MORPHOMETRY OF *FESTUCA BOSNIACA* KUMM. ET SENDTN. (POACEAE) AND RELATED SPECIES

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BACKGROUND & AIMS

The genus *Festuca* L. comprises perennial grasses with leaf blades mostly rolled or conduplicated; inflorescence in form of a panicle composed of two- to several-flowered spikelets; with specific upper glume, lemma and awn morphology. (**Figure 1**). *Festuca bosniaca* and its closely related species within *F. varia* complex occupy large area and diverse habitats in southern Europe, thus exhibiting a variety of morphological characters in leaf and panicle morphology. As a part of the AmphiAdriPlant project we investigate morphometry, phylogeny and genetics of *F. varia* complex in span over the Balkan and Apenine Peninsulas and the Alps (**Figure 2**). This poster presents first results on morphometry of *F. varia* complex through plot visualizations and PCA analysis of selected morphometry characters, along with RDA analyses on morphometry, geography and environmental conditions.

MATERIALS & METHODS

A total of 112 individuals divided through 34 populations representing seven species (*F. adamovicii*, *F. bosniaca*, *F. calva*, *F. cyllenica*, *F. eskia*, *F. varia* and *F. versicolor*) were collected along the Balkan and the Apennine Peninsulas and the Alps **(Figure 2)**. Most important diagnostic morphometric characters (anatomical and habitus) considering leaf and panicle segment were measured (abbreviations in **Table 1**). Quantitative morphometric characters between closely related species were examined with exploratory data analysis and ANOVA, Tukey post hoc and Kruskal-Wallis which were performed in order to obtain significant ($p<0.01$) characters within the dataset. This process generated ten characters used in the subsequent PCA analysis. Additionally, we performed RDA to test morphometric multivariate variation in response to explanatory environmental and geographical data variation.

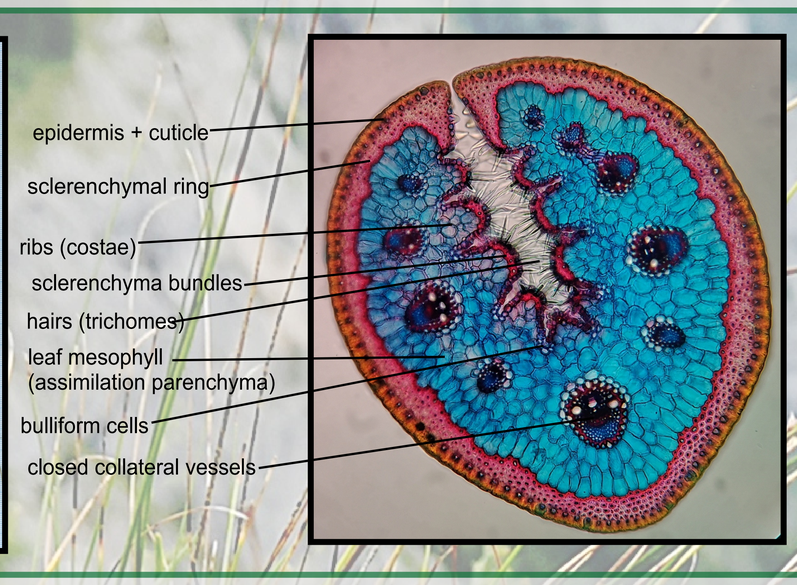


Figure 1. LEFT: *F. bosniaca* habitus with inflorescence showing most important parts of the plant which is quantified and measured. **RIGHT:** *F. bosniaca* leaf cross-section showing most important anatomical characters that were measured and quantified.

