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Ellenberg Indicator Values for the vascular flora alien to Italy

Abstract

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Studies to date about plants alien to Italy have had limited focus on the ecology of this component of the flora. Ellenberg's indicator values are a useful tool to delineate the relationship between plants and environment, recognizing for each species a functional role as biological indicator; these values have been proposed for estimating the influence of the main environmental factors in determining flora and vegetation changes on a specific surface area. This contribution includes a list of 1206 taxa of plants naturalized in at least one administrative region or casual in at least three regions of Italy. In addition, some methodological considerations on the attribution and use of Ellenberg's indicator values and a comparison with the average indices for the native Italian flora are reported.

Key words: non-native flora, EIVs, bioindicator, plant ecology.

Introduction

Plant invasions have become one of the main drivers of global environmental changes and the second major cause of the loss of global biodiversity after habitat loss (Sala & al. 2000). The Mediterranean region, and Italy in particular, host a large number of plants and plant communities, and are among the areas most threatened with homogenization and endemic extinction (Hulme & al. 2008). To date, studies in Italy about non-native flora have focused mostly on the number of taxa, their alien status, and a rough estimation of the biogeographic regions at regional scale (Celesti-Grapow & al. 2009, 2010, 2016). This kind of approach offers clues on the habitat quality of a given region, but the study of the ecological traits of the non-native taxa occurring in a given area could provide more information not only about the naturalness of this area but also about its ecological conditions and its potential for being prone to new alien invasions (Lodge 1993; Lloret & al. 2005).

The aim of this contribution, whose preliminary results were presented during the 112th Congress of the Botanical Society of Italy, held in Parma from 20 to 23 September 2017 (Domina & al. 2017), is to provide an overview of the ecological preferences of the alien flora of Italy through the use of Ellenberg's indicator values (from now on: EIVs).

The ecological requirements (Bazan & al. 2015), along with dispersal strategies (Vincente & al. 2014), seed traits (Vittoz & Engler 2007; Moravcová & al. 2015), and their adaptive responses to granivory (Guarino & al. 2005), are key factors in the establishment and success of neophytes.

EIVs have been proposed to estimate the influence of the main environmental factors in determining flora and vegetation changes on a specific surface area (Ellenberg 1974, 1996; Ellenberg & al. 1992). Ellenberg outlined the synecological preferences of all Central European vascular plants by means of numerical indices referring to seven main environmental factors. Three indices refer to climatic variables: light conditions (L), temperatures (T), and climatic continentality (K); and four refer to edaphic conditions: moisture (F), reaction (R), nutrient availability (N), and salinity (S).

In the original scales (Ellenberg & al. 1992), all indices ranged between 1 and 9, with the exceptions of F, ranging between 1 and 12, and S, ranging between 0 and 9. Subsequent to the original formulation, the range for S has been limited to 0 and 3 (Ellenberg 1996).

Pignatti & al. (2005) assigned EIVs to the taxa of the flora of Italy and modified Ellenberg's scales to adapt them to the Italian territory. In fact the same species can be an indicator of different habitats at different latitudes. For this reason, a recalibration at the regional scale is needed to allow an ecological comparison of the floras of different climates. An enlargement of the scales L and T to 12 values, to respect the statistical homogeneity with Ellenberg's original assumption, has been adopted (Pignatti & al. 2005).

The EIVs for the Italian flora published by Pignatti & al. (2005) were based on the species list of the first edition of the "Flora d'Italia" (Pignatti 1982). Recently we have seen the publishing of updates: the updated checklists of the native and alien flora to Italy (Bartolucci & al. 2018; Galasso & al. 2018) and the first two volumes of the second edition of the "Flora d'Italia" (Pignatti & al. 2017); the last two volumes and the digital supplements will be issued soon. Thus the new complete data set for the updated flora of Italy is under preparation. A recent update to the EIVs for the flora of Italy has been published for ferns, fern allies, gymnosperms, and monocots (Guarino & al. 2012).

The aim of this paper is to provide the integration of the EIVs for the non-native flora of Italy and, at the same time, to present some ecological considerations on the investigated flora based on EIVs.

