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DNA ploidy level variability of some fescues (*Festuca* subg. *Festuca*, Poaceae) from Central and Southern Europe measured in fresh plants and herbarium specimens

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Abstract: Using flow cytometry in fresh plants and herbarium vouchers, DNA ploidy levels for 411 individuals of 44 taxa of the genus *Festuca*, including 4 natural hybrids, originating from 237 sites in Austria, Bulgaria, Croatia, Czech Republic, Estonia, Germany, Hungary, Italy, Poland, Romania, Slovakia, Slovenia, and Switzerland were estimated. The following taxa and DNA ploidy levels are reported: *F. airoides* ($2n \approx 2x$), *F. alpestris* ($2n \approx 2x$), *F. alpina* s.l. ($2n \approx 2x$), *F. amethystina* subsp. *amethystina* ($2n \approx 4x$), *F. bosniaca* subsp. *bosniaca* ($2n \approx 2x$), *F. brevipila* ($2n \approx 6x$), *F. bucegiensis* ($2n \approx 2x$), *F. carnuntina* ($2n \approx 6x$), *F. csikhegyensis* ($2n \approx 4x$), *F. csikhegyensis* × *F. eggleri* ($2n \approx 4x$), *F. dalmatica* ($2n \approx 4x$), *F. duvalii* ($2n \approx 4x$), *F. eggleri* ($2n \approx 2x$, $4x$), *F. filiformis* ($2n \approx 2x$), *F. glauca* ($2n \approx 6x$), *F. heterophylla* ($2n \approx 4x$), *F. inops* ($2n \approx 2x$), *F. laevigata* ($2n \approx 8x$), *F. laxa* ($2n \approx 4x$), *F. lemanii* ($2n \approx 6x$), *F. norica* ($2n \approx 2x$), *F. ovina* subsp. *ovina* ($2n \approx 2x$), *F. ovina* subsp. *guesfalica* ($2n \approx 4x$), *F. ovina* × *F. pallens* ($2n \approx 4x$), *F. pallens* ($2n \approx 2x$, $3x$), *F. pallens* × *F. pseudodalmatica* ($2n \approx 3x$, $4x$), *F. pirinica* ($2n \approx 2x$), *F. polesica* ($2n \approx 2x$), *F. psammophila* subsp. *dominii* ($2n \approx 2x$), *F. pseudodalmatica* ($2n \approx 4x$), *F. pseudovina* ($2n \approx 2x$), *F. quadriflora* ($2n \approx 4x$), *F. rupicola* ($2n \approx 6x$), *F. rupicola* × *F. vaginata* ($2n \approx 3x$, $4x$), *F. saxatilis* ($2n \approx 6x$), *F. stricta* subsp. *bauzanina* ($2n \approx 8x$), *F. supina* ($2n \approx 4x$), *F. tatrae* ($2n \approx 2x$), *F. valesiaca* ($2n \approx 2x$), *F. versicolor* subsp. *pallidula* ($2n \approx 2x$), *F. versicolor* subsp. *versicolor* ($2n \approx 2x$), *F. violacea* subsp. *puccinellii* ($2n \approx 2x$), *F. wagneri* ($2n \approx 4x$), *F. xanthina* ($2n \approx 2x$). In *F. pallens*, up to 12–year-old herbarium specimens were proved to be suitable for DNA ploidy level measurements with flow cytometry.
DNA ploidy levels of *F. bucegiensis*, *F. bosniaca*, and *F. versicolor* subsp. *pallidula* are reported here for the first time. The taxonomy of some polyploid complexes and several records of mixed ploidy level populations are briefly discussed. *Festuca pseudodalmatica* and its hybrid *F.* ×*krizoviensis* were first recognised as native to the Czech Republic, and *F. brevipila* as native to Hungary. Also some new records of *F. filiformis*, *F. brevipila*, and *F. wagneri* from Slovakia are reported.

Key words: Fescue; flow cytometry; hybridisation; mixed ploidy populations; polyploidy; Alps, Carpathians

Introduction

Ploidy level is one of the main criteria discriminating among closely related Central European fescues, frequently representing difficult polyploid complexes. Recent karyological surveys demonstrated the importance of large-scale karyological sampling for understanding speciation and systematics of this genus (Huon 1970; Auquier & Kerguélen 1978; Tracey 1980; Šmarda & Kočí 2003). A large-scale sampling makes possible to detect rare polyploids and hybrids, and helps to improve the knowledge of the distribution of difficult polyploid taxa (Suda et al. 2004; Trávníček et al. 2004; Mahelka et al. 2005; Šmarda et al. 2005). An increase in number of investigated plants became possible by flow cytometry, recently becoming one of the fastest and most frequently used methods for DNA ploidy level and DNA content determinations in plants (Doležel 1991; Doležel & Bartoš 2005). Recent studies have shown that flow cytometry is useful also for the determination of DNA ploidy level in herbarium specimens and seeds (Suda 2004; Šmarda & Kočí 2005; Šmarda et al. 2005; Šmarda & Stančík 2006; Šmarda 2006; Suda & Trávníček, 2006).

This paper is a continuation of an earlier study (Šmarda et al. 2005) and includes further DNA ploidy level estimations made since 2001 within taxonomic study of various Central and southern European fescues. Special attention is paid to the *F. valesiaca* and *F. pallens* groups, and to the *F. airoides*-*F. supina* complex. The following taxa were included:

Festuca* sect. *Festuca
***Festuca ovina* group (*F.* ser. *Festuca*):** *F. airoides* Lam., *F.* ×*duernsteinensis* J. Vetter (= *F. ovina* × *F. pallens*), *F. eggleri* R. Tracey, *F. filiformis* Pourr., *F. lemanii* Bastard, *F. ovina* L. subsp. *ovina*, *F. ovina* subsp. *guestfalica* (Rchb.) K. Richt., and *F. supina* Schur.
***Festuca pallens* group (*F.* ser. *Psammophilae* Pawlus):** *F. csikhegyensis* Simonk. (incl. *F. pallens* Pannonisches-Hügelland, Steiermark-Kärnten types,

and Scabrifolia types, and *F. glaucina* Stohr; cf. Tracey 1980; Šmarda et al. 2007), *F. glauca* Vill., *F. inops* De Not. (incl. *F. gracilior* (Hack.) Markgr.-Dann.; cf. Foggi et al. 2006), *F.* ×*krizoviensis* Májovský (= *F. pallens* × *F. pseudodalmatica*), *F. pallens* Host, *F. polesica* Zapał. and *F. psammophila* subsp. *dominii* (Krajina) P. Šmarda.

***Festuca valesiaca* group (*F.* ser. *Trachyphyllae* Pawlus and *F.* ser. *Valesiacae* Pawlus):** *F. brevipila* R. Tracey, *F. carnuntina* R. Tracey, *F. dalmatica* (Hack.) K. Richt., *F. duvalii* (St.-Yves) Stohr, *F.* ×*interjecta* J. Vetter (= *F. rupicola* × *F. vaginata*), *F. laevigata* Gaudin, *F. pseudodalmatica* Krajina, *F. pseudovina* Wiesb., *F. rupicola* Heuff., *F. saxatilis* Schur, *F. stricta* subsp. *bauzanina* Pils, *F. valesiaca* Gaudin, and *F. wagneri* (Degen, Thaisz et Flatt) Degen, Thaisz et Flatt in Degen.

***Festuca* sect. *Eskia* Willk.**

F. alpestris Roem. et Schult., *F. bosniaca* Kumm. et Sendtn. subsp. *bosniaca* (excl. *F. pirinensis* (Acht.) Acht.), *F. quadriflora* Honck., *F. valida* (St.-Yves) Pénzes, *F. versicolor* Tausch subsp. *versicolor*, *F. versicolor* subsp. *pallidula* (Hack.) Markgr.-Dann., and *F. xanthina* Roem. et Schult.

***Festuca* sect. *Dimorphae* Joch. Müller et Catalán**

F. laxa Host

***Festuca* sect. *Aulaxyper* Dumort.**

***Festuca halleri* group**

F. alpina Suter s.l. (incl. *F. alfrediana* Foggi et Signorini)

***Festuca amethystina* group**

F. tatrae (Czakó) Degen, *F. amethystina* L. subsp. *amethystina*, *F. norica* (Hack.) K. Richt.

***Festuca violacea* group**

F. violacea subsp. *puccinellii* (Parl.) Foggi, Gr. Rossi et Signorini

ungrouped taxa

F. bucegiensis Markgr.-Dann., *F. heterophylla* Lam., *F. pirinica* Markgr.-Dann.

Material and methods

Flow cytometry was used for the determination of DNA ploidy level. Young, basal parts of leaves were used for analysis of both fresh and up to 12-year-old herbarium specimens. Measurements were done on a PA-I ploidy analyser (Partec) at the Institute of Botany and Zoology, Masaryk University in Brno. A two-step procedure (Otto 1990) was used for sample preparation. Leaf tissue of ca 0.5 cm^2 was chopped using a sharp razor blade in a glass Petri dish containing 0.5 mL Otto I buffer (0.1M citric acid, 0.5% Tween 20). The crude nuclei suspension was filtered through a 50 μm nylon mesh. 1 mL of Otto II buffer (0.4M $Na_2HPO_4 \cdot 12H_2O$) supplemented with 2 μg/mL 4,6-diamidino-2-phenylindole (DAPI) was then added to the nuclei suspension. The following fresh plants with known chromosome numbers were used as external standards to derive DNA ploidy levels of samples (Šmarda & Kočí 2003): *Festuca pallens* (plants F2 and F1229; $2n = 14$) for the *F. pallens*, *F. ovina*, *F. halleri*, and *F. violacea* groups, and ungrouped taxa; *F. rupicola* (plant F4; $2n = 42$) for the *F. valesiaca* group; *F. alpestris* (plant F1122; $2n = 14$) and *F. versicolor* (plant F152; $2n = 14$) for *Festuca* sect. *Eskia*; *F. amethystina* (plant F111; $2n = 28$) for the *F. amethystina* group and *F.* sect. *Dimorphae*.

Altogether 193 living plants and 208 herbarium specimens of 44 taxa (including 4 spontaneous hybrids) sampled in 237 sites were studied. Living plants from the author's collections were cultivated at the Institute of Botany and Zoology in Brno-Veveří, in the experimental garden of the Faculty of Education in Brno-Bohunice, and in a private garden in Moravské Budějovice (all Czech Republic). Additional living plants were obtained from the collections of J. Müller, cultivated in Jena and Göttingen (Germany), and from J. Ripka (Slovakia). Herbarium vouchers of all samples studied are deposited at the Herbarium of Masaryk University in Brno (BRNU), with the exception of 10 herbarium specimens borrowed from the Herbarium of the Institute of Botany, Slovak Academy of Sciences in Bratislava (SAV). The list of localities of samples studied and DNA ploidy levels observed is given in the Appendix. The measurements of morphological character discussed followed Šmarda et al. (2007). Geographical coordinates were recorded in the field (Garmin-Etrex GPS instrument; accuracy of tenths of a second), calculated from 1:50 000 maps (Austria, Slovakia), or obtained using the programs GeobázeČS (GeodézieČS, 1997–1998; Czech Republic) and Encarta World Atlas 99 (Microsoft Corporation, 1995–1998; other countries).

Results and discussion

Festuca valesiaca group

The tetraploid level was recorded in several samples of *F. pseudodalmatica* from Austria, the Czech Republic, Hungary and Slovakia (Fig. 1), including the population from the type locality in the Kováčovské kopce Hills (Krajina 1930). It corroborates the results of earlier karyological and cytometrical studies (Činčura 1967; Tveretinova 1977; Tracey 1980; Šmarda et al. 2005). *Festuca pseudodalmatica* is morphologically very similar to the diploid *F. valesiaca*, and both taxa differ only in quantitative morphological characters, correlated with ploidy level. Thus, for reliable identification, measurements of population samples are often necessary (Šmarda, in prep.). For this reason, the distribution of *F. pseudodalmatica* in Central Europe is still poorly known. Although it is traditionally reported to grow on volcanic rocks such as andesite, trachyte, and porphyrite (Májovský 1955; Soó 1973), its ecological amplitude is wider and includes also limestone (Májovský 1955; Beldie 1972), gypsum (Pawlus 1985), and solonchak soils (Tveretinova 1977). The occurrence of *F. pseudodalmatica* on siliceous bedrock in eastern Austria (Melzer 1957; Tracey 1978, 1980; Koó 1994) was questioned by Pils (1984), but it was later confirmed with karyological methods (Englmaier 2005; Šmarda et al. 2005). As for *F. valesiaca* s.l. in southwestern Moravia, the situation is similar, as both diploid and tetraploid populations were documented there (Fig. 1). A preliminary morphological analysis

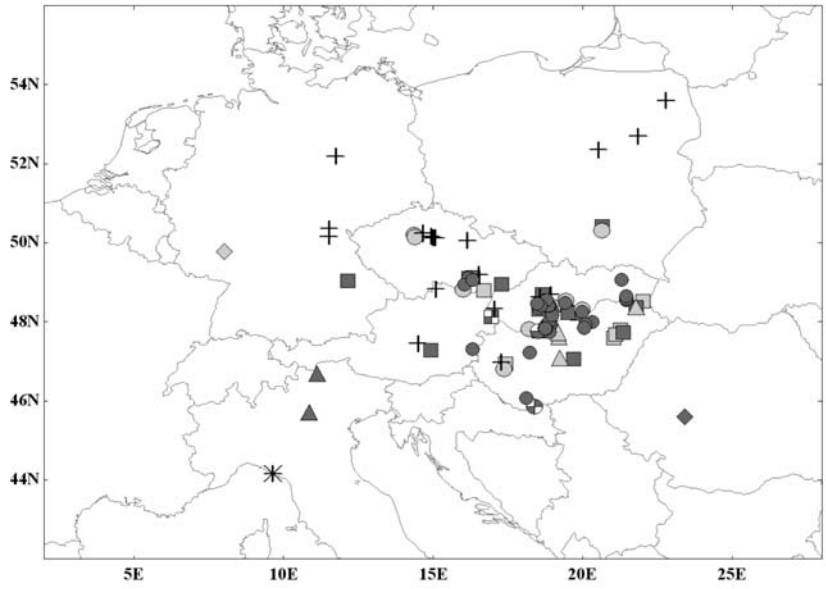

Fig. 1. Localities of investigated plants of the *F. valesiaca group*: grey circles – *F. valesiaca* ($2n \approx 2x$); dark circles – *F. pseudodalmatica* ($2n \approx 4x$); white/dark circles – *F. rupicola* × *F. vaginata* (*F.* ×*interjecta*, $2n \approx 3x$, $4x$); checked circles – *F. dalmatica* ($2n \approx 4x$); grey squares – *F. pseudovina* ($2n \approx 2x$); dark squares – *F. rupicola* ($2n \approx 6x$); checked squares – *F. carnuntina* ($2n \approx 6x$); grey triangles – *F. wagneri* ($2n \approx 4x$); dark triangle – *F. stricta* subsp. *bauzanina* ($2n \approx 8x$); grey diamond – *F. duvalii* ($2n \approx 4x$); dark diamonds – *F. saxatilis* ($2n \approx 6x$); cross – *F. brevipila* ($2n \approx 6x$); star – *F. laevigata* ($2n \approx 8x$).

of some populations from Moravia, Slovakia, Hungary, and Austria has shown that the Moravian tetraploid populations can be clearly assigned to *F. pseudodalmatica* (over 140 samples of *F. pseudodalmatica*, including those from the type locality, *F. valesiaca*, and *F. rupicola*; Šmarda, in prep.), which is the first record of *F. pseudodalmatica* from the Czech Republic.