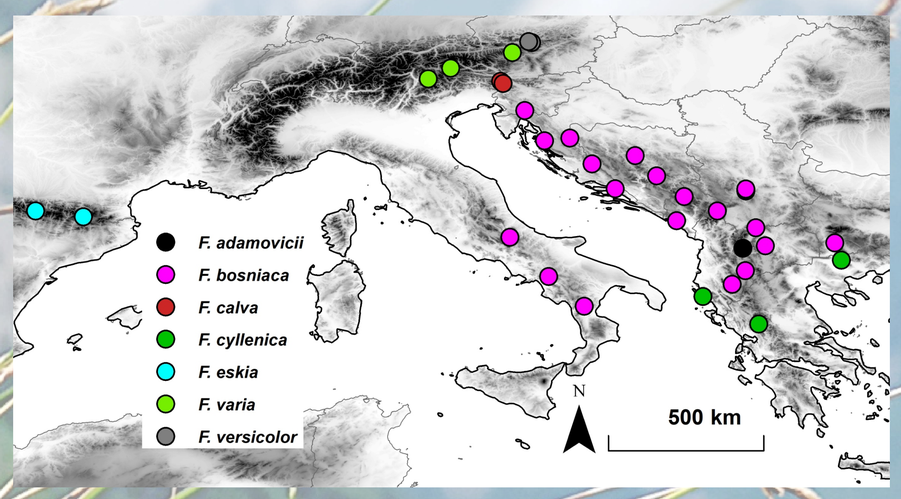


Figure 2. Map of sampled *Festuca* populations divided into seven species.

Table 1. Measured morphological characters and their abbreviations.

Abbreviation	Character
NoVB	No. of vascular bundles
NoRb	No. of ribs
NoSk	No. of sclerenchym bundle
LD	leaf diameter
LT	leaf thickness
Lwmax	maximum width
LAWmax	maximum leaf arm width
cRW	central rib width
cVBH	central vascular bundle height
LL1	average tiller leaf length
PlH	plant height
PL	panicle length
ShL	sheath length
NoSp	number of spikelets in panicle
Br1L	length of the first branch of panicle
NoFl	no of flowers in spikelet
SpL	spikelet length
SpL4	spikelet length up to fourth flower
G1L	length of the lower glume
G1W	width of the lower glume
G1NoV	number of veins on a lower glume
G2L	length of the upper glume
G2W	width of the upper glume
G2NoV	number of veins on an upper glume
LemL	lema length
LemW	lema width
PalL	palea length
PalW	palea width
AwnL	average awn length in spikelet
NoVLem	number of veins on lema

RESULTS

Our results showed very little or no species-specific discriminatory characters, suggesting that taxonomic identification based on selected morphological characters remains very challenging.

Represented through nine most significant morphological characters (their value distribution shown on boxplots for each species, **Figure 3**), *F. adamovicii*, *F. eskia* and *F. cyllenica* mostly overlap with *F. bosniaca*, while *F. calva*, *F. versicolor* and *F. varia* form separate clusters (**Figure 4, LEFT**). Ranges of morphological parameter values are largest for *F. bosniaca* which corresponds to higher number of populations and individuals measured. Generally, *F. versicolor* and *F. varia* (mostly represented in the Alps) had smallest values of all parameters with the exception of central rib width.

