




Revision of the Italian material of *Juncus* sect. *Tenageia* in the Herbarium Centrale Italicum: confirmations and novelties for Italy

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Abstract. In this study, we carry out a revision of the Italian specimens belonging to *Juncus* L. subgenus *Agathryon* Raf. sect. *Tenageia* Dumort stored in the Herbarium Centrale Italicum of the Museum of Natural History of the University of Florence. By re-examining the 650 specimens present, we find that all the taxa belonging to this section are present in the herbarium. This work also allows us to highlight several novelties concerning species distribution at the regional level, thus confirming the importance of studying herbarium material. On the other hand, the work calls attention to a lack of information at the regional level for some taxa (e.g., *J. sphaerocarpus*), showing it would be desirable for botanists to continue to send samples to the herbarium to fill these gaps. This study also has implications for some museological issues, allowing the movement of specimens stored under ancient or obsolete names to the correct folders and to update the nomenclatural herbarium database, so contributing to the improvement of the future usefulness of these collections.

Keywords: Herbarium collections, Juncaceae, Natural History Museum, Systematics, Taxonomy.

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Introduction

The species belonging to the genus *Juncus* L. subgenus *Agathryon* Raf. sect. *Tenageia* Dumort. are medium to small annual plants, mainly typical of freshwater or subhaline, and often temporary habitats (see Kirschner, 2002). This section has its distribution centre in the western Mediterranean (Kirschner, 2002), with some *taxa* geographically rather localised (e.g., *J. fernandez-carvajaliae* Romero-Zarco & Arán, see Romero-Zarco & Arán, 2013) while others, such as *J. bufonius* aggr., are widespread throughout the world but with lower frequencies in tropical and polar regions (Cope & Stace, 1978). Some species have been introduced outside their native ranges and are often considered crop weeds (Good, 1953), such as *J. hybridus* Brot. in Britain, South and Northwestern America, South Africa, Australia and probably New Zealand (Kirschner, 2002).

Kirschner (2002) included 11 species in the section *Tenageia*. The recently updated Checklist of the native Italian Flora (Bartolucci *et al.*, 2018; Portal to the Flora of Italy, 2020) reports eight taxa for Italy: *Juncus bufonius* L., *J. foliosus* Desf., *J. hybridus* Brot., *J. minutulus* (Albert & Jahand.) Prain., *J. ranarius* Songeon & E.P. Perrier, *J. sorrentinoi* Parl., *J. sphaerocarpus* Nees and *J. tenageia* L. f. subsp. *tenageia*. The taxonomic treatment of the Italian Checklist substantially follows the taxonomy proposed by Kirschner (2002). However, in the recent Flora

of Italy by Pignatti *et al.* (2017), the number of species reported is different. For example, Pignatti *et al.* (2017) accepts the autonomy of the name *J. ambiguous* Guss. This emphasises only one of the critical issues with this group which lends itself to various taxonomic interpretations (Carta, 2010). The determination of specimens is further complicated by high morphological variability. As pointed out by many authors (e.g., Cotterill, 1995; Ponder *et al.*, 2001; Lastrucci *et al.*, 2014; Andreone & Gippoliti, 2020; Lastrucci *et al.*, 2020) the study of natural collections is of fundamental importance to many research fields, including to taxonomic reviews and distributional analyses, especially as regards critical groups. In addition, herbaria such as the Herbarium Centrale Italicum of the Natural History Museum of the University of Florence (hereafter FI-HCI), which is the largest Italian herbarium and indeed one of the largest in the world, has grown continuously over nearly two centuries (Cuccuini & Lastrucci, 2007; Cuccuini, 2009). Hence, yet another problem is the nomenclatural stratification of the *exsiccata* accessed over that long period. This, on the one hand, is the consequence of changes in the taxonomic rankings of some entities over time and, on the other, of the proliferation of names, especially at the infraspecific level, as can be observed in ancient Italian floras also for the taxa of the *Juncus* sect. *Tenageia* (e.g., Parlatore, 1852; Fiori, 1923). From a practical point of view, the proliferation of names can also present an obstacle to specimen retrieval, as

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they may be stored under obsolete names or even in different taxonomic rankings. For this reason, regular revision and nomenclature updating of material assumes museological importance, facilitating the usefulness of the collections, in addition to the scientific value of the research.

