

## Taxonomy of *Poa jubata* and a new section of the genus (Poaceae)

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**Abstract:** *Poa jubata* A.Kern. is an ephemeral, southeastern European species of which little is known. A molecular phylogenetic analysis of *Poa* L., including all previously identified major lineages, shows this species to be isolated, with a genotype here designated as J (plastid) J (nrDNA). It is assigned to the monotypic *P.* sect. *Jubatae* sect. nov. The section is differentiated from other *Poa* sections in having 5-nerved upper glumes, very narrow palea flanges, an annual habit, and erect solitary culms. *Poa jubata* occurs along coastal regions of the Balkans and is rather rare. Two new collections were made in 2015 in Thrace, Turkey, in vernal pool habitats with clay soils, thus expanding its known habitat. The species is described in detail and illustrated, and its relationships are discussed.

**Key words:** Morphology, taxonomy, DNA, Europe, Balkans region, phylogeny, genotype, annual habit

### 1. Introduction

*Poa* L., with about 550 species, is a large genus of grasses. Edmondson (1985) recognized 24 species of *Poa* in Turkey. He noted one imperfectly known species as *P. hackelii* Post, and two doubtful species as *P. iberica* Fisch & C.A.Mey and *P. palustris* L. He also placed *P. eigii* Feinbrun under *P. bulbosa* L. s.l. In subsequent years, three more *Poa* species (*P. akmanii* Soreng, P.Hein & H.Scholz; *P. asiae-minoris* H.Scholz & Byfield; and *P. bussmannii* H.Scholz) were described from Turkey. In the checklist of the Poaceae of Turkey, Cabi and Doğan (2012) reported 30 species, including *P. densa* Troitsky, and the three questionably present taxa *P. palustris*, *P. iberica*, and *P. hackelii*. Cabi and Soreng (2016) accepted *P. eigii* as a separate species occurring in southern Turkey and confirmed *P. palustris* for northeastern Turkey. Cabi et al. (2016) documented *P. densa* as widespread in Turkey. The present paper is the third in a series of papers relevant to the revision of *Poa* in Turkey.

Many species of *Poa* from Africa and southwestern Asia to India, Japan, and New Zealand have not been formally placed in a modern infrageneric classification. The affinities of many of these species are unknown, while others are considered to belong to several informal species groups (Gillespie et al., 2007; Soreng et al., 2009).

Most species of *Poa* in Turkey have been, or can readily be, placed in sections that were accepted in Fl. Europaea (Edmondson, 1980), in Zlaki SSSR (Tzvelev, 1976), or in their correct equivalents (see Soreng, 1998; Soreng et al., 2009, 2010; Cabi et al., 2016). *Poa jubata* is the only one of the 44 species native to Europe that Edmondson (1980) left unplaced.

*Poa jubata* is an uncommon and enigmatic species of southeastern Europe. According to Euro+Med PlantBase (Valdés and Scholz, 2009), *P. jubata* is confined to Albania, Bulgaria, Croatia, Greece, and the European part of Turkey. The Global Biodiversity Information Facility (GBIF; <http://www.gbif.org/>) reports seven georeferenced collections, five from Greece (from three independent locations) and two from Turkey (ours), among 20 unique collections from 14 different cities.

The Flora Europaea and Flora of Turkey accounts for the genus *Poa* (Edmondson, 1980, 1985) consider *P. jubata* to be a species of sandy, mostly coastal habitats, and to be of uncertain affinity. It has not been included in previous DNA phylogenetic studies. Our two new gatherings in Turkey in 2015 allow us to evaluate its phylogenetic relationships, morphology, and habitat preferences. Here we describe *P. jubata* in detail, provide illustrations, and place it in a new section of *Poa*.

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## 2. Materials and methods

### 2.1. Plant material

We studied two populations of *Poa jubata* from Turkey (Soreng, Kaya & Kurt 9266; Soreng, Cabi & Kaya 9029) and additional specimens from Greece (Sterneck 300) and Turkey (A. Baytop, ISTE 31783). Herbarium acronyms follow Thiers (2015+) and authors of plant names follow Brummitt and Powell (1992).

### 2.2. Molecular analysis

Forty-nine samples were included in the molecular analysis: 44 *Poa* and five outgroup samples (Table). Forty-two species of *Poa*, including two samples of *P. jubata* and two subspecies of *P. trivialis*, were chosen to represent all subgenera of *Poa* (classification following Gillespie et al., 2007; Soreng et al., 2009, 2010, 2015a; Refulio et al., 2012; Peterson and Soreng, 2016). The *Poa* species included in our study represent selections from all 10 plastid and 11 nrDNA genotype groups previously identified (Soreng et al., 2010), including the x-clade (Gillespie et al., 2009). *Milium* L. (subtribe *Miliinae*), *Phleum* L. (subtribe *Phleaeae*; placed in *Poinae* s.l. by Soreng et al., 2015b), *Arctagrostis* Griseb., and *Nicoraepoa* Soreng & L.J.Gillespie (subtribe *Poinae*) were included as outgroups based on recent phylogenetic analyses (Gillespie et al., 2010; Soreng et al., 2015a). Genotype designations are represented by letters, with large capitals for plastid groups and small capitals for nrDNA groups (e.g., YY), as in Soreng et al. (2010), but leaving off the additional leading letters for subgenera that they employed.

