



Research papers

Palynological richness and pollen sample evenness in relation to local floristic diversity in southern Estonia

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ABSTRACT

The relationship between palynological diversity and floristic diversity was studied on the basis of sediment surface sample pollen data from nine small lakes and vegetation data within a 250 m radius from the lake shore of each. The nine study areas are situated in the patchy cultural landscape of Southern Estonia and were chosen to represent landscape changes along a gradient from closed forest to open vegetation. Two diversity measures – richness and evenness – were used to compare the palynological and floristic data.

A total of 307 plant species were recorded in the vegetation representing 127 pollen types. Only 52 pollen types were recorded in the sediment surface samples of which 43 had parent plants in the vegetation. Significantly lower floristic richness was found in closed surroundings than in more open surroundings. Study sites with open vegetation also had significantly higher palynological richness (number of pollen types recorded in surface sediments). The additional pollen types recorded in surface sediments from open vegetation were widespread types mostly of insect-pollinated taxa such as *Ranunculus*, Rubiaceae, *Melampyrum*, *Filipendula*, *Potentilla* or *Vaccinium*. The parent plants of these pollen types were frequent in the landscape. This suggests that the main mechanism governing palynological richness in this study was not floristic diversity but rather variance in pollen productivity. Since woodland has a higher pollen production than open areas (grassland and fields) per unit land surface, open areas tend to show a better representation of slightly rarer but widespread herb pollen types. No relationship was found between palynological and floristic diversity of wind-pollinated taxa and tree taxa partly because the pollen source area for these pollen types is much larger than 250 m.

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1. Introduction

Anthropogenic changes in land cover and the recent phenomenon of global warming are considered major threats to global biodiversity (Sax and Gaines, 2003; Brook et al., 2008; Sax and Gaines, 2008). Holocene extinctions of fauna and flora, caused primarily by human activities that lead to loss of natural habitats of plants and animals, are comparable, or nearly so, in rates of species diversity loss to previous mass extinction events (e.g. the Cretaceous–Tertiary extinction event) known in Earth history (Raup and Sepkoski, 1982; Leakey and Lewin, 1996; Lövei, 2001; Barnosky et al., 2011). Therefore, studies of past biodiversity, mechanisms of its maintenance and change through time and space are especially valuable in order to help predict the response of species richness to future climate variability and changing land-use.

Pollen grains are the most abundant and well-dispersed fossil plant remains and analysis of sedimentary pollen records is one of the most powerful methods for reconstructing past vegetation. It is also an

effective tool to detect and understand the effect of climate and land-use changes on landcover composition at various time scales (Elenga et al., 2000; Tarasov et al., 2000; Seppä et al., 2004; Nielsen and Odgaard, 2005; Marchant et al., 2009; Gaillard et al., 2010).

It has often been hypothesised that the number of pollen types in sedimentary assemblages is directly proportional to the floristic diversity of the pollen catchment area (e.g. MacDonald et al., 2008), but the relationship between the palynological diversity and the floristic diversity is still incompletely understood (Odgaard, 2001). Factors, such as achievable taxonomic precision, taxon specific differences in pollen production and dispersal strategies and the spatial scale of sample representation result in nonlinear relationships between pollen and vegetation representation (Prentice, 1985; Sugita et al., 1999). These factors also complicate the interpretation of floristic diversity from pollen data (Odgaard, 1999).

The number of pollen types in sediment samples, the so-called palynological richness (Birks and Line, 1992) is one of the most simple and widely used proxies of past vegetation diversity (Seppä, 1998; Veski et al., 2005; Berglund et al., 2008; Saare et al., 2009; Valsecchi et al., 2010). In contrast, pollen sample evenness has been much less exploited as a diversity measure. However, some recent studies suggest that pollen sample evenness can have a major effect on

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observed palynological richness (Odgaard, 2001; Weng et al., 2006; Peros and Gajewski, 2008).

The aim of this study is to test the hypothesis that palynological richness in lake sediments reflects floristic richness in the surroundings of the lake. We directly compare palynological diversity of sediment surface samples with measures of floristic diversity from a landscape varying along a gradient from closed forest to open vegetation.