The aim of this study is the revision of the Italian *exsiccata* of the *Juncus* sect. *Tenageia* stored in FI-HCI, the analysis of their distribution and their nomenclature update, based on recent taxonomic literature.

Materials and Methods

All the Italian material of *Juncus* sect. *Tenageia* stored in FI-HCI was taken into consideration. Due to the diagnostic importance of some characters related to the presence of capsules and seeds, we have favoured the study of mature samples, having analysed a total of 650 such samples. The specimens have been determined using the identification keys proposed by Cope & Stace (1978), Kirschner (2002), Romero-Zarco (2010) and Arrigoni (2015, 2017). The identification was carried out using a binocular microscope Zeiss 47-50-52 9901 and a Dino-Lite Digital Microscope. All collection sites identifiable with reasonable confidence have now been georeferenced and mapped using QGIS 3.12 software.

Results

The study led to the reevaluation of the taxonomy of 120 specimens. A nomenclature update was carried out for the specimens found to be correctly determined. Among the 650 specimens examined, 395 were determined as *Juncus bufonius*, eight as *J. foliosus*, 128 as *J. hybridus*, 31 as *J. minutulus*, 14 as *J. ranarius*, two as *J. sorrentinoi*, one as *J. sphaerocarpus*, and 60 as *J. tenageia*. Other specimens were assigned to taxa not belonging to the sect. *Tenageia*,

such as *J. acutiflorus* Ehrh. ex Hoffm. (three specimens), *J. articulatus* L. (one specimen), *J. bulbosus* L. (two specimens), *J. capitatus* Weigel (three specimens) and *J. compressus* Jacq. (one specimen). The distribution maps of the examined specimens are shown in Figures 1 and 2.

All the species of the section *Tenageia* so far known for Italy are present in FI-HCI. The analysis of the geographical distributions of the studied specimens shows how some species (e.g., *J. bufonius* or *J. hybridus*) are particularly well represented both in the number of specimens held and in the number of collection sites, while other species (e.g., *J. sorrentinoi* and *J. sphaerocarpus*) are represented in the herbarium by few specimens, from few sites. The complete list of specimens of *Juncus* sect. *Tenageia* analysed is provided in Table S1 (Supplementary Material).

Discussion

This study represents a snapshot of the representativeness of the material preserved in FI-HCI, compared to the state of national floristic knowledge regarding *Juncus* sect. *Tenageia*. As pointed out by Cuccuini & Lastrucci (2007), the taxa stored in FI-HCI can be considered a reliable indication of the Italian flora at least until the time of the publication of the first flora of Italy by Pignatti (1982). Any comparison with more recent national floristic checklists and databases (Bartolucci *et al.*, 2018; Portal to the Flora of Italy, 2020; Acta Plantarum, 2020; Peruzzi *et al.*, 2020) should take into account that the latter use wider sources of information, not necessarily based on herbarium data but also on literature data and field observations. Nevertheless, as already highlighted in several similar case studies (Lastrucci *et al.*, 2010, 2014, 2019, 2020), the revision of the herbarium materials highlights a number of novel findings regarding the distributions of some of the studied taxa (see Table 1).

Table 1. Occurrence of *Juncus* sect. *Tenageia* species in Italy. Abbreviations follow Bartolucci *et al.* (2018) (P = occurring as native species, PC = present as cryptogenic, NP = recorded by mistake, NC = no longer recorded, D = doubtfully occurring, empty cells = absence). Regional record updates emerging from this study are marked in bold.

