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*Published in:*
American Journal of Plant Sciences

*DOI:*
10.4236/ajps.2014.59152

*Publication date:*
2014

*Document version*
Publisher's PDF, also known as Version of record

*Citation for published version (APA):*
Johnsen, I. (2014). *Rhynchostegium megapolitanum* (Web. et Mohr) B.S.G.-A rare bryophyte in dune ecosystems of Zealand, Denmark. *American Journal of Plant Sciences*, *5*(9), 1378-1383. https://doi.org/10.4236/ajps.2014.59152

Download date: 03. Oct. 2026

**American Journal of Plant Sciences, 2014, 5, 1378-1383**
Published Online April 2014 in SciRes. http://www.scirp.org/journal/ajps
http://dx.doi.org/10.4236/ajps.2014.59152

# *Rhynchostegium megapolitanum* (Web. et Mohr) B.S.G.—A Rare Bryophyte in Dune Ecosystems of Zealand, Denmark

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Received 21 February 2014; revised 26 March 2014; accepted 15 April 2014

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## Abstract

**_Rhynchostegium megapolitanum_ was observed during a study of the effects of the invasive non-native _Rosa rugosa_ in a sand dune. The vascular as well as the epiphytic and epigeic cryptogam vegetation was recorded., and soil properties were measured. Epihytic lichens were abundant on dead or dying branches of _Rosa rugosa_ scrubs, under which the stable substrate and high light exposure provided growth conditions for an epigeic community dominated by lichens and bryophytes. The occurrence of the rare bryophyte _Rhynchostegium megapolitanum_ is discussed.**

## Keywords

***Rosa rugosa*; Coastal Sand Dune; Epiphytic Lichens; Epigeic Bryophytes**

## 1. Introduction

Along the east coast of Zealand, Denmark, several dune systems exist. They are all relatively small in area, and normally the coastal dunes are low in height [1]. They possess, however, often a valuable ecosystem dominated by lichens and bryophytes [2] [3]. Coastal ecosystems in Denmark are affected by the incresasing occurrence of the invasive *Rosa rugosa* Thunb. Ex Murray, an invasive shrub from East Asia to parts of Europe [4] [5]. The plant occurs mostly in coastal ecosystems, where it inflicts changes in biodiversity. However, little is known about the vascular and non-vascular plants associated to the invasive *Rosa rugosa* or its soil properties. *Rosa rugosa* may alter the diversity of the cryptogams, firstly by providing shelter during the growing season and the winter, which might mainly benefit some bryophytes, secondly by providing new substrates in the form of dead twigs for the epiphytes. Furthermore, the reduced trampling from man and animals in and close to the *Rosa rugosa* shrubs protect the slow growing lichen and bryophyte vegetation. Dying shrubs of *Rosa rugosa* thus

**How to cite this paper:** Johnsen, I. (2014) *Rhynchostegium megapolitanum* (Web. et Mohr) B.S.G.—A Rare Bryophyte in Dune Ecosystems of Zealand, Denmark. *American Journal of Plant Sciences*, **5**, 1378-1383.
http://dx.doi.org/10.4236/ajps.2014.59152

provide improved growth conditions for epiphytic as well as epigeic cryptogams.

*Rhynchostegium megapolitanum* (Web. et Mohr) B.S.G. was previously observed by Hansen and Vestergaard [3] in man-made sand dunes in East Denmark. This rare bryophyte has been studied in Austria recently by Zechmeister, Moser and Milasowszky [6], and it was hypothesized that the species is expanding, possibly due to climate change and increasing atmospheric nitrogen deposition. Only little is otherwise known of the ecological preferences of this species (see e.g. [7]).

The aim of this paper is to contribute to the knowledge of the ecology surrounding *Rosa rugosa* on these dune systems; with a focus on the epiphytic cryptogam vegetation and on the epigeic vegetation below, in particular *Rhynchostegium megapolitanum*.