Like the earlier literature records (cf. Šmarda et al. 2005 and references therein), all investigated individuals of *F. valesiaca* from the Czech Republic, Poland, Slovakia, and Hungary, and those of *F. pseudovina* from the Czech Republic and Hungary were diploid (Fig. 1).

The record of hexaploids in the population of *F. brevipila* from the type locality in Amaliendorf (Austria) corresponds to the results by Tracey (1980). Further hexaploid plants of this species were also documented from Poland, the Czech Republic, Slovakia, and Hungary (Fig. 1). Though being common in the neighbouring countries, *F. brevipila* was neglected for long in Slovakia (cf. Dostál 1989; Marhold & Hindák 1998) and has been recognised there only recently (Šmarda et al. 2005). Another three records of this species from rocky sites in the Vtáčnik Mts, Kremnické vrchy Hills, and from the sands of the Záhorie lowland are reported here (Fig. 1). For the flora of Hungary, *F. brevipila* is reported here for the first time. This species might have been overlooked there and misidentified (i) as *F. stricta* Host, which is a name used ambiguously in numerous European floras for plants with an interrupted sclerenchyma ring or (ii) as *F. wagneri*, a morphologically similar tetraploid species from sandy habitats in Pannonia.

All investigated individuals of *F. rupicola* were hexaploids, and those of *F. wagneri* tetraploids (Fig. 1), as known from the earlier chromosome counts (cf. Šmarda et al. 2005 and references therein). Both species are morphologically similar and also share some habitat preferences. *Festuca rupicola* occurs from Central Europe eastwards to southern Siberia, growing in many types of dry grasslands on rocks or sands, while *F. wagneri* is known only from sandy habitats in the Pannonian lowland where it can grow together with *F. rupicola*. The intricate taxonomy of both species in this region was discussed by Horánszky et al. (1972). The morphological delimitation of *F. wagneri* and *F. rupicola* in Hungary was studied by Penksza & Engloner (2000); however, a study within a wider geographical scope and including *F. rupicola* samples from rocky habitats and other related taxa, is still lacking. Penksza & Engloner (2000) suggest that the presence of macrohairs on tiller leaves is a reliable differential character of *F. wagneri*. However, macrohairs may be missing in some tetraploid plants of *F. wagneri* (samples F329 versus F330), and in contrast they may occur in some (hexaploid) populations of *F. rupicola*, especially in those from sandy habitats. In my opinion, only the combination of well developed macrohairs on tiller leaves and an interrupted sclerenchyma consisting of separate strands to irregular sclerenchyma ring, both observed within the population context, is necessary for a reliable identification of *F. wagneri*. For instance, in sandy habitats, such as in the Tarbucka Nature Reserve (eastern Slovakia), both taxa can co-occur. A hexaploid plant found there could clearly be assigned to *F. rupicola*, based on the DNA ploidy level, three-banded sclerenchyma pattern, and dense, long yellowish hairs on lemmas, even though tiller leaves had well developed macrohairs. The tetraploid plant represented *F. wagneri* and differed from the former in that it lacked long hairs on its lemmas, and had sclerenchyma (in the leaf cross section)

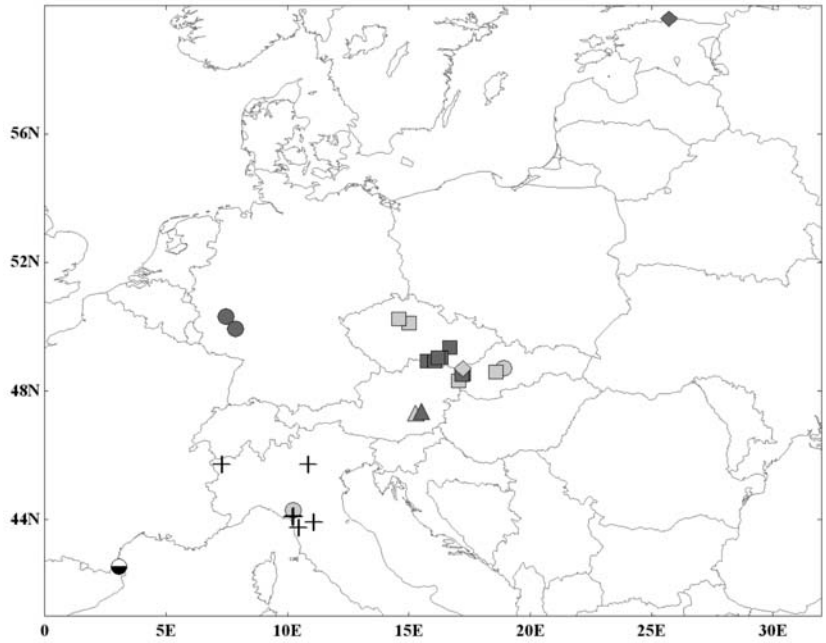

Fig. 2. Localities of investigated plants of the *F. pallens* and *F. ovina* groups (excl. *F. pallens* agg.): grey circles – *F. filiformis* ($2n \approx 2x$); dark circles – *F. lemanii* ($2n \approx 6x$); grey/dark circles – *F. glauca* ($2n \approx 6x$); grey squares – *F. ovina* subsp. *ovina* ($2n \approx 2x$); dark squares – *F. ovina* subsp. *guestfalica* ($2n \approx 4x$); grey triangles – *F. eggleri* ($2n \approx 2x$); dark triangle – *F. eggleri* ($2n \approx 4x$); grey diamond – *F. psammophila* subsp. *dominii* (2n≈2x); dark diamonds – *F. polesica* ($2n \approx 2x$); cross – *F. inops* ($2n \approx 2x$).

consisting of three thick strands with some additional ones on the leaf sides. Macrohairs were present; however, they were sparser than in the former. Although Dostál (1989) assumed that *F. wagneri* grows in the sandy habitats of southern Slovakia, only hexaploids of *F. rupicola* has been hitherto documented in several localities of this region (Šmarda & Řehořek, unpubl. data). The find of *F. wagneri* in the Tarbucka Reserve is therefore the first karyologically confirmed record of this species in Slovakia (for comments on *F.* ×*javorkae*, treated sometimes as *F. wagneri*, see below). The plants of *F. rupicola* with tiller leaves bearing macrohairs seem to occur mainly in sandy habitats of the Pannonian lowland, and further taxonomic study of these populations is necessary.

All specimens of *F. saxatilis*, sometimes treated as subspecies of *F. rupicola* (Beldie 1972), investigated in this study were hexaploid. The same ploidy level was also documented by Tveretinova (1977), Krahulec (1987), and Kožuharov & Petrova (1991).

The hexaploid level found in *F. carnuntina* from its type locality in the Hainburger Berge Hills is in accordance with the counts reported from there by Tracey (1980) and Šmarda et al. (2005). Although *F. carnuntina* is treated as separate species in Flora Europaea (Markgraf-Dannenberg 1980), Englmaier (1994, 2005) considers this morphotype only as a local xeromorphic modification of *F. rupicola*, deserving probably no formal taxonomic treatment. The record of tetraploid level in *F. dalmatica* in the Villany hegy Hill (Hungary) corroborates an earlier chromosome count published from this locality by Simon (1964).

The plants of *F. stricta* subsp. *bauzanina* and *F. laevigata* from northern Italy were octoploid (Fig. 1). These results are in accordance with the previous counts made in plants from different localities in the Alps by Pils (1979, 1984) and Arndt (2005).

Festuca ovina group

Festuca filiformis is a species of Atlantic distribution, and the diploid populations in Italy and Slovakia sampled for this study are situated near the southern and eastern distribution limits of this species (Fig. 2). The fact that this species is diploid was documented in several studies (see Šmarda & Kočí 2003 and references therein). Dostál (1989) assumed that *F. filiformis* is only adventive in Slovakia and reported it as expanding to exploited peat-bogs. However, two cytometrically confirmed records in this paper and another one from the Tříbeč Hills (J. Roleček, BRNU) are from natural grasslands and indicate that this species may rather have been overlooked in Slovakia. Further records of this species can be expected in submontane and montane dry grasslands on acidic bedrock, especially in western Slovakia. In the locality Kremnický Štós, *F. filiformis* was found together with another two frequently overlooked species, *F. brevipila* and *F. nigrescens*, which often occur together with *F. filiformis* in acidic grasslands of the Hercynian region.

Two DNA ploidy levels were found in *F. ovina*. The diploids reported from the Czech Republic correspond to *F. ovina* subsp. *ovina*, the tetraploids to *F. ovina* subsp. *guestfalica* (cf. Šmarda & Kočí 2003). The records of *F. ovina* subsp. *guestfalica* from Slovakia are the easternmost karyologically proved records of this taxon. The estimations of hexaploid level in three living plants of *F. lemanii* from Germany confirm measure-

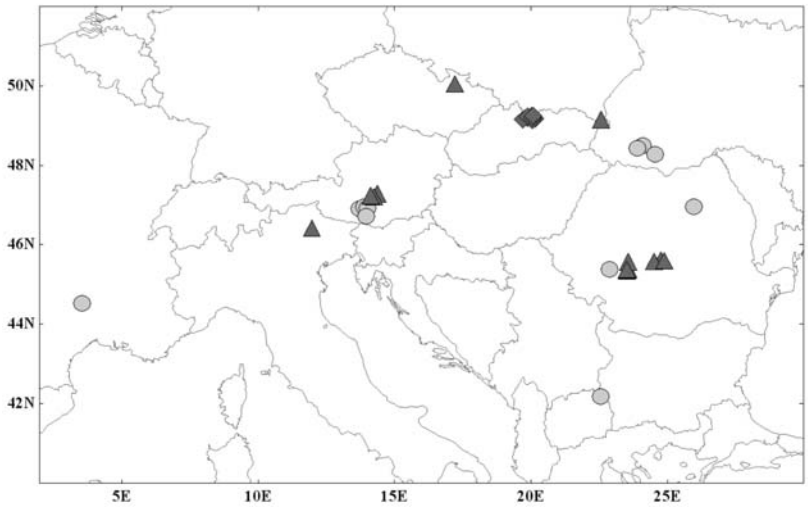

Fig. 3. Localities of investigated plants and the localities of previously published karyological records for the *F. airoides-F. supina* complex: grey circles – $2n \approx 2x$ (*F. airoides*); dark triangles – $2n \approx 4x$ (*F. supina*; incl. data for the tetraploid *F. vivipara* from the Alps; Pils 1985); dark diamonds – mixed populations of tetraploid and pentaploid plants, $2n \approx 4x$ or $5x$ (*F. supina*).

ments in herbarium specimens from the same localities (Šmarda et al. 2005).

The tetraploid level measured in *F. eggleri* from the type locality agrees with the results of Tracey (1980; as *F. eggleri* "Pernegg-Sippe"), who reported a frequent occurrence of transitional plants in the contact zone between *F. eggleri* and *F. csikhegyensis* (as *F. pallens*) in this locality. One of these morphological intermediates was measured and turned out to be tetraploid. The diploids of *F. eggleri* (Tracey, 1980; as *F. eggleri* "2x Sippe") were observed in another site, situated close to that reported by Pils (1980).

Polyploid complex Festuca airoides and F. supina

This complex includes the occasionally viviparous plants of the *F. ovina* group, typical of subalpine and alpine grasslands and distributed from the Massif Central in France throughout the Alps, the Sudeten Mts, and the Carpathians to Bulgaria (Fig. 3). Two DNA ploidy levels are reported here from Romania: the diploids ($2n \approx 2x$) found only in the Cehlau Mts and Gutii Mts (Eastern Carpathians), and the tetraploids ($2n \approx 4x$), widely distributed in the Parâng, Făgăraş and Sebeş Mts (Southern Carpathians; Fig. 3). The diploids of this complex are known also from the Massif Central (Kerguélen 1975), the Alps (Pils 1980, 1985), the Eastern and Southern Carpathians (Tveretinova 1977; Pashuk 1987; Stefanik et al. 1989; Ehrenbergerová 2001), and from Bulgaria (Kožuharov & Petrova 1991; Fig. 3). In the Sudeten Mts and Western Carpathians, only tetraploids were recorded (Piotrowicz 1950, 1954; Hadač & Hašková 1956; Uhríková et al. 1983; Mizianty & Pawlus 1984; Májovský & Uhríková 1985; Měsíček & Jarolímová 1992), in the Vysoké Tatry Mts growing together with some pentaploids (Piotrowicz 1950, 1954; Murín & Paclová 1979; Fig. 3).

The taxonomy of this complex has not been sufficiently known yet, and the only comparative morphological study, including populations from the Alps, was done by Pils (1985). He assigned the diploids to *F. supina* Schur, and the tetraploids, including tetraploid populations from the Czech Republic, Poland, and Slovakia, to *F. vivipara* (L.) Sm. This treatment was accepted, for instance, in the new field flora of Austria (Englmaier 1994, 2005). Other recent floras and checklists (Dostál 1989; Marhold & Hindák 1998; Ehrenbergerová 2001; Grulich et al. 2002) and also this study follow the opinions of Patzke (1966), Markgraf-Dannenberg (1980), and Pignatti & Markgraf-Dannenberg (1982), who considered *F. vivipara* not to occur in the Alps, and assigned the plants of this complex either to *F. supina* or to *F. airoides*, based on their ploidy level (Kerguélen 1983). *Festuca airoides* was described from the Massif Central and found to be diploid there ($2n = 14$; Kerguélen 1975). The name *F. supina*, published later, is used for the tetraploid and pentaploid plants in the Western Carpathians and the Sudeten Mts (Dostál 1989; Marhold & Hindák 1998; Ehrenbergerová 2001; Grulich et al. 2002). However, the status of this taxon remains still ambiguous as (i) no lectotype has been selected yet (Ehrenbergerová 2001), and (ii) both diploid and tetraploid populations are found in the Romanian Carpathians (see references above), from where the species was originally described by Schur (1866). In modern European floras (Markgraf-Dannenberg 1980; Conert 1998), all plants of this complex are therefore usually included under the oldest name *F. airoides* Lam.

