Considerations and distributional innovations for some taxa of the genus *Parapholis* (Poaceae) in the Adriatic basin with special reference to *Parapholis strigosa*, for which a new infraspecific taxon is proposed

Piero Cuccuini[1*], Lorella Dell'Olmo[2], Stefano Dominici[3]

Abstract - The distribution of *Parapholis strigosa* (Dumort.) C.E.Hubb. in the Adriatic basin has been analyzed. After the investigations by Hylander and Runemark, further collections were made, particularly during the years 1991-2002 and in 2017-2018 limited to Albania, that revealed the presence of an important population over the entire basin, which was especially dense along the northwestern coasts. These studies, together with a revision of the historical material gathered from the area and conserved in various Italian and foreign herbaria, highlighted a quantitative morphological character of clearly genetic origin, already considered as diagnostic within the genus. This trait, anther length, falls into two distinct size classes, their values constant within different areas of the basin, in turn, characterized by different geological and climatic situations. It was thus possible to establish a new intraspecific taxonomic entity named *Parapholis strigosa* var. *minor*, **var. nov.,** although the variability was significant in the *t*-test (p<0.0001). This distribution showed the new variety, occurring on the western (Gargano lakes) and eastern coasts (Dalmatia and Albania), both with a Mediterranean climate, to be almost entirely separated from the typical form, with only one point of overlap. The autonymic variety, on the contrary, is found along all the other coasts with a temperate climate. Moreover, other revised materials brought to light, the first report of *Parapholis marginata* Runemark for Montenegro and the northernmost station in the temperate area of the Mediterranean for the same taxon.

Key words: chorology, phylogeography, typification, variability, variety.

Riassunto - Considerazioni e novità distributive di alcuni taxa del genere *Parapholis* nel bacino adriatico con particolare riferimento a *Parapholis strigosa*, per la quale si propone un nuovo taxon infraspecifico.

È stata approfondita la distribuzione di *Parapholis strigosa* (Dumort.) C.E.Hubb. nel bacino adriatico. Dopo le indagini di Hylander e Runemark vi sono state successive raccolte in particolare negli anni 1991-2002 e, limitatamente all'Albania, nel 2017 e 2018 che hanno evidenziato la presenza di un consistente popolamento in tutto il bacino con particolare densità sulle coste nord-occidentali. Queste indagini, affiancate al controllo dei materiali storici raccolti nell'area e conservati in molti erbari sia italiani che stranieri, hanno confermato la presenza di un carattere morfologico quantitativo di chiara origine genetica, già considerato come diagnostico all'interno del genere (la lunghezza delle antere), che si differenzia in due classi di misura con valori costanti su aree diverse del bacino. a loro volta caratterizzate da situazioni geologiche e climatiche diverse. È stato quindi possibile individuare una nuova entità tassonomica infraspecifica indicata come *Parapholis strigosa* var. *minor*, **var. nov.** La variabilità è risultata significativa al *t*-test (p< 0,0001). Tale distribuzione ha separato quasi completamente, con un solo punto di sovrapposizione, questa nuova varietà dalla forma tipica, essendo diffusa sulle coste occidentali (laghi garganici) e orientali (Dalmazia e Albania) a clima mediterraneo. La varietà autonimica è invece presente su tutte le altre coste a clima temperato. Inoltre, fra gli altri materiali revisionati è stata individuata la prima segnalazione di *Parapholis marginata* Runemark per il Montenegro e, la stazione più settentrionale del medesimo taxon per il Mediterraneo in piena area temperata.

Parole chiave: corologia, filogeografia, tipificazione, variabilità, varietà.

[1]The University Museum System, Natural History Museum, Botany, Florence, Italy.
[2]Department of Biology, University of Florence, Italy.
[3]The University Museum System, Natural History Museum, Florence, Italy.

* Corresponding author: pierocuccuini9@gmail.com

Received for publication: 29 March 2024
Accepted for publication: 14 March 2025
Online publication: 14 March 2025

INTRODUCTION

The rather confined and peripheral position of the Adriatic basin in the Mediterranean, the marked morphological and geological diversity of its coasts, together with its northwest geographical alignment, shallow waters (at least in the central northern basin), all compete in characterising the climate of the area and determining the specific distribution of taxa pertaining to the genus *Parapholis* C.E.Hubb., particularly the species *P. strigosa* (Dumort) C.E.Hubb. The occurrence of *P. strigosa*, typical of the cold temperate areas of northern Europe, is a remarkable exception in the Mediterranean since the population in the Adriatic region has long been naturalized and widespread and is by far the most extensive around this sea. Numerous geological events, from the Messinian to the last glaciation (Würm) and the subsequent interglacial period, all contributed to the present situation of the Adriatic basin. In particular, after the apex of the Würm glaciation, the gradual adjustment of the amphi-Adriatic coast saw the permanence of extensive wetlands to the north and northwest, also in relation to the Po delta.

These conditions extended into the last prehistoric and

historical period; suffice it to recall the exclusively anthropical changes to the Venetian lagoon and Po delta (Filesi, 2019) up to almost the present day. Recent studies on the genus *Parapholis* and other Hainardieae Greuter (Cuccuini, 2002, 2018, 2019; Cuccuini & Fiorini, 2004, 2020; Fiorini & Cuccuini, 2002), currently included in the tribe Poeae R.Br., subtribe Parapholiinae Caro (Soreng *et al*., 2015; Soreng *et al*., 2017), revealed at least two different morphotypes of the taxon in question, but did not, however, provide any specific distribution or taxonomical conclusions.