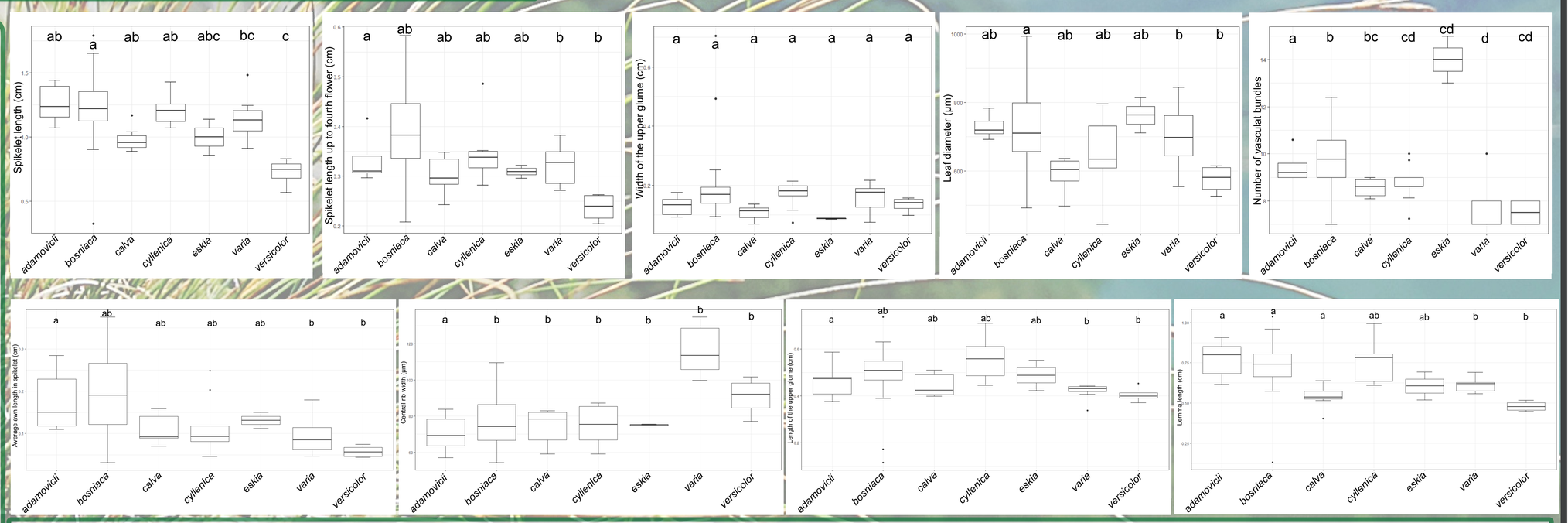
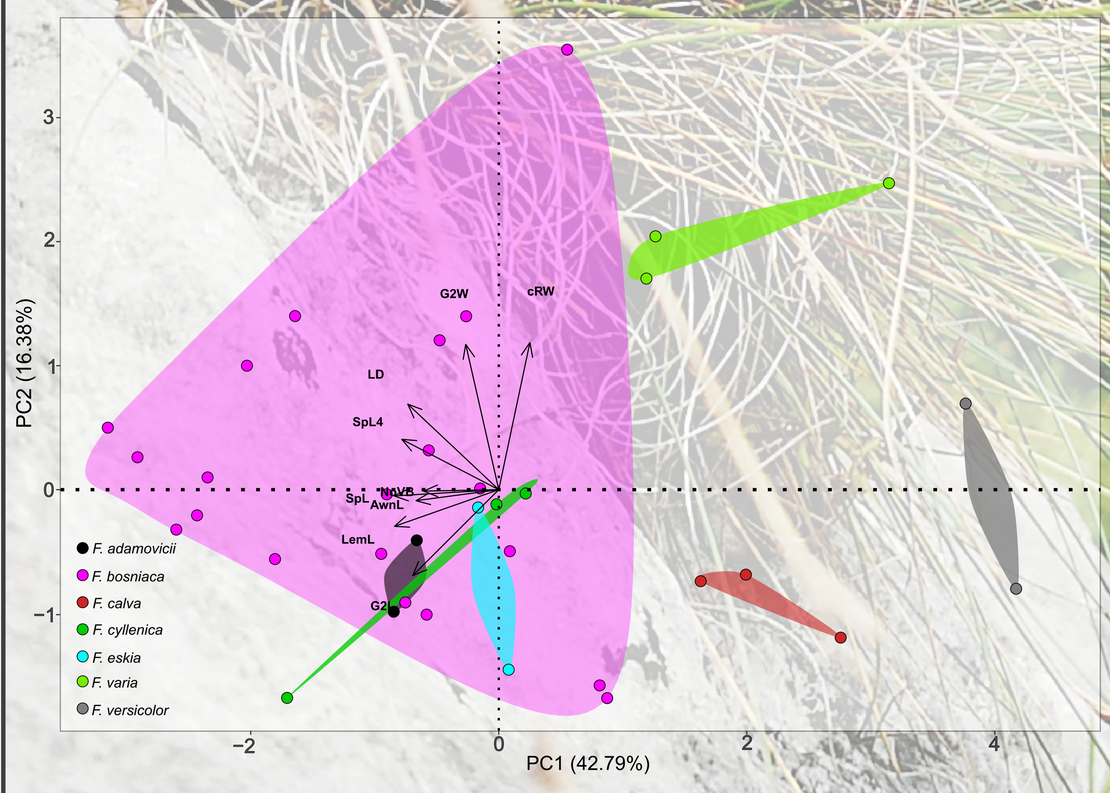


Figure 3. Boxplots showing morphometrical differences along the nine most important morphometry variables revealed by Kruskal Wallis test as significantly different between species within *F. varia* complex. Means not significantly different at $p<0.01$, according to the Tukey post-hoc test, are indicated by the same letter above the boxplots.