Three plastid (*MatK*, *rpoB-trnC*, and *trnT-trnL-trnF* [TLF]) and two nuclear ribosomal (nr) DNA markers (internal transcribed spacer – ITS 1 and 2, and external transcribed spacer – ETS) were sequenced. DNA extraction methods were described by Gillespie et al. (2008). Primers, amplification, and sequencing protocols were described in our previous studies (ITS and TLF, Gillespie et al., 2008; ETS, Gillespie et al., 2009, 2010; *MatK* and *rpoB-trnC*, Soreng et al., 2015a). Sequences were assembled and edited using Geneious ver. 6.1.5 (Biomatters Ltd., <http://www.geneious.com>), aligned using the MAFFT ver. 7.017 plugin (Katoh and Standley, 2013), and then manually adjusted. The five alignments (ITS, ETS, *MatK*, *rpoB-trnC*, and TLF) were concatenated in Geneious.

Maximum parsimony (MP) analyses were performed in PAUP\* 4.0b10 (Swofford, 2002) on separate and combined alignments using the heuristic search command with default settings, including tree-bisection reconnection (TBR) swapping and saving all multiple shortest trees (Multrees). Strict consensus trees were computed in PAUP\* and viewed in FigTree v1.4.0 (Rambaut, 2006–2014). Branch support was assessed using MP bootstrap analysis performed in PAUP\* with a heuristic search strategy, default settings except Multrees option turned

off, and 10,000 bootstrap replicates. Bootstrap (BS) values of 90%–100% are interpreted as strong support, 70%–89% as moderate, and 50%–69% as weak. Bayesian trees were inspected for conflicting topologies prior to performing analyses on combined alignments. No conflict was detected among the separate Bayesian plastid trees (*MatK*, *rpoB-trnC*, and TLF), or between Bayesian ITS and ETS trees, but there was incongruence between plastid and nrDNA trees. Although one node in the plastid analyses collapsed in the parsimony strict consensus tree (SCT), the majority-rule (MR) consensus tree branching pattern matched the Bayesian tree. Both the parsimony SCT and the MR trees were less resolved than the Bayesian tree for ITS plus ETS analyses. As deep branch arrangements differed substantially between plastid and nuclear trees, our final analyses were performed on separate nrDNA and plastid datasets.

Optimal models of molecular evolution for individual markers were determined using the Akaike information criterion (AIC; Akaike, 1974) and the Bayesian information criterion (BIC; Schwarz, 1978), conducted through likelihood searches in jModeltest v2.1.4 with default settings (Darriba et al., 2012). Bayesian Markov chain Monte Carlo analyses were conducted in MrBayes v3.2.2 (Ronquist et al., 2012) on the combined partitioned nrDNA and plastid datasets. Models were set at GTR +  $\Gamma$  for ETS and *rpoB-trnC* partitions, and at GTR + I +  $\Gamma$  for the ITS, *MatK*, and TLF partitions, based on the above AIC and BIC scores. For each dataset two independent runs of four-chained searches were performed for 1.5 (plastid) or 2 million generations (nrDNA), sampling every 500 generations, with default parameters. A 25% burn-in was implemented prior to summarizing a maximum clade credibility tree and calculating Bayesian posterior probabilities (pp).

## 3. Results

### 3.1. Plastid phylogenetic analyses

The plastid data matrix has 4260 characters, of which 313 are variable and parsimony-informative. The MP analysis generated 149 trees of length 471, consistency index (CI) 0.75, retention index (RI) 0.92, and rescaled consistency index (RC) 0.69. Figure 1 presents the Bayesian analysis of the plastid data with pp and MP bootstrap statistics, and branches detected in the MP strict consensus tree are in bold.

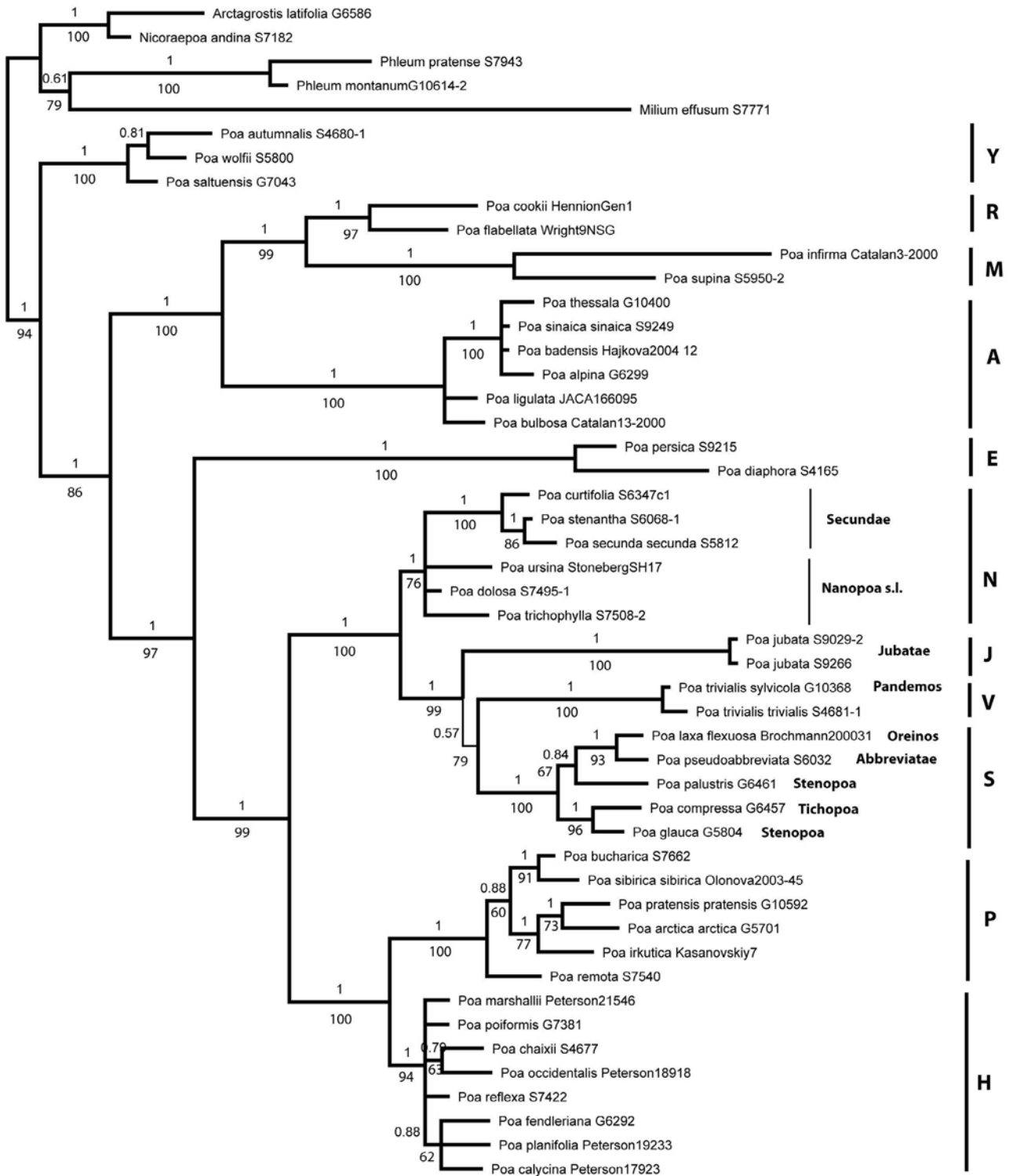
*Poa* has good support (BS 94, pp 1). Of the 11 major genotype lineages identified in Figure 1, N has moderate support (BS 76, pp 1), whereas the other 10 have strong support (BS 94–100, pp 1). The following collective clades of genotypes have strong support (BS 99–100, pp 1.): **R, M**, and **A**, with **R** and **M** as sister to **A**; **P** as sister to **H**; and **N** as sister to **J, V**, and **S**. **E** is strongly supported as sister