2. Material and methods

2.1. Study area

Estonia is located at the northern limit of the boreo-nemoral forest zone. This study was carried out in South-Estonia (Fig. 1A) where the land-cover is patchy and consists of a mixture of forests, mires, cultivated fields, grasslands and settlements. Forests cover about 58% of the area (Pärt et al., 2008). The dominating forest species are: pine (*Pinus sylvestris* L.) - 40%, spruce (*Picea abies* (L.) H. Karst.) - 24%, birch (*Betula pendula* Roth and *B. pubescens* Ehrh.) - 30% of the forested area. Alder (*Alnus incana* (L.) Moench, *A. glutinosa* (L.) Gaertner) and aspen (*Populus tremula* L.) are less abundant (Pärt et al., 2008). The broad-leaved deciduous trees, such as *Acer platanoides* L., *Fraxinus excelsior* L., *Quercus robur* L., *Tilia cordata* Mill. and *Ulmus glabra* Huds. occur in low numbers. The main crops grown in the fields are cereals (*Avena sativa* L., *Hordeum vulgare* L., *Secale cereale* L., and *Triticum aestivum* L.), rape (*Brassica napus* L. em. Metzg.) and potato (*Solanum tuberosum* L.). The most abundant species in the grasslands are graminoids, such as *Agrostis capillaris* L., *Alopecurus praetensis* L., *Dactylis glomerata* L., *Elymus repens* (L.) Gould, *Festuca rubra* L., *F. pratensis* Huds., *Phleum pratense* L. and *Poa trivialis* L. (Kukk and Kull, 2005).

Nine small lakes with median diameter 200 m and between 1 and 14 ha in size were selected for the study (Fig. 1B, Table 1). The greatest distance between two lakes is about 100 km the shortest is 1 km. The lakes were selected according to the following criteria: a regular shoreline with no bays, no major inlets or outlets, not surrounded by extensive mires and no dense settlements within the reach of some kilometres. The lakes were selected along a gradient of different land-cover patterns, and openness varied from 0.5 to 69% within a radius of 250 m (Fig. 2, Table 1).

2.2. Vegetation mapping

Detailed vegetation mapping was implemented within a radius of 250 m around each lake. The 250 m was chosen as a compromise between representativeness and available resources. An inscribed circle was fitted to aerial photos of each lake so that it touched the nearest edge of the lake. A 250 m wide buffer area was defined from the inscribed circle and inside the 250 m wide buffer vegetation was recorded.

The vegetation was surveyed using two methods:

- 1) Plots: On aerial photos (map scale 1:10,000) the 250 m wide band was divided into four equal sectors and in each sector ten 1 × 1 m plots were placed as evenly as possible considering the landscape patchiness. The coordinates of the plots were read from the map and each plot located in the field using GPS. In each of the 40 plots all vascular plant species and their percentage cover were recorded visually.
- 2) Community species list: Inside the 250 m wide band vegetation communities and their borders were identified in the field and a full species list, including abundance estimates, was recorded for each community type. The Braun-Blanquet cover-abundance scale (rare – 1, uncommon – 2, moderately common – 3, frequent – 4, dominant – 5) was used and the estimates were applied visually for the entire community surface.



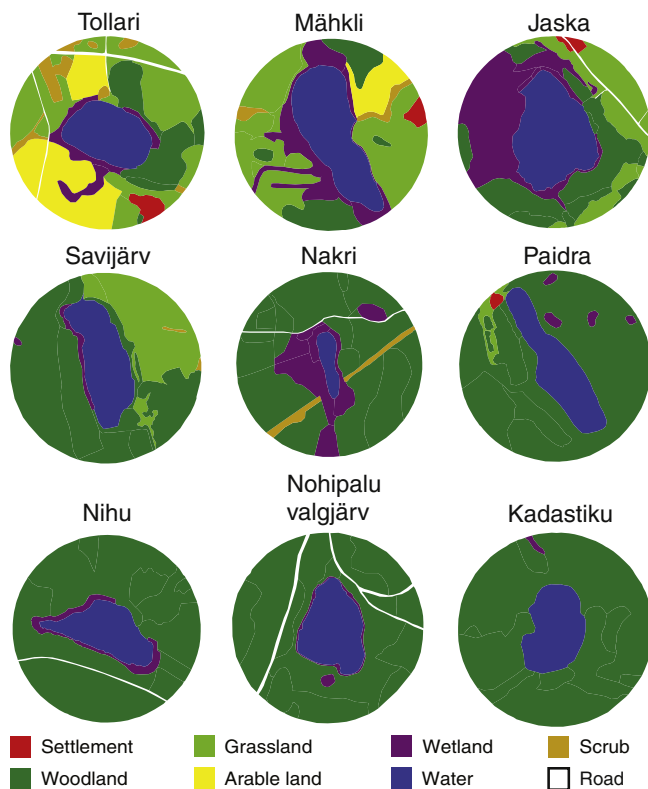


Fig. 2. Land cover maps within a radius of 250 m of the nine lake sites studied.