Festuca pallens group

In Central Europe, the group consists of six or seven taxa growing in relict rocky habitats and on windblown sand dunes. Within *Festuca pallens* s.l., the most intensively karyologically investigated part of this group, two ploidy levels are usually reported (Šmarda & Kočí 2003). Morphological differences between the diploid and the tetraploid populations supported its division into two species: the diploid *F. pallens* and the

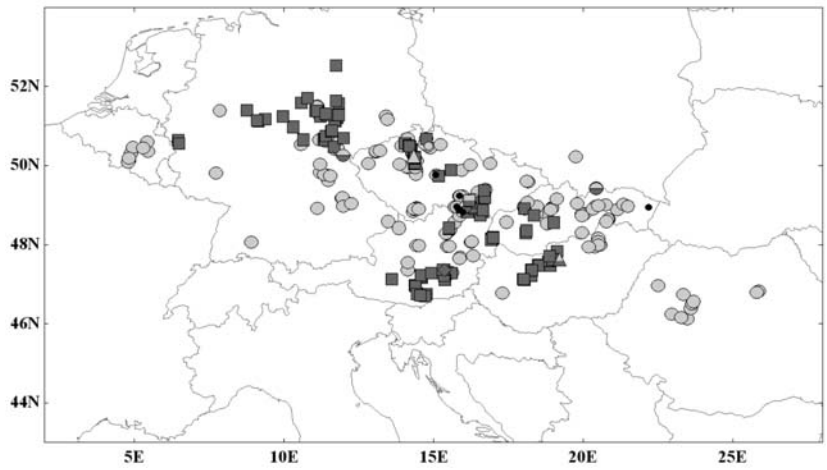

Fig. 4. Localities of investigated plants of the *F. pallens* agg. and their hybrids, including previously published karyological records: grey circles – *F. pallens* ($2n \approx 4x$); dark squares – *F. csikhegyensis* ($2n \approx 4x$); dark/grey circles – *F. pallens* ($2n \approx 3x$); dark/grey triangle – *F. csikhegyensis* × *F. vaginata* ($2n \approx 3x$); dark/grey squares – *F. pallens* × *F. pseudodalmatica* (*F.* ×*krizoviensis*, $2n \approx 3x$, $4x$); small black circles – *F. ovina* × *F. pallens* (*F.* ×*duernsteinensis*, $2n \approx 4x$); small grey circles – *F. pallens* × *F. psammophila* (*F.* ×*belensis*, $2n \approx 2x$); grey triangle – *F. pallens* × *F. valesiaca* ($2n \approx 2x$); dark diamond –*F. csikhegyensis* × *F. eggleri* ($2n \approx 4x$). The dashed line shows the distribution range of *F. pallens* agg.

tetraploid *F. csikhegyensis* (Šmarda et al. 2007). The DNA ploidy level estimates reported here improve the knowledge of the distribution of both species. Based on earlier chromosome counts and ploidy level estimates (Šmarda & Kočí 2003 and references therein; Šmarda et al. 2005; Šmarda et al. 2007; Šmarda 2006; Šmarda & Bureš 2006), a revised distribution map of both taxa is provided (Fig. 4). The wide distribution of *F. csikhegyensis* (syn. *F. glaucina* Stohr) in northwestern Germany is of particular interest. Two DNA ploidy level estimates in *F. duvalii* (tetraploid) and *F. psammophila* subsp. *dominii* (diploid), both studied in detail by Šmarda et al. (2005) and Šmarda et al. (2007), are also reported here. The record of diploids in the populations of *F. polesica* from Estonia corroborates earlier counts and measurements from Germany, Denmark, Poland, Ukraine, and Romania (Böcher 1947; Tveretinova 1977; Mizianty & Pawlus 1984; Šmarda 2006; Šmarda et al. 2007). The only tetraploid chromosome count by Lewitsky & Kuzmina (1927, as *F. ovina* subsp. *beckeri*), assigned to *F. polesica* by Alexeev et al. (1988), has to be reconsidered.

Among the Mediterranean relatives of this group, only diploids were found in nine populations of *F. inops* from Italy (Fig. 2); the same ploidy level was documented from Italy by Bechi & Miceli (1995) and Foggi et al. (2006). *Festuca inops* was formerly considered endemic to central Italy (Pignatti & Markgraf-Dannenberg 1982); however, the recent taxonomic study by Foggi et al. (2006) demonstrated its conspecificity with *F. gracilior*, another diploid taxon known from northeastern Spain, southern France, and Italy (Markgraf-Dannenberg 1980; Ortúñez Rubio & Fuente Garcia 1995; Portal 1999). All investigated plants of *F. glauca* from the eastern Pyrenees were hexaploid, which is in accordance with the results of Auquier & Kerguélen (1978).

Ungrouped taxa of Festuca sect. Aulaxyper

Three samples of *F. bucegiensis* from the Parâng Mts and the Făgăraş Mts turned out to be diploid (Fig. 5). The DNA ploidy level for this species, an endemic of acidophilous alpine grasslands in the highest parts of the Southern Carpathians (Markgraf-Dannenberg 1978, 1980), is reported here for the first time. The diploid level found in *F. pirinica*, a stenoendemic of the Pirin Mts in Bulgaria, corresponds to the earlier chromosome counts of Kožuharov & Petrova (1991) and Strid & Andersson (1985). The tetraploid level found in *F. heterophylla* is in accordance with the karyological data by Brandberg (1948), Auquier & Rameloo (1973), Uhríková (1974), Kerguélen (1975), Strid & Franzen (1981), and Nikolov (1991).

Festuca amethystina group

The locality of the diploid *F. norica* in northern Italy reported here (Fig. 5) is situated on the southern distribution limit of this species (cf. Foggi et al. 1999). It corresponds to the assumed distribution of the diploid cytotype documented from the Central Alps by Pils (1980). The representatives of the similar *F. tatrae* from Slovakia were also diploid, which agrees with the counts published by Brandberg (1948), Bielecki (1957), and Uhríková (1970b). The tetraploid level previously reported in *F. amethystina* by Wittman & Strobl (1984) and Šmarda et al. (2005) was confirmed in one specimen of the nominate subspecies collected in Austria (Fig. 5).

Festuca halleri group

Several samples of *F. alpina* s.l. from the Apuan Alps (Northern Apennines, Fig. 5) were found to be diploid, which agree with the parallel chromosome counts by Foggi (pers. comm.). The taxonomic identity of the populations studied remains unclear. They were formerly referred to as *F. vizzavonae* Ronn. (Markgraf-

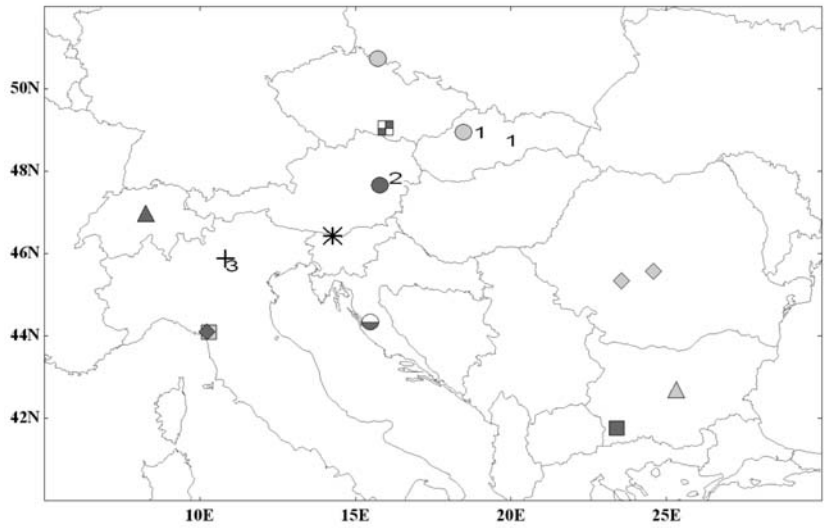

Fig. 5. Localities of investigated plants of *Festuca* sect. *Eskia*, *F.* sect. *Amphigenes*, and *F.* sect. *Aulaxyper*: 1 – *F. tatrae* ($2n \approx 2x$); 2 – *F. amethystina* subsp. *amethystina* ($2n \approx 4x$); 3 – *F. norica* ($2n \approx 2x$); grey circles – *F. versicolor* subsp. *versicolor* ($2n \approx 2x$); dark circle – *F. versicolor* subsp. *pallidula* ($2n \approx 2x$); white/dark circle – *F. bosniaca* subsp. *bosniaca* ($2n \approx 2x$); grey triangle – *F. xanthina* ($2n \approx 2x$); dark triangle – *F. quadriflora* ($2n \approx 4x$); grey square – *F. violacea* subsp. *puccinellii* ($2n \approx 2x$); dark square – *F. pirinica* ($2n \approx 2x$); checked square – *F. heterophylla* ($2n \approx 4x$); grey diamonds – *F. bucegiensis* ($2n \approx 2x$); dark diamonds – *F. alpina* s.l. ($2n \approx 2x$); cross – *F. alpestris* ($2n \approx 2x$); star – *F. laxa* ($2n \approx 4x$).

Dannenberg 1980; Pignatti & Markgraf-Dannenberg 1982); however, the type of this name is referrable to *F. cyrnea* (Litard. et St.-Yves) Markgr.-Dann. (Signorini et al. 2003a,b). The use of the name *F. alfrediana* Foggi & Signorini (Foggi & Signorini 1997), based on the populations of alpine fescues from Corse, is also controversial, as *F. alfrediana* is reported to be tetraploid (Portal 1999). Since the relationships of the tetraploid *F. alfrediana*, the diploid populations from Italy, and the diploid populations of *F. alpina* s. str., known from the Alps and the Western Carpathians (Pils 1982; Šmarda & Kočí 2005), remain unclear, the provisional name *F. alpina* s.l. (Foggi, pers comm.) is accepted here.

Festuca violacea group

The diploid level found in*F. violacea* subsp. *puccinellii* from the Apuan Alps agrees with the the diploid chromosome numbers reported in plants from this region by Foggi et al. (1999).

Festuca sect. Eskia

The investigated plants from the locus classicus of *F. versicolor* in the Krkonoše Mts and *F. versicolor* subsp. *pallidula*, an endemic of the Austrian Eastern Alps, were diploid (Fig. 5). The diploid level found in the nominate subspecies is in accordance with earlier karyological reports from the western Carpathians (Uhríková 1970a; Mizianty & Frey 1973; Murín & Májovský 1978, 1987; Šmarda & Kočí 2003; Šmarda et al. 2005). The DNA ploidy level of *F. versicolor* subsp. *pallidula* is reported here for the first time. The investigated specimens of *F. bosniaca* and *F. xanthina,* both endemic to the Balkan Peninsula, were also diploid (Fig. 5). The DNA ploidy level of *F. bosniaca* (excl. *F. pirinensis* (Acht.) Acht.) is reported here for the first time. The estimates in *F. xanthina* are in accordance with the counts reported by Starlinger et al. (1994) and measurements made by Šmarda (2006).

The tetraploid level was proved in the plants of *F. quadriflora* from the Central Alps in Switzerland (Fig. 5). In the Alps, *F. quadriflora* seems to include two closely related types with different ploidy levels (Kerguélen & Plonka 1989). The tetraploids are assumed to occur inside the Alp mountain range, and the diploids in its foreland (Kerguélen & Plonka 1989). The results presented here support this assumption.

Festuca sect. *Amphigenes*

The tetraploid level found in the plants of *F. laxa* from the type locality in the southeastern Alps (Fig. 5) is in accordance with the results of Gervais (1965) and Löve & Löve (1974). The hexaploid chromosome count in *F. laxa* reported for Swiss plants (Hill 1965) is doubtful as this species is not known to occur in Switzerland (cf. Hess et al. 1967).

Flow cytometry and herbarium specimens

The first application of flow cytometry for the measurements of dessicated plant tissues dates back to 2000, when it was succesfully used for the estimation of ploidy level of 1/2 to 2-year-old herbarium specimens of *Festuca* (Šmarda et al. 2005). Later, the use of this technique was tested also in other genera, under different storage conditions, and in herbarium specimens of different age (Suda 2004; Suda & Trávníček 2006). To this date, it was possible to measure up to 6-year-old specimens in *Vaccinium* (Suda 2004) and up to 5-$^1/_2$-year-old specimens in South American fescues (Šmarda & Stančík 2006). In this paper, up to 12 years-old herbarium specimen of *F. pallens* is documented to be suitable for the determination of DNA ploidy level by flow cy-

tometry. The DNA signal of such old specimens is usually weak and degraded, and the DNA content seemed to be smaller compared to measurements in fresh living samples (Šmarda & Stančík 2006; Suda & Trávníček 2006; Šmarda 2006). This limits the use of flow cytometry in herbarium specimens for reliable DNA content measurements, and restricts the application of flow cytometry here only to the determination of DNA ploidy level.

Mixed ploidy populations and hybrids

Several mixed ploidy populations reported previously by Šmarda & Kočí (2003) and Šmarda et al. (2005) were here reinvestigated, and some others were found during search for morphologicaly deviating plants within some populations (Figs 1, 4). Within *Festuca* populations, the rare occurrence of morphologically distinct individuals of different ploidy levels is assumed to be most probably related with hybridisation. Records of rather large sub-populations of plants with different ploidy levels are referred here to as a sympatric occurrence of two different taxa.

In Chvalatice and Tulešice (southwestern Moravia; Fig. 4), tetraploid plants were rarely found in large population of the diploid *F. pallens* in the contact zone with the tetraploid *F. ovina* subsp. *guestfalica*. The general appearance of these plants resembled much that of *F. pallens* (thick leaves, large spikelets and lemmas), but they resembled *F. ovina* in the slightly scabrid leaves and the panicles erect before the anthesis (the diploid *F. pallens* of these populations had completely smooth leaves and panicles nodding before the anthesis). Because of the intermediary characters and because of their rarity in the populations, they are assumed to be hybrids (*F.* ×*duernsteinensis*).

A similar situation was reported from Zruč nad Sázavou and Moravský Krumlov [Šmarda & Kočí (2003) as *F. pallens* "scabrifolia type"; Šmarda et al. (2005) as *F. pallens* "Pannonisches-Hügelland type"]. The two tetraploid *F. pallens* plants from Zruč nad Sázavou, found in the otherwise diploid population, became similar to a robust *F. ovina* during cultivation, so both were reclassified as *F.* ×*duernsteinensis*.

The cultivation of tetraploid plants from Třebíč-Hrádek previously referred to as *F.* ×*duernsteinensis* (Šmarda & Kočí 2003), made necessary their reclassification: they had to be assigned to *F. pseudodalmatica*, a species not previously known from the Czech Republic (see above). Sclerenchyma on the cross sections of tiller leaves in *F. pseudodalmatica* consist usually of two thick bands along both leaf margins and one opposite to the central vein, frequently with additional lateral slender strand on abaxial leaf sides. Sometimes the additional lateral strands are well developed and may fuse with the main strands, forming an irregular sclerenchyma ring. The latter sclerenchyma pattern is quite common in plants from the Třebíč-Hrádek population, and such plants may easily be confused with the taxa of the *F. ovina* or *F. pallens* groups.