**Table.** Collections of *Poa* and outgroup taxa used in the phylogenetic analysis, with section or higher group if no section, country of origin, voucher information, and GenBank accession numbers for the five markers sequenced (nrDNA ITS and ETS; plastid *trnT-trnL-trnF* (TLF), *MatK*, and *rpoB-trnC*).

Taxon	Section (unless otherwise stated)	Country of origin	Voucher	ITS	ETS	TLF	<i>MatK</i>	<i>rpoB-trnC</i>
<i>Arctagrostis latifolia</i> (R.Br.) Griseb.		Canada, Nunavut	Gillespie et al. 6586 CAN	EU792351	GQ324245	DQ353969	KM523924	KM523954
<i>Milium effusum</i> L.		Sweden	Soreng 7771 US	KM523785	KM523711	KM524072	KM523870	KM523983
<i>Nicoraepoa andina</i> (Trin.) Soreng & L.J.Gillespie		Chile	Soreng & Soreng 7182 US	EU792354	GQ324275	DQ353971	KM523874	KM523987
<i>Phleum montanum</i> K.Koch		Turkey	Gillespie et al. 10614+2 CAN	KM523793	KM523720	KM524081	KM523883	KM523996
<i>Ph. pratense</i> L.		Russia	Soreng 7943 US	KM523796	KM523723	KM524084	KM523886	KM523999
<i>Poa alpina</i> L.	<i>Alpinae</i>	USA, Colorado	Gillespie 6299 CAN	GQ324483	GQ324287	DQ353985.2	KM523888	KM524001
<i>P. arctica</i> R.Br. subsp. arctica	<i>Malacanthae</i>	Canada, Nunavut	Gillespie & Aiken 5701 CAN	GQ324487	GQ324291	DQ354009	KY378860	KY378826
<i>P. atammadis</i> Elliott	<i>Sylvestres</i>	USA, Maryland	Soreng 4680 US	EU792379	GQ324294	DQ353979	KM523889	KM524002
<i>P. badensis</i> Haenke ex Willd.	<i>Alpinae</i>	Bulgaria	Hajkova et al. 2004-12 US	GQ324490	GQ324295	GQ324402	KY378861	KY378827
<i>P. bucharica</i> Roshev.	<i>Macropoa</i>	Kyrgyz Republic	Soreng et al. 7662 US	KX118735	KX118717	KX118752	KY378862	KY378828
<i>P. bulbosa</i> L.	<i>Bolbophorum</i>	Spain	Catalan 13-2000 UZ	EU792388	GQ324297	DQ354034, DQ354035	KY378863	KY378829
<i>P. calycina</i> (J.Presl) Kanth	Supersect. <i>Homalopoa</i>	Peru	Peterson et al. 17923 US	EU792425	KU763395	EU792467	KY378864	KY378830
<i>P. chaixii</i> Vill.	<i>Homalopoa</i> s.s.	Russia	Soreng 4677 US	EU792404	GQ324299	EU854590	KM523890	KM524003
<i>P. compressa</i> L.	<i>Tichopoa</i>	Canada, Quebec	Gillespie 6457 CAN	EU792395	KY378818	DQ354003	KY378865	KY378831
<i>P. cookeyi</i> (Hook.f.) Hook.f.	<i>Paradiachloa</i>	Subantarctic islands, Crozet Islands	Hennion Genl P	EU792383	GQ324306	EU792454	KY378866	KY378832
<i>P. curtifolia</i> Scribn.	<i>Secundae</i>	USA, Washington	Soreng & Soreng 6347c-1 US	EU792394	KY378819	DQ353994	KY378867	KY378833
<i>P. diaphora</i> Trin.	subg. <i>Pseudopoa</i>	Turkey	Soreng & Giney 4165 US	EU792400	GQ324311	DQ353988	KY378868	KY378834
<i>P. dolosa</i> Boiss. & Heldr.	<i>Oreinas</i>	Greece	Soreng et al. 7495-1 US	GQ324502	GQ324312	GQ324414	KM523891	KM524004
<i>P. fendleriana</i> (Steud.) Vasey	<i>Madropoa</i>	USA, Colorado	Gillespie 6292 CAN	EU792403	GQ324319	DQ354027	KY378869	KY378835
<i>P. flabellata</i> (Lam.) Raspail	<i>Paradiachloa</i>	South Georgia Islands	Wright 9NSG	EU792381	GQ324321	EU792453	KM523892	KM524005
<i>P. glauca</i> Vahl	<i>Stenopoa</i>	Canada, Nunavut	Gillespie 5804 CAN	AY237839	GQ324324	GQ324421	KY378870	KY378836
<i>P. infirma</i> Kunth	<i>Micranthrae</i>	Spain	Catalan 3-2000 UZ	GQ324516	GQ324334	GQ324427	KY378871	KY378837
<i>P. irkutica</i> Roshev.	<i>Poa</i> subsect. <i>Nivicolae</i>	Russia, Irkutsk	Kasanovskiy 2002-7 CAN	EU792402	GQ324335	DQ354007	KY378872	KY378838
<i>P. jubata</i> A.Kern.	<i>Jubatae</i>	Turkey	Soreng et al. 9029-2 US	KY378810	KY378820	KY378814	KY378873	KY378839