	Valle d'Aosta	Piemonte	Lombardia	Trentino-Alto Adige	Veneto	Friuli-Venezia Giulia	Liguria	Emilia-Romagna	Toscana	Marche	Umbria	Lazio	Abruzzo	Molise	Campania	Puglia	Basilicata	Calabria	Sicilia	Sardegna
<i>Juncus bufonius</i>	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
<i>J. foliosus</i>							NC					D			P		P	P	NC	P
<i>J. hybridus</i>	NP		P		P	NC	NC	P	P	P	P	P	P	P	P	P	P	P	P	p
<i>J. minutulus</i>	NC	P	NC	P	NC	P		NC	P	NC										P
<i>J. ranarius</i>	PC	NC	P	P		P		P	P	NC					NC			D	NC	P
<i>J. sorrentinoi</i>									P										NC	P
<i>J. sphaerocarpus</i>	P	P	P	P	P															
<i>J. tenageia</i>	P	P	P		P	P	P	P	P		P	P			P	NC		P	P	P

The Italian regional distribution of *Juncus bufonius* L. (see the Portal to the Flora of Italy, 2020) fits perfectly with the distribution of the samples present in FI-HCI, collected in all Italian administrative regions (Figure 1A). This species is confirmed as the most common of the Section, as regards both its

geographical distribution and the number of samples deposited in the herbarium (Figure 3). The most represented regions in FI-HCI are Toscana, Piemonte and Sardegna. An analysis of the record sites shows a certain ecological range for this species, collected from many different habitats.

