1. Introduction
Several hypotheses concerning the factors which determine phytodiversity were examined. Most of these hypotheses are dealt with the species- Richness of vascular plant communities; very few papers about the processes controlling diversity of bryophytes and lichens exist. Ecological studies from dry grasslands in the southern part of Öland were used to study patterns of both vascular plant and cryptogam species-richness, and these were compared. Because of the non-linear species-area relationship, comparison of species-richness between different areas causes considerable methodological problems. In addition, comparing species-Richness of communities both rich and poor in cryptogams raises the question of scale-dependence in research of this kind.

HOBOHM (1998, 2000) proposed the α-index as a scale-independent measure of species richness. It is deduced from the powerfunction assuming that there is a linear log-log relationship between species number and area. Whereas several studies found such a linear log-log-relationship for bigger areas, for example whole islands or regions, only few empirical data are available for small plots. In most cases only the species-area function of vascular plants were regarded, but not that of bryophytes and lichens.

Both total, and group-specific species-area relationships of the dry grassland communities on the Great Alvar were investigated.

2. Methods
During May 20th and July 31st 2001, 469 phytosociological relevés (each 4 m²) of dry grasslands were carried out in the southern part of Öland. Spearmann’s rank-order correlation was used to examine the relationships between group-specific diversity measures and different environmental and structural variables. After standardizing the data, the principal component analysis SPSS was also applied using a correlation matrix. All analyses were carried out using the SPSS statistics package.

To examine the effect of scale on the species-richness-results, we studied the species-area relationship at each of the four islands or regions. Spearman’s rank-order correlation was used to examine the relationships between group-specific diversity measures and different structural/environmental parameters. The cover of cryptogams did not influence the species richness of vascular plants, although a slightly positive effect was observed. ‘Evenness’ was positively associated with the number of cryptogam taxa, but we found no correlation between it and the number of vascular plants.

3. Results
3.1 Uneven distribution of phytodiversity in different types of dry grasslands
The dry grasslands studied showed differing phytodiversity (fig. 1). Species numbers ranging from 7 up to 80 per 4 m² plot. The mean species number was highest in the associations of the Sedo-Scleranthena (A, communities on shallow skeletal soils) followed by the Festuco-Brometea (C, grassland on sandy soils). Species number was at its maximum in the Gypsophilo-Globularietum (A, 54.4) and at its minimum in the Corunciolum ascellulare-Corynephorenio carcinosum (B1, 8). The distribution of bryophytes and lichens varied between 8% and 74%.

As expected, cryptogam and vascular plant species richness were affected by environmental factors. Of all tested environmental variables, soil pH, carbon content and soil depth showed the strongest correlation with species density, the first two being negatively correlated with the number of vascular plant taxa and positively correlated with that of lichens and bryophytes. For the third, the opposite was observed. The factors were intercorrelated to a highly significant level and also associated with the percentage cover of bare rocks. Less easily explained were the results for ‘wetness’ (F Ellenberg-value) and ‘micro-relief’; both were positively associated with the number of cryptogam taxa, but there was no significant correlation with the number of vascular plant taxa.

The first two axes extracted by principal component analysis were associated with species-richness at a highly significant level (fig. 4). Environmental and structural factors correlated with axis 1 seemed to affect cryptogam species diversity, whereas those correlated with axis 2 may have influenced species Richness of communities rich in vascular plants. An interesting observation is that factor 2 is not only positively correlated with the number of vascular plants, but also with that of cryptogams. Axis 1 separated the cryptogam dominated communities of the Sedo-Scleranthena from those of the Koelerio-Corynephorenio and Festuco-Brometea. The plots of these groups showed a great overlap, but those of the latter tend to lie more in the upper half of the graph.

4. Discussion/Conclusion
It is clear from this study that more than one model is needed to explain the complex phenomenon of ‘species richness’. For dry grassland types, the variables affecting diversity of communities dominated by cryptogams are different from those affecting communities with high densities of vascular plants. The correlation analysis showed clear differences between the distribution of cryptogam and vascular plant phytodiversity (tab. 1). Cryptogam species density decreases with increasing cover of vascular plants (fig. 3a), indicating that competition with vascular plants influences cryptogam diversity. In contrast, species-richness of vascular plants showed a strong linear increase with increasing cover (fig. 3b). Hence inter-specific competition seems not to affect within-group diversity. The cover of cryptogams did not influence the species density of vascular plants, indeed a slightly positive effect was observed. ‘Evenness’ was positively associated with the number of cryptogam taxa, but we found no correlation between it and the number of vascular plants.

3.2 Associations between total and group-specific species-richness and structural/environmental variables
The correlation analysis showed clear differences between the distribution of cryptogam and vascular plant phytodiversity (fig. 1). Cryptogam species density decreased with increasing cover of vascular plants (fig. 3a), indicating that competition with vascular plants influences cryptogam diversity. In contrast, species-richness of vascular plants showed a strong linear increase with increasing cover (fig. 3b). Hence inter-specific competition seems not to affect within-group diversity. The cover of cryptogams did not influence the species density of vascular plants, indeed a slightly positive effect was observed. ‘Evenness’ was positively associated with the number of cryptogam taxa, but we found no correlation between it and the number of vascular plants.

3.3 Species number-area relationships
The small-scale species-area functions (1 cm² to 9 m²) of all investigated Alvar communities mainly showed the same picture. They generally followed a linear trend in the log-log representation but become gradually steeper for very small areas (fig. 5a). Comparison of the species-area curves for vascular plants and cryptogams showed that those for the lichens and bryophytes start to flatten at an area of 9 m² whereas the number of vascular plants still shows a strong increasing trend at this scale (fig. 5b).

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Fig. 1: Means of total and group-specific species numbers per 4 m² for the dry grassland communities studied. In addition, the proportions of vascular plant, bryophyte and lichen taxa are shown. A1-B6: associations of the Koelerio-Corynephorenio (A), Sedo-Scleranthena (B1), Festuco-Brometea (B2-B6). C1-C4: associations of the Festuco-Brometea.

Fig. 2: The Gypsophilo-Globularietum on the Great Alvar is dominated by cryptogams (35.9 cryptogam taxa, 74% of all species). It grows on shallow skeletal soils or bare limestone.

Fig. 3a: Correlation of number of cryptogam taxa per 4 m² plot and percentage cover of vascular plants (r = -0.576, n = 469).

Fig. 3b: Correlation of number of vascular plant taxa per 4 m² plot and percentage cover of vascular plants (r = 0.544, n = 469).

Fig. 4:ordination of the plots by principal component analysis carried out on the standardized data of the ecological and biodiversity parameters.