Table. (Continued).

Taxon	Section (unless otherwise stated)	Country of origin	Voucher	ITS	ETS	TLF	MatK	rpoB-trnC
<i>P. jubata</i> A.Kern.	<i>Jubatae</i>	Turkey	Soreng et al. 9266 US	KY378811	KY378821	KY378815	KY378874	KY378840
<i>P. laxa</i> subsp. <i>flecusosa</i> (Sm.) Hyl.	<i>Oreinos</i>	Norway	Brochmann 2000-3-1	GQ324520	GQ324342	GQ324418	KY378875	KY378841
<i>P. ligulata</i> Boiss.	<i>Alpinae</i>	Spain	JACA 166095	GQ324522	GQ324346	GQ324432	KY378876	KY378842
<i>P. marshalii</i> Tovar	supersect. <i>Homalopoa</i>	Peru	Peterson et al. 21546 US	KM523799	KM523726	KM524086	KM523895	KM524008
<i>P. occidentalis</i> Vasey	<i>Homalopoa</i> s.s.	Mexico	Peterson & Valdes Reyna 18918 US	KU765640	KU763486	KU763514	KY378877	KY378843
<i>P. palustris</i> L.	<i>Stenopoa</i>	Canada, Ontario	Gillespie 6461 CAN	EU792396	KY378822	DQ354000	KY378878	KY378844
<i>P. persica</i> (Trin.)	subg. <i>Pseudopoa</i>	Turkey	Soreng & Cabi 9215 (US)	KY378812	KY378823	KY378816	KY378879	KY378845
<i>P. planifolia</i> Kunze	<i>Acutifoliae</i>	Argentina	Peterson et al. 19233 US	KM523800	KM523727	KM524087	KM523896	KM524009
<i>P. poiformis</i> (Labill.) Druce	<i>Brizoides</i>	Australia	Gillespie et al. 7381 CAN	GQ324534	GQ324361	GQ324445	KM523897	KM524010
<i>P. pratensis</i> L. subsp. <i>pratensis</i>	<i>Poa</i> subsect. <i>Poa</i>	Turkey	Gillespie et al. 10592 CAN	KX118746	KX118726	KX118764	KY378880	KY378846
<i>P. pseudobreviata</i> Roshev.	<i>Abreviatae</i>	USA, Alaska	Soreng & Soreng 6032-1 US	EU792398	GQ324370	DQ353997	KY378881	KY378847
<i>P. reflexa</i> Vasey & Scribn.	<i>Homalopoa</i> s.l.	USA, Colorado	Soreng 7422 US	GQ324543	KX118730	GQ324450	KY378882	KY378848
<i>P. remota</i> Forselles	<i>Homalopoa</i> s.s.	Kyrgyz Republic	Soreng et al. 7540 US	GQ324545	GQ324372	GQ324452	KY378883	KY378849
<i>P. saltuensis</i> Fernald & Wiegand	<i>Sylvestres</i>	Canada, Ontario	Gillespie 7043 CAN	EU792378	GQ324374	EU792451	KM523899	KM524012
<i>P. secunda</i> J.Presl. subsp. <i>secunda</i>	<i>Secundae</i>	USA, Nevada	Soreng 5812 US	EU792393	KU763450	DQ353991	KY378884	KY378850
<i>P. sibirica</i> Roshev. subsp. <i>sibirica</i>	<i>Macropoa</i>	Russia, Khakasia?	Olonova 2003-45 CAN	GQ324547	KY378824	GQ324455	KY378885	KY378851
<i>P. sinatica</i> Steud. subsp. <i>sinatica</i>	<i>Bolbophorum</i>	Turkey	Soreng 9249 US	KX118748	KX118731	KX118766	KY378886	KY378852
<i>P. stenantha</i> Trin.	<i>Secundae</i>	USA, Alaska	Soreng & Soreng 6068-1 US	KU756554	KU763455	DQ354057	KY378887	KY378853
<i>P. supina</i> Schrad.	<i>Micrantharae</i>	USA, cult. (from Europe)	Soreng & Cayouette 5950-2 US	EU792387	GQ324383	DQ353984	KY378888	KY378854
<i>P. thessala</i> Boiss. & Orph.	<i>Alpinae</i>	Turkey	Gillespie et al. 10400 CAN	KM523802	KM523729	KM524088	KM523901	KM524014
<i>P. trichophylla</i> Helder. & Sart. ex Boiss.	<i>Nanopoa</i>	Greece	Soreng et al. 7508 US	GQ324554	GQ324386	GQ324461	KY378889	KY378855
<i>P. trivialis</i> L. subsp. <i>trivialis</i>	<i>Pandemos</i>	USA, Maryland (introd.)	Soreng 4681-1 US	GQ324555	GQ324387	GQ324462	KY378891	KY378857
<i>P. trivialis</i> subsp. <i>syriacola</i> (Guss.) H.Lindb.	<i>Pandemos</i>	Turkey	Gillespie et al. 10368 CAN	KY378813	KY378825	KY378817	KY378890	KY378856
<i>P. ursina</i> Velen.	<i>Bolbophorum</i>	Bulgaria	Stoneberg SH17 US	GQ324527	GQ324352	GQ324437	KY378892	KY378858
<i>P. wolffii</i> Scribn.	<i>Sylvestres</i>	USA, Missouri	Soreng 5800 US	EU792377	GQ324389	DQ354032, DQ354033	KY378893	KY378859