Verification of specimens belonging to historical herbaria contributed to this investigation also by providing data from accidental collections made when the taxon was still unknown in the Mediterranean. The taxon had never been reported as such, at least until the studies on its sporadic occurrence by Hylander (1953), and subsequently Runemark (1962) in his revision of the genus in the Mediterranean.

Notes on the geological features of the Adriatic coast

The Adriatic Sea is a narrow semi-enclosed basin bounded by the Italian Peninsula to the WSW and the Balkan Peninsula to the ENE, with considerable freshwater inflow. The average outflow of the largest rivers ranges from 940 to 1100 m^3/s for Albanian rivers to 1500 m^3/s for the Po River, the largest tributary (Vodopivec *et al*., 2022).

The highly complex orography has a considerable effect on the weather in this area, especially on wind direction and speed, with significant differences in spatial and temporal structure (Signell *et al*., 2005).

The Italian peninsula is characterized by the Tyrrhenian-Apennine system, shaped by W-dipping subduction which began to migrate eastward from the eastern margin of Sardinia about 10-15 Ma. The northern Apennines are mainly formed by thick Cenozoic siliciclastic formations (turbiditic sandstones), subordinately by Mesozoic limestones (Conti *et al*., 2020). The sand-based lithology, high slope gradients, and low organic matter accumulation rates hinder soil development. However, higher pedodiversity occurs at altitudes >1000 m a.s.l. compared with those at ≤1000 m, likely due to the higher vegetation diversity and larger mean air temperature ranges (Vittori Antisari *et al*., 2023). The southernmost part of the southern Apennines in Italy is formed by the Apulian platform, geologically similar to the Croatian coast (Bosellini & Morsilli, 2001; Santantonio *et al*., 2013; Scisciani & Esestime, 2017).

The Adriatic side of the Balkan Peninsula is occupied by the Dinaric Alps, a rugged and extensive mountainous area structured in Cretaceous and Palaeogene times (Schmid *et al*., 2008). The eastern sectors of the Dinaric Alps are mainly constituted by Mesozoic limestones (Velić, 2007; Kilibarda & Schassburger, 2017). Soils at the onset of formation and with weak horizon differentiation are widespread (cambisols: Husnjak *et al*., 2011).

The coastal lakes of the Gargano peninsula deserve a discussion apart. Lago di Lesina and Lago di Varano are two coastal lagoons separated from the sea by a sandy strip which is interrupted by two artificial channels communicating with the sea. The first lagoon, however, is elongated and very shallow (max 1.6 m), whereas the second is quadrate, deeper than 4.0 m (Molinaroli *et al*., 2014) and modeled around a tectonic feature possibly inherited from the Cretaceous (Bosellini *et al*., 1999).

Notes on the climatic characteristics of the area

The Adriatic basin is the most extensive area of the Mediterranean and overall does not present typical Mediterranean climatic characteristics. Indeed, from the first modern climatic studies by Köppen (1936), subsequently revised together with Geiger (Köppen & Geiger, 1954), the Adriatic basin is classified as the general type "C", rainy temperate-mesothermal climates (Warm gemäßigte Regenklimate) characterized by a mean temperature for the coolest month between -3 °C and 18 °C. Almost all the western and northern coasts and part of the eastern coast of the basin (from Istria to the Kvarner Gulf) fall within the temperate area (indicated as sub-type Cfa: "f", precipitations distributed uniformly over the year; "a" hot summers). Only to the south of Gargano on the western coast, can we find a truly Mediterranean climate (indicated as sub-type Csa: "s", dry summer season; "a", hot summers). Later studies by Rivas-Martinez *et al.* (2011) and, for Italy in particular (Biondi *et al*., 2015), consider as far as macrobioclimates are concerned, all the northern and western coast up to the northern Marche region, as truly temperate areas and from there to the Gargano lakes in Puglia, as almost sub temperate, better described as of the sub-Mediterranean variant.

The two systems are almost superimposable, with the only spatial difference being the Gargano with its lakes, which Biondi *et al*. (2015) include almost entirely in the truly Mediterranean area, whereas Köppen & Geiger (1954) consider it to be a transitional area with a typically Mediterranean climate, which they indicate as starting immediately after the Gargano peninsula.

Both climatic systems consider the remaining part of the eastern coast, from Dalmatia to Albania (defined as Csa by Köppen & Geiger, 1954), as an area with a truly Mediterranean climate. The only difference between the two approaches is the amount of territory to be allocated to the Mediterranean region, which appears narrower in the system proposed by Rivas-Martinez *et al.* (2011), particularly regarding the Dalmatian coast.

MATERIALS AND METHODS

As for the specimens, those from peninsular Italy, as well as historical and more recent Istrian and Albanian collections and those already considered by Cuccuini (2002), were reviewed, and all of them were revised in light of the proposed new taxonomic subdivision. We also considered all the material kept in the B, BEOU, BM, BR, BREM, FER, FI, FI-W, G, GZU, K, LD, MFU, MOD, NAP-Cavara, NHMS, P, PAD, PRC, S, TIR, TO, TSM, ULT, UPS, VER, W, WU, ZA, ZAGR herbaria (codes according to Index Herbariorum, 2023 onwards), for the most part not examined in the previous studies. When examining the anthers, those in the apical spike were not considered as they are always longer than the others or material for seeding. For cartographic distribution and the variability graph, we only considered specimens with anthers, and the same applies to the "Specimina visa selecta" (*Supporting Information*). After verifying the normality of the distribution of the variation of the character "long or short anthers" with the Shapiro-Wallis test (0.942 and 0.8688 for long and short anthers respectively), the *t*-test with 9999 permutations was

performed to check its significance. All tests were performed with the PAST software (Hammer *et al*., 2001).

