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DATA NOTE

ITV-net: a dataset of intraspecific leaf traits data across major Italian habitats

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ABSTRACT

Over the last decades plant ecology has greatly benefited from open data on functional traits. Nowadays, several national and international trait databases are available, but trait data from Southern European countries are generally missing or underrepresented. In addition, most of the available databases lack detailed trait information at the intraspecific level, an important source of trait variation linked to species potential for adaptation. Data were gathered from 21 Italian research groups. Individual measurements of leaf area (LA) and specific leaf area (SLA) for the most abundant vascular plant species were provided at the plot level using standardised protocols of trait measurement. The ITV-net dataset includes 8,518 records of leaf area (LA) and specific leaf area (SLA) in 1,043 georeferenced plots spanning most of the Italian peninsula and eight EUNIS habitat types. Individual LA and SLA measurements are available for 709 native and alien species (77 families, 353 genera). The ITV-net dataset is freely available in the Zenodo repository and will contribute to expanding research on a largely underrated source of trait variation and on its ecological consequences.

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Introduction

Plant functional traits are defined as any morphological, chemical, physiological, and phenological features that can be measured at the individual level (Violle et al. 2007). They are related to plant fitness and determine how plants respond to the environment (Funk et al. 2017). During the last decades, trait-based approaches have developed rapidly, providing new tools for understanding plant-environment and plant-plant interactions at multiple scales. As a result, the availability of global and local databases of plant functional traits (e.g. BROT2.0, Tavşanoğlu and Pausas 2018; TRY, Kattge et al. 2020; AusTraits, Falster et al. 2021; FunAndes, Báez et al. 2022; Díaz et al. 2022; PADAPT 1.0, Sonkoly et al. 2023; Rasgos-CL, Alfaro et al. 2023) rapidly increased in the last decade, together with the interest to use them to answer more general questions in plant eco(physio)logy. Thus, collating data from multiple sources and making them readily available to the scientific community is at the forefront of modern plant functional ecology.

Despite the unprecedented amount of trait information freely available to researchers, two significant shortcomings still exist. First, the geographical coverage of trait measurements is not uniform across the globe. For example, even in the highly studied European ecosystems, some regions are underrepresented (e.g. the Mediterranean region; Chelli et al. 2019) compared to others (e.g. Western and Central Europe; Kattge et al. 2020). Secondly, while major databases provide multiple species-level trait values (e.g. Falster et al. 2021; Báez et al. 2022), most of the others present single trait values aggregated at the species level. This reflects the inherent limitation of large databases that often incorporate intraspecific trait values only across datasets, but rarely within a single dataset. The inclusion of multiple measurements for a given species within the same dataset (i.e. encompassing intraspecific trait variation, ITV) mostly depends on the specific objective of the study, together with the constraints imposed by the spatial and taxonomic scale, the trait type, and the level of biological organisation addressed. For example, TRY, the largest plant trait database, is a "database of databases" (Kattge et al. 2020), resulting in many underlying datasets being provided without individual trait measurements at the species level. Besides, collating ITV-level data is largely time- and energy-consuming, thereby limiting the availability of such information.

However, in more recent years, there has been a renewed interest on ITV in trait-based studies to answer different research questions, spanning from community assembly rules to the effect of ITV in modifying plant adaptive strategies at multiple scales (Violle et al. 2012; Siefert et al. 2015; Des Roches et al. 2018; Puglielli et al. 2024). Indeed, any plant species experiences variable environmental conditions both across and within populations, resulting in multiple phenotypes within a single species. Exposing multiple phenotypes to the environment might help plants buffering the effect of environmental changes and eventually adapt to novel ecological contexts. Thus, the variability of functional traits within species represents the raw material for natural selection (Bolnick et al. 2011; Puglielli et al. 2022; Palacio et al. 2024). Overall, these considerations highlight the need for more extensive information on plant ITV.