Unlike in the two localities described above, the tetraploids of *F. pallens* s.l. in the Pod Floriánem Nature Reserve near Moravský Krumlov are not scatered in the population of diploids but they form a small colony on the plateau above the river canyon. Only in the closest surrounding, the tetraploids penetrate into the population of diploids, which dominate the rocky steppes on the slopes of the river valley (cf. Šmarda & Bureš 2006). The habitat of the tetraploids is a partly ruderalised mown dry grassland, and another two species, the tetraploid *F. ovina* subsp. *guestfalica* and the tetraploid *F. pseudodalmatica*, are frequent there (Šmarda & Kočí 2003). The morhological similarity to *F. csikhegyensis* makes possible to assign the local tetraploid population from this site to that species.

Near the village of Plaveč (soutwestern Moravia), the triploids of *F. pallens* were reported to grow by Šmarda et al. (2005). *Festuca pallens* survived there as a very small population of several dozens of diploid and triploid plants on a small rock overgrown by *Robinia pseudacacia*. Like in Moravský Krumlov, the tetraploid *F. pseudodalmatica* and the tetraploid *F. ovina* subsp. *guestfalica* occur in the close vicinity. However, the triploids have the same general appearance as the diploids do, so there is no morphological evidence for their hybrid origin.

Near the village of Větrušice (Central Bohemia, Vltava River valley), the diploids and the tetraploids of *F. pallens* s.l. were found growing side by side. A carefull inspection revealed the existence of a large diploid population within the area occupied otherwise by the tetraploids (cf. Šmarda & Bureš 2006). This situation is interpreted as the sympatric ocurrence of two separate taxa, the diploid *F. pallens* and the tetraploid*F. csikhegyensis*.

Triploid and tetraploid plants were also rarely found in a large diploid population on serpentine and granulite rocks in the Mohelenská hadcová step Nature Reserve (southwestern Moravia, Jihlava River valley; Fig. 4). The plants reported here were found growing together in small group in the contact zone of the diploid *F. pallens* with the abundant tetraploid *F. pseudodalmatica*. The triploids and tetraploids are very similar and resemble *F. pallens* in their general appearance and in the cross sections of tiller leaves. Like the hybrids of *F. pallens* and *F. ovina* discussed above, they have scabrid leaves and erect panicles before the anthesis, in which they clearly differ from the diploid *F. pallens* occurring frequently in this site. Both the triploids and the tetraploids are considered hybrids of *F. pallens* with the sympatric *F. pseudodalmatica*. Common hybridisation on the contact of both species was documented from Slovakia, and the hybrid was described as *F.* ×*krizoviensis* Májovský (Májovský 1955). This name is used here also for the populations from Mohelno.

A small population of triploid and tetraploid fescues, representing very probably putative hybrids of the co-occurring diploid *F. vaginata* and the hexaploid *F. rupicola*, was found on sand dunes near Čenkov (southern Slovakia, Fig. 1). The earliest and the only correct name for this hybrid combination is

F. ×*interjecta* Vetter. *Festuca* ×*javorkae* Májovský (1962), a later name for the same parental combination, based on the plants collected in the surrounding of Čenkov, was published invalidly (Art. 37.1, 52.1 of the Nomenclatural Code; McNeill et al. 2006). Also another later name, *F. majovskyi* Holub, published validely by the reference to Májovský's description of *F.* ×*javorkae* (Májovský 1962), with a type designated by Holub (1983) from the large collection of fescues from Čenkov surrounding by Májovský in 1963 (SLO!), cannot be used as the selected holotype and three isotypes are referable to *F. rupicola* and not to the hybrids, only rarely present in this collection.

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Appendix

List of taxa and localities of investigated living plants and herbarium specimens. Observed DNA ploidy levels are given in parentheses behind the taxon name. The place name before the colon in the locality descriptions represents the nearest town or village. Collector name(s), the date of collection and plant cultivation numbers are given in parentheses following the locality description. The letter "F" indicates cultivated plants, "H" samples in which only herbarium specimen was available. Herbarium specimens borrowed from the Herbarium of the Institute of Botany, Slovak Academy of Sciences in Bratislava are marked by "SAV".

Festuca airoides **Lam.** ($2n \approx 2x$): **Romania:** Cehlau Mts, Cehlau: 1 km NNE of Cehlau Mt. (1900 m), trampled places on hiking trail in conglomerate gravel, 1650 m a.s.l., 46°59′07″N, 25°57′31″E (M. Valachovič, 19 Jul 2000; H672). – Gutii Mts, Baia Sprie: Creasta Cocaşului Nature Reserve, about 9 km ENE of the town, volcanic rock, 1300 m a.s.l., 47°43′03″N, 23°47′08″E (J. Košťál, 18 Jul 2004; SAV).

Festuca alpestris **Roem. et Schult.** ($2n \approx 2x$): **Italy**: Riva del Garda (near Lago di Garda lake): Bocca Sperone saddle 2.5 km SW of the town, limestone rocks in shrubs on W exp. rocky slope, common, 950 m a.s.l., 45°52′41″N, 10°49′22″E (P. Šmarda, 10 Jun 2000; H60).

Festuca alpina **Suter s.l.** ($2n \approx 2x$): **Italy:** Alpi Apuani Mts, Forno: 4.2 km E of the village, limestone rocky slope, abundant, ±1000 m a.s.l., 44°05′51″N, 10°13′49″E (V. Grulich, Sep 2001; F209). – Alpi Apuani Mts, Resceto: about 2.5 km from the village, along the Via Vandelli route, calcareous rocks, scattered, ±1300 m a.s.l., 44°05′39″N, 10°13′55″E (P. Šmarda, 29 May 2003; F469, F470). – Alpi Apuani Mts, Resceto: Passo Tambura saddle, calcareous rocks, scattered, 1638 m a.s.l., 44°06′04.9″N, 10°14′03.5″E (P. Šmarda, 29 May 2003; F457, F458).

Festuca amethystina **L. subsp.** ***amethystina*** ($2n \approx 4x$): **Austria:** Niederösterreich, Winzendorf: 0.6 km SW of the top of Schlossberg Hill on N village periphery, 150 m E of the castle ruin, fringe of forest track in *Pinus nigra* forest, calcareous bedrock, single tuft, 475 m a.s.l., 47°49′08″N, 16°16′18″E (J. Roleček, 1 Jun 2005; F735).

Festuca bosniaca **Kumm. et Sendtn. subsp.** ***bosniaca*** ($2n \approx 2x$): **Croatia:** Velebit Mts, Starigrad-Paklenica: Paklenica Nature Reserve, along the hiking trail between Lugarnica and Paklenica chalets, about 5 km NNE of the village centre, calcareous rocks, in stand of *Carex halleriana*, single tuft, 380 m a.s.l., 44°20′14.8″N, 15°28′39.0″E (P. Šmarda, 17 Jun 2005; F746).

Festuca brevipila **R. Tracey** ($2n \approx 6x$): **Austria:** Niederösterreich, Amaliendorf: 300 m NE of the church in the village, surroundig of the house Nr. 55 (type locality), edge of seminatural meadow dominated by *Festuca nigrescens*, siliceous, nutrient-poor substrate, scattered, 550 m a.s.l., 48°49′45″N, 15°05′21″E (P. Šmarda, 22 Jun 2001; F213, F214, F215). – Steiermark, Trieben: 3.8 km S of the railway station in the village, artificially consolidated slope above the road composed from limestone blocks, small colony, 951 m a.s.l., 47°27′22.1″N, 14°29′28.5″E (P. Šmarda, 13 Jun 2003; F522). **Czech Republic:** Brno-Kohoutovice: 1.35 km NNW of Kamenný kopec Hill near the Bašného street, stony edge of the road, common, 380 m a.s.l., 49°11′41″N, 16°31′54″E (P. Šmarda, 20 May 2000; H35, H37, H40, H42, H43, H45, H46). – Čermná nad Orlicí: 0.8 km SSE of the railway station, sands along railway, common, 270 m a.s.l., 50°03′36″N, 16°08′40″E (P. Filippov, Jun 2000; H107, H108). – Kersko: NE part of the village, 1.15 km SW of the church in Hradišťko village, near the fence along the road, grassland along the forest track, in pine wood on sand together with *Festuca psammophila*, small colony, 185 m a.s.l., 50°09′45″N, 14°55′20″E (P. Šmarda, 3 Jun 1999; H62). – Kostelní Lhota (near Sadská): 1.5 km NW of the church in the village, W exp. grassy edge of pine forest on sand, scattered, 186 m a.s.l., 50°07′54″N, 15°00′42″E (P. Šmarda, 19 Jun 2000; H79). – Lhota (near Dřísy): 1.05 km E of the village centre, enclosed waterworks building near the southernmost projection of Jezero reservoir, acidic sands in pine wood, small colony, 175 m a.s.l., 50°14′29.5″N, 14°40′18.3″E (P. Šmarda, 30 Jun 2002; F354, F355). – Písková Lhota: SE village periphery, S exp. edge of pine forest on sand, abundant, 186 m a.s.l., 50°07′46″N, 15°04′47″E (P. Šmarda, 18 Jun 2000; H54). **Germany:** Bayern, Stoffelsmühle: near the branch road to Nordhalben, in railway yard below a siliceous rocky slope, small colony, 450 m a.s.l., 50°21′33″N, 11°31′19″E (O. Rotreklová & P. Šmarda, 12 Jul 2000; H138). – Bayern, Stadtsteinach (NE of Kulmbach): end of railway on E village periphery, crushed stone heaps (probably transported from a nearby quarry), small colony, 330 m a.s.l., 50°09′49″N, 11°30′49″E (O. Rotreklová & P. Šmarda, 12 Jul 2000; H130, H131). – Sachsen-Anhalt, Gerwish: 1.5 km N of the village, S margin of former military training area, sandy place along a rural road, common, 46 m a.s.l., 52°11′32.9″N, 11°44′33.4″E (P.

Šmarda & Z. Rozbrojová, 5 Jun 2004; F656, F657, F658). **Hungary:** Veszprém county, Sümeg: distinct hill with a castle in the village, NE exp. calcareous rocky slopes, common, 250 m a.s.l., 46°59′03.4″N, 17°17′01.2″E (P. Šmarda, 2 Jun 2002; F292, F296). **Poland:** Warszawa region, Kampinoski National Park, Górki: 2.6 km NNW of the village, 300 m W of the crossroad of rural roads and the motor way, sand dunes, S exp. pine forest margin, small colony, 85 m a.s.l., 52°21′01″N, 20°31′40″E (P. Šmarda, 8 Jun 2001; F195). – Białystok region, Biebrzański National Park, Kuligi: Czerwone bagno Nature Reserve, about 5 km SE of the village, sand dune with *Corynephorus canescens*, small colony, 120 m a.s.l., 53°35′54″N, 22°46′53″E (P. Šmarda, 6 Jun 2001; F202 glaucous plant, F203 green plant, H154, H155). – Ostroleska region, Brok: SW village periphery, sunny pine forest margin, sand, in places, 100 m a.s.l., 52°41′48″N, 21°50′56″E (P. Šmarda, 7 Jun 2001; F192, H153). **Slovakia:** Kremnické vrchy Hills, Kremnica: Kremnický Štós Nature Reserve on SE town periphery, isolated tufts, 750 m a.s.l., 48°41′35″N, 18°56′10″E (J. Ripka, 2001–2002; H703). – Vtáčnik Hills, Kamenec pod Vtáčnikom: about 4 km SE of the village, above Gepniarova valley, andesite rocks, 600 m a.s.l., 48°38′04″N, 18°33′33″E (J. Ripka, 2001–2002; H712). – Záhorská lowland, Lozorno: sands in the village surrounding, 190 m a.s.l., 48°20′N, 17°03′E (J. Ripka, 2001–2002; H675).

***Festuca bucegiensis* Markgr.-Dann.** ($2n \approx 2x$): **Romania:** Făgăraş Mts, Avrig: top of Negoiu peak, siliceous rocky ridge, scattered, 2532 m a.s.l., 45°34′39″N, 24°34′13″E (P. Šmarda, 1 Aug 2002; F370). – Parâng Mts, Petroşani: main range 450 m ESE of Parângu Mare peak, near saddle above Lacul Mândra tarn, fissures in E exp. rocky slope, small colony, 2300 m a.s.l., 45°20′19″N, 23°32′48″E (P. Šmarda, 4 Aug 2001; H315, F352).

***Festuca carnuntina* R. Tracey** ($2n \approx 6x$): **Austria:** Niederösterreich, Heinburger Berge Hills, Hundheim-Neusiedlung: Nature Reserve above the village, S exp. dolomite rocky slopes, common, 336 m a.s.l., 48°07′20.9″N, 16°56′04.2″E (P. Šmarda, 1 Jun 2002; F308, F309).