For the description and identification of the material, floristic lists and herbarium databases of the study areas were accessed. In addition, all up-to-date revisions of the genus containing information on the study area and on the Mediterranean, in general, were consulted (Dumortier, 1823; Fiori, 1927; Hayek, 1933; Hylander, 1953; Runemark, 1962; Paunero, 1964; Tutin, 1980; Demiri, 1983; Sherif & Siddiqi, 1988; Hoda & Mersinllari, 2000; Vangjeli *et al.,* 2000; Cuccuini, 2002; Fiorini & Cuccuini, 2002; Vangjeli, 2003; Pulević, 2005; Sarika *et al*., 2005; Mitić *et al*., 2009; Shehu *et al*., 2010; Ball, 2011; Bergmeier *et al*., 2011; Meyer, 2011; Masin *et al*., 2014; Nikolić, 2015; Vangjeli, 2015; Pils, 2016; Banfi, 2017; Barina, 2017; Barina *et al.*, 2017; Barina *et al.*, 2018; Cuccuini, 2018; Dítě *et al*., 2018; Cuccuini, 2019; Cuccuini & Fiorini, 2020; Nikolić, 2020; Cuccuini *et al*., 2021). The ratio between the internodal part covered by the previous glume (A) and its length (B) (hitherto considered associated with the habitus of the plant) was calculated for the median part of the spike. In fact, this choice was imperative because it allowed the fertile spikes to be found in more or less the same position since it turned out that the number of fertile flowers is, on average, about half or two-thirds of the total for various reasons: abortion, irregular seasons, fungus or small insect attacks, which can limit the number of fertile flowers from a minimum of 3-4 to a maximum of 8-9 per spike, the first situation being prevalent.

It should also be borne in mind that the material gathered from Adriatic coasts and lagoons was not equally abundant. In fact, most of the material available (as well as historical collections) for the western and northern coasts was collected specifically for this study.

Apart from the new collections that marginally concern the Trieste coast, the areas west of Istria, and, in the far south, Albania, all the material considered for the east coast consists of specimens on loan from Italian and foreign herbaria.

RESULTS

Diagnostic characters

All studies on the genus *Parapholis* or its specific taxa (Runemark, 1962; Paunero, 1964; Tutin, 1980; Sherif & Siddiqi, 1988; Cuccuini, 2002; Fiorini & Cuccuini, 2002; Romero Zarco, 2015; Banfi, 2017; Cuccuini, 2018, 2019; Cuccuini & Fiorini, 2020; Nikolić, 2020) with regard to macrocharacters with a clear diagnostic value for *P. strigosa,* specify the lack of folding on the glume's carina and/or partial plication, which pertain to the group within the genus showing longer anthers (2 mm and over), as well as a mostly erect habitus with prevalently linear and robust spikes. As well as phenotypic characteristics, such as plant size, which is strongly influenced by variations in the climate (temperature and precipitation) and glume dimensions. The macrocharacters, such as anther length, can vary from 1.5-1.8 to 3.1-3.2 mm, which up to now has been held valid for the whole of the Mediterranean and the north European coasts. This study diagnosed two distinct size classes for the Mediterranean Sea and particularly for the Adriatic basin: 1.5-2.3 (-2.4) and 2.5-3.2 mm, which we consider to be of diagnostic value for the proposed new infraspecific taxon and the typical form, respectively. The *t*-test proved that the variability of this character is statistically significant ($p<0,0001$). The variation of the two sets is shown in Fig. 1. This study did not re-examine microcharacters.

Taxonomic setting

Parapholis strigosa (Dumort.) C.E.Hubb.

Bas. *Lepturus strigosus* Dumort., Observ. Gramin. Belg. 146. 1824 (1823 publ. Jul-Sep 1824), as "*Lepiurus*"

Typus: "*Lepiurus*, Ostenda, s.d "campione sulla sinistra del foglio, n° 1088499 (*Herb. Dumortier*, BR!). Lectotypus designated by Cuccuini, 2002: 23, which automatically establishes the typus of autonym, *P. strigosa* var. *strigosa*, see Arts. 7.7, 26.1 of the ICN (Turland *et al*., 2018).[1]

Parapholis strigosa var. *minor* Cuccuini, var. nov.

Typus: Holotypus: Puglia, riva interna del tombolo di Varano, margini coltivi su terreno battuto (Prov. di Foggia), 7/06/1990, *Cuccuini, Luccioli & Padovani* (FI barcode FI068162) (Fig. 2).

Isotypus: (FI barcode FI068213). For paratypes see: Attachment 1- Specimina visa selecta, *Supporting Information*.

Diagnosis: differs from the type species in the shorter length of mature anthers, 1.9-2.3 (-2.4) mm. in the middle portion of the spike.

