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An approach to the study of morphological relationships among the sweet vernal grasses (*Anthoxanthum*: *Poaceae*, *Pooideae*) in the Iberian Peninsula

Abstract

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The genus *Anthoxanthum* L. (*Poaceae*: *Pooideae*) is distributed throughout Europe, Asia, Africa, and the Mediterranean Region is considered its Centre of Diversification. This genus includes annual and perennial species, but the taxonomic status in some of them is doubtful.
The purpose of this study was to establish morphological relationships and clarify the taxonomic status of the taxa present in the Iberian Peninsula using a statistical approach. Twenty-two wild populations of the different taxa were analized: seven for *A. odoratum* L., seven for *A. aristatum* Boiss., six for *A. amarum* Brot. and two for *A. ovatum* Lag. A total of twenty-one characteristics (quantitative and qualitative) were studied in 30 - 35 samples from each population.
Statistical analysis was achieved using the program SPSS 10.0. A principal component analysis was employed to determine which of the characteristics studied could be used to best characterise each taxon. With the previously selected characteristics the relationships among populations were established using the Phi coefficient for qualitative data and the Manhattan distance for quantitative values. These relationships were represented in two phenograms obtained using UPGMA clustering methods.

Introduction

The genus *Anthoxanthum* (*Poaceae*, *Pooideae*), commonly known as sweet vernal grasses, is distributed throughout Europe, Asia and Africa. A variable number of species has been reported for this genus, making its morphological characterisation difficult and generating certain disagreement about its taxonomic status. According to Gould & Shaw (1992) four species may be distinguished, while Dahlgren & al. (1985) consider that 20 is the correct number. Nicora & Rugolo (1987) on the other hand defend the existence of around 15 species.

In the Iberian Peninsula, four of the seven species of known European distribution can be found (Tutin & al. 1980): *Anthoxanthum amarum* Brot., an endemic species from NW Iberian Peninsula, *Anthoxanthum odoratum* L., covering the entire Peninsula, *Anthoxanthum aristatum* Boiss., with a latimediterranean distribution and *Anthoxanthum ovatum* Lag., limited to the E and SW Mediterranean region. Within the two latter species several subspecies or varieties have been described (Paunero 1953; Valdés 1973; Valdés & al. 1987).

Although differentiation among *taxa* is based on their life-cycles (perennial and annual), plant height, panicle shape, the length and shape of the sterile lemma, and awn length, numerous exceptions have been published (López- González 1994).

Materials and methods

Samples for morphological analysis, selected based on previously revised material from different Herbaria (MA, SANT, SEV and UNEX), were obtained from 22 populations found throughout western Iberian Peninsula. For each population 30-35 samples were collected and identified using monographic papers on this genus (Paunero 1953; Valdés 1973). For each sample 21 taxonomically interesting quantitative and qualitative characters were studied (Table 1).

To shed light on the behaviour of the different characteristics in each population the coefficient of variation was calculated. Also, a principal component analysis was carried out to determine which of the morphological quantitative characteristics had the greatest importance to explain the sample variance. Finally, a discriminant analysis (DA) was performed to check if the identifications attained agreed with the taxa. Qualitative characters were analized using a contingency table analysis.

With the previously selected characters, the relationships among populations were established using the Phi coefficient for qualitative characters and the Manhattan distance

Table 1. Quantitative and qualitative morphological characteristics analyzed.

Characteristics	Mesure type	Code of clustering
Size	Quantitative	-
Leaf length	Quantitative	-
Leaf width	Quantitative	-
Inflorescence length	Quantitative	-
Spikelet length	Quantitative	-
Lower glume length	Quantitative	-
Upper sterile floret length	Quantitative	-
Upper sterile floret width	Quantitative	-
Fertile lemma length	Quantitative	-
Sheath hairiness	Qualitative	-
Ligule shape	Qualitative	L (0.- Truncate; 1.- Acute)
Stems tuberous at base (yes/no)	Qualitative	B (0.- Stem not tuberous; 1.- Stem tuberous)
Stoloniferous plant (yes/no)	Qualitative	ES (0.- Stoloniferous; 1.- Not stoloniferous)
Glumes hairiness	Qualitative	G (0.- Glabrous; 1.- Hairy)
Upper glume mucronate (yes/no)	Qualitative	-
Awn shape (straight or elbowed)	Qualitative	A (0.- Truncate; 1.- Acute)
Sterile florets hairiness	Qualitative	-
Degree of covering of the steril florets over the fertile one (yes/no)	Qualitative	FL (0.- Covered; 1.- Uncovered)
Leaf hairiness	Qualitative	F (0.- Glabrous; 1.- Hairy)
Spikelet reddish (yes/no)	Qualitative	E (0.- Green; 1.- Reddish)
Upper sterile floret with a forked apex (yes/no)	Qualitative	ET (0.- without forked apex; 1.- With it)

for quantitative data. The phenograms were obtained using UPGMA clustering methods. The program SPSS 10.0 was used for these analyses.