Material and methods

The floristic list used as a basis for this study was the updated checklist of the vascular flora alien to Italy (Galasso & al. 2018). This list includes 1597 taxa (including hybrids), with their family, main synonyms, and indication of their ecological behaviour (invasive, naturalized, casual) in each administrative region. From this list, we extracted the taxa invasive or naturalized in at least one region or casual in at least three regions of Italy, and we added their EIVs. Besides the values already published in Pignatti & al. (2005) and Guarino & al. (2012), more than 570 still lacking indices are newly proposed here. To assign these new values, we considered the environmental conditions of the Italian localities in which they were recorded. All the criteria and recommendations adopted by Ellenberg & al. (1992)

have been followed, even if the criterion "per analogy" was leading our choices in most of the cases (see Guarino & al. 2012 for details). The main problems in the assignment of EIVs concerned taxa with a wide ecological niche, such as *Ailanthus altissima* (Mill.) Swingle and *Senecio inaequidens* DC. or casual rare ones such as *Gomphrena globosa* L. and *Russelia equisetiformis* Schltdl. & Cham. occurring in a few localities, often close to cultivated plants. The same for species cultivated for human consumption since long time, on a large scale, such as *Avena sativa* L., *Brassica oleracea* L., *Triticum turgidum* L., etc.

The significance of the differences observed in the EIVs of native vs. non-native flora was checked by means of a two-tailed T-test, assuming that the two data sets had unequal variance (heteroscedastic). All graphics and basic statistical analysis were produced by means of MS Excel.

Results

On the whole, 1206 taxa recorded as naturalized at least in one administrative region or casual in at least three administrative regions of Italy, were considered in this contribution.

Average EIVs for the non-native flora of Italy are: L= 7.81, T= 7.64, K= 4.96, F= 4.54, R= 5.45, N= 4.49.

There are 16 taxa (mainly *Acacia* sp. pl. and *Sporobolus* sp. pl.), tolerant to salinity (S >1) and 31 (*Tamarix* sp. pl. and *Aizoaceae*) with some tolerance (S = 1). For these, the average value of S is 1.63, denoting an overall relatively low tolerance to soil salinity.

Several ornamental species as *Aeonium* sp. pl., that in nature grow on semi-natural habitats, in Italy have synecological preferences toward anthropized environments.

Others as *Amaranthus* sp. pl. show the same behaviour in countries where are native and in those where are alien as well. A direct comparison with the average indices of the native flora of Italy given in Pignatti & al. (2005) (Table 1 and Fig. 1) suggests that the alien flora have similar light requirements (L= 7.85 vs. 7.84), higher temperature requirements (T= 7.67 vs. 6.36), slightly higher continentality (K= 4.96 vs. 4.60), slightly higher edaphic humidity (F= 4.50 vs. 4.17), similar soil reaction (R= 5.43 vs. 5.45), and a preference for higher nutrient availability (N= 4.34 vs. 3.26).

In general (Table 1 and Fig. 2), the distribution of EIVs for the non-native species has a lower variance and higher kurtosis, resulting in infrequent outliers as opposed to frequent modestly sized deviations. This is particularly true for the T value, confirming that the non-native component of the flora of Italy is significantly more thermophilous than the native one.

The list of considered EIVs for the flora alien to Italy is available as Electronic supplementary file to be readily used for data processing. As already suggested by Pignatti & al. (2005) and Guarino & al. (2012), the current list of EIVs has to be considered a first approximation, which may require a long period of adjustments and revisions. Ellenberg (1974) himself, when proposing the first edition of his indicator values, stated that it was a work in progress. This is particularly true for the exotic species that are found in one or very few regions, often under dissimilar environmental conditions.