***Festuca csikhegyensis* Simonk.** ($2n \approx 4x$): **Austria:** Kärtnen, Friesach: church near the Ruine Rotturm ruin, W town periphery, crown of garden wall made by limestone stones, small colony, 644 m a.s.l., 46°56′59.9″N, 14°24′14.3″E (P. Šmarda, 13 Jun 2003; F519). – Kärtnen, Griffen: top of prominent limestone cliff in the village, rocks in the ruin area, common, 609 m a.s.l., 46°42′16.0″N, 14°43′39.0″E (P. Šmarda, 13 Jun 2003; F514, F515). – Kärtnen, Hochosterwitz: SW part of a prominent cliff with a castle, boottom of vertical limestone wall below the castle, abundant, 629 m a.s.l., 46°45′18.3″N, 14°27′06.6″E (P. Šmarda, 13 Jun 2003; F518). – Kärtnen, Klein St. Veit: 1.8 km SE of the church in the village centre, bottom of siliceous rocky promontory above the road, larger colony, 519 m a.s.l., 46°42′51.5″N, 14°33′45.4″E (P. Šmarda, 13 Jun 2003; F516, F517). – Niederösterreich, Dürnstein: 1.5 km NNE of the church in the village, near the way to Vogelberg Hill, W exp. limestone rocky slopes, very abundant, 400 m a.s.l., 48°24′31″N, 15°31′41″E (K. Kočí, May 2000; H91). – Niederösterreich, Hundsheim-Neusiedlung: Nature Reserve on NE village periphery, rocky steppe on SW exp. dolomite slopes, common, 340 m a.s.l., 48°07′50″N, 16°55′48″E (P. Karlík, 20 May 2000; H128). – Steiermark, Judendorf: 2.6 km ESE of the railway station, 300 m SW of Kanzelkogel Hill, limestone cliff above the road and Mur river, larger colony, 457 m a.s.l., 47°06′54.6″N, 15°22′40.8″E (P. Šmarda, 12 Jun 2003; F510, F511). – Steiermark, Kraubath an der Mur: Gulsenberg Hill, 2.9 km SSW of the church in the village, patches in pine forest on serpentine scree, very abundant, 640 m a.s.l., 47°16′59″N, 14°55′36″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H112, H113, H114, H115). – Steiermark, Kraubath an der Mur: Wintergraben valley, 2.1 km SE of Chromwerk village, bare loamy slopes with fine debris on the edge of *Erico-Pinetea* forest, small colony, 800 m a.s.l., 47°17′15″N, 14°58′18″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H63). – Steiermark, Oberkurzheim (S of Pöls): N village periphery, limestone rocks on the edge of a local quarry, common, 818 m a.s.l., 47°13′51.5″N, 14°35′03.2″E (P. Šmarda, 13 Jun 2003; F520, F521). – Steiermark, Peggau: 400 m W of the railway station, bottom of limestone cliffs above the town, common, 413 m a.s.l., 47°12′33.0″N, 15°20′51.1″E (P. Šmarda, 12 Jun 2003; F507, F508, F509). – Steiermark, Pernegg: 1.05 km NE of the church in the village, serpentine outcrop near the the forest track, small colony, 800 m a.s.l., 47°21′54″N, 15°21′35″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H47, H48). – Steiermark, Preg: 0.55 km N of the railway station, S exp. steep serpentine rocky slope, dominant, 719 m a.s.l., 47°16′59.6″N, 14°55′34.8″E (P. Šmarda, 12 Jun 2003; F502). – Steiermark, Zlatten: above the road opposite a power station near a bridge, calcareous rocky face, abundant, 490 m a.s.l., 47°22′10″N, 15°19′06″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H64). **Czech Republic:** Bohutice: U Michálka Nature Reserve, SW exp. siliceous rock, dense steppe stand with *Iris arenaria* and *Helictotrichon pratense*, abundant, 270 m a.s.l., 48°54′04″N, 16°21′29″E (T. Vymyslický, 15 May 2001; H6). – Blansko: 3.15 km ENE of the railway station, Punkevní údolí valley, S exp siliceous rocky slope with open pine-oak forest, together with *Festuca ovina* subsp. *guestfalica*, small colony, 410 m a.s.l., 49°21′42″N, 16°41′22″E (D. Dvořák & P. Šmarda, 27 Jul 2005; F736, F754, H1421, H1422, H1423). – Hrdly (near Roudnice nad Labem): 0.6 km NE of the railway station in the village, S exp. edge of pine forest on sand, scattered, 160 m a.s.l., 50°29′21″N, 14°10′53″E (P. Šmarda, 19 Jun 2000; H18). – Máslovice (near Libčice nad Vltavou): 250 m S of the church in the village, S exp. siliceous rocks, common, 220 m a.s.l., 50°12′25″N, 14°22′45″E (P. Šmarda, 1 Jul 2002; F365). – Miroslav: Miroslavské kopce Nature Reserve, 400 m SSW of Markův kopec Hill, limestone outcrops in dense steppe grassland, scattered, 280 m a.s.l., 48°56′09″N, 16°18′39″E (T. Vymyslický, 1 May 2000; H55). – Moravský Krumlov: Pod Floriánkem Nature Reserve, near ″312 m″ elevation point on Křepelčin vrch Hill, terrace on the upper edge of NW exp. conglomerate slope of the canyon, small colony, 310 m a.s.l., 49°02′48″N, 16°19′08″E (O. Rotreklová, 24 May 1998; H1). – ibid., 49°02′48″N, 16°19′17″E (P. Šmarda, 28 May 2000; H22, H29). – Oleško (near Roudnice nad Labem): 0.3 km E of the church in the village, sands near the forest track overgrown by *Robinia pseudacacia*, small colony, 165 m a.s.l., 50°28′50″N, 14°12′07″E (P. Šmarda, 19 Jun 2000; H12, H13, H14). – Oleško (near Roudnice nad Labem): 0.5 km NW of the church in the village, sunny SW exp. edge of pine forest on sand, small dense colony, 160 m a.s.l., 50°29′03″N, 14°11′34″E (P. Šmarda, 19 Jun 2000; H7, H8, H9, H10, H11, H15). – Pavlov (Pálava Hills): 0.4 km SW of Děvín Hill, above the ″Soutěska″ elevation point, upper edge of relict W exp. limestone cliff, abundant, 500 m a.s.l., 48°52′03″N, 16°38′38″E (P. Šmarda, 26 May 2000; H66). – Řež (near Roztoky u Prahy): 350 m NE of the Řež railway station, foot of spilite rocky slopes above the railway, scattered, 210 m a.s.l., 50°10′52.4″N, 14°21′31.9″E

(P. Šmarda, 30 Jun 2002; F360). – Třemošnice (near Ronov nad Doubravou): Lichnice Nature Reserve, 1.4 km NE of the railway station, SSE exp. gneiss rocky ridge, abundant, 400 m a.s.l., 49°52′59″N, 15°35′06″E (J. Juřička & J. Čech, 28 Jun 2002; F366). – Větrušice: Větrušická rokle Nature Reserve, top of Velký vrch Hill, acidic schistaceous rocks dominated by *Avenella flexuosa*, *Calluna vulgaris* and *Pilosella officinalis*, small colony, 280 m a.s.l., 50°11′08″N, 14°22′36″E (P. Šmarda, 30 Jun 2002; F361). **Germany:** Hessen, Maden: Maderstein Hill NE of the village, SW exp. basalt cliff, 250 m a.s.l., 51°10′03″N, 9°22′53″E (J. Müller, 24 May 2000; H359). – Hessen, Reitzenhagen (W periphery of Bad Wildungen): Bilstein Hill on NW village periphery, S exp. diabase cliff, 320 m a.s.l., 51°07′48″N, 9°05′52″E (J. Müller, 24 May 2000; H349). – Hessen, Wellingerode: upper S slope of Bilstein Hill N of the village, diabase cliff, 270 m a.s.l., 51°13′42″N, 9°58′07″E (J. Müller, 24 May 2000; H362). – Niedersachsen, Neuhof: W slope of Sachsenstein Hill N of the village, top of gypsaceous cliff, 300 m a.s.l., 51°34′38″N, 10°34′57″E (J. Müller & C. Renker, 21 Jun 1998; H354). – Sachsen-Anhalt, Wendelstein: S exp. gypsaceous cliff W of the village, 120 m a.s.l., 51°16′46″N, 11°27′16″E (J. Müller, 24 May 2000; H353). – Sachsen-Anhalt, Hasselfelde: Wilder Rabenstein elevation point in the Rappbode valley, 5.2 km W of the village, diabase cliff, 490 m a.s.l., 51°41′35″N, 10°47′33″E (D. Korneck, 15 Jun 1997; H358). – Sachsen-Anhalt, Mücheln: Lauchenberge Hill SE of the village, porphyry rock, 110 m a.s.l., 51°17′18″N, 11°49′54″E (G. Degtjareva, 15 May 2001; H366). – Sachsen-Anhalt, Mücheln: porphyry rock S of the town, 90 m a.s.l., 51°16′07″N, 11°50′03″E (D. Korneck, 17 May 1994; H357). – Sachsen-Anhalt, Rothenburg: E side of Saale river about 2 km S of the village, Carbonian sandstone cliff with *Stipa capillata*, *Carex humilis*, *Botriochloa ischaemum*, *Erysimum crepedifolium*, *Seseli hippomarathrum* etc., 100 m a.s.l., 51°37′37″N, 11°45′07″E (D. Korneck, 17 May 1994; H356). – Thüringen, Bottendorf: Galgenberg Hill N of the village, dry grassland, 200 m a.s.l., 51°18′45″N, 11°24′26″E (J. Müller, 24 May 2000; H361). – Thüringen, Ebersdorf: foot of Heinrichstein Hill SSE of the village, SSE exp. diabase cliff, 430 m a.s.l., 50°27′58″N, 11°40′46″E (J. Müller, 18 Jun 2000; H360). – Thüringen, Maua: Rabenschüssel elevation point, E of the village, WSW exp. Triassic sandstone cliff, 200 m a.s.l., 50°52′03″N, 11°36′21″E (J. Müller, 24 May 2000; H350). – Thüringen, Weissendorf: upper S slope of Teufelsberg Hill W of the village, schistum cliff, 380 m a.s.l., 50°40′51″N, 11°59′14″E (J. Müller, 5 May 2001; H364). – Thüringen, Zella-Mehlis: Reisinger Stein Hill WSW of the village, SE exp. siliceous cliff, 580 m a.s.l., ±50°38′35″N, 10°38′30″E (J. Müller, 23 Jun 2001; H370). **Hungary:** Balaton lake, Királyszentistván: N village periphery, grazing steppe on calcareous bedrock, abundant, 300 m a.s.l., 47°06′30″N, 18°02′58″E (P. Šmarda & T. Vymyslický, 24 Jun 2000; H126). – Budai hégy Hills, Nagykovácsi: Nagy-Szenás Hill on N village periphery, 500 m a.s.l., 47°35′59″N, 18°52′58″E (M. Valachovič, 29 May 2002; SAV). – Budai hégy Hills, Budaörs: NW village periphery, about 2 km N of the highway, top of deforested hill, limestone rock with *Seseli leucospermum* and *Aurinia saxatilis*, common, 290 m a.s.l., 47°27′49″N, 18°54′26.0″E (P. Šmarda, 3 Jun 2002; F326). – Budai hegy Hills, Nagykovácsi: N village periphery, S exp. calcareous rocky slopes with steppe vegetation (*Poo badensis-Festucetum pallentis*), common, 500 m a.s.l., 47°35′27″N, 18°52′50″E (P. Šmarda & T. Vymyslický, 23 Jun 2000; H119, H120). – Fejér county, Csór: limestone quarry in the village, abundant, 160 m a.s.l., 47°12′27″N,4 18°15′30.5″E (P. Šmarda, 3 Jun 2002; F327). – Fejér county, Vertés Hills, Csákberény: about 3 km W of the village, S exp. calcareous steppe slopes, common, 328 m a.s.l., 47°20′55.2″N, 18°17′57.6″E (P. Šmarda, 3 Jun 2002; F314). – Pilis Mts, Csobánka: E village periphery, W exp. limestone steppe slopes, common, 400 m a.s.l., 47°37′56″N, 18°58′18″E (P. Šmarda & T. Vymyslický, 22 Jun 2000; H85, H86). – Pilis Mts, Dobogókő: 1.7 km SW of the village centre, top of limestone promontory above the road, small colony, 600 m a.s.l., 47°42′28″N, 18°53′06″E (P. Šmarda & T. Vymyslický, 22 Jun 2000; H125). – Veszprém county, Sóly: 2.3 km W of the village, large steppe stands with *Seseli leucospermum*, shallow limestone bedrock, just afforested by pine, abundant, 198 m a.s.l., 47°07′44.6″N, 18°00′11.8″E (P. Šmarda, 2 Jun 2002; F318, F319, F320). – Veszprém county, Sóly: N village periphery, steppe grassland on shallow limestone bedrock, common, 176 m a.s.l., 47°07′44.6″N, 18°01′43.4″E (P. Šmarda, 2 Jun 2002; F321, F322). **Slovakia:** Kremnické vrchy Hills, Budča: Boky Nature Reserve, about 3.5 km W of the village, andesite rocks, 500 m a.s.l., 48°33′48″N, 19°01′28″E (J. Ripka, 2001–2002; H681, H682). – Malé Karpaty Hills, Devín: Devínský hrad castle ruin, fissures in dolomite rock, common, 230 m a.s.l., 48°10′41″N, 16°58′88″E (P. Šmarda & T. Vymyslický, 25 Jun 2000; H89). – Tríbeč Hills, Nitra: Kalvária Hill in the town centre, ±S exp. slopes above the former limestone quarries near a chapel, common, 165 m a.s.l., 48°17′45″N, 18°05′27″E (O. Rotreklová, 6 Sep 2002; F369). – Tríbeč Hills, Nitra-Zobor: Zoborská lesostep Nature Reserve, about 1 km WNW of Zobor Hill, above the Svoradova cave, steppe limestone rocky slopes, common, 400 m a.s.l., 48°20′57″N, 18°05′51″E (O. Rotreklová, 7 Sep 2002; F367, F368).

Festuca csikhegyensis* × *F. eggleri ($2n \approx 4x$): **Austria:** Steiermark, Pernegg: 1.05 km NE of the church in the village, serpentine outcrop near the forest track, scattered, 800 m a.s.l., 47°21′54″N, 15°21′35″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H49).

***Festuca dalmatica* (Hack.) K. Richt.** ($2n \approx 4x$): Hungary: Villányi hegység Hills, Szársomlyó: Nature Reserve above the village, S. exp. calcareous rocky slopes, common, 250 m a.s.l., 45°51′08.1″N, 18°24′15.2″E (P. Šmarda, 7 Jun 2002; F290, F291).

***Festuca duvalii* (St.-Yves) Stohr** ($2n \approx 4x$): **Germany:** Rheinland-Pfalz, Flonheim: S of the village, ENE of Aulheimermühlen, dry grassland on S exp. andesite slope, 180 m a.s.l., 49°46′58″N, 08°01′55″E (J. Müller et al., 17 Apr 1999; F158).

***Festuca eggleri* R. Tracey** ($2n \approx 2x$): **Austria:** Steiermark, Laufnitzdorf: Laufnitzbachgraben valley, 3.8 km NW of the church in the centre of the village, 4.3 km of the creek mouth, shaded granite rocks above the creek, larger colony, 559 m a.s.l., 47°18′54.3″N, 15°16′56.8″E (P. Šmarda, 12 Jun 2003; F505, F506). –

***Festuca eggleri* R. Tracey** ($2n \approx 4x$): **Austria:** Steiermark, Pernegg: 1.05 km NE of the church in the village, serpentine outcrop near the forest track, small colony, 800 m a.s.l., 47°21′54″N, 15°21′35″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H50).

***Festuca filiformis* Pourr.** ($2n \approx 2x$): **Italy:** Alpi Apuani Mts, Resceto: ca 1 km E of Passo Tambura saddle, along tourist road to Campocatino, above the marmor quarry, siliceous rocks with *Calluna vulgaris*, small colony, 1163 m a.s.l., 44°06′28.1″N, 10°14′54.9″E (P. Šmarda, 29 May 2003; F455). **Slovakia:** Kremnické vrchy Hills, Kremnica: Kremnický Štós Nature Reserve on SE town periphery, isolated

tufts, 800 m a.s.l., 48°41′35″N, 18°56′10″E (J. Ripka, 2001–2002; H702).

***Festuca glauca* Vill.** ($2n \approx 6x$): **France:** Pyrenées-Orientales Mts, Port Vendres surrounding: from the cultivation of R. Portal in Vals près le Puy, Haute Loire, ±100 m a.s.l., ±42°31′03″N, 03°04′43″E (R. Portal, 3 Jun 1999; H381).