Here, we present the ITV-net dataset, the first open-access plant trait dataset for Italy. The database includes standardised measurements of two key leaf traits, namely leaf area (LA) and specific leaf area (SLA), which reflect two main independent axes of the global spectrum of leaf form and function (i.e. size and resource economics, respectively; Wright et al. 2004; Díaz et al. 2016) for 709 species (i.e. about 9% of the vascular Italian flora; Bartolucci et al. 2024) across eight habitat types. ITV-net provides researchers in plant functional ecology with an unprecedented empirical data compilation that contributes to partially filling the gap in trait data for Southern Europe and enabling approaches that encompass intraspecific trait variability (e.g. Puglielli et al. 2024).

Materials and methods

A proposal for a national collaboration was initiated within the Italian research community building on a previous review of Italian studies on plant functional traits (Chelli et al. 2019). Data were collected from 21 research groups across the country. The individual measurements for vascular plant species were provided at the plot level (1,043 plots in total) including all species whose cover accounted for at least 80% of the relative abundances in their sampling plots (Pakeman and Quested 2007). LA and SLA were always determined using standardised protocols (Pérez-Harguindeguy et al. 2016). The datasets were merged by retaining measurements of LA (mm^2) and SLA (mm^2*mg^{-1}) for vascular plants. Species nomenclature across datasets was manually harmonised by consulting the Portal to the Flora of Italy (2025) (https://dryades.units.it/floritaly/) in agreement with two sources: 1) Italian national checklists (Bartolucci et al. 2024 for native species; Galasso et al. 2024 for alien species), and 2) the

World Flora Online (https://www.worldfloraonline.org/) using the R package WorldFlora (Kindt 2020, accessed in July 2023). In addition, we also maintained the original nomenclature provided by the contributors for each dataset as additional information to the users. To ensure the best quality for the retained trait values, we searched for possible outliers by excluding the trait values exceeding the range reported in global compilations (Díaz et al. 2016; Carmona et al. 2021), following the approach of Puglielli et al. (2024).

Data description

The final dataset (Chelli et al. 2025) is composed of two files: i) metadata related to plots (including coordinates in WGS84, elevation, sampling area, plot size, year of sampling, and EUNIS Level I habitat type classification); and ii) species cover and leaf traits data. All the taxonomic information reported in the following text and figures follows the Portal to the Flora of Italy. Trait data includes 8,518 records of LA and SLA for 709 native (77 families, 353 genera) among them 4% are alien species (Table 1) in eight EUNIS Level I habitat types (Chytrý et al. 2020): coastal habitats (N; 72 species, 827 records), forests (T; 156 species, 645 records), grasslands (R; 416 species, 6045 records), wetlands (Q; 26 species, 55 records), heathlands, scrub and tundra (S; 106 species, 429 records), inland surface waters (C; 20 species, 123 records), inland unvegetated or sparsely vegetated habitats (H; 40 species, 190 records), and vegetated man-made habitats (V; 29 species, 204 records). We also distinguished between "intensive" and "extensive" trait collection. The former refers to cases where a data provider measured the traits of a given species for each plot in which the species was abundant (i.e. contributing to 80% of the relative abundance). In this way, ITV is incorporated at the plot level, as the same species occurring in different plots may exhibit different trait values. In the latter case, the data provider measured the traits of a given species

Table 1. Number of alien species and their division into invasive, casual and naturalized, across all datasets and for each EUNIS habitat type.

	All habitats	Coastal habitat	Grasslands habitat	Heathlands, scrub and tundra	Inland surface waters	Vegetated man-made habitats
Invasive species	24	9	4	1	6	4
Casual species	1		0			1
Naturalized species	4		1			3
Total number	29	9	5	1	6	8