## 2. Materials and Methods

### 2.1. Study Area and Its Vegetation

Ølsemagle Revle is a sandy off-shore barrier, situated at the bay of Køge Bugt SW of Copenhagen, Denmark (55˚29' N, 12˚12' E). A general description of geomorphology, vegetation and soil of the barrier was presented by Gravesen and Vestergaard [1]. The barrier is composed by a linear, uniform sand dune along the seaward side, dominated by *Ammophila* x *baltica* (Flügge) Link and *Leymus arenarius* L. (Hochst.) and a coastal meadow, dominated by *Festuca rubra* L. and *Phragmites australi* (Cav.) Trin. ex Steudel, along the landward side. Rabbits are not present in the area, and hares and roe deer are rare.

Along the dune ridge, several patches of *Rosa rugosa* shrubs occur, and some of those were found dead or dying [5]. The epiphytic vegetation on the dead twigs was extremely dominated by *Hypogymnia physodes* (L.) Nyl. with occasional occurrence of *Hypogymnia tubulosa* (Schaer.) Hav.and *Evernia prunastri* (L.) Ach. (**Figure 1** and **Figure 2**).

Nomenclature: vascular plants: [8]; mosses: [9]; lichens: [10].

**Figure 1.** Photo of app. one $m^2$ dead *Rosa rugosa* twigs covered with epiphytic *Hypogymnia physodes*. Between the twigs different lichens and bryophytes are seen. The photo is taken at the beginning of a transect line running through an almost dead *Rosa rugosa* oval shaped shrub covering app. 50 $m^2$. Study site at Ø lsemagle Revle, spring 2005.

**Figure 2.** Photo of an almost dead *Rosa rugosa* shrub covering app. 100 $m^2$. In the background a living rose shrub is seen. Study site at Ølsemagle Revle, spring 2005.

### 2.2. Vegetation Analyses

Five 20 m transects passing from open surroundings through living and dead oval shaped *Rosa rugosa* shrubs at the top of the dune ridge were established. 21 plots (0.5 × 0.5 $m^2$) with a mutual distance of 0.5 m were established along the transects. A total of 105 plots were studied. The vascular plant species as well as the bryophyte and lichen species were recorded for each plot. The rose shrubs varied from dead to vigorous and dense (measuring up to 1.5 m in height), but mainly the lichen vegetation seemed to be responsive to this variation, being far more abundant as epiphytes on twigs and on the ground between the dead roses.

The bark properties of neither the dead nor the living roses were measured.

### 2.3. Soil Properties

Soil samples from 0 - 5 cm and 5 - 10 cm depth were taken with an auger (5 cm diameter). The samples were dried at 60˚C for a minimum of 3 days; they were passed through a 2 mm sieve and four soil properties were investigated. Soil pH and specific conductivity were measured after 24 h extraction with demineralised water; soil-water ratio was 1:5 [11]. The pH and conductivity measurements were made using a Radiometer PHM 240 and a Radiometer CDM 83 Conductivity Meter, respectively. Plant available P was measured after 24 h extraction with 0.2 N $H_2SO_4$; soil:$H_2SO_4$ ratio was 1:200. The measurements were made using a Foss FIA Star 5000 Analyzer. Soil organic matter was measured as loss on ignition at 550˚C for 6 hours.

Statistical analyses according to [12].

## 3. Results

### 3.1. Vegetation

The epigeic lichen and bryophyte species are listed in **Table 1**. The species *Rhynchostegium megapolitanum* is believed to be rare in Denmark, and its ecology is quite unknown.

Only three epiphytes on dead or dying *Rosa rugosa* twigs were present: *Hypogymnia physodes* (very domi-

nant) and occasional *Hypogymnia tubulosa* and *Evernia prunastri*.

Twelve species of epigeic mosses were recorded, with between 1 - 5 species per plot, and seven species of epigeic lichens were found, with 0 - 3 species per plot (**Table 1**).

The vascular plant species found are listed in **Table 2**.