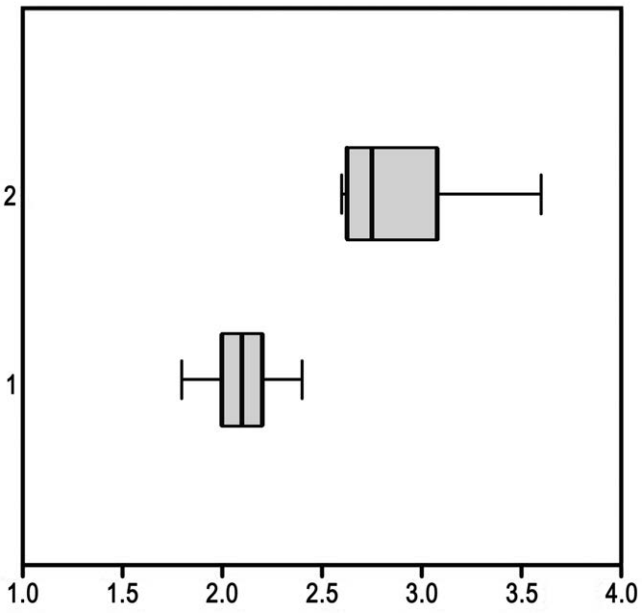

Fig. 1 – Box–plot of anthers variability in *Parapholis strigosa* var. *minor* (1) and *P. strigosa* var. *strigosa* (2) in the Adriatic Basin. The top, bottom and line across the boxes (in bold) correspond to the 75th percentile (top quartile), 25th percentile (bottom quartile) and 50th percentile (median) respectively. The whiskers on the bottom extend from the 10th percentile (bottom decile) and top 90th percentile (top) decile). / Diagramma a scatola e baffi sulla variabilità delle antere in *Parapholis strigosa* var. *minor* (1) and *P. strigosa* var. *strigosa* (2) nel bacino adriatico. La parte superiore, quella inferiore e la linea che attraversa le scatole (in grassetto) corrispondono rispettivamente al 75° percentile (quartile superiore), al 25° percentile (quartile inferiore) e al 50° percentile (mediana). I baffi in basso si estendono dal 10° percentile (decile inferiore) e dal 90° percentile (decile superiore).

Fig. 2 – Holotypus of *Parapholis strigosa* var. *minor* Cuccuini. / Olotipo di *Parapholis strigosa* var. *minor* Cuccuini.

Description: annual, erect, sometimes slightly decumbent plants (when accrescent). Single or organized in small clusters, with a single spike or a few ramifications either at the base (less frequent) or along the stem (more frequent). Spikes generally straight or sometimes slightly curved. Glumes generally lanceolate-ovate but also tend to be acuminate. Generally, 1/4 to 1/6 (<1/3) of the internode is covered by the apex of the preceding glume. Mature anthers, in the central portion of the spike, normally 1.9-2.3 mm long, <<(2.4). When stripped approx. 0.1 mm shorter (Fig. 3).

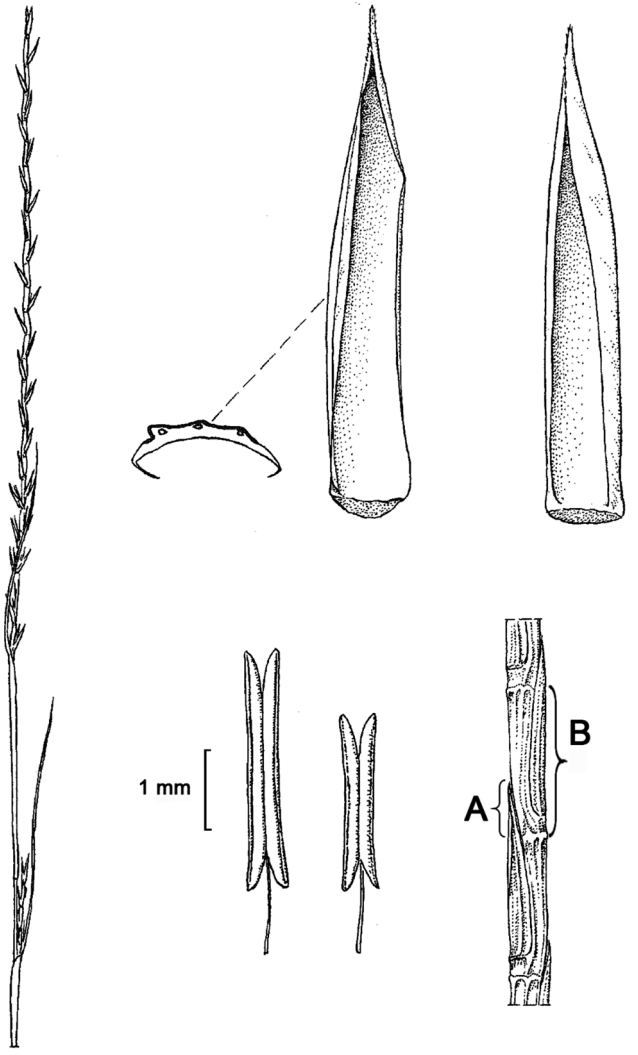

Fig. 3 – *Parapholis strigosa* complex. From the left: complete spike (×0.8), top – upper glume section, upper and lower glume (×25); bottom – *Parapholis strigosa* var *strigosa* mature anther, *P. strigosa* var. *minor* mature anther (×11.5), portion of spike (×12), (A) internode part covered by glume, (B) internode length, from Cuccuini (2002) (Fig. 5) modified. / Complesso di *Parapholis strigosa*. Da sinistra: spiga completa (×0,8), in alto: sezione della gluma superiore (×25), gluma superiore e inferiore (×11,5); in basso: *Parapholis strigosa* var. *strigosa*, antera matura; *P. strigosa* var. *minor*, antera matura (×11,5), porzione di spiga (×12) (A) parte dell'internodo coperto dalla gluma, (B) lunghezza dell'internodo, da Cuccuini (2002) (Fig. 5) modificato.