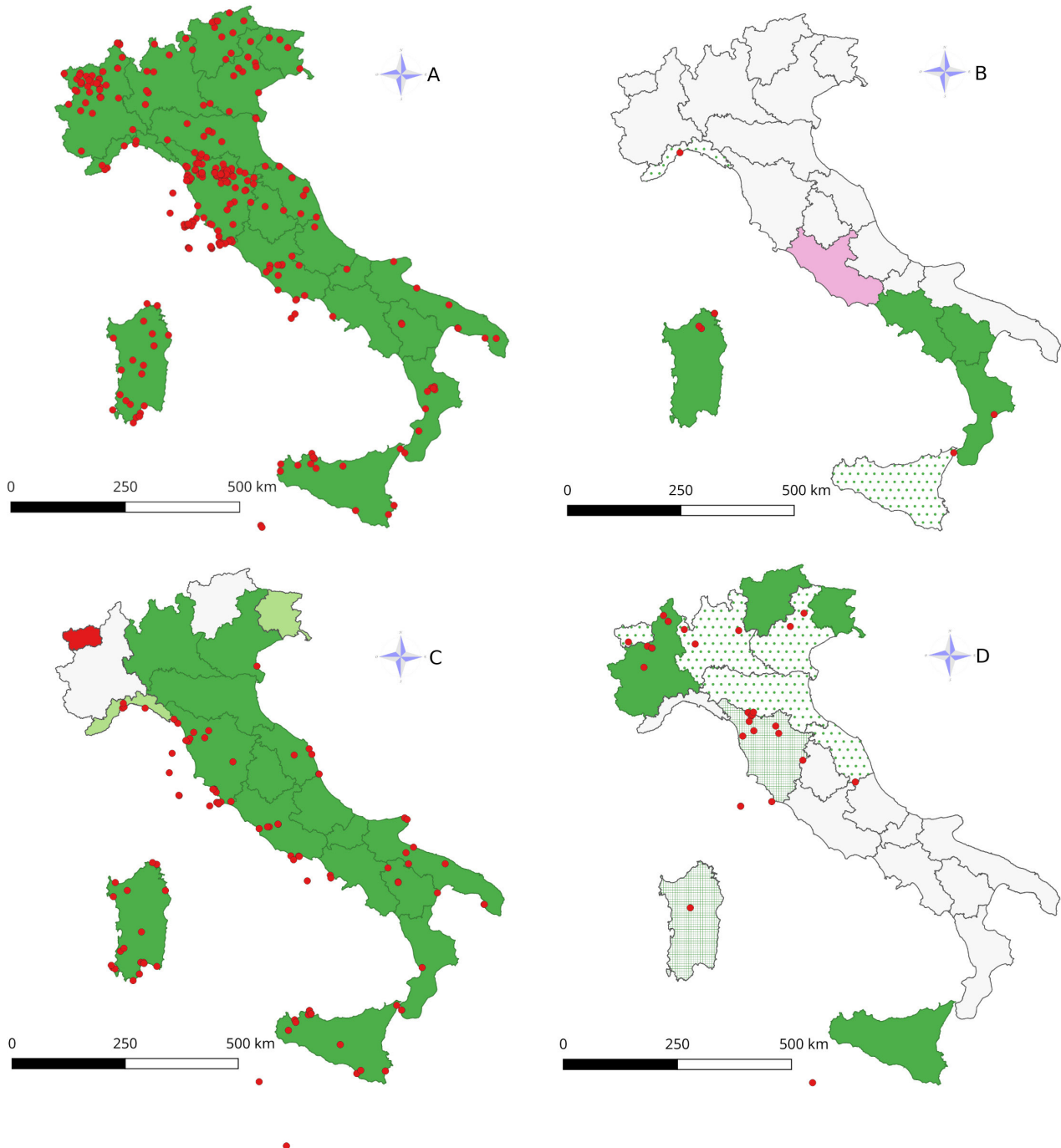


Figure 1. Map showing the distributions of the specimens analysed. A, *Juncus bufonius* L.; B, *J. foliosus* Desf.; C, *J. hybridus* Brot.; D, *J. minutulus* (Albert & Jahand.) Prain. For confirmed or literature data, the map colours follow the Portal to the Flora of Italy (green: present; light green: historical records; pink: doubtful records; red: wrong records); distribution novelties are evidenced by the following colours: grid green (present); dot green (historical records).