The vegetation maps were subsequently digitised using MapInfo Professional 7.5 (MapInfo Corporation, Troy, NY, USA).

2.3. Pollen sampling and analysis

From the centre of each lake a sediment sample (upper 1 cm) was taken with a Willner-type gravity corer (produced in Uppsala University), which operates similarly to Kajak-type corers (Glew et al., 2001). The sedimentation rates are known for three of the lakes: Nohipalu Valgjärv ca 1.8 mm yr⁻¹ (Heinsalu and Alliksaar, 2009a), Tollari 0.9 mm yr⁻¹ (Heinsalu pers. comment), and Nakri ca 0.8 mm yr⁻¹ (Heinsalu pers. comm.). Overall, 1 cm of top sediment represents, on average, between 1 and 15 years (Heinsalu and Alliksaar, 2009a, 2009b).

Each sample was homogenised and 2 ml of sediment was taken for pollen analysis. Samples were prepared with standard KOH and acetolysis treatment (Erdtman, 1969) and mounted in silicone oil (Andersen, 1960). A total of 1500 arboreal pollen grains were counted for each sample. Pollen identification was carried out according to keys in Fægri and Iversen (1989) and Beug (2004) and using the modern pollen reference collection of the Department of Botany at the Estonian University of Life Sciences. Polypodiaceae spore types were pooled into one type as the diagnostic perine layer (Fægri and Iversen, 1989) had usually been lost. *Ambrosia*, *Fagus* and *Carpinus betulus* were regarded as exotic and excluded from the dataset prior to the numerical and statistical analyses.

2.4. Diversity measures

Floristic richness (Fr) is the number of taxa recorded per sampling area or per uniform number of observations while **vegetation evenness (Fe)** describes the equality of distribution of species abundances (Magurran, 2004; van Dyke, 2008). **Frp** and **Fep** are the corresponding terms when vegetation is reduced to pollen type equivalents.

Palynological richness (Pr) is the number of pollen types in a pollen sample at a specific counting sum (Birks and Line, 1992;

Odgaard, 1999) while **pollen sample evenness (Pe)** refers to the frequency distribution of pollen types. **P_{rm}** signifies the number of pollen types in a sediment surface sample that have matching parent plants in the vegetation within the 250 m.

All the species identified during the vegetation survey were grouped into pollen-type equivalent taxa according to Fægri and Iversen (1989) and Beug (2004).

2.4.1. Richness

All the identified taxa in the pollen samples and in the vegetation were grouped into sub-sets according to:

- I Life form: 1) trees (trees and scrubs), 2) herbs (herbs, grasses, dwarf shrubs and Pteridophytes);
- II Pollination mode: 1) wind-pollinated taxa, 2) insect-pollinated taxa.

Floristic richness (Fr) was calculated based on the taxon lists from the plots (vegetation mapping method according to point 1 in paragraph 2.2). Since the vegetation plots contained only herb taxa, the tree taxon richness recorded in the community species lists (vegetation mapping method according to point 2 in paragraph 2.2) was added to Fr. Frp was calculated as the number of pollen-type equivalent taxa per site for each sub-set separately. Palynological richness was estimated using rarefaction analysis (Birks and Line, 1992) at the constant counting sum of the subgroup, which is different for each subgroup. The result of rarefaction analysis represents the estimated number of taxa reduced to the lowest pollen sum of samples being compared. The estimated number of taxa [$E(T_n)$] is calculated according to the formula:

$$E(T_n) = \sum_{i=1}^T 1 - \frac{(N-N_i)!(N-n)!}{(N-N_i-n)!N!}$$

where $E(T_n)$ is the expected palynological richness in standardised pollen count N_i , T is the palynological richness in the original pollen count, N is the overall pollen sum, and n is the number of grains selected for standardisation in the rarefied sample (Birks and Line, 1992).

2.4.2. Evenness

We chose the Simpson evenness index ($E_{1/D}$) to calculate Pe and Fe, as ($E_{1/D}$) is an index of evenness, which is independent of the number of taxa (Smith and Wilson, 1996). $E_{1/D}$ is calculated according to the formula:

$$E_{1/D} = \frac{1}{\sum_{i=1}^S p_i^2}$$

where p_i is the proportion of taxon i and S is the total number of taxa in the sample. The $E_{1/D}$ ranges from zero (one taxon is dominant) to one (all taxa are equally abundant). Fep was calculated according to the community species list converted into pollen-type equivalent taxa and the frequency estimates of the taxa there (vegetation mapping method according to point 2 in paragraph 2.2).

