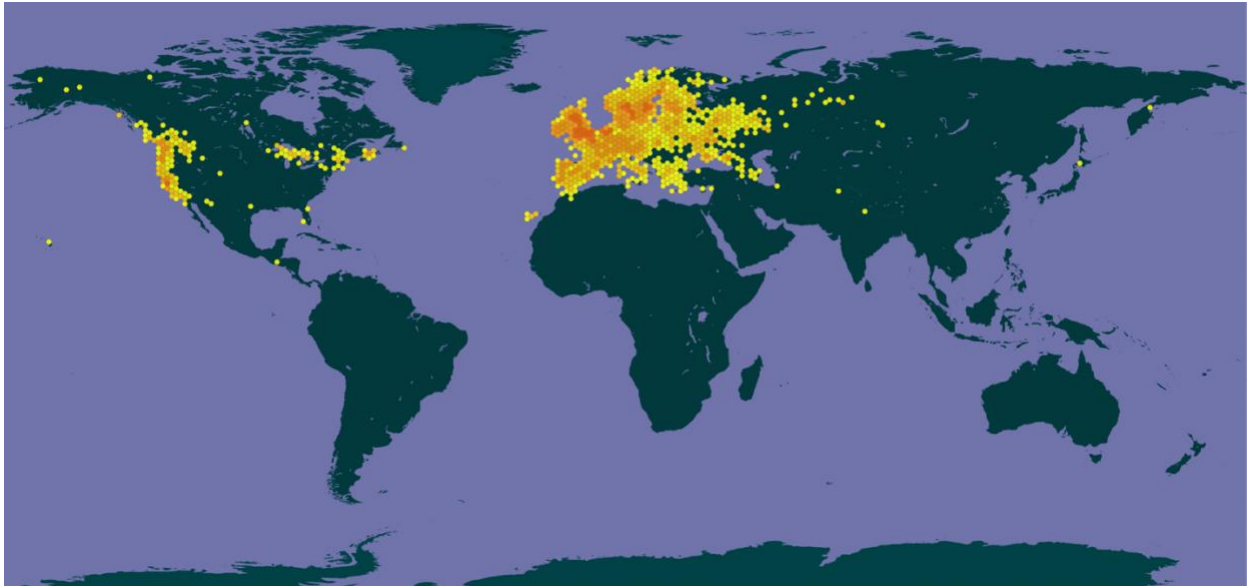


Figure 5. Geographic distribution of *E. prunastri*, with darker orange to red areas indicative of greater population density and light yellow to orange areas indicating low density (*Evernia Prunastri* (L.) Ach., 2021)

Propagation

The harvesting process of oakmoss, particularly in the perfume industry, involves careful cutting of the thallus as to preserve a large portion of the body for future propagation. The thallus body typically grows at a very slow rate, only about 3-11 mm/year (Totally Wild UK, 2022). As such, the high demand for *E. prunastri* extracts for commercial consumption presents a very taxing pressure on the growth rate and abundance of this species, and numerous other propagation methods have been proposed to aide in the rate of reproduction.

Innovation by Ahmadjian & Jacobs (1981) involved using lichen spores as bases for growth was applied as a means to produce additional lichen species for harvesting, though more modern methods have since been discovered. In particular, the use of thallus sections as a basis for culturing was successfully developed by Yamamoto (2000): a 1cm section of the thallus is selected and removed from the main body, homogenized by sterile water and a double filtration, and placed within agar and incubated to produce new lichen propagules (Yamamoto et al., 2002). From here, the newly formed *E. prunastri* can be grown and eventually harvested for extraction into Oakmoss Concrète and eventually Oakmoss Absolute, as per the means discussed in the *Features* section of this biological report.

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