***Festuca heterophylla* Lam.** ($2n \approx 4x$): **Czech Republic:** Příštpo: 2.9 km SE of the bridge over the Rokytná River in the village, slope above a streamlet, oak-hornbeam forest with linden, single tuft, 415 m a.s.l., 49°03′05″N, 15°57′38″E (P. Šmarda, 29 Jun 2001; F223).

***Festuca inops* De Not.** ($2n \approx 2x$): **Italy:** Alpi Apuani Mts, Massa province, Forno: 4.2 km E of the village, slope of limestone ridge, abundant, ±1000 m a.s.l., 44°05′47″N, 10°13′47″E (V. Grulich, Sep 2001; F207). – Alpi Apuani Mts, Resceto: about 1 km E of Passo Tambura saddle, along tourist road to Campocatino, above the marmor quarry, siliceous rocks, sparse, 1163 m a.s.l., 44°06′28.1″N, 10°14′54.9″E (P. Šmarda, 29 May 2003; F454). – Alpi Apuani Mts, Resceto: about 1 km from the village, along the Via Vandelli route, calcareous rocks, common, 614 m a.s.l., 44°05′44.4″N, 10°12′44.6″E (P. Šmarda, 29 May 2003; F460). – Monte Baldo Mts, Ferrara di Monte Baldo: about 4 km N of the village, open alpine grassland above the road, common, 1577 m a.s.l., 45°43′08.4″N, 10°51′19.1″E (P. Šmarda, 31 May 2003; F475). – Monti Pisani Mts, San Guliano di Terme: E village periphery, above the road to Lucca, SW exp. calcareous slope with mediterranean shrubs vegetation, scattered, 97 m a.s.l., 43°45′34.4″N, 10°27′00.1″E (P. Šmarda, 27 May 2003; F459). – ibid. NE village periphery, scattered, 125 m a.s.l., 43°45′52.5″N, 10°27′01.6″E (P. Šmarda, 27 May 2003; F482, F483). – Tuscany, Prato: N town periphery, about 3.5 km ENE of Montemurlo village centre, serpentine rocks, common, 212 m a.s.l., 43°55′28.9″N, 11°05′10.6″E (P. Šmarda, 26 May 2003; F476, F479, F480, F481). – ibid., ±3.6 km ENE of Montemurlo village centre, common, 236 m a.s.l., 43°55′35.0″N, 11°05′07.6″E (P. Šmarda, 26 May 2003; F486). – Valle d′Aosta, Gressan: moraine on a hill E of the village, dry grassland, 740 m a.s.l., ±45°43′04″N, 7°17′42″E (J. Müller, 31 May 1999; H389).

***Festuca laevigata* Gaudin** ($2n \approx 8x$) **Italy:** Cinque Terre National Park, Monterosso: about 1 km NW of the village centre, rocky slope, scattered, ±300 m a.s.l., 44°09′41.2″N, 09°38′37.4″E (P. Šmarda, 28 May 2003; F473).

***Festuca laxa* Host** ($2n \approx 4x$): **Slovenia:** Karavanken Mts, Loibel Pass (type locality): 700 m NE of the mouth of the road tunnel on Slovenian side, along forest track to Loibel Pass, fissure on crown of limestone wall on the road, scattered, 1183 m a.s.l., 46°26′06.3″N, 14°15′56.3″E (P. Šmarda, 18 Jun 2005; F748).

***Festuca lemanii* Bastard** ($2n \approx 6x$): **Germany:** Rheinland-Pfalz, Dieblich: Blumsley Hill, E of the village, upper SW exp. schistaceous slope, 200 m a.s.l., 50°18′39″N, 7°28′30″E (J. Müller, 24 May 2000; F173, F174). – Rheinland-Pfalz, Dorsheim: Eierfels Hill NE of the village, Permian conglomerate rock, 160 m a.s.l., 49°55′45″N, 7°52′22″E (J. Müller, 24 May 2000; F159).

***Festuca norica* (Hack.) K. Richt.** ($2n \approx 2x$): **Italy:** Monte Baldo Mts, Ferrara di Monte Baldo: about 4 km N of the village, open alpine grassland above the road, common, 1577 m a.s.l., 45°43′08.4″N, 10°51′19.1″E (P. Šmarda, 31 May 2003; F472).

Festuca ovina* L. subsp. *ovina ($2n \approx 2x$): **Czech Republic:** Kostelní Lhota (near Sadská): 1.5 km NW of the church in the village, W exp. grassy edge of pine forest on sand, abundant, 186 m a.s.l., 50°07′54″N, 15°00′42″E (P. Šmarda, 19 Jun 2000; H78). – Kozly (near Neratovice): 2.1 km ESE of the church in the village, near ″170.6″ elevation point, about 200 m from the road, sunny edge of pine-oak forest, acidic sands, small colony, 165 m a.s.l., 50°14′45.2″N, 14°35′06.6″E (P. Šmarda, 30 Jun 2002; F359).

***Festuca ovina* subsp. *guestfalica* (Rchb.) K. Richt.** ($2n \approx 4x$): **Czech Republic:** Chvalatice: Petrovy skály Nature Reserve, 2.0 km SW of the church in the village, SW exp. siliceous rocky slopes, thermophilous oak forest, scattered, 420 m a.s.l., 48°56′29″N, 15°46′20″E (P. Šmarda, 12 May 2002; H393, H394, H397, H398). – Blansko: 3.15 km ENE of the railway station, Punkevní údolí valley, S exp. siliceous rocky slope with open pine-oak forest, together with *Festuca pallens*, scattered, 410 m a.s.l., 49°21′42″N, 16°41′22″E (P. Šmarda, 27 Jul 2005; H1419, H1420). – Moravský Krumlov: Pod Floriánkem Nature Reserve, near ″312 m″ elevation point on Křepelčin vrch Hill, terrace on the upper edge of the NW exp. slopes of the canyon, shallow soil on conglomerate bedrock, small colony, 310 m a.s.l., 49°02′48″N, 16°19′17″E (P. Šmarda, 28 May 2000; H19, H20, H21, H23, H24, H25, H26, H27, H28, H30). – Plaveč: 1.7 km NW of the church in the village, left bank of Jevišovka river, opposite the mouth of Plenkovický potok brook, overgroven oak forest on siliseous rocks, common, 254 m a.s.l., 48°56′15.2″N, 16°03′45.9″E (P. Šmarda, 5 Oct 2004; F724, F725). – Tulešice: S village periphery, S edge of a quarry on the Rokytná river bank, SW exp. siliceous rocky steppe slope, scattered, 295 m a.s.l., 49°02′12.0″N, 16°12′11.5″E (P. Šmarda, 6 Sep 2003; F568). **Slovakia:** Borská lowland, Mikulášov: about 4 km SSE of the village, sand dunes dominated by *Calluna vulgaris*, 220 m a.s.l., 48°32′09″N, 17°13′42″E (M. Valachovič, 4 Jun 2002; SAV). – Borská lowland, Mikulášov: about 5 km SSE of the village, sand dunes above a sandpit, 200 m a.s.l., 48°32′07″N, 17°14′56″E (M. Valachovič, 6 Jul 2002; SAV). – Vtáčnik Hills, Kľak: Buchlov Hill 6 km NW of the church in the village, andesite rocks, 1000 m a.s.l., 48°36′00″N, 18°34′52″E (J. Ripka, 2001–2002; H674). – Záhorská lowland, Lozorno: sands in the village surrounding, 190 m a.s.l., 48°20′N, 17°03′E (J. Ripka, 2001–2002; H691). – Záhorská lowland, Studienka: 4 km E of the church in the village, fringe of pine forest on sands, abundant, 200 m a.s.l., 48°31′00.6″N, 17°10′59.1″E (P. Šmarda, 7 Jun 2003; F491 green plant, F492 glaucous plant).

***Festuca ovina* × *F. pallens* (*F.* ×*duernsteinensis* J. Vetter)** ($2n \approx 4x$): **Czech Republic:** Chvalatice: Petrovy skály Nature Reserve, 2.0 km SW of the church in the village, SW exp. siliceous rocky slopes, on contact zone of diploid *F. pallens* and tetraploid *F. ovina* subsp. *guestfalica*, rare, 420 m a.s.l., 48°56′29″N, 15°46′20″E (P. Šmarda, 12 May 2002; H396). – Tulešice: S village periphery, S edge of a quarry on the Rokytná river bank, SW exp. siliceous rocky slope, rare, 295 m a.s.l., 49°02′12.0″N, 16°12′11.5″E (P. Šmarda, 6 Sep 2003; F567).

***Festuca pallens* Host** ($2n \approx 2x$): **Austria:** Burgenland; Forchtenstein bei Mattesburg: 300 m NW of Forchtenstein castle, dolomitized limestone rocks, common, 580 m a.s.l., 47°42′43″N, 16°19′43″E (K. Kočí, May 2000; H94, H95). – Niederösterreich, Aggsbach-Dorf: 0.7 km S of the main crossroad, W exp. limestone rocks above the Donau river, abundant, 280 m a.s.l., 48°17′13″N, 15°24′28″E (K. Kočí, May 2000; H96). – Niederösterreich, Mödling: 0.5 km E of Ruine Burg Mödling ruin, N exp. edge of dolomite rocky

slope in autochtonous *Pinus nigra* forest, in places, 340 m a.s.l., 48°04′50″N, 16°16′33″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H51). – Niederösterreich, Schottwien: NW village periphery, gorge near the road, rocky slopes, abundant, 600 m a.s.l., 47°39′33″N, 15°52′14″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H110). – Steiermark, Mixnitz: Bärenschützklamm glen, 1.35 km NE of the central crossroads in the village, top of limestone promontory, small colony, 575 m a.s.l., 47°20′10.2″N, 15°22′47.4″E (P. Šmarda, 12 Jun 2003; F503, F504). – Steiermark, Weiz: Weizklamm glen, W exp. limestone rocky slopes, abundant, 600 m a.s.l., 47°16′23″N, 15°34′50″E (K. Kočí, May 2000; H93). – Steiermark, Weiz: N edge of Weizklamm glen, about 8 km NNW of the railway station in the village, foot of W exp. limestone cliffs above the road, larger colony, 663 m a.s.l., 47°16′38.7″N, 15°34′27.2″E (P. Šmarda, 12 Jun 2003; F512, F513). – Steiermark, Wörschach: Wolkenstein ruin, N village periphery, limestone rocks and ruin walls, common, 750 m a.s.l., 47°33′23.3″N, 14°09′05.9″E (P. Šmarda, 13 Jun 2003; F523, F524, F525). **Czech Republic:** Raškov u Hanušovic: Modřínový vrch Nature Reserve 1.2 km NW of the church in the village, S exp. serpentine rocks, abundant, 580 m a.s.l., 50°02′28″N, 16°53′15″E (P. Šmarda, 17 Jun 2000; H101, H102). – Chvalatice: Petrovy skály Nature Reserve, 2.0 km SW of the church in the village, SW exp. siliceous rocky slopes, rocky outcrops in thermophilous oak forest, common, 410 m a.s.l., 48°56′29″N, 15°46′20″E (P. Šmarda, 12 May 2002; H395). – Doudleby: right bank of Malše river, 1 km ENE of the village, gneiss rocks, abundant, 430 m a.s.l., 48°53′43″N, 14°30′30″E (V. Grulich, May 2001; F188). – Havraníky u Znojma: Havranické vřesoviště Nature Reserve, 1 km NW of the church in the village, small rocky outcrop on heath, in places, 330 m a.s.l., 48°48′49″N, 16°00′31″E (M. Kočí et al., 26 May 1999; H103). – Havraníky u Znojma: Nad Papírnou rocks above the Dyje river, 200 m W of ″400.6 m″ elevation point, siliceous rocky slopes, common, 300 m a.s.l., 48°49′31″N, 15°58′53″E (P. Šmarda, 27 May 1999; H2). – Mimoň: SW slope of Ralsko Hill, Julina viewpoint, sandstone terraces with shallow sandy substrate with *Artemisia campestris*, small colony, 400 m a.s.l., 50°40′09″N, 14°45′23″E (R. Řepka, 21 May 2002; F263). – Mohelno: Mohelenská hadcová step Nature Reserve, 900 m S of the church in the village, top of serpentine rocky slopes, common, 335 m a.s.l., 49°06′19.8″N, 16°11′23.3″E (P. Šmarda & T. Vymyslický, 10 Jun 2003; F501). – Oslavany: Oslavanské stará hora Hill, 0.5 km SW of the church in the town, shady siliceous rocks above the river, heath, small colony, 240 m a.s.l., 49°07′21.7″N, 16°19′28.2″E (P. Šmarda & T. Vymyslický, 10 Jun 2003; H933). – Plaveč: 1.7 km NW of the church in the village, left bank of Jevišovka river, opposite the mouth of Plenkovický potok brook, several dozens of plants, 254 m a.s.l., 48°56′15.2″N, 16°03′45.9″E (P. Šmarda, 5 Oct 2004; F727). – Rašovice: Rašovické skály Nature Reserve SSE of the village, upper edge of basalt rocky ridge, 500 m a.s.l., 50°21′55″N, 13°12′28″E (Č. Ondráček, 31 May 2001; H392). – Tulešice: S village periphery, S edge of a quarry on the Rokytná river bank, SW exp. siliceous rocky steppe slope, common, 295 m a.s.l., 49°02′12.0″N, 16°12′11″E (P. Šmarda, 6 Sep 2003; F566, F569, F570). – Újezd pod Troskami: Trosky castle ruin 2.3 km NW of the village, 480 m a.s.l., 50°30′58″N, 15°13′58″E (M. Horsák, 11 Jul 2000; H129). – Větrušice: N edge of Větrušická rokle Nature Reserve, 500 m E of Libčice nad Vltavou railway station, siliceous rocks overgrown by *Robinia pseudacacia*, common, 245 m a.s.l., 50°12′03″N, 14°22′16″E (P. Šmarda, 1 Jul 2002; F363, F364). – Větrušice: Větrušická rokle Nature Reserve, 700 m NNE of Libčice nad Vltavou-Letky railway station, clefts in enbankment wall made by schist and spilite stones, common, 175 m a.s.l., 50°11′38″N, 14°22′42″E (P. Šmarda, 1 Jul 2002; F362). **Germany:** Bayern, Kreis Amberg-Sulzbach, Weidlwang: N of the village, W exp. Jurassic limestone cliff, 450 m a.s.l., 49°43′56″N, 11°33′19″E (J. Müller, 13 Jun 2001; H373). – Bayern, Kleinziegenfeld: above the road in the village, limestone rocks, small colony (abundant in marble quarry near this locality), 430 m a.s.l., 50°01′23″N, 11°12′01″E (O. Rotreklová & P. Šmarda, 12 Jul 2000; H134). – Bayern, Sulzbach a. d. Donau: village periphery, S exp. siliceous rocks above the Danube river, abundant, 400 m a.s.l., 49°01′39″N, 12°14′44″E (O. Rotreklová & P. Šmarda, 11 Jul 2000; H133). – Rheinland-Pfalz, Schlossböckelheim: Heimberg Hill E of the village, rocky slope, 280 m a.s.l., 49°48′28″N, 7°43′43″E (J. Müller, 5 May 1990; H355). – Sachsen, Diesbar: upper SW slope of Heinrichsburg on the SE village periphery, granite rocky slope within former wineyard, 120 m a.s.l., 51°14′20″N, 13°25′15″E (J. Müller, 5 May 2001; H363). – Sachsen, Meissen: above a cliff on SE slope of Hoher Eifer Hill, SSW of the town, clear forest on porphyry bedrock containing mika, 160 m a.s.l., ±51°09′23″N, 13°27′27″E (J. Müller, 5 May 2001; H365). – Sachsen-Anhalt, Questenberg: upper W slope of Hoher Kopf Hill, N of the village, top of gypsaceous cliff, 280 m a.s.l., 51°30′38″N, 11°07′36″E (J. Müller, 14 Jun 1998; H351). – Sachsen-Anhalt, Thomaslehde: valley E of the village (N of Dittichenrode), gypsaceous rock, 240 m a.s.l., 51°29′04″N, 11°06′16″E (J. Müller, 31 May 1998; H352). – Thüringen, Fischersdorf: Gossitzfelsen rocks WSW of the village, foot of E exp. Permian conglomerate cliff, 260 m a.s.l., 50°36′58″N, 11°24′01″E (J. Müller, 24 May 2001; H367). – Thüringen, Göritz: S of the village, Lehestenwand elevation point, S exp. schistum cliff, 470 m a.s.l., 50°25′06″N, 11°47′36″E (J. Müller, 24 May 2001; H368). – Thüringen, Krölpa: SE of the village, SW exp. Permian limestone cliff, 300 m a.s.l., 50°40′22″N, 11°52′59″E (J. Müller, 24 May 2001; H369). – Thüringen, Leutersdorf: W foot of Anstein Hill N of the village, top of SW exp. Triassic limestone cliff, 380 m a.s.l., 50°31′20″N, 10°33′53″E (J. Müller, 23 Jun 2001; H371). – Thüringen, Schwarzburg: below the Schwarzburg castle, WSW exp. schistum cliff, 320 m a.s.l., 50°38′13″N, 11°11′37″E (J. Müller, 16 Jun 2001; H372). **Hungary:** Zala county, Gyenesdiás: Keszthelyi hegység Nature Reserve, top of the hill about 2 km NW of the village, calcareous rocks with *Seseli leucospermum*, *Fumana procumbens*, *Stipa* ssp., sparse, 160 m a.s.l., 46°46′12.8″N, 17°18′03.0″E (P. Šmarda, 8 Jun 2002; F335, F336, F337). **Slovakia:** Malá Fatra Mts, Kraľovany: 1.8 km WSW of the railway station, quarry above the road, S exp. limestone rocks, scattered, 500 m a.s.l., 49°08′59″N, 19°06′42″E (P. Šmarda, 29 Sep 2002; F375, F376). – Muránska planina Mts, Tisovec: Šarkanica Nature Reserve, 4.2 km NNE of the church in the village centre, upper edge of limestone cliff with *Festuca tatrae*, *Minuartia kitaibeliana*, *Primula auricula*, *Seseli osseum*, *Saxifraga paniculata*, larger colony, 1049 m a.s.l., 48°43′01.1″N, 19°57′51.2″E (P. Šmarda, 17 Jun 2003; F526). – Nízke Tatry Mts, Kráľova Lehota: 2.8 km ESE of the railway station, bend of Biely Váh river, calcareous rocky outcrop with pine forest, small colony, 670 m a.s.l., 49°01′13″N, 19°48′38″E (P. Šmarda, 6 May 2002; F251). – Slanské vrchy Hills, Hermanovce nad Topľou: Hermanovské skaly Nature Reserve 2.7 km SSW of the church in the village, andesite rocks,