**Table 1.** Epigeic lichens and bryophytes observed 2005 at the plots (see text) on Ølsemagle Revle (DAFOR: D: Dominant; A: Abundant; F: Frequent; O: Occasional; R: Rare).

| **Bryophytes** | DAFOR | **Family** |
|---|---|---|
| *Aulacomnium androgynum* | R | *Aulacomniaceae* |
| *Brachythecium albicans* | A | *Brachytheciaceae* |
| *Brachythecium rutabulum* | O | *Brachytheciaceae* |
| *Bryum* sp. | F | *Bryaceae* |
| *Cephaloziella* sp. | R | *Cephaloziellaceae* |
| *Ceratodon purpureus* | A | *Ditrichaceae* |
| *Dicranum scoparium* | A | *Dicranaceae* |
| *Hypnum cupressiforme* | A | *Hypnaceae* |
| *Oxyrrhynchium* sp. | R | *Brachytheciaceae* |
| *Pleurozium schreberi* | R | *Entodontaceae* |
| ***Rhynchostegium megapolitanum*** | O | *Brachytheciaceae* |
| *Rhytidiadelphus squarrosus* | O | *Hypnaceae* |
| **Lichens** | DAFOR | |
| *Cladonia diversa* | F | *Cladoniaceae* |
| *Cladonia furcata* | F | *Cladoniaceae* |
| *Cladonia glauca* | O | *Cladoniaceae* |
| *Cladonia macilenta* | O | *Cladoniaceae* |
| *Cladonia merochlorophaea* | R | *Cladoniaceae* |
| *Cladonia scabriuscula* | A | *Cladoniaceae* |
| *Cladonia squamosa* | R | *Cladoniaceae* |

**Table 2.** Vascular plant species observed 2005 at the plots (see text) on Ølsemagle Revle (DAFOR: D: Dominant; A: Abundant; F: Frequent; O: Occasional; R: Rare).

| **Vascular species** | DAFOR | **Family** |
|---|---|---|
| *Ammophila* x *baltica* | A | *Poaceae* |
| *Aira praecox* | O | *Poaceae* |
| *Arrhenatherum elatius* | F | *Poaceae* |
| *Artemisia campestris* | O | *Asteraceae* |
| *Carex arenaria* | A | *Cyperaceae* |
| *Cerastium glutinosum* | O | *Caryophyllaceae* |
| *Chamaenerion angustifolium* | R | *Onagraceae* |
| *Elytrigia repens* | A | *Poaceae* |
| *Epilobium montanum* | O | *Onagraceae* |
| *Festuca rubra* | A | *Poaceae* |
| *Hypochoeris radicata* | F | *Asteraceae* |
| *Lathyrus japonicus* | F | *Poaceae* |
| *Linaria vulgaris* | F | *Scrophulariaceae* |
| *Poa pratensis* | O | *Poaceae* |
| *Polypodium vulgare* | F | *Polypodiaceae* |
| *Rumex acetosella* | F | *Polygonaceae* |
| *Senecio vernalis* | A | *Asteraceae* |
| *Tanacetum vulgare* | A | *Asteraceae* |
| *Viola tricolor* | F | *Violaceae* |

### 3.2. Soil Factors

The content of organic matter in the uppermost 5 cm of the soil was 1.6% ± 1.0% (range: 0.4% - 4.3%), and in depth 5 - 10 cm between 0.8% ± 0.4 % (range: 0.3% - 2.0%). The difference between the means was significant ($z = 9.37$; $P < 0.01$; $N = 102$).

The specific conductivity of the uppermost 5 cm was 29 ± 15 µS (range: 10 - 61 µS), and in depth 5 - 10 cm it was 20 ± 8 µS (range: 10 - 38 µS). The difference between the means was significant ($z = 8.06$; $P < 0.01$; $N = 102$). The conductivity increased significantly with soil organic matter ($R^2 = 0.734$; $P < 0.001$).

The variation in soil pH was less clear cut. In the uppermost 5 cm of the soil, pH was 5.5 ± 0.9 and in depth 5 - 10 cm it was 5.0 ± 0.4. pH was not correlated with the very low amount of soil organic matter; this is probably due to the supply of calcium carbonate from decaying sea shells and the impact of sea spray.

The amount of plant available P in the uppermost 10 cm of the soil was in the range 12 - 69 ppm with no significant difference between the soil layer means. P increased with soil organic matter ($R^2 = 0.168$; $P < 0.001$).