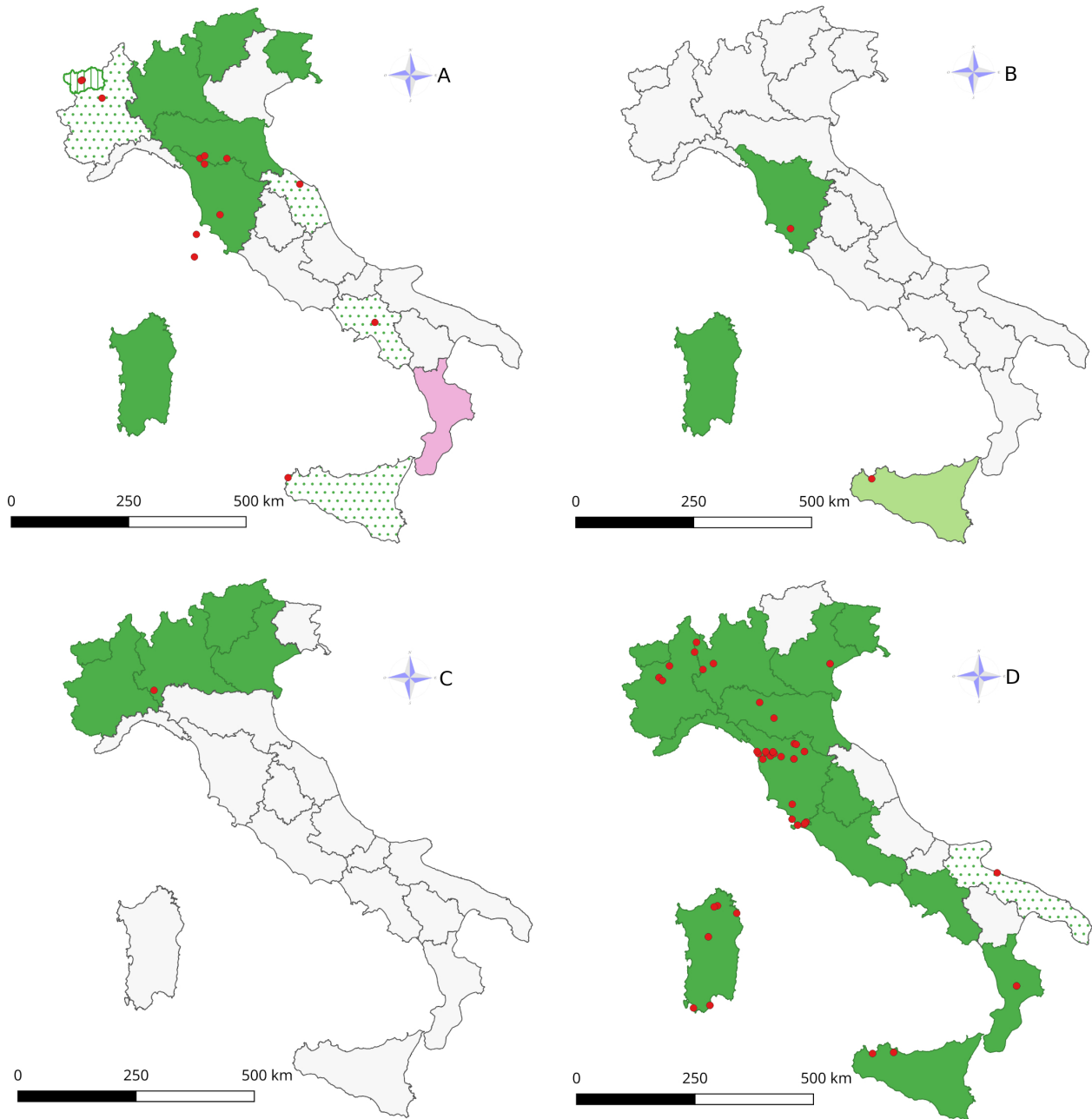


Figure 2. Map showing the distributions of the specimens analysed. A, *Juncus ranarius* Songeon & E.P. Perrier; B, *J. sorrentinoi* Parl.; C, *J. sphaerocarpus* Nees; D, *J. tenageia* Ehrh. ex L.f. For confirmed or literature data, the map colours follow the Portal to the Flora of Italy (green: present; light green: historical records; pink: doubtful records; green lines: cryptogenic); distribution novelties are evidenced by the following colours: grid green (present); dot green (historical records).

Juncus foliosus Desf. (Figure 4) is reported for Sardegna, Campania, Basilicata and Calabria and doubtfully for Sicilia and Lazio (Portal to the Flora of Italy 2020). Even if not all the above-mentioned regions are represented among the herbarium specimens, this study allows the extension of the national areal for this species to Liguria (Figure 1B) and confirms its earlier presence in Sicilia. These records, however, come from rather ancient samples, so the current presence of the species in these regions should be confirmed by field investigation.

Juncus hybridus Brot. (Figure 5) is known to be present in almost all the Italian regions (Portal to the Flora of Italy, 2020) with the exception of Valle d'Aosta (where it was earlier reported based of erroneous records), Piemonte and Trentino-Alto Adige. Historical records are reported from Liguria and Friuli-Venezia Giulia. The data from FI-HCI (Figure 1C) allow coverage of almost all the published distribution reports for Italy with few exceptions, even if many of the specimens are somewhat old. It must be noted that some specimens from Emilia-

Romagna present in FI-HCI were formerly determined as *J. hybridus* but have been renamed as *J. minutulus* and *J. ranarius*. According to Pignatti (1982) and Kirschner (2002), *J. hybridus* together with *J. sorrentinoi* are the

most notable Mediterranean species. This conclusion is confirmed by the analysis of the collection sites of the *J. hybridus* specimens present in FI-HCI, mostly coming from the Mediterranean climate belt of the Peninsula.



Figure 3. Herbarium specimen of *Juncus bufonius* L. from FI-HCI



Figure 4. Herbarium specimen of *Juncus foliosus* Desf. from FI-HCI

Juncus minutulus (Albert & Jahand.) Prain. (Figure 6) is known for Piemonte, Trentino-Alto Adige, Friuli-Venezia Giulia and Sicilia (Portal to the Flora of Italy, 2020). Our study confirms the presence of this species in Piemonte and Sicilia and, in addition, it allows us

to report its presence also in Valle d'Aosta, Veneto, Emilia-Romagna, Toscana, Marche and Sardegna (Figure 1D), even though often based on ancient specimens. As highlighted by Kirschner (2002), this species has been rather overlooked and it is probably

more common than reported, also considering that detailed information and specific surveys come from only a few regions. Indeed, it should be noted that in the first edition of the Flora of Italy (Pignatti, 1982), *J. minutulus* was included in *J. bufonius* L., and thus

no taxonomic nor distributive information has been reported for this taxa. Probably as a consequence of the previous taxonomic treatment, over 50 % of the *J. minutulus* specimens retrieved in our revision were originally determined as *J. bufonius*.