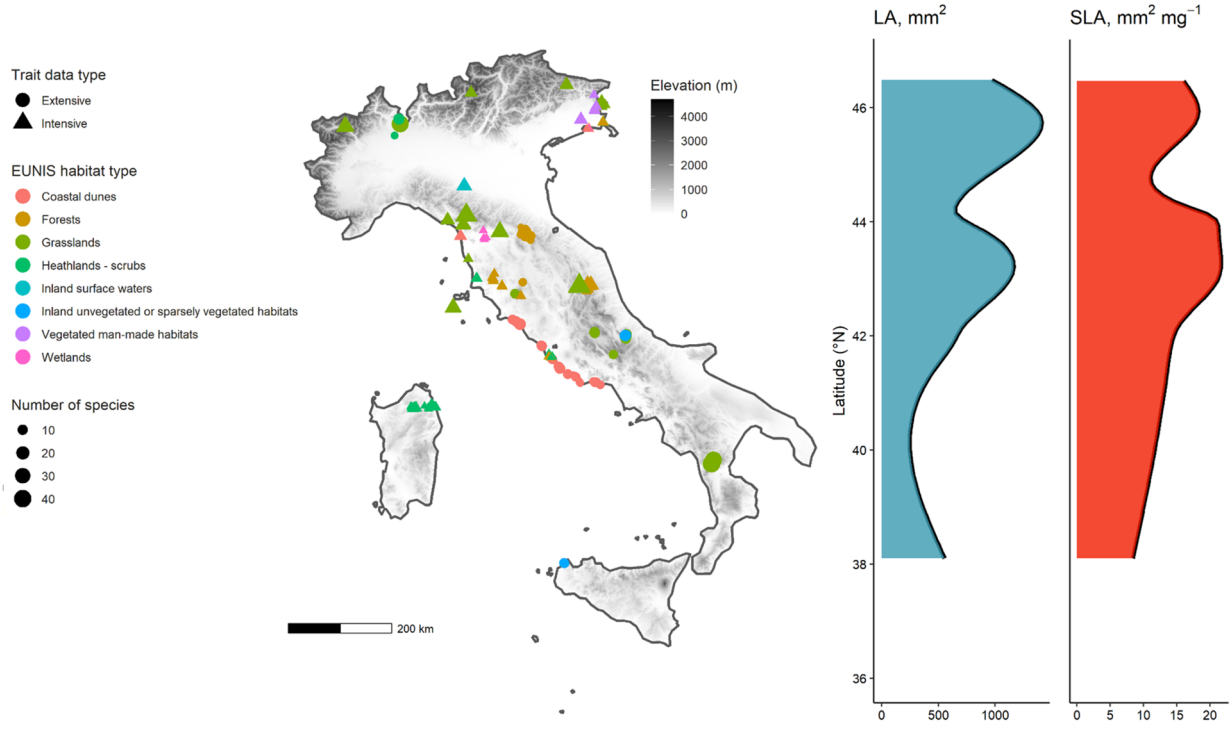

Figure 1. Geographic distribution of plots across Italy and within EUNIS Level I habitat types. Trait density for leaf area LA (mm^2) and specific leaf area (SLA, $mm^{2}*mg^{-1}$) along the latitudinal gradient are displayed.