3. Results

3.1. Floristic diversity

A total of 307 plant species corresponding to 127 pollen/spore types were recorded. Of these 23 species (representing 18 pollen types) could be classified as trees and 284 (representing 109 pollen/spore types) as herbs. According to the classification based on pollination 114 were wind-pollinated species (representing 29 pollen/spore types) and 192 were insect-pollinated species (representing 98 pollen types). The total loss of resolution in species richness due to the conversion to pollen/spore types was around 60%. Broken down into groups the reduction was 22% for tree species, 62% for herb species, 75% for wind-pollinated species, and 51% for insect-pollinated species. This reduction of

resolution in species richness was mainly caused by the low taxonomic resolution for the pollen of some large families such as Poaceae and Cyperaceae. The members of these two families alone when converted to pollen equivalent taxa diminished the species richness of wind-pollinated taxa by about 55%.

Floristic richness (Fr and Frp) was strongly correlated with vegetation openness (Fig. 3A, B) and was highest around Tollari, Jaska, Nakri and Mähkli.

Vegetation evenness (Fep) was highest around Nakri, Tollari, Mähkli and lowest around Paidra and Nihu (Table 2).

3.2. Palynological diversity

The total number of pollen/spore types determined was 52, which corresponded to only 41% of the floristic richness of pollen/spore types (Frp) and was less than 20% of the total species richness (Fr). According to life form there were 11 tree pollen types (61% of Frp of tree pollen taxa) and 41 herb pollen/spore types (38% of Frp of herb pollen/spore types). Twenty six of the pollen/spore types were derived from wind-pollinated plants (90% of Frp of wind-pollinated pollen/spore taxa) while 26 were from insect-pollinated plants (27% of Frp of insect-pollinated pollen taxa).

Palynological richness (Pr) was correlated with vegetation openness (Fig. 3C) and was highest in sediments from Nakri, Tollari and Jaska (Table 2).

Pollen sample evenness (Pe) was 2–4 times lower than the vegetation evenness (Fep, Table 2). The highest Pe was recorded in lakes Mähkli, Kadastiku and Savijärv and the lowest in lakes Nohipalu

Table 2
Palynological and floristic diversity of the study sites.

Lake name	Floristic diversity			Palynological diversity	
	Fr	Frp	Fep	Pr[E(T1612)]	Pe
Tollari	163	78	0.429	34	0.107
Mähkli	153	71	0.409	31	0.139
Jaska	147	74	0.384	32	0.119
Savijärv	110	55	0.399	28	0.132
Nakri	118	71	0.443	33	0.128
Paidra	99	58	0.245	30	0.132
Nihu	80	46	0.326	26	0.119
Nohipalu Valgejärv	83	54	0.349	30	0.104
Kadastiku	101	53	0.345	28	0.132

Valgejärv, Tollari and Nihu (Table 2). Pe was generally low because of the dominance of four wind-pollinated tree taxa – *Betula*, *Pinus*, *Alnus* and *Picea*, accounting for 80–99% of the total pollen sum (Fig. 4). *Betula* was especially important in determining total Pe. *Betula* pollen percentages and Pe were negatively correlated ($r = 0.83$, $p = 0.006$).

Pollen sample evenness (Pe) was not correlated with palynological richness (Pr).

3.3. Palynological diversity in relation to floristic diversity

A total of 43 pollen/spore types (10 trees and 33 herbs) were found both in the sedimentary samples and as parent plants in the vegetation (Appendix 1). Total palynological richness (Pr) and total floristic richness (Frp) were positively correlated (Fig. 5A). There was also a statistically significant positive relation between Pr and Frp of insect-pollinated taxa (Fig. 5D). However, there was no statistically significant relationship between Pr and Frp of herb taxa, between Pr and Frp of tree taxa, or between Pr and Frp of wind-pollinated pollen taxa (Fig. 5B, C, E). Most of the insect-pollinated taxa detected in pollen samples were also represented by their parent plants in the vegetation (Appendix 1). In contrast, in pollen samples wind-pollinated taxa were often not present within a radius of 250 m. The same applies to some insect-pollinated taxa (*Filipendula*, *Tilia* and *Calluna*), which can shift their pollination mode towards anemophily after the insects have visited the flowers (Hesse, 2000). In the present study 61–75% of Frp had no matching pollen types in the sediment samples.