Figure 5. Herbarium specimen of *Juncus hybridus* Brot. from FI-HCI

Among those investigated here, *J. ranarius* Songeon & E.P. Perrier (Figure 7) likely represents the most critical entity from nomenclatural and taxonomic points of view.

In the past Italian floras (e.g., Fiori, 1923; Pignatti, 1982) this species was considered a synonym of *J. ambiguus*, a species described more than thirty years earlier for Sicilia

by Gussone (1827). As put in evidence by Parlato (1852) and Cope & Stace (1978) among the distinctive characters of this species, compared to *J. bufonius*, we cite the obtuse internal tepals and the capsule equalling or exceeding the internal tepals and, sometimes, as long as the outer tepals. The same relations between capsule and tepals characterise *J. ranarius*, as reported by Songeon & Perrier (1859) so that Cope & Stace (1978) also considered the two species as synonyms, giving priority to the name *J. ambiguus*. In the second edition of the *Flora Europaea*, however, Snogerup (1980) reported a different interpretation,

considering the name *J. ranarius* Songeon & E.P. Perrier autonomous and estimating *J. ambiguus* Guss. as a synonym of *J. hybridus* Brot. In fact, as put in evidence by Kirschner (2002), Snogerup designated the lectotype of *J. ambiguus* on a specimen stored in the general Herbarium of Conservatoire et Jardin botaniques de la Ville de Genève (G), determining it as *J. hybridus*, thus leading him to synonymise the name *J. ambiguus* Guss. with *J. hybridus* Brot. Consequently, the specimens of *J. ambiguus* Auct. non Guss. converged under *J. ranarius* Songeon & E.P. Perrier. This species is considered present



Figure 6. Herbarium specimen of *Juncus minutulus* (Albert & Jahand.) Prain. from FI-HCI

in Valle d'Aosta (cryptogenic), Lombardia, Trentino-Alto Adige, Friuli-Venezia Giulia, Emilia-Romagna, Toscana, Sardegna and doubtfully for Calabria (see Portal to the Flora of Italy, 2020). Three of these regions are represented in FI-HCI (see Figure 2A). In addition, four new regions emerge from this study (Piemonte, Marche, Campania and

Sicilia), even though based mainly on ancient specimens. Even if *J. ranarius* is often considered a halophyte (e.g., Romero-Zarco, 2010), this species can also be found in freshwater habitats as already put in evidence by Songeon & Perrier (1859). This is also confirmed by the distribution of the Italian herbarium specimens present in FI-HCI,

represented not only by coastal or Mediterranean sites but also by northern or Apennine freshwater habitats. One ancient specimen (FI058297) from Lago Nero (Tuscan mountain) shows some physiognomic affinities with *J. rechingeri* Snogerup, a species reported for the first time in Europe by Romero-Zarco (2008). However, this species, not present in FI-HCI and easily confused with

J. bufonius and related species, has strongly reticulated seeds. According to Romero-Zarco (*in litt.*) we preferred to provisionally determine the Lago Nero specimen as *J. ranarius*, due to the absence of clear reticulation in the seeds. Nevertheless, further field investigations will be carried out next season to collect new fresh material from the aforementioned site.



Figure 7. Herbarium specimen of *Juncus ranarius* Songeon & E.P. Perrier from FI-HCI



Figure 8. Lectotype of *Juncus sorrentinoi* Parl. from FI-HCI

Table 2. Names of old herbarium folders emptied after the material revision and new taxonomic arrangement of their specimens.