Table 1. Arithmetic mean, variance, kurtosis, skewness, and T-test of the EIVs of the native flora and of the alien flora to Italy considered in this study.

	native flora **mean**	alien flora **mean**	native flora **var.**	alien flora **var.**	native flora **kurt.**	alien flora **kurt.**	native flora **skew.**	alien flora **skew.**	**T-test**
L	7.84	7.85	3.78	2.42	0.07	0.30	-0.09	-0.10	n.s.
T	6.36	7.67	6.07	2.36	-0.49	0.91	-0.12	0.16	p<0.001
K	4.60	4.93	1.21	1.11	2.07	2.83	0.14	-0.28	p<0.001
F	4.17	4.50	5.22	5.52	1.48	1.37	1.27	1.25	p<0.001
R	5.45	5.43	4.08	1.81	-0.49	1.39	-0.48	-0.20	n.s.
N	3.26	4.34	4.37	4.47	-0.16	-0.89	0.85	0.25	p<0.001

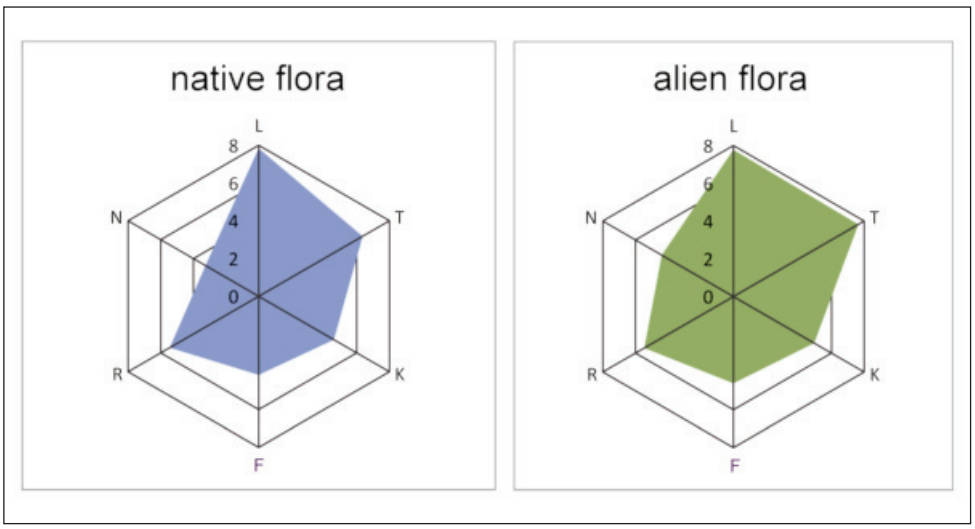

Fig. 1. Ecograms for the native flora of Italy (in blue) and the alien flora (in green) from the means of the six ecological values: L – light; T – temperature; K – continentality; F – soil moisture; R – soil reaction; N – soil nutrients. Only the numeric values have been considered (X values have been ignored).

Discussion and conclusions

Ellenberg's indices should be seen as practical tools to draft quick estimates for ecological interpretations of plant-species lists. This can be particularly useful in anthropogenic and disturbed habitats, often hosting a high number of alien species, to make comparisons with the ecological preferences of the surviving elements of the native plant cover. To date, the application of EIVs to "fingerprint" the ecological context of plant communities including a high percentage of non-native species has been quite limited. The reason could