There is a positive correlation between Frp and Prm (Fig. 6A). However, the additional pollen types at high Frp sites, which are missing at low Frp sites, are types from common plants such as *Filipendula*, *Artemisia*, *Ranunculus*, *Melampyrum*, *Plantago lanceolata* and *Potentilla*. Two thirds of the additional types were recorded as parent plants in more than half of the lake surroundings (Appendix 1). Most of the additional plant taxa at sites with high Frp were not recorded as pollen types in the sediment samples (Fig. 6B).

There was a positive correlation between Pr and vegetation evenness (Fep) although it is not statistically significant ($r = 0.58$, $p = 0.105$). There was no statistically significant correlation between Pe and Frp ($r = -0.07$, $p = 0.823$), or between Pe and Fep ($r = -0.08$, $p = 0.836$).

4. Discussion

Our results reflect a statistically significant correlation between floristic richness and palynological richness when large pollen sums are used (>1500). However, while the Frp gradient is 46–78, the corresponding Pr gradient is only 26–33 resulting in a low slope of the regression line (Fig. 5A). This reflects that the higher the floristic richness is the more it will be underestimated by the palynological richness of sediment samples. In other words, there are a large number of pollen type equivalent taxa (66%), the pollen of which are rarely, if ever, recorded in sediments.

The pollen counts of the sediment pollen samples are very small compared to the total amount of pollen produced in the pollen source

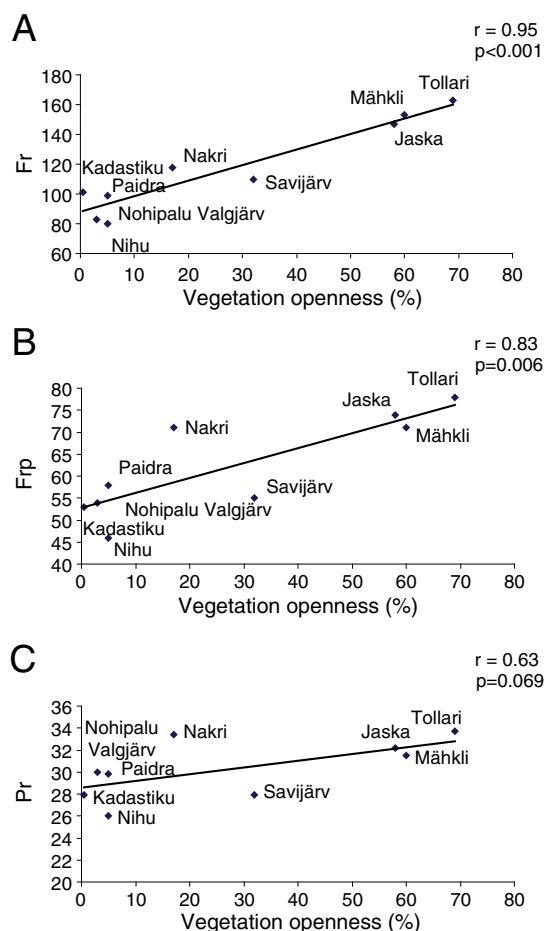


Fig. 3. The relationships between vegetation openness (%) and richness estimates. A – floristic richness (Fr); B – floristic richness of pollen types (Frp); C – palynological richness (Pr).