Results and discussion

The pattern of variation found was constant in all populations. The vegetative characteristics were more variable than the floral ones, and the coefficient of variation was higher in the annual species (C.V. > 0.32) than in the perennials, in which *A. odoratum* (C.V. > 0,25) was more variable than *A. amarum* (C.V. > 0,20).

The quantitative characteristics studied were strongly correlated and all were necessary for the differentiation of each taxon. As a result of the principal component analysis, two components were obtained to explain the 97% variance observed, which included all characteristics. The most important traits in the first component were: panicle length, flower length and leaf width. On the other hand, the lemma width of sterile florets, which is normally considered an important characteristic in the differentiation of these taxa, was found in the second component with low weight. This finding justifies the existing confusion in the identification of the different species. Figure 1 shows the DA values based on quantitative characters and a certain continuity between species can be observed, although the centroids for each one were clearly separated.

In the dendrogram obtained using all quantitative characters (Fig. 2), three groups were

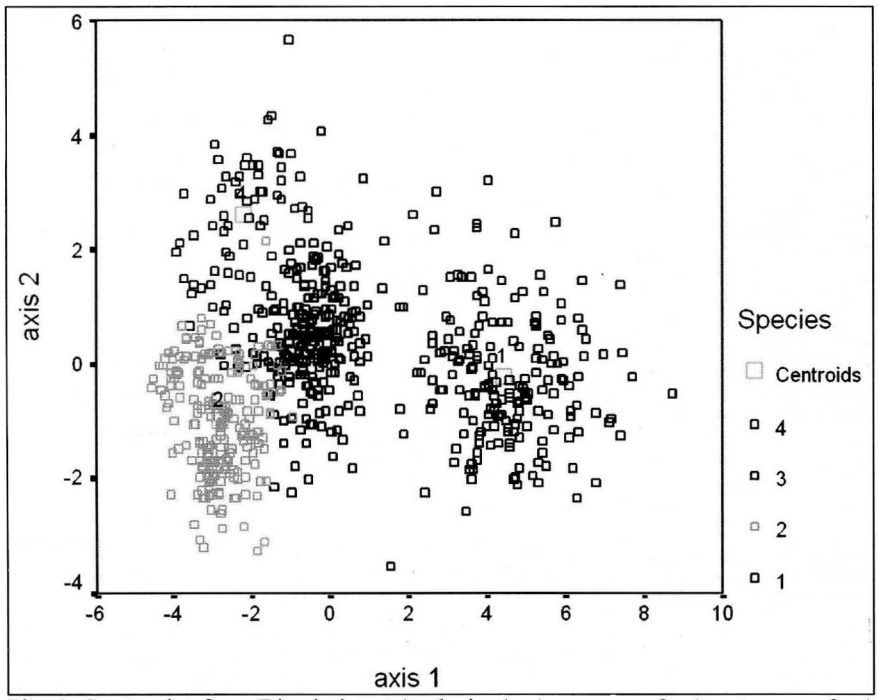

Fig. 1. Scatterplot from Discriminant Analysis. 1. *A. amarum*; 2. *A. aristatum*; 3. *A. odoratum*; 4. *A. ovatum*.

evident at a high level, based on plant height and leaf width, but they did not coincide with the specific status. These results confirm the existence of a continuity among different taxa for these characteristics, with extensively overlapping limits in some cases.