**Figure 1.** Bayesian maximum clade credibility tree of *Poa* and outgroups based on plastid MatK, rpoB-trnC, and TLF sequences. Bayesian posterior probabilities are shown above branches, maximum parsimony bootstrap values below branches; branches detected in the MP strict consensus tree are in bold.

to the collective clade of N, J, V, S, P, and H (BS 99, pp 1), and this larger clade is strongly supported as sister to the

clade including R, M, and A (BS 97, pp 1). Y is moderately supported as the sister to all other *Poa* clades (BS 86, pp 1).

*Poa jubata* (BS 100, pp 1) appears in a strongly supported clade (BS 99, pp 1). The **J** clade is moderately (BS 79) to weakly (pp 0.57) supported as sister to the clade of **V** (*P. trivialis*) plus **S**. This clade, comprising the **J**, **V**, and **S** lineages, collapses in a polytomy in the strict consensus tree (SCT).

### 3.2. nrDNA phylogenetic analyses

The nuclear data matrix (ETS plus ITS) has 1252 characters, of which 305 are variable and parsimony-informative. The MP analysis generated 59,401 trees of length 748, CI 0.56, RI 0.80, and RC 0.45.

Figure 2 presents the Bayesian analysis of the nrDNA data with pp and MP bootstrap statistics, and branches detected in the MP strict consensus tree are in bold. *Poa* has moderate support (BS 76, pp 1). Of the 12 major genotype lineages identified in Figure 2, most have strong support (BS 94, pp 1), and **P** and **H** are not resolved as independent. **P** and **H** lineages are joined with strong support (BS 92, pp 1), but the taxa are intermingled, and the resolved subsets, with one exception, are not, or only weakly to moderately, supported (BS < 50–74, pp 0–1). *Poa arctica* R.Br., which has a **P** plastid genotype (sister to *P. pratensis*), but which represents the **X-clade** here, is moderately supported as sister to the **N** clade (BS 83, pp 0.99). The **X-clade** does not appear in the plastid tree. The relationships among the major clades are mostly not supported or poorly to moderately supported. **M** is sister to **Y** (BS < 50, pp. 58), but this clade collapses in the SCT. **E** has strong support as sister to the set of **N**, **X**, and **P-H** (BS 89, pp 1), and the latter set has moderate support (BS 84, pp 0.99).

*Poa jubata* (**J**, BS 100, pp 1) has strong support as part of the clade including the **S**, **V**, and **A** genotypes (BS 85, pp 1). **V** is moderately supported as sister to **A** (BS 74, pp 0.91), but the relationship of **J**, as sister to **S**, **V**, and **A** (BS < 50, pp 0.89), collapses in the SCT. The clade of **J**, **S**, **V**, and **A** is sister to **R** with moderate support (BS 67, pp 0.97).

## 4. Discussion

Soreng et al. (2010) presented a simple scheme for naming ten consistently detected well-supported clades resolved within *Poa* in molecular phylogenetic studies (e.g., Gillespie et al., 2007, 2009). These clades often have minimal internal variation among the species and among the sections applied to the species within those clades. They employed a capital letter for the plastid genotype and a small capital letter for the nrDNA genotype (e.g., **Yy** for the clade including *Poa* sect. *Sylvestres* V.L.Marsh ex Soreng). The rationale for this scheme was to get away from having to list all sections within these clades, especially as the sections were frequently found to be polyphyletic, and authors differed in their circumscriptions of them. The practicality and simplicity

of the system is noted, particularly for indicating hybrids (e.g., **SH**, for *Poa abbreviata* R.Br., a stable hybrid arising from a cross of parents from *P.* sect. *Abbreviatae* Nannf. ex Tzvelev **Ss** and sect. *Madropoa* Soreng **Hh**; superscript numbers were used for hybrids within lettered lineages). The system was also adopted by Nosov et al. (2015) for characterizing *Poa* species and hybrids in Russia. Soreng et al. (2010) sometimes used an additional leading letter to identify a collective larger clade (**OM**, **OA**, in the **O** clade; **SV** and **SS**, in the larger **S** clade, etc.). However, the larger clade assemblages, while consistent among studies in the plastid data, have varied among nrDNA studies, especially once ETS nrDNA sequence data are introduced. Here we use only single (the second) letter codes for consistently resolved clades (e.g., **M**, **A**, **V**, and **S**).