Name of the old herbarium folder	Specimen redetermination
<i>Juncus ambiguus</i> Guss.	<i>J. bufonius</i> (67%); <i>J. hybridus</i> (17%); <i>J. ranarius</i> (8%); <i>J. foliosus</i> (8%)
<i>J. bufonius</i> L. var. <i>typicus</i> Fiori	<i>J. bufonius</i> (100%)
<i>J. bufonius</i> L. var. <i>pumilio</i> Grieseb.	<i>J. bufonius</i> (100%)
<i>J. bufonius</i> L. var. <i>parvulus</i> Hartm.	<i>J. minutulus</i> (100%)
<i>J. bufonius</i> L. var. <i>laxus</i> Celak.	empty folder

Juncus sorrentinoi Parl. is a species distributed in the western and central northern Mediterranean (Kirschner, 2002). According to Bartolucci *et al.* (2018) and Portal to the Flora of Italy (2020), it is known in Italy for Toscana, Sardegna and Sicilia (historical records). In

FI-HCI two specimens are present (Figure 2B): the lectotype from Sicilia (FI002919, Figure 8) and a recent specimen from Toscana (FI057907). Two additional and rather critical specimens, stored in the folder of *J. hybridus* but formerly identified as *J. bufonius* var.

hybridus f. *sorrentinii* by Gresini, collected near Celle Ligure (Liguria), were here attributed to *J. hybridus* after an in-depth comparison with the above-mentioned type material (Kirschner, *in litt.*).

Juncus sphaerocarpus Nees (Figure 9) seems to be a less well represented species in FI-HCI compared

to the national information. In fact, Bartolucci *et al.* (2018) and the Portal to the Flora of Italy (2020) report the species for almost all the northern regions of Italy, with the exclusion of Friuli-Venezia Giulia. In FI-HCI, however, only a specimen from Lombardia is present (Figure 2C).