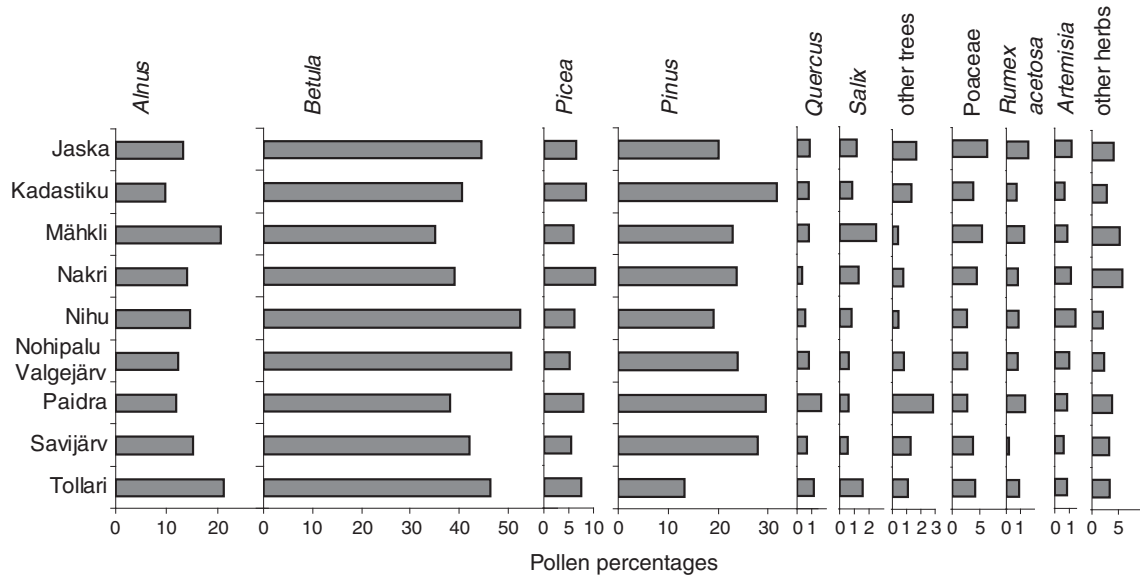


Fig. 4. Pollen percentages from the nine study lakes.

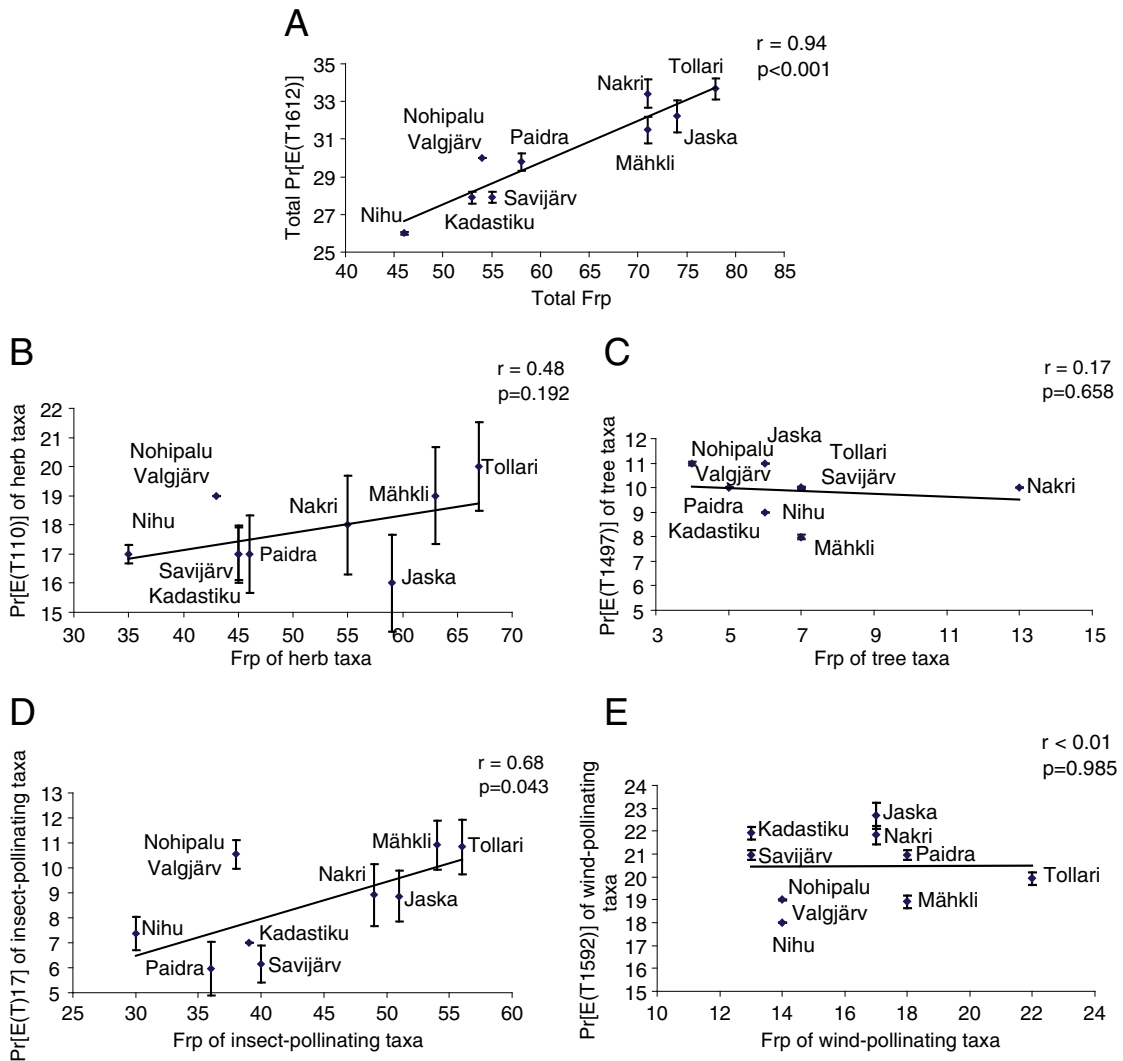


Fig. 5. The relationship between palynological richness (Pr) and floristic richness (Frp). A – all taxa; B – herb taxa; C – tree taxa; D – insect-pollinating taxa; E – wind-pollinating taxa.

