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Habitat requirements of *Peniophora junipericola* (Basidiomycota, Russulales)

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Peniophora junipericola is a decayer on dead junipers (*Juniperus communis*). It is locally-common near the shores of the Baltic Sea. The aim of the present study was to characterise its habitat requirements by measuring the diameter of the substrate, as well as the stage of decay and the pH values of the infested twigs. Precipitation at the localities where *P. junipericola* is present was also taken into account. The results of the study show that the fungus can grow on thin and thick juniper branches as well as on hard, newly dead ones and on twigs more or less decayed. Most of its habitats are situated close to the sea.

Introduction

Peniophora junipericola (Fig. 1), a wood-rotting fungi on junipers common in the Baltic states and Scandinavia (*see* Fig. 2), was described more than 60 years ago (Eriksson 1950). Its favourite habitats are located near shores, especially in sunny, periodically warm localities where it grows on dead, but still attached branches or dead trunks of junipers. According to Eriksson *et al*. (1978), it grows on *Juniperus communis* in Sweden, France and Estonia. However, it has also been reported from other juniper species (*Juniperus excelsa, J. oxycedrus, J. semiglobatus, J. virginiana*) in Spain, Macedonia, Ukraine (Crimean peninsula), Kazakhstan, North-West Caucasus, and Louisiana in the United States (García-Manjón & Moreno 1981, Gilbertson & Blackwell 1985, Mukhamedsin 1992, Parmasto & Parmasto 1992, Boidin 1994, Karadelev 1995).

Studies of the genus *Peniophora* have to date been focused on the taxonomy and reproductive compatibility (Boidin & Pomeys 1961, Hallenberg 1984, 1986, 1987, 1988, 1991, Hallenberg & Larsson 1991, 1992, Hallenberg *et al*. 1996), hence, the habitat preferences of *P. junipericola* remain poorly known. Eriksson (1950) mentioned that all its localities are situated close to water (sea, lakes, etc.). According to Parmasto and Parmasto (1992) the distribution pattern very much resembles that of xerothermic species.

The aim of the present study was to characterise habitat requirements of *P. junipericola* by measuring the diameter of the substrate, as well as the stage of decay and the pH values of the infested twigs. Precipitation at the localities

Fig. 1. *Peniophora junipericola in situ* (*Estonia, Hiiu Co., Käina Comm., Kassari, 27 Sep. 2007, Kotiranta 21988 & Sell*). Photo Indrek Sell.

where *P. junipericola* is present was also taken into account. Also the life style of the fungus (parasite/saprobe) is discussed, and how the distance from the sea influences the frequency of infested junipers.

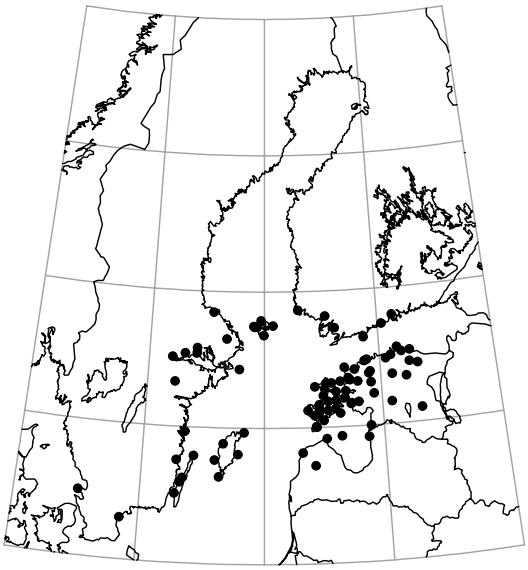

Fig. 2. The distribution of *Peniophora junipericola* in Estonia, Finland, Sweden and Latvia.

Material and methods

The material we studied is preserved in the herbaria TAAM, H, TUR, UPS, S, and GB or in the reference herbarium of Heikki Kotiranta (HK). The 399 specimens studied constitute almost the complete body of collections of *Peniophora junipericola* in Estonia (268), Finland (35) and Sweden (87), also entailing samples from Latvia (9). In all cases, the substrate was *Juniperus communis*.

The substrate diameter of each specimen was measured with the galliper gauge to the nearest 1 mm. The decay stage was estimated using a five-point scale described by Renvall (1995), but modified by us, since Renvall's method is for trunks, not for twigs. The degree of decay was estimated with a fingernail, since a knife is too robust for small twigs. When the substrate of the herbarium specimen was not a twig, but bark, the decay stage was not measured.