600 m a.s.l., 48°57′54″N, 21°29′40″E (J. Ripka, 2001–2002; H683). – Štiavnické vrchy Hills, Lehotka pod Brehmi: Szabóova skala Nature Reserve on E village periphery, rhyolite rocks, 300 m a.s.l., 48°32′11″N, 18°48′23″E (J. Ripka, 2001–2002; H679). – Strážovské vrchy Hills, Zliechov: top of Strážov Hill, about 2 km W of village centre, S exp. limestone rocks, small colony, ±1200 m a.s.l., 48°57′14″N, 18°27′54″E (T. Vymyslický, Jun 2003; F529). – Veľká Fatra Mts, Rakša: Rakšianske rašelinisko peat bog, about 1 km E of the village centre, S slopes of a small dolomite quarry near a local way, larger colony, 560 m a.s.l., 48°52′39″N, 18°54′21″E (P. Šmarda, 29 Sep 2002; F378). – Vršatecké Podhradie: 250 m NE of Vršatec ruin, limestone rock by the road, common, 734 m a.s.l., 49°04′03.8″N, 18°09′10.4″E (P. Šmarda, Jun 2003; F528).

Festuca pallens **Host** ($2n \approx 3x$): **Czech Republic:** Plaveč: 1.7 km NW of the church in the village, left bank of Jevišovka river, opposite to the mouth of Plenkovický potok brook, overgrown siliceous rock, rare, 254 m a.s.l., 48°56′15.2″N, 16°03′45.9″E (P. Šmarda, 5 Oct 2004; F723).

Festuca pallens × ***F. pseudodalmatica*** (***F.*** ×***krizoviensis*** **Májovský**) ($2n \approx 3x$, $4x$): **Czech Republic:** Mohelno: Mohelenská hadcová step Nature Reserve, 0.9 km S of the church in the village, top of S exp. siliceous rocky slope, on the contact of the putative parental species, rare, 335 m a.s.l., 49°06′19.8″N, 16°11′23.3″E (P. Šmarda & T. Vymyslický, 10 Jun 2003; $2n \approx 3x$: F500; 2n≈4x: F499, H940).

Festuca pirinica **Markgr.-Dann.** ($2n \approx 2x$): **Bulgaria:** Pirin Mts, Vichren Mt.: 300 m S of the mountain top, marmor rocks in alpine zone, abundant, 2800 m a.s.l., 41°45′52″N, 23°23′59″E (D. Dvořák, 8 Aug 2005; F757).

Festuca polesica **Zapał.** ($2n \approx 2x$): **Estonia:** Lahenaa National Park, Loksa: N town periphery, sand dune near the coast, pine forest fringe, 10 m a.s.l., 59°35′25″N, 25°43′10″E (M. Dančák, 25 Jul 2003; F563, F564, F565).

Festuca psammophila subsp. ***dominii*** **(Krajina) P. Šmarda** ($2n \approx 2x$): **Slovakia:** Záhorská lowland, Mikulášov: 3.5 km S of the village centre, sand dunes by the asfalt road, larger colony, 220 m a.s.l., 48°32′35.3″N, 17°13′45.0″E (P. Šmarda & M. Valachovič, 7 Jun 2003; F493).

Festuca pseudodalmatica **Domin** ($2n \approx 4x$): **Austria:** Burgenland, Rumpersdorf : 0.95 km SSE of the church in the village, road bank, small colony, 380 m a.s.l., 47°18′29″N, 16°20′05″E (K. Kočí, May 2000; H92). **Czech Republic:** Mohelno: Mohelenská hadcová step Nature Reserve, 700 m SSW of the church in the village, serpentine, grassland along the footpath, abundant, 360 m a.s.l., 49°06′30″N, 16°11′17″E (P. Šmarda, K. Kočí & J. Müller, May 2001; F177). – Moravský Krumlov: Pod Foriánem Nature Reserve, W exp. slope near St. Florian chappel, edge of conglomerate rocky slope, trampled grassland, abundant, 310 m a.s.l., 49°02′53″N, 16°19′07″E (P. Šmarda, K. Kočí & J. Müller, May 2001; F176). – Moravský Krumlov: Pod Floriánkem Nature Reserve, near ″312 m″ elevation point on Křepelčin vrch Hill, terrace on the upper edge of the NW exp. slopes of the canyon, shallow soil on conglomerate bedrock, small colony, 310 m a.s.l., 49°02′48″N, 16°19′17″E (P. Šmarda, 28 May 2000; H31, H33). – Oslavany: 650 m NEE of the church in the town, left bank of the Oslava river, close to Dědičná šachta shaft; scree on a local slag heap, common, 241 m a. s. l., 49°07′37.4″N, 16°20′18.7″E (P. Šmarda & T. Vymyslický, 10 Jun 2003; H937). – Oslavany: 700 m NE of the church in the town, left bank of the Oslava river, rocky steppe slope above the river, common, 250 m a.s.l., 49°07′40″N, 16°20′21″E (T. Vymyslický, 25 Sep 1999; F1036). – Oslavany: 700 m E of the church in the town, left bank of the Oslava river; humose rock outcrop near the dirt road, shaded by trees, common, 235 m a. s. l., 49°07′24.7″N, 16°20′22.5″E (P. Šmarda & T. Vymyslický, 10 Jun 2003; H938, H939). – Oslavany: 700 m ENE of the church in the town, left bank of the Oslava River; rocky steppe on argillaceous and sandstone arkose, dominant, 240 m a. s. l., 49°07′33.4″N, 16°20′22.0″E (P. Šmarda & T. Vymyslický, 10 Jun 2003; F498, H931, H932). – Plaveč: 1.7 km NW of the church in the village, left bank of Jevišovka river, opposite the mouth of Plenkovický potok brook, overgrown siliceous rock, rare, m a.s.l., 48°56′15.2″N, 16°03′45.9″E (P. Šmarda, 5 Oct 2004; F726, F728). – Rokytná: Tábor Nature Reserve, 0.4 km SSE of the church in the village, W exp. conglomerate steppe slope, common, 250 m a.s.l., 49°03′43″N, 16°19′29″E (P. Šmarda, 5 Jun 2003; H719, H720). **Hungary:** Börszöny Hills, andesite rocks, ±400 m a.s.l., ±47°56′N, 18°56′E (J. Ripka, 2001–2002; H684, H685). – Börszöny Hills, Ipolytőlgyes: Bánya Hegy, andesite rocks, ±300 m a.s.l., 47°55′N, 18°48′E (J. Ripka, 2001–2002; H711). – Börszöny Hills, Perecsény: Drino, andesite rocks, ±300 m a.s.l., 47°59′N, 18°52′E (J. Ripka, 2001–2002; H715). – Bükk Mts, Szarvaskö: andesite rock, 330 m a.s.l., 47°59′25″N, 20°19′54″E (J. Ripka, 2001–2002; H687). – Fejér county, Csór: N village periphery, ruderal vegetation with with *Salvia aethiops*, *Xeranthemum annuum*, *Achillea nobilis*, *Potentilla recta*, stony shallow limestone bedrock, scattered, 200 m a.s.l., 47°12′25.0″N, 18°14′50.1″E (P. Šmarda, 3 Jun 2002; F323). – Heves county, Recsk: 1 km NW of the railway station near the village, distinct volcanic hill between the railway and the river, N exp. rocky slopes dominated by *Poa scabra*, abundant, 190 m a.s.l., 47°56′00.9″N, 20°05′54.0″E (P. Šmarda, 4 Jun 2002; F295). – Mátra Mts, Markaz: Cseres Hill about 1.2 km N of the village, andesite quarry, 265 m a.s.l., 47°50′32″N, 20°03′59″E (M. Valachovič, 30 May 2002; SAV). – Mecsek Hills, Cserkút: Nature Reserve on SW village periphery, steppe on andesite rocks, abundant, 250 m a.s.l., 46°04′17.1″N, 18°08′01.1″E (P. Šmarda, 8 Jun 2002; F331). – Mecsek Hills, Cserkút: Nature Reserve on SW village periphery, steppe on andesite rocks, common, 250 m a.s.l., 46°04′17.1″N, 18°08′01.1″E (P. Šmarda, 8 Jun 2002; F332). – Pilis Hills, Dobogókő: Ram-hegy Hill, 1.3 km N from town centre, calcareous rocks, 465 m a.s.l., 47°43′46″N, 18°53′31″E (M. Valachovič, 28 May 2002; SAV, three specimens). – Zemplényi hégy Hills, Füzer: Füzeri vár ruin, andesite rocks, 540 m a.s.l., 48°32′30″N, 21°27′35″E (M. Hájek, P. Hájková & J. Ripka, 15 May 2002; F252). – Zemplényi hégy Hills, Füzer: S slopes of Nagy Milic Hill on the Hungarian and Slovakian borders, andesite rocks, ±800 m a.s.l., 48°34′50″N, 21°28′03″E (M. Hájek, P. Hájková & J. Ripka, 16 May 2002; F253). **Slovakia:** Cerová vrchovina Hills, Blhovce: Steblová skala Nature Reserve, 3.8 km SSE of the church in the village, basalt rock, shaded by *Quercus cerris*, 400 m a.s.l., 48°14′44″N, 19°58′47″E (J. Ripka, 2001–2002; H699). – Kováčovské kopce Hills, Kováčov: above the railway station, S exp. andesite rocky steppe slope, scattered , 190 m a.s.l., 47°49′26.6″N, 18°46′38.8″E (P. Šmarda & J. Roleček, 22 May 2003; F445, F446, F447, F448, F449, F450). – Kováčovské kopce Hills, Kamenica nad Hronom: Kováčovské kopce-juh Nature Reserve, above the Hron and Danube rivers conflux (type locality), E village periphery 1.5 km ESE of the church, steppes and thermophilous oak forests on S exp. andesite rocks, very abundant, 174 m a.s.l., 47°49′33.7″N, 18°44′53.4″E (P. Šmarda & J. Roleček, 26 Jun 2004; F694). – Kováčovské kopce Hills, Kamenica nad Hronom: andesite rocks on the NE village