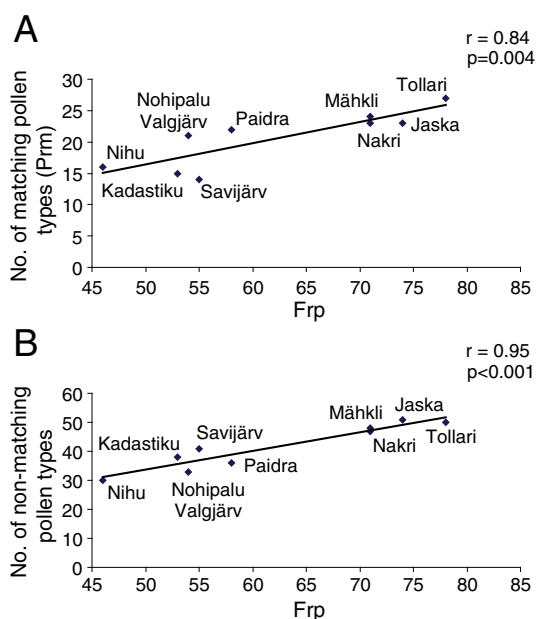


Fig. 6. A – The relationship between floristic richness of pollen types (Frp) and number of pollen types from sediment samples that have matching parent plants in the vegetation; B – The relationship between Frp and number of pollen types from sediment samples that did not have matching parent plants in the vegetation.

area over the years represented in the sample, probably in the order of $1:10^{16}$ – 10^{17} (Odgaard, 2007). It is, therefore, likely that correlations between palynological richness (Pr) and vegetation richness (Frp) are mediated through secondary mechanisms rather than being direct. The indirect mechanisms causing the correlation between Frp and Pr may be at least two, both related to the vegetation openness. A) Pollen dispersal in open habitats can be expected to be more efficient than in forested ones due to generally higher wind speeds and stronger convection over open areas. Therefore, pollen from herbaceous plants may have a better chance to become airborne and reach a lake surface in open landscapes than in forested ones. B) Pollen productivity is lower in open areas than in wooded areas because trees generally have much higher pollen productivities than herbs and dwarf shrubs (Broström et al., 2008). For this reason pollen types of herbs may be better represented in samples from open areas. If mechanism A was important, pollen types from local populations would be expected to be well represented in the sediment pollen samples from open areas. However, the fact that the additional pollen types at highest Pr are all widespread types from plants common in the landscape suggests that mechanism B is more important.

The vegetation maps for this study were constructed for an area with a radius of 250 m from the shore of the sampling site. This radius was found to be sufficient for insect-pollinated herb taxa, when investigating the pollen-vegetation relationships of heathlands, meadows and pastures (Hjelle, 1997, 1999; Bunting, 2003; Broström et al., 2004). These moss polster studies show that for the entomophilous species the source area could be only a few metres from the sampling site (Hjelle, 1997; Bunting, 2003). For anemophilous species with high pollen production and low fall speed the pollen source area is certainly larger (Bradshaw and Webb, 1985; Sugita, 1993, 1994; Calcote, 1995; Hjelle, 1998). Poska and Pidek (2010) showed when modelling pine pollen distribution that the major pollen source area for pine could extend over several kilometres. Further studies of Fr and Pr for wind-pollinated taxa within the relevant source area of pollen (defined by Sugita (1994) as the area around the basin beyond which the correlation between pollen and vegetation data does not improve) of a sedimentation basin would be necessary to understand the mechanisms

governing the palynological richness of wind-pollinated taxa in sediment samples.