Our phylogenetic analysis resolved *Poa jubata* as an isolated lineage on a long branch within *Poa* that we here designate as **Jj**. This lineage appears to be allied to the **Vv** (*P. trivialis*) and **Ss** lineages, and may be sister to these, but it is not clear beyond that what its affinities are, especially as the arrangement of the set of **Vv**, **Ss**, and **Jj** clades is not stable between plastid and nrDNA analyses, and support values are poor to moderate in the nrDNA trees.

*Poa jubata* is unique morphologically and molecularly among species of the genus in Europe and around the world. We therefore describe a new section of the genus to accommodate it. There are about 30 annual species in *Poa*, most having **HH** (8), **HX** (6), **EE** (5), **MM** (3), **RR** (1), and **JJ** (1) genotypes, and six are not yet characterized (RJS and LJG, unpublished data). No annual *Poa* other than *P. jubata* have solitary culms (some rhizomatous species have isolated flowering shoots), or a palea with appressed flanges. A 5-nerved upper glume is absent among the annuals and rare in *Poa* [3 (<15 spp. sometimes 5, or 7)-veined]. Breeding systems vary among the annuals. Most are perfect-flowered, although monoecism occurs in all perennial and annual species of *P.* sect. *Micrantherae* Stapf (**MM**) and a few other annual species; *P. chapmaniana* Scribn. (**RR**) has one tiny anther [0.1–0.2 (0.3) mm] per flower rather than the normal complement of three mostly larger ones.

### 4.1. Taxonomy

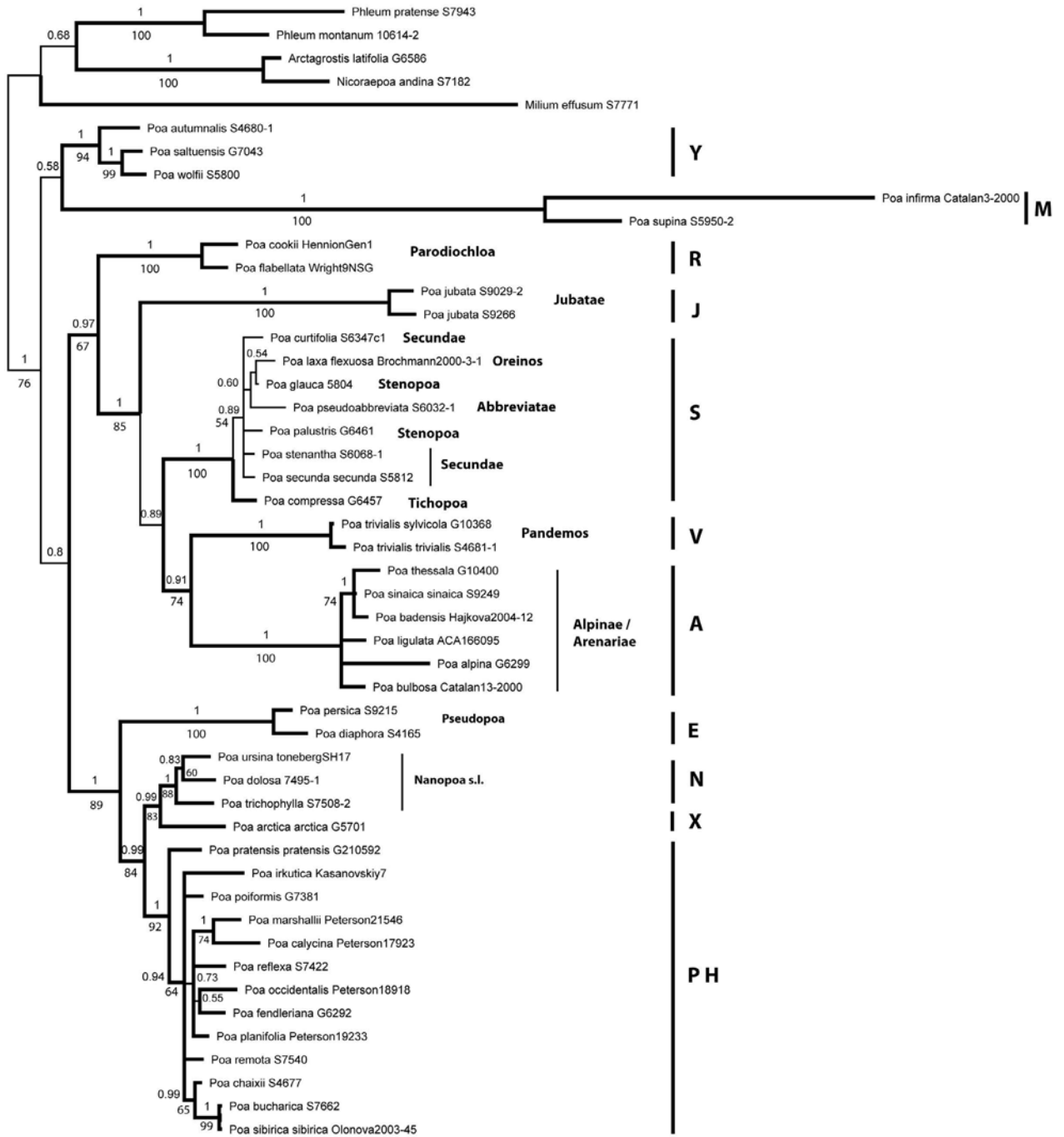
*Poa* sect. *Jubatae* Cabi, L.J. Gillespie & Soreng, sect. nov.  
Type: *Poa jubata* A.Kern.