In order to measure pH, a modification of the the potentiometric method 943.02 (originally utilised for measuring pH of flour, AOAC 1990) was used. Since only 103 specimens were large enough (at least 5 grams per specimen is required) we were not able to measure the pH of all specimens. The steps of the procedure were as follows: (1) a twig sample was milled to less than 1 mm particle size using a Cyclotec™ Tecator; (2) the particles were mixed with distilled water, and the pH of the solution was measured with a Sentron pH-meter. The measurements were carried out in the Plant Biochemistry Laboratory of the Estonian University of Life Sciences in Tartu.

In addition to the data mentioned above, the locality data given on the label of each specimen were taken into account. The distance of a locality from the sea was evaluated using a map and a ruler and assigned to one of the following classes: (1) 0–2 km, (2) 2–20 km, (3) 21–40 km, (4) 41–60 km, and (5) 61 km or more.

In order to analyze how the amount of precipitation influences the distribution of *P. junipericola*, precipitation data (courtesy of the Estonian Meteorological and Hydrological Institute, the Swedish Meteorological and Hydrological Institute, the Latvian Environment, Geology and Meteorology Agency, and the Finnish Meteorological Institute) from the nearest meteorological station located at the same distance from the seashore, were used. In case there were several meteorological stations near the locality, the average values of two to three stations were used. As the distribution of annual precipitation

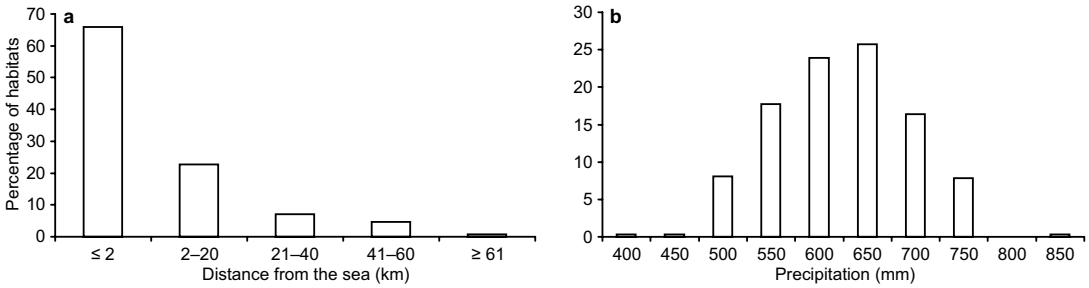

Fig. 3. The habitats of *Peniophora junipericola*. — **a**: Distance of the localities from the sea; — **b**: Localities partitioned by amount of precipitation.

is uneven and the forming period of basidiocarps is not exactly known, the average yearly precipitation was calculated from a longer period, e.g., in Estonia 1961–2007, Finland 1961–2007, Latvia 1966–2007, Sweden 1961–1990 (because all Swedish specimens were collected between 1961 and 1990).

A Spearman rank correlation analysis was used to study associations between variables. Additionally, the principal component analysis (PCA) on the selected variables was performed. Calculations were performed using SAS ver. 9.1.

Results

Diameters of the substrate twigs varied from 0.3 cm to 4.0 cm (mean ± SD = 1.08 ± 0.46 cm, n = 381). The percentage of twigs with a diameter of ≤ 0.5 cm was 8.4% and branches with a diameter ≥ 1.5 cm was 12.6%.

The twigs (n = 341) belonged to decay classes 1–4 (percentages being 70.1%, 21.1%, 7.9% and 0.9%, respectively), and no occurrences of very rotten twigs (5th class) were recorded.

Peniophora junipericola favours strongly acidic (pH_{KCl} ≤ 3.5, 52.4% of the twigs [n = 103]) or acidic (pH_{KCl} = 3.6–4.5, 45.6% of the twigs) juniper twigs. However, it apparently can also grow on moderately acidic twigs (pH_{KCl} = 4.6–5.5, 1.9% of the twigs).

About two thirds (65.7%) of all the localities were situated ≤ 2 km from the sea (Fig. 3a); 22.5%, 6.8% and 4.5% were 2–20 km, 21–40 km and 41–60 km from the sea, respectively. There were only two localities (both in Estonia) > 61 km from the sea.