With regard to the ten qualitative characteristics analized, all presented significant differences among species but numerous exceptions within each character were observed. Among the qualitative vegetative characteristics, the presence of tuberous stems at the base in *A. amarum* and acute ligules in *A. aristatum* was interesting because their frequency

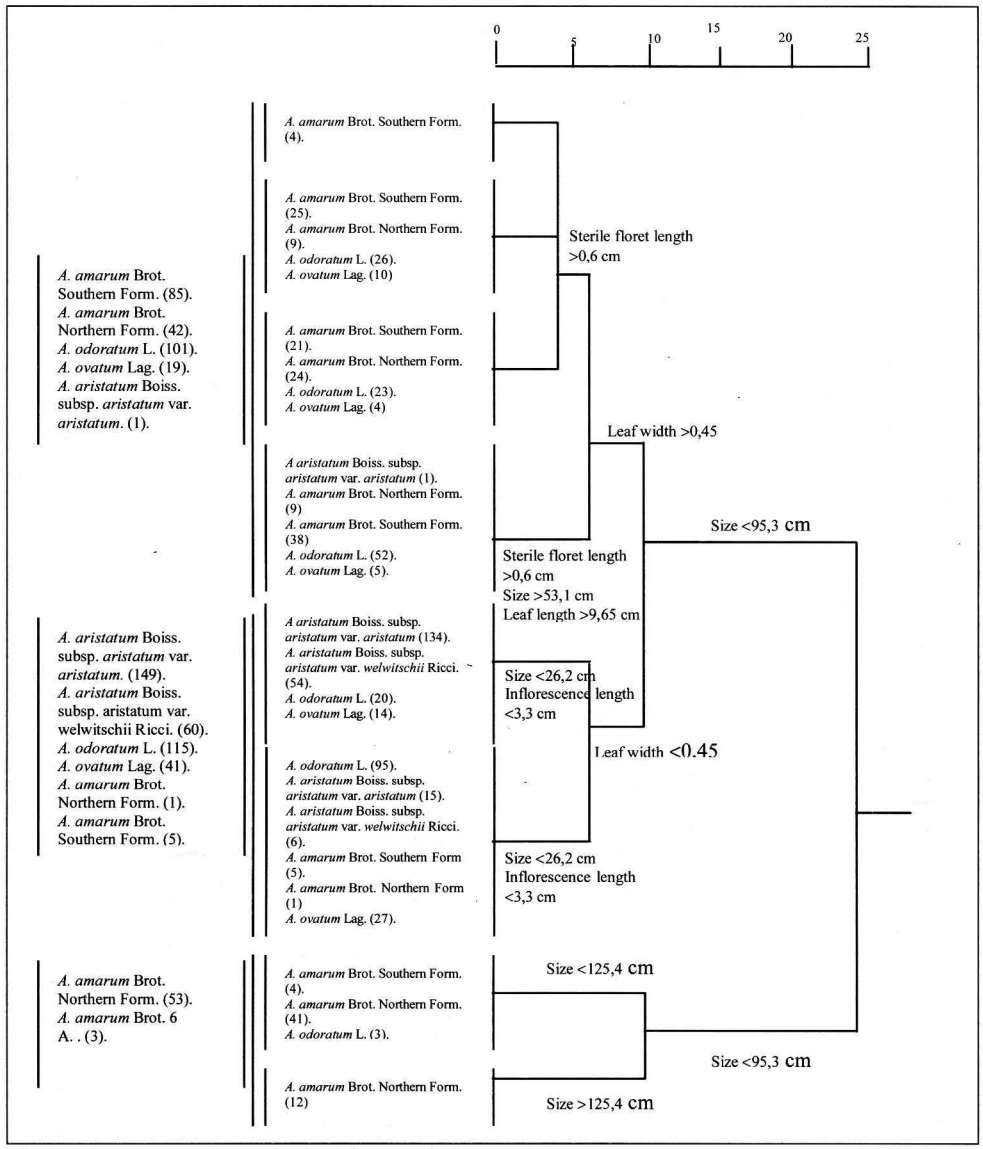

Fig. 2. Phenogram of quantitative characteristics.