### 4.2. Diagnosis

Differing from other sections of *Poa* by the annual habit with mostly solitary erect culms, upper glume 5-nerved, lemma with broadly scarious upper margins with cell-lines distinctly arched outward, palea flanges absent or very narrow and appressed.

### 4.3. Description

Annuals, culms erect, solitary or few together, slender; vegetative branching intravaginal. Upper culm sheaths



**Figure 2.** Bayesian maximum clade credibility tree of *Poa* and outgroups based on nuclear ribosomal ITS and ETS sequences. Bayesian posterior probabilities are shown above branches, maximum parsimony bootstrap values below branches; branches detected in the MP strict consensus tree are in bold.

closed 25-35 (50) percent their length, lightly scabrous; ligules 2-4 mm long. Panicles 2-7 cm long, open; branches 1-3 per node, fairly strict, spreading to patent, moderately scabrous, weakly angled, with spikelets clustered in the distal halves. Spikelets broadly ovoid, laterally compressed, upper glume 5-nerved; lemmas 5-nerved, densely silky

pubescent on the keel and marginal veins, and sometimes on the intermediate veins; callus with a well-developed dorsal tuft of long, silky, tangled hairs; palea keels finely scabrous, sometimes a bit silky haired medially, lateral flanges absent or very narrow and appressed. Flowers perfect; anthers 0.4-0.8(-1) mm long.

*Poa jubata* A.Kern., Oesterr. Bot. Z. 23: 6. 1873. Type specimen: Dalmatia, in sylvis et sub dumetis in Zuppas pr. Cattaro [Montenegro; Kotor], May 1872, *T. Pilcher* [s.n.]. Holotype: WU 0061933 (image seen); IT: WU 0061932. (image seen). Figures 3 and 4.

=*Poa grimbergii* Hack., Oesterr. Bot. Z. 48: 12. 1898. Type specimen: In arenosis submarinis prope ostium fluminis Potamos Corcyrae, 12 Apr 1897, *K. Grimberg* [s.n.]. Holotype: W 1916-0014329 (image seen); isotype: US fragm. ex W!.

#### 4.4. Description

Hermaphroditic. Annuals; without rhizomes or stolon branches, tufted; tufts tiny, slender, violaceous; unbranched or with branching intravaginal. Culms 12–45 cm tall, erect (or weakly geniculate at base), solitary or few together, slender (to 1 mm diam.), terete, smooth, glabrous, with 1–2 nodes exerted. Leaf sheaths keeled, weakly compressed, smooth or sparsely to moderately retrorsely scabrous, glabrous, bases of basal sheaths glabrous; flag-leaf sheaths 4–8.5 cm long, margins fused



Figure 3. *P. jubata*: (a) habit, (b) inflorescence, (c) ligule, and (d) lemma.





**Figure 4.** *P. jubata* photo taken at the Kırklareli locality.

25-35(-50) percent the length, much longer than the blade, not inflated; throats and collars smooth, glabrous; ligules 2-4(-5) mm long, abaxially smooth, glabrous, milky-white, narrowly decurrent, apices acute, sometimes erose; sterile shoots absent; culm blades 0.3-4 cm long, 0.6-1 mm wide (expanded), folded, moderately thin, withering in age, abaxially smooth, adaxially smooth or sparsely scabrous, margins sparsely to moderately scabrous, apices abruptly prow-tipped, flag-leaf blades sub-erect. Panicles 2-7 cm long, ellipsoid, rhomboid, or pyramidal, erect or slightly lax, open, sparse, with 6-40 spikelets; axis with 1-2(-3) branches per node; primary branches, ascending to spreading, spreading to patent (at and after flowering), weakly angled, sparsely to moderately scabrous mainly over the weak angles, longest branches 1-4 cm, with 3-7 spikelets clustered in 2s and 3s near branch tips; pedicels 0.5-1 mm long, mostly less than 1/4 as long as the spikelet. Spikelets 3.5-4.5 mm long, broadly ovate, laterally compressed, slightly plump; not bulbiferous, green or violaceous, with 3-6(-11) florets; rachilla internodes short (ca 0.4 mm long), terete, smooth or sparsely muriculate; glumes, lanceolate to broadly ovate, subequal to equal, slightly shorter than adjacent lemmas, distinctly veined, distinctly keeled, slightly thinner than lemmas, keel

smooth or apically slightly scabrous, surfaces smooth or obscurely sparsely papillate, margins broadly hyaline, edges smooth; lower glumes ca 2.5-3.2 mm long, 3-veined, lanceolate to broadly ovate; upper glumes 2.5-3.5 mm long, 5-veined, broadly ovate; calluses webbed, hairs sparse or denser, elongated, more or less plicate; lemmas 2.7-3.5 mm long, obscurely 5-veined, obovate to subflabellate, green or violaceous, distinctly keeled, keels and marginal veins densely villous on lower 3/5, hairs often over 0.5 mm long, slender, blunt-tipped, between veins smooth, glabrous, intermediate veins glabrous (infrequently sparsely sericate), intermediate veins moderately distinct, running to the hyaline zone, margins and edges smooth, broadly scarios with distal cell-lines slightly curved outward as in *Briza*, apices obtuse, blunt, broadly hyaline; palea keels long scabrous along at least 1/2 the length or sericate medially, intercostal zone broad, white, scarios, smooth, glabrous, flanges absent or very narrow, appressed. Flowers bisexual; lodicules 0.5 mm long, lanceolate, unlobed, glabrous; anthers 0.4-0.8(-1) mm long; styles slender lanceolate, sparsely plumose. Caryopses 1.7 mm long, ovate, subtrigonal, hilum 0.3 mm long, elliptical, sulcus broad and shallow, loosely adherent to the floret.