Further data

Only data totally differing from those previously reported in Cuccuini, (2002) and in particular those relative to distribution in the Mediterranean of the new variety are given. Partially different data from Cuccuini, (2002) as "Chromosome number" see also (Fiorini & Cuccuini, 2002; Lövkvist & Hultgård, 1999) or in "Ecology" see (Masin *et al*., 2014).

Iconography: Cuccuini (2002): Fig. 5, top from left: anthers morphotype A, B; Cuccuini & Fiorini (2020): Fig. 1, anther morphotypes 1, 2 in E.

Distribution in the Adriatic: distribution of the 2 varieties as shown in Fig. 4, is treated in the Discussion section.

Distribution in the Mediterranean: distribution in the Italian non-Adriatic Mediterranean regions: outside the Adriatic, distribution of both varieties of *P. strigosa* is modest (*Supporting Information*). We are prevalently dealing with information from historical collections and in some locations, the plant is no longer found (for example at the mouth of the Cinquale or on the Elba Island in Tuscany, as var. *strigosa*), although in Italy, as well as verified stations in Tuscany, Sicily (*P. strigosa* var. *minor*), Lazio (*P. strigosa* var. *strigosa*) and Calabria (*P. strigosa* var. *strigosa*), recent findings have been reported from certain localities in central south Tuscany. In southern Sicily and eastern and northern Sardinia, the Asinara archipelago, and in southern Nurra (Biondi *et al*., 2001), and Cape Teulada (Peruzzi *et al*., 2019 onwards). The problem with this otherwise very useful tool (Peruzzi *et al.*, 2019 onwards) lies in the fact that it is not always possible to check the material, as the information often comes from the observation of the plants in their habitat, whereas it would be more useful to collect the samples and report where the specimens are kept. In the rest of the Mediterranean, the species is stable almost exclusively in the west and along the Côte d'Azur coast (the lagoon population south of Montpellier and Narbonne) as var. *minor*. Nearer, sightings have also been reported from Spain even within salt lakes (*P. strigosa* var. *minor*), while its presence is rather punctiform in Greece (Ionian islands-Corfù) (Dimopoulos *et al.*, 2016), as *P. strigosa* s.l. On the North African coast, finds are very rare. There are historical reports from a station that no longer exists near Tripoli in Libya (Scholz, 1974), which are difficult to attribute to either variety, as well as perhaps some reports from the Moroccan coast that we were unable to verify in this study. As regards Northern Europe and the rest of the world, data already reported in Cuccuini (2002) are confirmed.

The A/B parameter (A = portion of the internode covered by the glume /B = internode length)

Runemark (1962) was the first to mention the debated parameter of the internode covered by the underlying glume, generally taking the median portion of the spike, and especially its consideration as a specific character. We investigated this situation using data from all the materials for both varieties of *P. strigosa* examined from the Mediterranean basin. The parameter did not prove to be directly diagnostic but still showed different variability in the two varieties for large areas. Tab. 1 shows the results expressed in rational numbers for the typical distribution areas for each variety (including the only true "inclusion" of individuals with short anthers in the area where long anthers predominate)