## 4. Discussion

The bryophyte species at the site are mostly common and widespread, reflecting the pioneer stage of succession as well as the existence of more sheltered growth conditions, e.g. under the living *Rosa rugosa* shrubs. *Aulacomnium androgynum* (Hedw.) Schwaegr. and *Oxyrrhynchium* (B.S.G.) Warnst. sp. often occur under more shaded conditions, *Pleurozium schreberi* (Brid.) Mitt is frequent in open heath communities, *Hypnum cupressiforme* Hedw. has a wide range of habitats, mostly acid substrates, while the remaining species with the exception of *Rhynchostegium megapolitanum*, are characteristic of early succession stages in open, exposed habitats [9]. *Ceratodon purpureus* (Hedw.) Brid., *Hypnum cupressiforme* and *Brachythecium rutabulum* (Hedw.) B.S.G. were most common outside or at the edge of the *Rosa rugosa* shrubs. *Ceratodon purpureus* is a pioneer species typical of open habitats [9], and may therefore have been suppressed by lack of light below *R. rugosa*. The common *Dicranum scoparium* Hedw. has a wide ecophysiological range and may form carpets on open sandy soils as well as in more shaded humus rich habitats [13].

The finding of *Rhynchostegium megapolitanum* was unexpected, and the species is rare in Denmark. Dierssen [7] states, that *Rhynchostegium megapolitanum* may thrive well in more or less shaded habitats. The shade provided by *Rosa rugosa* may thus not inhibit the growth of this moss. On the contrary, the stable substrate and diminished disturbance within the open *Rosa rugosa* scrubs may favour the epigeic community as a whole. Even living scrubs of *Rosa rugosa* permit ample penetration of nearly full sunlight during fall, winter and spring, where the twigs are naked. Isermann [14] found, however, in dunes at the German North Sea coast a reduction in relative irradiance inside *R. rugosa* shrub to below 10% at about 45% - 50% cover of *R. rugosa*. The reduction of irradiance inhibited growth of light-demanding species typical for dunes, which after some years were outcompeted in favour of less light demanding species.

The soil properties measured are consistent with a nutrient poor sandy soil, with some impact from the sea in terms of shell fragments and sea spray. The pH level of the sandy soil at the study site reflects this impact in particular; pH values between 5 and 7 was recorded. The low P content and organic matter indicates a substrate that only sustains a vascular vegetation with small productivity and little competitiveness. It is thus not surprising, that weakening of *Rosa rugosa* shrubs results in a plant community dominated by slowly growing cryptogams.

The regional value for East Zealand of atmospheric deposition of nitrogen compounds amounts to 14 kg N $ha^{-1} \cdot yr^{-1}$ [15] due to prevailing westerly winds and proximity of highways and industry. This value is close to the critical load for this coastal dry grassland system.

The epigeic lichens found were exclusively *Cladonia* spp. Most species were found outside or in the periphery of the rose scrubs, presumably due to the suboptimal light conditions at the soil surface below the roses. So, most species recorded are typically found in open habitats like dunes and heathlands. The species least influenced by *R. rugosa*, *Cladonia macilenta* Hoffm. and *Cl. merochlorophaea* Asahina, are the most organophilic species observed [16].

The epiphytes, nearly exclusively *Hypogymnia physodes*, which is characteristic for acid bark and sandy substrates in dunes, reveal the nutrient poor conditions of the substrate and indeed the limited impact of atmospheric nutrients. The reason for the total dominance of *Hypogymnia physodes* on dead or dying twigs of *Rosa rugosa* is most probably, that *Hypogymnia physodes* occurred as a part of the epigeic cryptogam community before the

invasion of *Rosa rugosa*.

## 5. Concluding Remarks

This study by no means closes the chapter on the ecology of *Rhynchostegium megapolitanum*. Is the species always confined to early succession stages, or is it becoming an integral element in climax systems? [17] Due to the lack of Danish studies of the species, the national distribution is not well known, and the question of increasing distribution of the species, as suggested by Zechmeister, Moser and Milasowszky [6], can not yet be verified. This study seems to indicate that the ecophysiological range of the species may be broader than previously envisaged. The species is often believed to be confined to relatively nutrient rich substrates with high pH, which clearly is not the case here. Further studies of distribution and growth conditions are needed, before the ecology of this rare bryophyte is understood.

## Acknowledgements

I wish to thank Peter Vestergaard for inspiring collaboration during the field work, data treatment and synthesis. Also thanks to Karna Heinsen and Karin Larsen for assistance in the field with soil sampling, and for soil analyses.

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