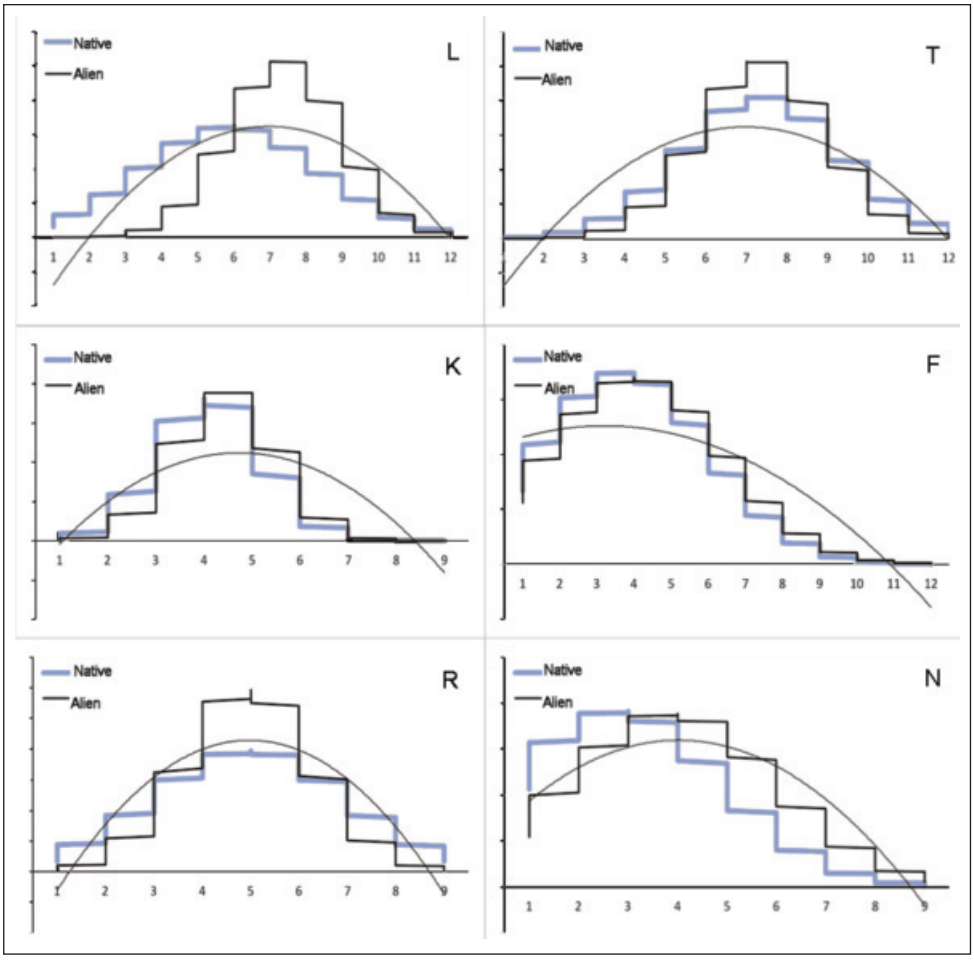

Fig. 2: Comparative distribution and polynomial regression curve of EIVs for the native vs. the alien flora to Italy.

be the lack of such indices for many exotic species. In the present paper, EIVs are proposed for most of the non-native flora of Italy, and their statistical properties have been compared to the EIVs previously assigned to the nativeo flora of Italy.

We are aware that assigning EIVs to non-native species includes some critical points, particularly because their ecological behaviour can shift from one region to another and in many cases their distribution patterns are rather discontinuous, thus making difficult the "averaging" of their ecological preferences at the national level.

Working on taxa coming from different areas, with a wide variability, the corrections suggested by Berg & al. (2017) to assign the value of continentality proved to be very useful for homogenizing data reducing subjectivity.

However, it should be recognized that the Italian territory hosts many more narrow-ranging species than broad-ranging ones, and their coexistence or close proximity with broad-ranging and non-native species offers many useful indications for assigning the most appropriate EIV to them.

Until now, for the Italian territory, the following papers corroborate the EIVs and their utility: Pignatti & al. (1996, 2001a, 2001b); Pignatti (1998, 1999); Guarino & Bernardini (2002); Fanelli & al. (2007); Schwabe & al. (2007); Gristina & Marcenò (2008); Mossa & al. (2008); Burrascano & al. (2009); Brunialti & al. (2010); Pretto & al. (2010); Blasi & al. (2012); Pignatti E. & Pignatti (2014); Del Vecchio & al. (2015); Filibeck & al. (2015); Guarino & al. (2015); and Marcenò & Guarino (2015). We hope that this contribution will encourage new applications.

Some authors (Durwen 1982; Böcker & al. 1983; Kowarik & Seidling 1989; Möller 1992), even if sometimes recognising a practical utility in calculating average EIVs of a species list, state that this is not mathematically correct, because EIVs are ordinal scales, without dimensional correlation with chemical/physical parameters. This is certainly true, but on the other hand it is demonstrated by vegetation data (see, for instance, Pignatti & al. 2001a) that, when the number of samples is high enough, EIVs fit the normal distribution, whose essential parameters are average and variance. So, in addition to non-parametric statistics, all kinds of statistical tests based on average and variance can be used. If only a small number of samples is available, a parametric statistical approach can be essayed anyway, because in the case of Ellenberg's scales it is always possible to transform data into their respective ranks, to better approximate the normal distribution and to create the conditions to use a parametric approach. This widens the potential applications of EIVs as a practical tool to sketch biodiversity traits.

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