#### 4.5. Habitat

Flora Europaea indicates the habitat as sandy places near the coast (Edmondson, 1980). A newly discovered population in Turkey from near Enez (Edirne) and a rediscovered population in Kırklareli, which are ca. 200 km apart, suggest that the species may be found on clay soils of vernal swales in two differing habitats (Figures 5a and 5b).

The Enez population was collected in late flower and seed (10 May 2015), within ca. 0.5 km of the Aegean Sea coast, at about 11 m elevation, in a swale, in an open thicket of *Pyrus elaeagnifolia* Pall., in deep, black, loamy, shrink-swell clay, with a species-rich, dense thatch of annual and perennial herbs and graminoids, including *Ranunculus* sp., *Knautia* sp. (or *Scabiosa*?), *Trifolium resupinatum* L., *Alopecurus rendlei* Eig, *Juncus* sp., *Carex* sp., *Poa bulbosa* L. var. *vivipara* Koeler, *P. trivialis*, and *P. pratensis* (Figure 5a). This population was included in the class Quercetea pubescentis (Oberd., 1948) Doing Kraft (1955) and its order Querco-Carpinetalia (Quezel, Barbero & Akman 1980). In northwestern Anatolia, the *Quercus pubescens* Willd. scrubs were exploited by overgrazing and now these form very loose communities in patches. The species composition of this new *P. jubata* site can be recognized as part of the *Quercus pubescens*-*Pyrus elaeagnifolia* association. Main threats for the Enez population are selection cuttings by the local people, replacement by forest plantations with species not typical for the area, intensive grazing, general aridification of the climate, and construction of roads and buildings.





**Figure 5.** Habitat of *P. jubata* populations in (a) Enez (Edirne) and (b) Kirklareli locations (photos taken by RJ Soreng).

The Kirklareli population was collected in early inflorescence emergence (19 April 2015), ca. 50 km inland from the Black Sea, ca. 100 km N of the Marmara Sea, at ca. 190 m elevation, in a swale, in a *Paliurus spina-christi* Mill. thicket, in shallow wet depressions on a nearly level, low bedrock rise, in thin gray-brown clay soil, within a somewhat sparse, mossy, herb, and graminoid meadow including *Cerastium* sp., *Muscari* sp., *Thinopyrum intermedium* (Host) Barkworth & D.R.Dewey, *Poa annua* L., *Piptatherum miliaceum* (L.) Coss., and *Aira caryophyllea* L. (Figure 5b). At both of these collection sites the species was locally common, suggesting these are primary habitats. Searches of sandy places near the coast and elsewhere in the Thrace region have not turned up any *P. jubata* populations, but new searches in the above habitats are likely to yield new localities. *Paliurus spina-*

*christi* grows on calcareous-clay soils and occurs from coastal areas up into the hills (to about 500 m a.s.l.), where it grows along sunny slopes.

#### 4.6. Suggested conservational status

The status of *Poa jubata* is reevaluated here according to the IUCN (2016) criteria at the national level. It was previously considered Endangered (EN) in the Red List of Turkish Plants (Ekim et al., 2000) because it was known from one collection site and had not been reported since. After discovering a new site for the species, only two precise subpopulations are known in the northwestern part of the country. Given its actual restricted distribution and the drastic potential decline in the number of subpopulations, as well as the extent and quality of habitat, *P. jubata* is evaluated here as Critically Endangered under B1ab(i,ii,iii,iv)+ 2ab(i,ii,iii,iv). The above-mentioned

subpopulations and their environs were covered once by forest and maquis that have been completely cleared by human activities, such as road construction, establishment of new settlement areas, and overgrazing.

#### 4.7. Distribution

Bulgaria, Croatia, Greece, Montenegro, Turkey.

**Specimens examined:** GREECE: Topotypes of *P. grimbergii* Hack., Sterneck 300 (US) and Kérkyra, 9 May 2000, *W.Gutermann. et al.* 34620 (W 2006-0015229; image seen); Aitolía kai Akarnanía, 10 May 2013, *R.Willing & E.Willing* 235042 (B 10 0581970); Fokídos, 9 May 2013, *R.Willing & E.Willing* 234561 (B 10 0581968). TURKEY: Trakya, Edirne, S of Enez, north side of Gaziömerbey, 40.68523°N 26.06508°E, 11 m, 10 May 2015, *R.J.Soreng, M.Kaya & E.Kurt* 9266 (US); Kırklareli, 12 km east of Kırklareli on road to Demirköy, just west of Üsküpdere, 41.591944°N 27.358056°E, 190 m, 19 Apr 2015, *R.J.Soreng, E.Cabi & M.Kaya* 9029 (US); 14 km north of Kırklareli on road to Dereköy, *A.Baytop* (ISTE 31783).

The location given on the label of the *A. Baytop* collection as 14 km north of Kırklareli toward Dereköy may be incorrect. That general vicinity was searched by us on several occasions and the plant was not found. Baytop would have followed the old road north from Kırklareli but the routes are overlapping or adjacent at this distance. However, we found the species quickly when we searched east of Kırklareli on the road to Demirköy at approximately the specified distance.

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The morphological affinity of *Poa* sect. *Jubatae* is not clear. On one hand, it appears to share various characteristics and aspects with the species of sections *Alpinae* and *Arenariae*. On the other hand, its sheaths are more closed than the species in *P.* sect. *Alpinae* and *Arenariae*, as are typically found in sect. *Homalopoa*. Although it is an annual, it is clearly distantly related to *Poa* sect. *Micrantherae* (*P. annua* complex), for species of that section are quite smooth and exhibit declinous breeding systems. For now, we place it in *incertae-sedis* for the subgenus. *Poa jubata* seems to have no close relatives.

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