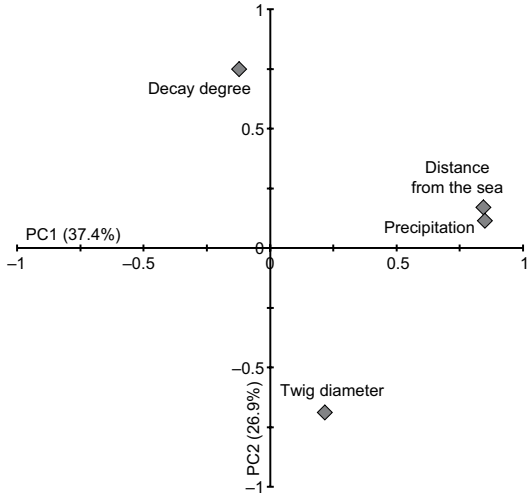

Fig. 4. Principal component analyses for twig diameter, decay degree, precipitation and distance from the sea (n = 331).

Mean (± SD) annual precipitation at the *P. junipericola* localities was 599.5 ± 69.0 mm (range = 396.3–807.5 mm). Almost half of the habitats (49.5%) had the annual precipitation between 551 and 650 mm; at one locality the annual precipitation exceeded 800 mm and at one it was less than 400 mm (Fig. 3b).

We found statistically significant, positive correlation between precipitation at the locality and the distance of the locality from the sea (Spearman r = 0.55, p < 0.001). Correlations between the diameter and the decay degree of twigs (Spearman r = –0.10, p = 0.07), and between the decay degree of twigs and their pH (Spearman r = 0.16, p = 0.10) were not significant.

The first and second principal components of the PCA (Fig. 4) explained 64.3% of the total vari-

ation in twig diameter, decay degree, precipitation and distance from the sea. PC1, characterising the habitat, was positively correlated with precipitation and distance from the sea, and almost not correlated with the decay degree and twig diameter. PC2, characterising the substrate, was positively correlated with decay degree and negatively correlated with twig diameter, but almost not correlated with precipitation and distance from the sea.

In the second PCA, where additionally acidity of the 103 specimens was considered, the relationships between principal components and initial variables used also in the first PCA remained the same. Acidity was positively correlated with PC2 and not correlated with PC1.

Discussion

The results show that *P. junipericola* can grow on thin as well as on thick juniper twigs, or even on stems, with the minimum diameter 0.3 cm (mean = 1.08 cm). *Peniophora pini*, which also infects mostly dead branches, grows on pine twigs (*Pinus sylvestris*) which are 1–2 cm in diameter (Eriksson *et al*. 1978). Jahn (1971) indicated that *P. pini* can grow on thin twigs, with the thickness 0.3 cm which is in line with our findings for *P. junipericola*.

Eriksson (1950) mentioned that juniper branches are very tough and resistant, but those infected by *P. junipericola* are easily broken. The results of our study show that *P. junipericola* grows both on hard, newly dead twigs even with needles still attached, as well as on highly decayed twigs. The basidiocarp formation on newly dead, almost fresh branches, indicates that *P. junipericola* is a parasite, which can continue its growth as a saprobe. Sometimes it was accompanied by *Peniophora pithya* which, however, does not infect living bushes and whose fruitbodies emerge on stems, not twigs. *Amylostereum laevigatum*, which is one of the most common decayers of junipers in the study area, attaches also to living bushes, and the basidiocarp formation on thin twigs is rare.

In the study area, *P. junipericola* grows near the sea coast. As compared with the other areas of the country, the western islands of Estonia, where *P. junipericola* is especially common, are characterized by warm and dry summers, mild autumns and fairly mild winters (Parmasto & Parmasto 1992, Tammets & Jaagus 2007). In some earlier studies (Eriksson 1950, Eriksson *et al*. 1978) *P. junipericola* was reported to occur close to waterbodies. We can now confirm that preference; two thirds of the *P. junipericola* habitats are situated ≤ 2 km from the sea.

As evidenced by PCA, precipitation and distance from the sea had the similar loadings on PC1 (Fig. 4). The decay degree, pH and twig diameter had the highest loadings on PC2, whereby the loadings of twig diameter were opposite to those of decay degree and acidity.

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