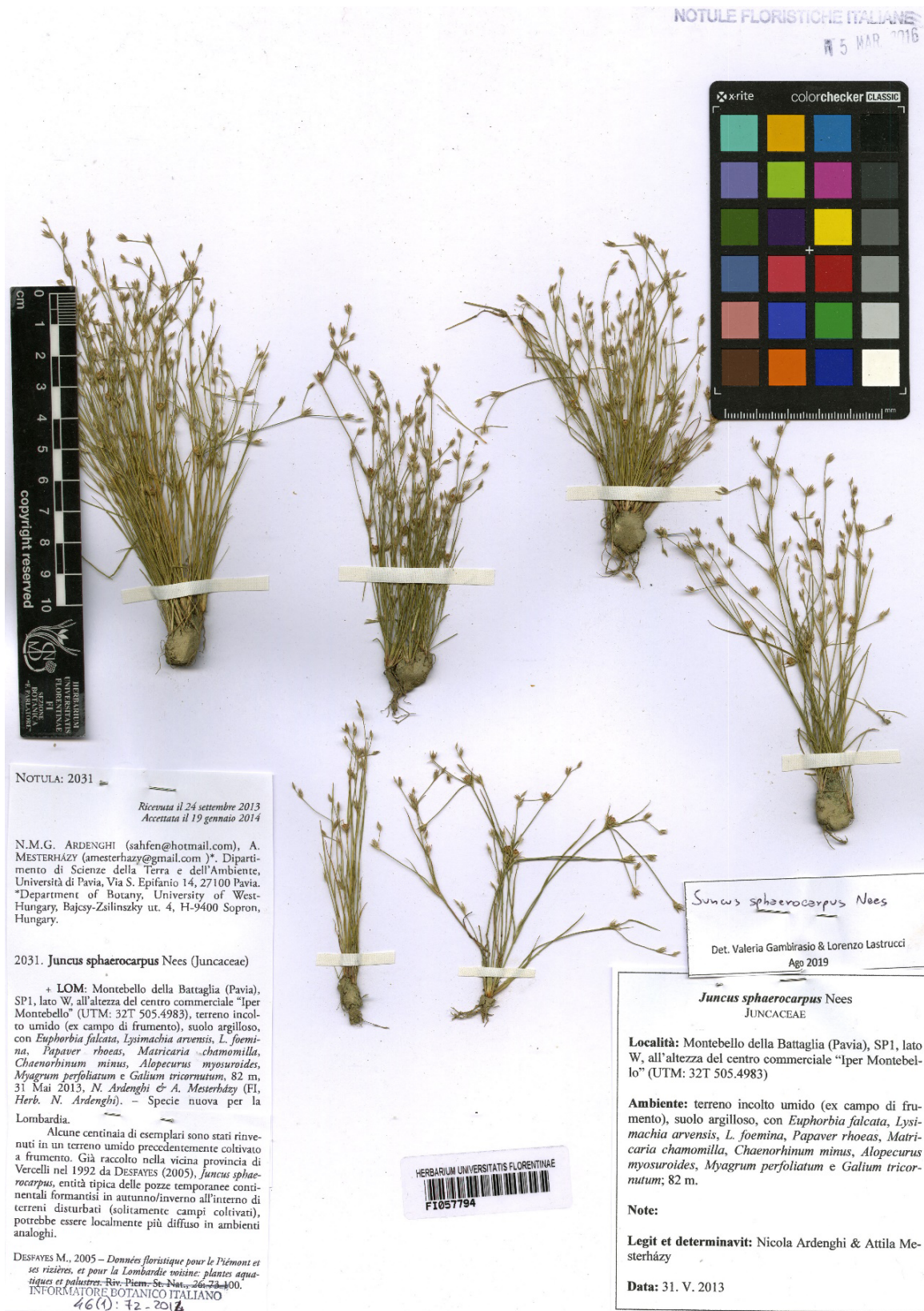


Figure 9. Herbarium specimen of *Juncus sphaerocarpus* Nees from FI-HCI

Juncus tenageia Ehrh. ex L.f. (Figure 10) is reported by the Portal to the Flora of Italy (2020) for almost all the northern regions of Italy (with the exception of Trentino-Alto Adige) and for the regions of the Tyrrhenian side. Several northern and western regions with some lacunae are represented in FI-HCI (Figure 2D); in addition, the re-determination of an ancient specimen from Puglia allowed us to extend the distribution of this species to

the eastern Italian regions, although the current presence of the species in the latter region should be confirmed by field investigation. From a taxonomic point of view, since the taxonomic value of *J. tenageia* subsp. *perpusillus* Fern.-Carv. & Navarro and other forms described in the past are not currently accepted in the treatment of Flora Iberica (Romero Zarco, 2010), we agree with the treatment of *J. tenageia* only at the species rank.



Figure 10. Herbarium specimen of *Juncus tenageia* Ehrh. ex L.f. from FI-HCI

As previously mentioned, a revision of herbarium material has not only taxonomic and distributive repercussions but also allows updating of the storage of the specimens according to the most recent taxonomic and nomenclatural updates, rationalising the arrangement of the materials in the Museum and facilitating their access and use. Independent folders with obsolete names at several taxonomic levels have been freed, the materials have been arranged within folders with updated names (see Table 2) and the database of the herbarium has been upgraded, moving the old names in the synonym field. In addition to the aforementioned materials of *J. ambiguus*, mostly re-determined as *J. bufonius* or *J. hybridus*, we also updated the position for further taxa whose synonymy was already consistent with their current taxonomic arrangement. For example, all the specimens of the folder *J. bufonius* var. *pumilio* Grieseb. have been identified and renamed as *J. bufonius* L. and all the specimens stored under the name *J. bufonius* var. *parvulus* Hartm. correctly belong to *J. minutulus* (Albert & Jahand.) Prain., according to the currently accepted nomenclature (see Kirschner, 2002).

Conclusions

The present study confirms the importance of herbarium materials in taxonomic and distributive botanical studies. The revision of the specimens stored in the most important Italian herbarium (FI-HCI) has allowed us to highlight various distribution novelties at the national level. FI-HCI is confirmed as an important source of information concerning both the overall taxonomic representativeness of the material hosted and the opportunities it offers for systematic study. On the other hand, for some regions and also for some taxa (e.g., *J. sphaerocarpus*) there are some shortcomings with respect to the reports in the most up-to-date national checklists. For these cases, it would be desirable to receive the missing samples from the Italian botanical community, to fill these gaps and to render the material stored in FI-HCI increasingly consistent with the updated distribution data at the national level.

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Supplementary Material

Table S1. List of the studied specimens. When the collection date was missing of the collection year, misinterpreted or confused with the year of accession in the herbarium, we use the note ND.