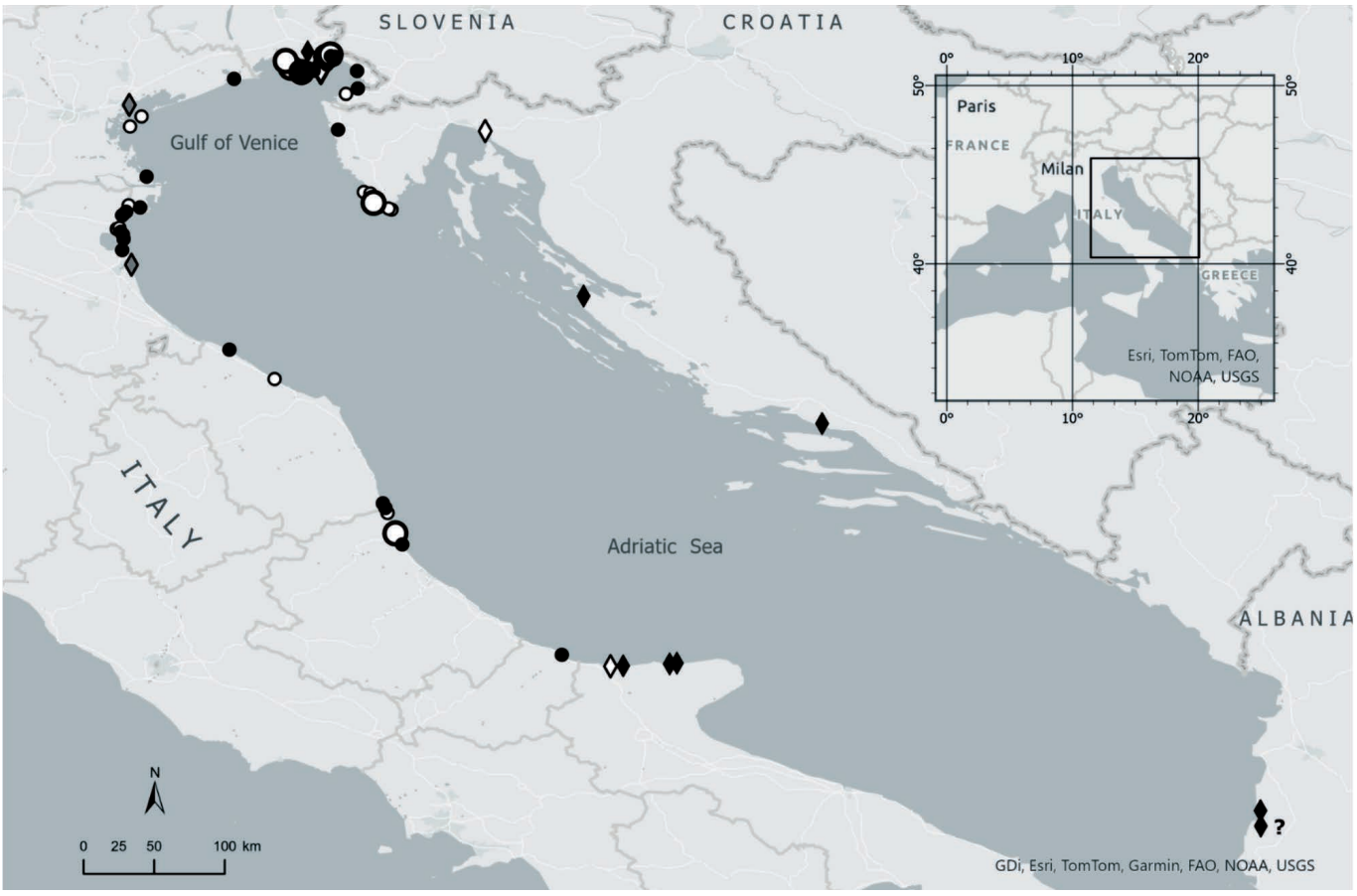

Fig. 4 – The symbols ○ and ◊ indicate the distribution of *Parapholis strigosa* var. *strigosa* and *P. strigosa* var. *minor* in the Adriatic Basin, respectively; when the two symbols are white they represent collections ≤ of 1950, when black collections > 1950, when gray = extinct; ? dubious identification; when the two symbols (white or black) are small they indicate 1-2 collections in the same station, when large + of 2 collections. / I simboli ○ e ◊ indicano rispettivamente la distribuzione di *Parapholis strigosa* var. *strigosa* e *P. strigosa* var. *minor* nel bacino adriatico; quando i due simboli sono bianchi rappresentano raccolte ≤ del 1950, quando sono neri raccolte > 1950; quando i due simboli (bianchi o neri) sono piccoli indicano 1-2 raccolte nella medesima stazione, quando sono grandi + di 2 raccolte; quando sono grigie indicano stazioni estinte.

Tab. 1 – Main ratio values for *P. strigosa* var. *strigosa* (long anthers) and *P. strigosa* var. *minor* (short anthers), i.e. length of portion of glume covering subsequent internode (A) / length of internode (B), in the Adriatic Basin (>, >>, prevalence -60-75%-, strongl prevalence -over 75%-; <, <<, minority -25-40%-, strong minority -10-25%-). / Valori prevalenti in *P. strigosa* var. *strigosa* e *P. strigosa* var. *minor* del rapporto: lunghezza parte internodo ricoperto dalla gluma precedente (A) / lunghezza internodo (B), nel bacino adriatico (>, >>, prevalenza -60-75%-, forte prevalenza -oltre 75%-; <, <<, minoritario -25-40%-, fortemente minoritario –10-25%-).

P. strigosa var. *strigosa* Long anthers	Ratio valueA/B	*P. strigosa* var. *minor* Short anthers	Ratio valueA/B
Northern Italy, North Coast/ Emilia-Veneto-F. Venezia Giulia p.p.	>>1/3-1/5; <<1/2 Very frequent	F.V. Giulia, Grado Lagoon (Val Goppion - ditches in front of S. M. di Barbana); Emilia (former Pineta Monaldina)	1/3-1/5 Frequent, limited to area (F.V. Giulia)
Northern Italy/Gulf of Panzano-Triestine area	> 1/3-1/4; < 1/5-1/6 Frequent		
Slovenian/Croatian Istria, western coast	>1/3-1/4; <<1/6		
Central and Southern Adriatic coast Italy (up to Molise)	>1/3-1/4; <1/2		
Southern Italy-Apulia (Gargano-Lesina)	1/3 Sporadic	Italy-Apulia-lakes of Lesina and Varano (Gargano)	>>1/4-1/6; <<1/3 Very frequent
Italy-Apulia - south of S. Margherita di Savoia	Casual	Italy-Apulia-south of S. Margherita di Savoia	Casual
East Coast - Croatia- Kvarner Islands p.p	1/3 Sporadic	Croatia-Central Dalmatia and Albania	1/3-1/5 Infrequent

shows that although each variety has a different variability in different areas, a clear line of tendency marks a strong majority (over 75%) of lesser (internode) covering (1/4-1/5; 1/4-1/6) for the short anther population of *P. strigosa var. minor*. Given the scarce amount of material for central Dalmatia and Albania, results are less significant but in line with previous findings.

Further updates on specific taxa of the genus *Parapholis* in the Adriatic area

During our study, other important data relative to the situation of the genus *Parapholis* in the Mediterranean emerged from an examination of the material received. We report the first sighting of *Parapholis marginata* Runemark for Montenegro (material from BEOU) as well as confirmation of the occurrence of this taxon on the islet of "Otočić Figarola-Figarola grande" opposite Rovinj-Rovigno in Croatian Istria (material from GZU), which is the most northern station for this taxon in the whole Mediterranean. In effect, the northward advance of this taxon in the Adriatic also occurred in the presence of important Libyan populations to the south (see material from Cyrenaica in the FI and ULT and recently those of Tripolitania revised in NAP- Cavara, in the Supplementary file), as well as those, in the eastern Mediterranean, of the Cyclades where the taxon was first identified.