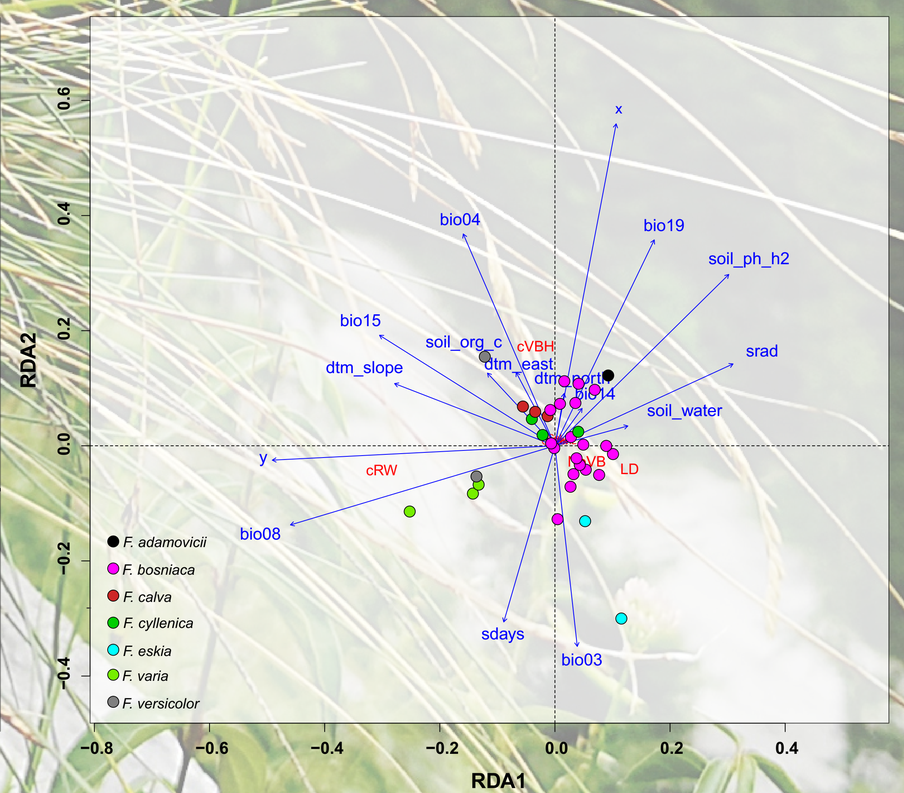


Figure 4. LEFT: Principal component (PCA) based on 9 most significant morphological characters and 34 populations belonging to seven species from *F. varia* complex. **RIGHT:** Redundancy analysis (RDA) plot of the full RDA model including environmental and geographical variables as explanatory variables (matrices) in relation to the variability of 9 morphological characters measured in 34 populations of *F. varia* complex. **Environmental variables abbreviations:** bio03: isothermality; bio04: temperature seasonality ; bio08: mean daily air temperatures of the wettest quarter; bio15: precipitation seasonality; sdays: no. of snow days per year; soil_water: soil water content at 33kPa; srad: surface solar radiation; dtm_slope: slope; soil_org_c: soil organic carbon content; dtm_north: northness; dtm_east: eastness; soil_ph_h2: soil pH x 10 in H_2O; x: longitude; y: latitude.

RESULTS

Combined morphometry with environmental and geographical variables showed differences in correlation of some phenotypes (e.g. *F. versicolor*) with geography and environmental conditions. Additionally, populations within *F. eskia* show divergence from the rest of the populations when shown on combined RDA plot (**Figure 4, RIGHT**).

CONCLUSIONS

These results suggest that species identification and differentiation within *F. varia* complex is extremly difficult. Sampling efforts need to be broaden and more individuals measured in respect to other species, rahter than *F. bosniaca sensu stricto*. Accompanying research investigating phylogenetical identification of these species suggest also difficult dicrimination of species within *F. bosniaca sensu lato* (*adamovicii*, *cyllenica*, *varia*), however, *F. versicolor* and *F. calva* correspond to well-established clades suggesting that differences within morhological parameters could be used for correct identification.

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