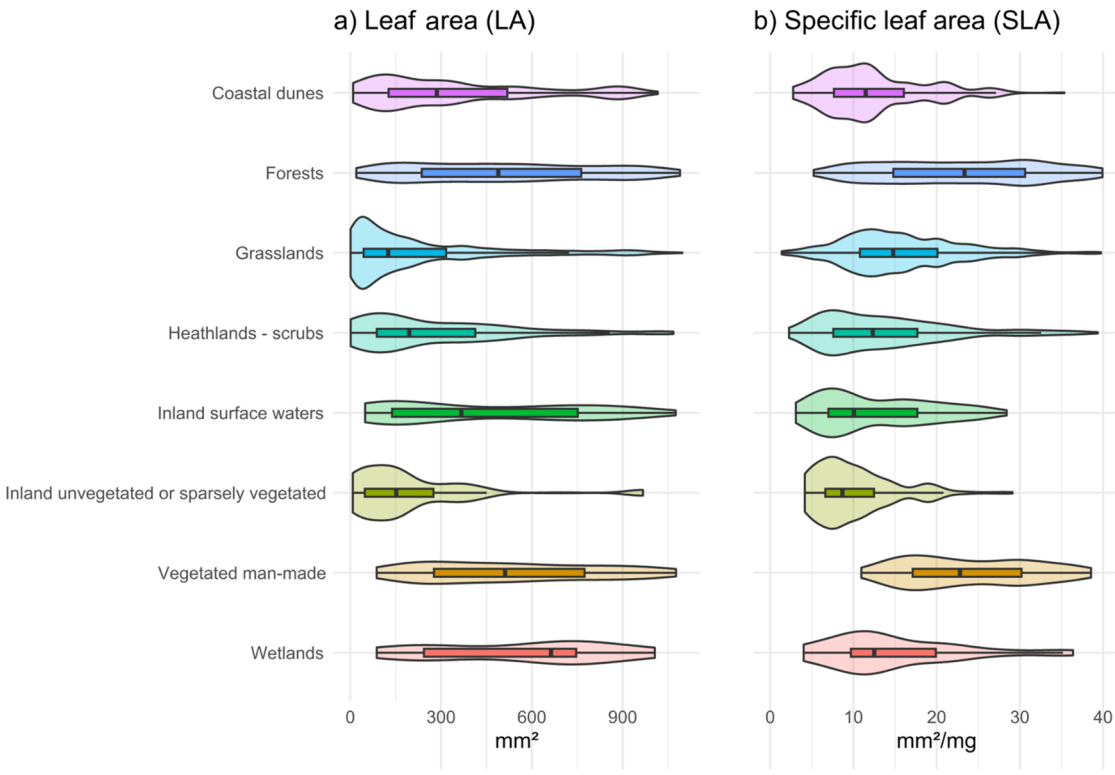

Figure 2. Distribution of leaf area (LA) and specific leaf area (SLA) values of each EUNIS Level I habitat type. Outliers for each habitat type were excluded.