Odgaard (2001) suggested that more attention should be paid to pollen sample evenness (Pe) rather than to palynological richness (Pr) as Pr theoretically may depend on the Pe. Many studies show that the detection of rare pollen taxa is hampered for pollen assemblages dominated by a few taxa with high pollen productivity and as a result Pr is apparently lowered (Odgaard, 2001; Räsänen et al., 2004; Weng et al., 2006; Peros and Gajewski, 2008; van der Knaap, 2009). In the present study, however, Pe was found to be uncorrelated with the both floristic and palynological richness. This lack of correlation could partly be caused by the usage of different evenness indices by different authors. Some evenness indices are influenced by richness (Smith and Wilson, 1996) and in that case a correlation between Pr and Pe may be induced. Another reason could be that pollen sample evenness of the nine study lakes was found to be rather similar (Table 2), the range being only 0.027 units.

5. Conclusions

The results of our study showed that there was a considerable reduction (about 60%) in richness when floristic species richness (Fr) was transformed into pollen equivalent taxa (Frp). A positive and statistically significant relationship was found between total Frp and Pr and between Frp and Pr of insect-pollinated taxa. The facts that the slope of the relationship was low, that sample to population ratios are extremely small and that almost all additional pollen types at highest Pr were of widespread herb pollen types suggest that the relationships between Pr and Frp in this study were controlled by general differences in pollen productivities between forested and more open vegetation.

The relationship between the palynological and the floristic diversity of wind-pollinated taxa, herb taxa and tree taxa was not found to be statistically significant. These findings may be caused by the complications mentioned above combined with the likelihood that source areas of wind-pollinated taxa are generally much larger than the radius of 250 m used in this study.

Finally, we found no relationship between the evenness of pollen samples (Pe) and palynological richness (Pr).

Studies relating floristic richness to palynological richness are hampered by the large field work resources required to document vegetation diversity. In this study we report results from a limited number of sites (nine) but the results are consistent. The landscape of South-Estonia is patchy and the whole study area could be considered as one homogeneous landscape and, therefore, comparing sites within one region may result in a relationship between Frp and Pr. But still our results clearly reflect that the relationship between the floristic richness and the palynological richness of sediments is complex. These results strongly indicate that palynological richness should not be considered a reliable proxy of floristic richness, especially when comparing sites from different regions or landscapes.

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**Appendix 1. Pollen types recorded in the lake sediment samples (P) that had matching parent plants in the vegetation within 250 m (V).
Pollination mode: 1 – wind-pollination; 2 – insect-pollination**

Pollen/spore type	Pollination mode		Tollari		Mähkli		Jaska		Savijärv		Nakri		Paidra		Nihu		Nohipalu Valgjärv		Kadastiku		
	1	2	P	V	P	V	P	V	P	V	P	V	P	V	P	V	P	V	P	V	
	Trees and shrubs																				
<i>Alnus</i>	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Betula</i>	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Corylus</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Fraxinus</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Picea</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Pinus</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Quercus</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Salix</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Tilia</i>		+	+				+				+			+			+			+	
<i>Ulmus</i>	+		+				+				+			+			+			+	
Herbs, grasses, small shrubs and Pteridophytes																					
<i>Apiaceae</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Artemisia</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Asteraceae</i>		+			+						+		+				+		+		+
<i>Brassicaceae</i>		+	+		+				+		+		+				+		+		+
<i>Calluna</i>		+			+						+		+			+		+		+	+
<i>Cerastium</i>		+			+		+		+		+		+		+		+		+		+
<i>Cerealia</i>	+		+		+		+		+		+		+				+		+		+
<i>Chamaedaphne</i>		+									+			+			+		+		+
<i>Chenopodiaceae</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Chrysosplenium</i>		+			+		+		+				+				+		+		+
<i>Cichorioideae</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Cirsium</i>		+			+		+		+		+		+		+		+		+		+
<i>Cyperaceae</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Ericaceae</i>		+	+				+		+		+		+		+		+		+		+
<i>Filipendula</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Galium</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Lycopodium annotinum</i>	+						+		+		+		+		+		+		+		+
<i>Melampyrum</i>		+					+		+		+		+		+		+		+		+
<i>Plantago lanceolata</i>	+				+		+		+		+		+		+		+		+		+
<i>Plantago major/media</i>	+				+		+		+		+		+		+		+		+		+
<i>Poaceae</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Polygonum sect. Persicaria</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Polypodiaceae</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Potentilla</i>		+			+		+		+		+		+		+		+		+		+
<i>Ranunculus acris</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Rosaceae</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Rumex acetosa</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Secale cereale</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Solidago</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Trifolium</i>		+	+		+		+		+		+		+		+		+		+		+
<i>Typha latifolia</i>	+		+		+		+		+		+		+		+		+		+		+
<i>Urtica</i>	+				+		+		+		+		+		+		+		+		+
<i>Vaccinium</i>		+			+		+		+		+		+		+		+		+		+

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