We can, moreover, clarify the citation by Baldacci (1894) regarding the occurrence of *Pholiurus pannonicus* (Host) Trin. (sub *Lepturus pannonicus* (Host) Kunth) on the Valona plain in Albania, which remained doubtful for the lack of finding this specimen in FI, in that it refers to specimens of *P. filiformis* (from material held in WU). Besides, Masin *et al*. (2014) reported isolated findings (*Parapholis filiformis* (Roth) C.E.Hubb.) quite inland (up to 55-60 km) in western Polesine. If confirmed, this would be a significant novelty for the distribution of this species in Italy.

DISCUSSION

We do not know if hybrid genes or other phenomena took place, but it is a fact that this small taxonomic group today confluences with probable hybrids like ×*Hainardiopholis pauneroae* Castrov. (Castroviejo, 1980), today considered to belong to the genus *Parapholis* as *Parapholis* ×*pauneroae* (Romero Zarco, 2015). Other parts of this plant, for example, the apical portion, and wing of carena (regardless of the plicature) of the glume, do not always fit the descriptions given. We believe that the ultimate comprehension of these phenomena calls for deeper examination.

In addition, the Adriatic Sea underwent a very complex genesis in the late Holocene, particularly from the beginning of the last interglacial period after the Würm glaciation (12,000-13,000 years ago). In this period, the sea covered about half of the present-day surface due to a depth difference of -120 m compared to the present, which caused the Po delta to be located about 120 km southeast of Mount Conero. Considering the present coastline, we can subdivide the basin into three parts (north, middle, and southern), differing substantially from one another on account of their mean depth, salinity, the origin of the base, and the influx of sediments over various times. Suffice it to think that the mean depth in the northern sector of the Po delta reaches an average of 30-34 m, which is comparable to that of a lake. In this situation, the outflow of freshwater from the Po into the Adriatic is such that it forms a permanent lighter layer of freshwater that 'floats' on the surface, leading to a marked reduction in salinity and the formation of a current that laps part of the basin's western coastline (Trincardi *et al*., 2011), certainly influencing ecological conditions.

The new advancement of the water left the north and northeastern coastlines long undefined up to almost our present time, influencing the evolution of these habitats and of human history as well. All these conditions contributed to the spread of therophytes such as *Parapholis*, not only on the coasts but in numerous natural shelters such as lagoons, marshes, and man-made stretches of water and favored their relocation not only through natural causes, like marine currents, fauna but also by human activities linked to the water and the evolution of agriculture. In particular, the years of the Republic of Venice (the so-called "Serenissima") saw the succession of major hydraulic works for the reclamation of lagoons, the creation of fishing valleys, and the regulation of river mouth channels for the implementation of safety measures.

The data obtained from approximately 80 collection sites scattered along the entire coast of the basin (with tens of collections repeated over time), revealed the following situation (Fig. 4): in the west and north coasts (as far as the Gulf of Panzano) almost all collections showed the presence of specimens of *P. strigosa* var. *strigosa* (with anthers measuring 2.6 to 3.0-3.2 mm, and the >>2.8-3.0 mm). The distribution of the plant reached as far as Molise and had the greatest concentration in the northern part of the basin, encompassing all types of water bodies linked to lagoons, fishing valleys, as well as the mouth of the river Isonzo and the entire Gulf of Panzano in the north-east. The density of *P*. var. *strigosa* in this area is high and, sometimes, along the inland coasts of some of the lagoons (Grado p.p. and Gulf of Panzano), equal to that of *P. incurva*. Moreover, it is completely vicariant with *P. filiformis*, which can be considered rare in this area. Density is similarly high along the north-west coast, in the marshes behind the extensive coastal stands of pine of Emilia-Romagna.

Exceptions to these are a few, partly disappeared, stations of *P. strigosa* var. *minor*, in the locality of "ex val Cavarera" (Val Goppion area, Grado). These are consolidated brackish marshes, mostly of anthropogenic origin, including the banks with substantial saline deposits of the ditches in front of Santa Maria di Barbana, an area in which the continuous presence of var. *minor* is evidenced by historical data. It is also worth mentioning two historical specimens (1845) found near the ponds, which no longer exist, of the former Pineta Monaldina (Ravenna-north sector of the San Vitale pine forest) and collected at the time when the pine forest was chopped down (De Renzi, 2004), as well as two other reports from historical sites now disappeared, in the Marghera area before the expansion of the city, which date back to the times of the Austrian Empire rule.

In contrast, in the Gargano (southwestern coast), where the climate is already Mediterranean (Biondi *et al*., 2015), adjacent to the large coastal lakes of Lesina and Varano differing considerably in their geological origins, there is a marked presence of *P. strigosa* var. *minor*. Here,

the plant is generally more robust and branched, with short anthers <2.5 mm (on average 2.0-2.2 mm). The plant is commoner and grows denser along the banks of Lake Varano, the cultivated lands of the isthmus, and the beaten ground along the cart tracks (a fairly rare situation for this taxon in Italy), thus representing the majority of the *Parapholis* present. South of the Gargano, the coastline becomes rocky, and *P. strigosa* s.l. no longer or only sporadically occurs as a casual.