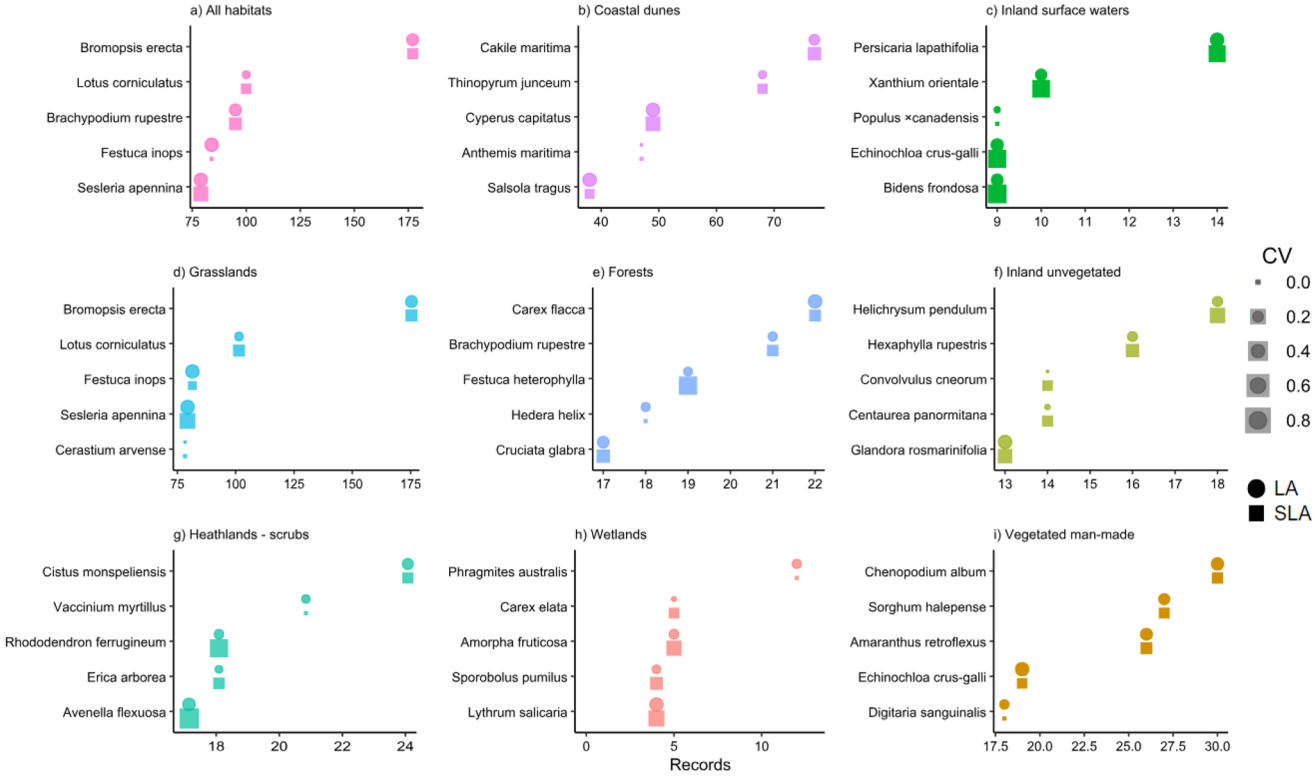

Figure 3. Number of records for the 5 most frequent species for all habitats (a) and for single EUNIS habitat types (b–i). The size of the symbols is proportional to the coefficient of variation (CV) of the trait for each species (LA, leaf area; SLA, specific leaf area). Species nomenclature referred to Portal to the Flora of Italy.

only in one plot, regardless of how many plots the species was abundant in. Thus, in the case of "extensive" trait collection, each species has the same trait values across all the plots provided per each dataset (absence of ITV; Lepš et al. 2011). The geographic coverage of the final dataset and the trait distribution across and within EUNIS habitat types are shown in Figures 1 and 2(a,b). The number of records (i.e. trait measurements) and trait variability for the most frequent species across and within EUNIS habitat types are shown in Figure 3.

Discussion

Despite covering eight habitat types across wide elevational and latitudinal gradients (Figures 1 and 2), ITV-net still exhibits data gaps in the Alps and southern Italy. This is particularly relevant in light of climate change, which is expected to primarily affect alpine and Mediterranean ecosystems (Frate et al. 2018; Tordoni et al. 2022). Given the country's high plant diversity and the notable heterogeneity in climate and physiography, a greater effort is therefore needed to measure and share additional plant trait data for these unrepresented areas (e.g. those rich in endemic taxa; see Selvi et al. 2023). A relatively large amount of trait data is available for grasslands, forests, coastal habitats, and heathlands, while other habitat types i.e. wetlands, inland surface waters, and vegetated man-made habitats are largely undersampled. Considering the significant human impact on these habitats, it is essential to increase the trait data collection to study the effects of disturbance and land use on the functioning of these ecosystems. Focusing on individual species, herbaceous plants (both forbs and graminoids) are well represented in our dataset (596 species, representing 81%); however, in comparison, woody plants (including trees) are generally underrepresented (113 species, representing 19%). This gap should be addressed to bridge the connection between individual traits and ecosystem functioning, particularly in habitat types where woody plants are dominant.

The ITV-net dataset represents a significant step forward for plant trait ecology and improves the coverage of global trait databases by addressing the geographical gap in leaf trait data for southern Europe. ITV-net facilitates analyses of the role of intraspecific trait variation at different biological levels (from individuals to communities), both within and across habitat types. Moving forward, we prioritise not only filling data gaps but also improving coordination between Italian and other European research groups working on functional ecology. Expanding ITV-net to include additional traits would be particularly beneficial, given the multifunctional nature of plant functional strategies.

Authors' contributions

SC, GP, AB, FPe and ET conceived the research network idea. SC, AB, and GP conceptualised the study, and wrote the first draft of the manuscript with substantial inputs from ET and FPe. GP, AB, and ET organised and managed the data. GC revised species nomenclature. The other authors provided the data and contributed to the critical revision of the manuscript to produce the final version.

Disclosure statement

The authors do not have conflicts of interest to declare.

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Data availability statement

The dataset is stored in the Zenodo repository at the following link: https://doi.org/10.5281/zenodo.15642699 (Chelli et al. 2025). The dataset is under the Creative Commons Attribution 4.0 International license.

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