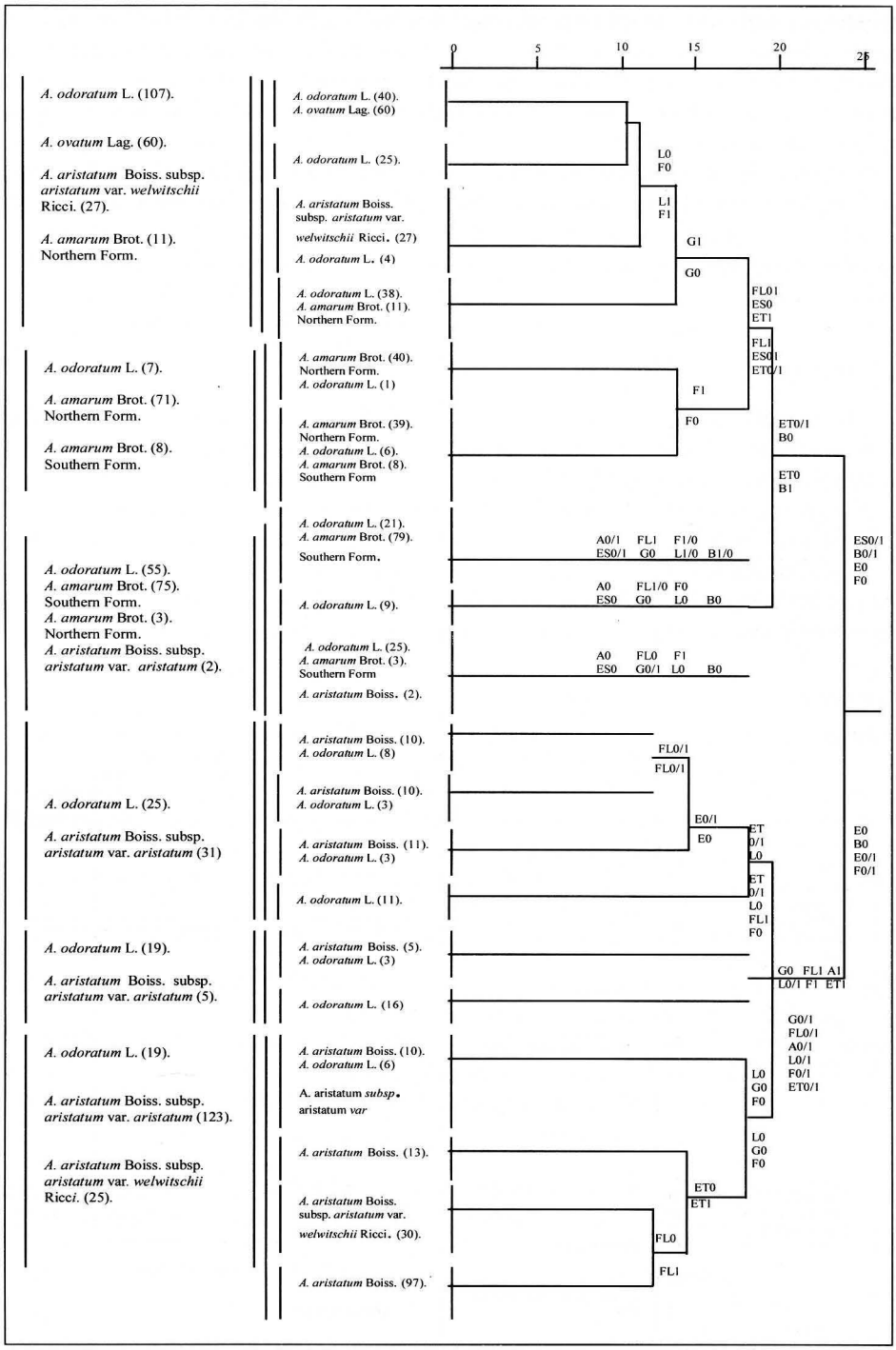

Fig. 3. Phenogram of qualitative characteristics (for abbreviations see Table 1).

distributions were limited to these species. The qualitative floral characteristics were also rather variable, even those pointed out as taxonomically interesting by some authors (Paunero 1953; Valdés 1973). For example, the coverage of fertile florets by sterile ones showed high variability, which is coincident with the results obtained by other authors (López - González 1994).

A cluster analysis was performed with the ten qualitative characteristics studied. In the dendrogram obtained (Fig. 3), in which all samples from different populations were mixed, *A. odoratum* presented greater affinity with the three remaining species than with the others and the differentiation between the varieties of *A. aristatum* subsp. *aristatum* analized was not supported.

Conclusions

The morphological analysis carried out with samples from the four species of the genus *Anthoxanthum* found in the Iberian Peninsula reveals the existence of a continuity among morphological characteristics, making their differentiation difficult.

The characteristics traditionally used (plant height, shape of panicle, ear length and flowers, leaf width, shape of sterile lemmas and pubescence) were not decisive, owing to the high variability observed within both the populations and the taxa. Our results do not support the subspecific differentiation within *A. aristatum* and show that *A. ovatum* would appear to be morphologically closer to *A. odoratum* than to *A. aristatum*.

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