The situation is more complex for the east coast, geologically and, to a large extent, climatically different from the west. Along the entire Italian north-eastern coast (Trieste area), and as far as the western shores of Croatian Istria, situated in a climatically temperate and geologically rocky zone, *P. strigosa* var. *strigosa* is always present, albeit less frequently. This is probably due to the proximity of the Gulf of Panzano, where there is a significant population of the typical *P. strigosa*, whose dispersion originated for both natural and anthropic reasons linked to fishing and tourist-recreational activities. Further on, in the Gulf of Kvarner (Quarnaro), which includes almost all the islands off the Istrian coast up to Losjni (Lussino), where there is a climatic transition zone from temperate to Mediterranean climate, *P. strigosa* var. *strigosa* is regularly present, although considerably less frequent. Again, *P. strigosa* var. *minor* already begins to appear in the Gulf of Bakar (Buccari) almost opposite the Island of Krk (Veglia) and, further on particularly in Dalmatjy (Dalmazia), in a distinctly Mediterranean climatic zone, with the rare occurrences documented all to be ascribed to *P.* var. *minor*. However, its occurrence is extremely fragmented, and *P. strigosa* var. *minor* gives way to the more Mediterranean *P. filiformis* (again not very frequent). Besides, papers on vegetation and investigations into rare plants of the salt marshes of the Croatian coasts (Stančić *et al*., 2008; Mitić *et al*., 2009; Jasprica *et al*., 2015; Jasprica & Milović 2016; Jasprica *et al.*, 2016; Milović *et al*., 2016; Dítě *et al.*, 2018; Bogdanović & Ljubičić, 2019) never mention *P. strigosa*. Even *P. incurva* and *P. filiformis* are both indicated as "vulnerable species" and "Rare species not included in Red list", respectively. Finally, Nikolić (2020) cites *P. strigosa* for the Croatian coast but does not provide evidence of available material in his possession or preserved in the most important Croatian herbaria (Z, ZAGR). This situation extends all the way to the Albanian coast where *P. strigosa* var. *minor* becomes extremely rare, and *P. filiformis* a vicariant.

CONCLUSIONS

This study was favored by the geomorphological and climatic features of the Adriatic Sea, which favored our evaluation of the distribution of this new botanical variety, whose distinctive morphological characters made it possible to effectively discriminate it from the typical form.

We chose to place the observable difference within a nomenclatural frame and institute a new taxon, *Parapholis strigosa* var. *minor*. Variety is a suitable category for the treatment of 'populations' that are not completely separated geographically as is required, for biological reasons, for the establishment of a subspecies.

It should also be said that the relatively small size of the basin could have favored genetic exchanges between the two distribution areas, but this calls for a phylogeographical study to verify population dynamics. The absolute prevailing presence of the taxon with short anthers from the north European coasts, particularly from the north-eastern German and Swedish coasts, in a situation of profoundly different geological and climatic situations compared to the Adriatic, demands for further research

This consideration was further motivation for not using the already validly published but synonymized name *Lepturus incurvatus* var. *strictus* Fr. (Fries, 1845; POWO, 2023), which undoubtedly refers to *P. strigosa* (as is evident from the original collection kept in UPS, 3 specimens and LD, 1 duplicate), to indicate *P. strigosa* with short anthers both in the Adriatic basin, and in the areas of North Europe, not only because presented problems of ambiguity[2], but also because of a reasonable doubt that it was in fact a cytotaxonomically different entity.

Despite these limits, our study highlights a controversial aspect regarding this plant. The occurrence of the two varieties both in the Mediterranean and in northern Europe calls for investigations into the population dynamics and phylogeography of this plant. A molecular approach could elucidate whether this is phenotypic selection mainly due to geographic and environmental conditions in the presence of weak genetic isolation (Franzoni *et al.*, 2023; Franzoni *et al.*, 2024) or cytotaxonomically different taxa.

SUPPORTING INFORMATION / INFORMAZIONI SUPPLEMENTARI

- Additional supporting information may be found online for this article. / Per questo articolo sono disponibili informazioni supplementari online.
- Additional data on materials of *Parapholis strigosa* in the Mediterranean (including the Adriatic basin), and *Parapholis marginata* in Libya (unpublished collection), N. Africa (east-central), and Greece (Cyclades) / Dati supplementari su materiali di *Parapholis strigosa* nel Mediterraneo (compreso il bacino adriatico) e di *Parapholis marginata* in Libia (collezione non pubblicata), N. Africa (centro-orientale) e Grecia (Cicladi).

REMARKS

[1] Further controls of the type material (in BR) in the median parts of the inflorescence underlined the size of the anthers that vary from between 2.5 mm (<), and 3.0 mm (>) (Sofie De Smedt, for Ivan Hoste in litteris, 8/12/2022), while the ratio between the part of the internode covered by the underlying (upper) glume and the total length of the internode of intermediate spikelets was 1/3 (>) to 1/4 (<).

[2] Of the 4 specimens in the original collection – 16 individuals – only one individual had an anther that was in bad shape, all the rest had gone to seed (×UPS, M. Hjertson in litteris, 2023; ×LD, P. Frödén in litteris, 2023).

ACKNOWLEDGMENTS

We thank our colleague Chiara Nepi for her thorough and critical revision of the text, our colleague Bruno Foggi for his advice on the box plot and development of the study

in general and Lorenzo Cecchi for his suggestions in the course of the work, Dr. Lia Pignotti for the German translation and her advice during the study. We also wish to thank our colleagues and the directors of the B, BEOU, BM, BR, BREM, FER, FI, FI-W, G, GZU, K, LD, MFU, MOD, NAP-Cavara, NHMS, P, PAD, PRC, S, TO, TIR, TSM, ULT, UPS, VER, W, WU, ZA, ZAGR herbaria for sending exsiccata or relative images and in particular our colleague Snežana Vukojičić, curator of the BEOU Herbarium, for the material, bibliography of the Balkan Region and the frequent changes of ideas and opinions on the paper.

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