periphery, abundant, 200 m a.s.l., 47°49′32″N, 18°45′33″E (J. Ripka, 2001–2002; H688). – Krupinská planina Hills, Hontianske Nemce-Tepličky: 3.1 km SSE of Tepličky settlement, above the road, W exp. vertical andesite rocky slope, scattered tufts, 260 m a.s.l., 48°18′13″N, 18°58′30″E (J. Ripka & P. Šmarda, 22 May 2002; F258). – Krupinská planina Hills, Plášťovce: Šipka Nature Reserve, S exp. andesite rocky slope above the village, steppe grassland, dominant, 233 m a.s.l., 48°09′43″N, 18°59′01″E (P. Šmarda, 21 May 2002; F262). – Ostrôžky Hills, Budiná: Budinská skala rock, 3.5 km WNW of the church in the village, andesite rock, scattered, 800 m a.s.l., 48°27′50″N, 19°25′46″E (J. Ripka, 2001–2002; H689). – Slanské vrchy Hills, Slanec: Slanský hradný vrch Nature Reserve on NW village periphery, andesite rock, common, 500 m a.s.l., 48°38′16″N, 21°28′14″E (J. Ripka, 2002; F497, H700). – ibid., S exp. overgrown andesite rocks in the bottom part of the hill, common, 420 m a.s.l., 48°38′10.0″N, 21°28′15.4″E (P. Šmarda, 1 Jul 2004; F705). – Šarišská vrchovina Hills, Fintice: Fintické skaly Nature Reserve, 1 km NNE of the church in the village, andesite rocks, common, 550 m a.s.l., 49°03′30″N, 21°17′45″E (J. Ripka, 2001–2002; H678, H690). – Štiavnické vrchy Hills, Hronský Beňadik: andesite rocks on the S village periphery, 240 m a.s.l., 48°20′17″N, 18°33′30″E (J. Ripka, 2001–2002; H686). – Štiavnické vrchy Hills, Ilija: 0.7 km S of Sitno Hill, andesite rock hidden in forest, small colony, 860 m a.s.l., 48°23′57″N, 18°53′17″E (P. Šmarda, 23 May 2002; F261). – Štiavnické vrchy Hills, Ilija: 1.1 km SSW of Sitno Hill, relict forest free site on an isolated andesite rock, often with *Woodsia ilvensis*, dominant, 710 m a.s.l., 48°23′38″N, 18°52′21″E (P. Šmarda, 23 May 2002; F256, F257). – Štiavnické vrchy Hills, Ilija: 300 m SE of Sitno Hill, top of andesite rocks on S part of a wievpoint, surrounded by *Spiraea media*, 970 m a.s.l., 48°24′00″N, 18°52′43″E (P. Šmarda, 23 May 2002; F260). – Štiavnické vrchy Hills, Lehotka pod Brehmi: Szabóova skala Nature Reserve on E village periphery, rhyolite rocks, 300 m a.s.l., 48°32′11″N, 18°48′23″E (J. Ripka, 2001–2002; H680). – Štiavnické vrchy Hills, Tekovská Breznica: NW village periphery, above the road to Nová Baňa town, andesite/rhyolite rocks, 300 m a.s.l., 48°23′42″N, 18°36′50″E (J. Ripka, 5 Jun 2001; H706, H707). – Vtáčnik Hills, Topoľčianky: Včelár Nature Reserve, 6 km NE of the village, S exp. slope, dry steppe on andesite rocks, abundant, 390 m a.s.l., 48°27′01″N, 18°28′42″E (P. Šmarda, 24 May 2002; F255).

***Festuca pseudovina* Wiesb.** ($2n \approx 2x$): **Czech Republic:** Sedlec: Slanisko u Nesytu Nature Reserve, 150 m N of the railway station, halophilous grassland, scattered, 180 m a.s.l., 48°46′96″N, 16°42′04″E, (P. Šmarda, 25 May 2000; H68). **Hungary:** Hajdú-Bihar county, Cserepes: about 1.5 km along the road E of the village, halophilous sheep pasture, dominant, 90 m a.s.l., 47°41′08.3″N, 21°06′39.4″E (P. Šmarda, 5 Jun 2002; F293). – Hajdú-Bihar county, Görbeháza: 13 km SE of the village, near the main road, salt marsh with *Limonium gmelinii*, *Artemisia santonicum*, dominant, 80 m a.s.l., 47°44′18.4″N, 21°21′34.2″E (P. Šmarda, 10 May 2003; H767). – Hajdú-Bihar county, Görbeháza: 2.8 km SSE of the village, near a water canal, on the rural road near a poplar windbreak, five tufts, 87 m a.s.l., 47°48′19.1″N, 21°15′41.2″E (P. Šmarda, 10 May 2003; H769). – Hajdú-Bihar county, Hortobágyihalastó: by the road 4 km W of the village, salt marsh on sheep pastures (*Artemisio santonici-Festucetum pseudovinae*), dominant, 87 m a.s.l., 47°35′20.3″N, 21°01′50.4″E (P. Šmarda, 30 Jun 2004; F698). – Veszprém county, Zalahaláp: 3.7 km NNW of the village, nearby the road, dry grassland on shallow stony limestone pastures, in places, 200 m a.s.l., 46°56′15.4″N, 17°25′38.0″E (P. Šmarda, 9 Jun 2002; F333). **Slovakia:** Latorica protected landscape area, Čičárovce: about 2 km S of the village, Latorica river alluvium, alluvial meadow behind a dam, common, 110 m a.s.l., 48°31′10.7″N, 22°01′15.9″E (M. Hájek & P. Hájková, 15 May 2005; F734).

***Festuca quadriflora* Honck.** ($2n \approx 4x$): **Switzerland:** Nidwalden, Hergiswil: Pilatus Mt. W of the village, upper NW slope of Esel peak, limestone rock, 2060 m a.s.l., 46°58′53″N, 08°15′43″E (J. Müller, 24 Jul 2000; F163).

***Festuca rupicola* Heuff.** ($2n \approx 6x$): **Austria:** Steiermark, Kraubath an der Mur: Gulsenberg Hill, 2.85 km SSW of the church in the village, patches in pine forest on serpentine scree, on an anthill, sparse, 620 m a.s.l., 47°16′59″N, 14°55′45″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H111). **Czech Republic:** Bzenec: Vojenské cvičistě Bzenec Nature Reserve, 2.25 km SE of the railway station, grassland on sand, scattered, 195 m a.s.l., 48°57′31″N, 17°17′19″E (P. Šmarda, K. Kočí & J. Müller, May 2001; F178). – Mohelno: Mohelenská hadcová step Nature Reserve, 750 m SSW of the church in the village, S exp. serpentine rocks, abundant, 340 m a.s.l., 49°06′29″N, 16°11′14″E (P. Šmarda, K. Kočí & J. Müller, May 2001; F182). – ibid., 950 m SSW of the church, near the road, 350 m a.s.l., 49°06′20″N, 16°11′25″E (P. Šmarda, K. Kočí & J. Müller, May 2001; F180). – Oslavany: 650 m ENE of the church in the town, left bank of Oslava river near Dědičné šachty shaft, scree on local mullock tip, common, 241 m a.s.l., 49°07′37.4″N, 16°20′18.7″E (P. Šmarda & T. Vymyslický, 10 Jun 2003; H936). **Germany:** Bayern, Schwabelweis: Fellingerberg Nature Reserve N of the village, foot of S exp. limestone slope, scattered, 350 m a.s.l., 49°01′49″N, 12°09′28″E (O. Rotreklová & P. Šmarda, 11 Jul 2000; H135, H136). **Hungary:** Hajdú-Bihar county, Görbeháza: 13 km SE of the village, near the main road, salt marsh dominated by *Festuca pseudovina*, sparse, 80 m a.s.l., 47°44′18.4″N, 21°21′34.2″E (P. Šmarda, 10 May 2003; H768). – Pest county, Nagykőrös: 7 km NW of the town, sandy steppe patches in oak and poplar forests, most sun-exposed parts, abundant, 135 m a.s.l., 47°03′38.2″N, 19°41′51.1″E (P. Šmarda & J. Roleček, 30 Jun 2004; F697, H1396). **Poland:** Kielce region, Skorocice: Skorocicki wawóz Nature Reserve on NE village periphery, cloughs with steppe vegetation on gypsum (*Bromion*), abundant, 180 m, 9 Jun 2001, 180 m a.s.l., 50°24′20″N, 20°39′21″E (P. Šmarda, 9 Jun 2001; F200, H152). **Slovakia:** Cerová vrchovina Hills, Čakanovce: andesite bedrock, ±300 m a.s.l., 48°13′N, 19°50′E (J. Ripka, 2001–2002; H677). – Čenkov: Čenkovská step Nature Reserve, 500 m NW of the village centre, sandy steppe within pine forest dominated by *Festuca vaginata*, scattered, 110 m a.s.l., 47°46′05.3″N, 18°31′23.1″E (P. Šmarda & J. Roleček, 26 Jun 2004; F692, H1327). – Ostrôžky Hills, Ábelová: sheep pasture on andesite bedrock, 600 m a.s.l., 48°25′N, 19°26′E (J. Ripka, 2001–2002; H692, H704, H705). – Ostrôžky Hills, Budiná: Budinská skala rock, 3.5 km WNW of the church in the village, andesite rock, scattered, 800 m a.s.l., 48°27′50″N, 19°25′46″E (J. Ripka, 2001–2002; H717). – Streda nad Bodrogom: Tarbucka Nature Reserve, 3.3 km SSE of the railway station in the village, S exp. slopes, sandy steppe with *Dianthus serotinus*, very abundant, 169 m a.s.l., 48°22′20.2″N, 21°46′58.4″E (P. Šmarda & J. Roleček, 1 Jul 2004; H1380). – Štiavnické vrchy Hills, Dolná Strehová: 2.3 km SSE of the church in the village centre, Dedinská hora Nature Reserve, andesite rocks, in stand of *Poa scabra*, 190 m a.s.l., 48°14′06″N, 19°30′40″E (J. Ripka, 2001–2002; H676). – Štiavnické vrchy Hills, Kozárovce: andesite rocks

above the railway, 200 m a.s.l., 48°18′41″N, 18°32′22″E (J. Ripka, 2001–2002; H708). – Vtáčnik Hills, Podhradie pod Vtáčnikom: N village periphery, Sivý kameň Nature Reserve, andesite rocks, 600 m a.s.l., 48°41′15″N, 18°38′15″E (J. Ripka, 2001–2002; H694, H709, H710).

***Festuca rupicola* × *F. vaginata* (*F.* ×*interjecta* J. Vetter)** ($2n \approx 3x$, $4x$): **Slovakia:** Čenkov: Čenkovská step Nature Reserve, 500 m NW of the village centre, *Robinia pseudacacia* stand on the edge of sandy steppe dominated by *Festuca vaginata*, small colony, 110 m a.s.l., 47°46′05.3″N, 18°31′23.1″E (P. Šmarda & J. Roleček, 26 Jun 2004; $2n \approx 3x$: F693, H1337; $2n \approx 4x$: H1336).

***Festuca saxatilis* Schur** ($2n \approx 6x$): **Romania:** Sebeş Mts, Petroşani: bottom of Negru Hill, 6 km W of Şureanu peak, rocky steppe on ESE exp. calcareous slope, large colony, 1770 m a.s.l., 45°35′58″N, 23°24′55″E (P. Šmarda, 8 Aug 2001; F346, F347, H316, H619).

***Festuca stricta* subsp. *bauzanina* Pils** ($2n \approx 8x$): **Italy:** Monte Baldo Mts, Ferrara di Monte Baldo: about 3.5 km N of the village, alpine grassland on steep dolomite rocky slope, dominated by *Helictotrichon parlatorei*, small colony, 1635 m a.s.l., 45°42′59.5″N, 10°51′12.9″E (P. Šmarda, 31 May 2003; F466, F467, F468). – Trentino-Alto Adige, Merano: 4 km NNW of the town centre, 0.5 km W from the upper station of cable railway above the Tirol castle, alpine meadow dominated by *Avenella flexuosa* and *Calluna vulgaris*, siliceous substrate, abundant, 1500 m a.s.l., 46°41′56″N, 11°07′27″E (V. Grulich, Jul 2000; F1232, F1233, F1234).

***Festuca supina* Schur** ($2n \approx 4x$): **Romania:** Făgăraş Mts, Arpaşu de Sus: top of Moldoveanu peak, alpine grassland on siliceous bedrock, together with *Carex curvula* and *Juncus trifidus*, scattered, 2544 m a.s.l., 45°35′59″N, 24°44′11″E (P. Šmarda, 4 Aug 2002; F372). – Făgăraş Mts, Avrig: 2 km SW of Scara peak (about 19 km SSE of the railway station in the town), alpine grassland on siliceous rocks near a tarn, common, 2150–2200 m a.s.l., 45°34′26″N, 24°29′10″E (P. Šmarda, 2 Aug 2002; H614). – Făgăraş Mts, Breaza: main range, 12 km S of the village, near the tourist path between Leaota peak and curmatura Zirnei saddle, wind-exposed rocky plateau with open *Festuca supina* grassland, common, 1950 m a.s.l., 45°34′59″N, 24°56′08″E (P. Šmarda, 6 Aug 2002; H615, H617, H618). – Parâng Mts, Petroşani: main range, saddle S (above) Lacul Mândra tarn, 500 m ESE of Parângu Mare peak, grazed alpine grassland on siliceous rocks, abundant, 2350 m a.s.l., 45°20′18″N, 23°32′58″E (P. Šmarda, 5 Aug 2001; F353, H646). – Parâng Mts, Petroşani: main ridge, Cârja peak, 2.8 km NNW of Parângu Mare peak, alpine grassland on siliceous substrate, abundant, 2400 m a.s.l., 45°21′47″N, 23°31′15″E (P. Šmarda, 3 Aug 2001; H666, H667, H668). – Parâng Mts, Petroşani: main ridge, top of Parângu Mare peak, open alpine grassland on siliceous rocks, common, 2510 m a.s.l., 45°20′24″N, 23°32′25″E (P. Šmarda, 4 Aug 2001; H655, H658, H659, H668). – Parâng Mts, Petroşani: main ridge, top of Parângul Mic peak; 10.1 km ESE of the railway station in the town, alpine grassland on siliceous substrate, abundant, 2070 m a.s.l., 45°22′42″N, 23°30′49″E (P. Šmarda, 3 Aug 2001; H638, H639, H640). – Parâng Mts, Petroşani: rocks 200 m S of Lacul Câlcescu tarn, 5.7 km ENE of Parângu Mare peak, alpine grassland on siliceous rocks along a creek, scattered, 2000 m a.s.l., 45°21′05″N, 23°35′60″E (P. Šmarda, 5 Aug 2001; F349, H661, H663, H664). – Sebeş Mts, Petroşani: top of Varf lui Pâtru peak, dense grassland on siliceous substrate, dominant, 2100 m a.s.l., 45°32′60″N, 23°32′17″E (P. Šmarda, 8 Aug 2001; F350).

***Festuca tatrae* (Csakó) Degen** ($2n \approx 2x$): **Slovakia:** Muránska planina Mts, Muráň: about 6.5 km NNW from the village, Studňa hut surrounding, below the "1278.9 m" elevation point, SW edge of limestone promontory, together with *Melampyrum sylvaticum*, *Phyteuma orbiculare*, *Polygala brachyptera*, 1237 m a.s.l., 48°47′28″N, 20°00′17″E (M. Valachovič & J. Kliment, 13 Jul 2001; SAV). – Muránska planina Mts, Tisovec: Šarkanica Nature Reserve, 4.5 km NNE of the church in the village centre, NW edge of limestone cliff, small colony, 1085 m a.s.l., 48°43′19.9″N, 19°58′05.0″E (P. Šmarda, 17 Jun 2003; F527). – Veľká Fatra Mts, Blatnica: saddle between Ostrá Mt. and Tlstá Mt., calcareous rocks, common, 1100 m a.s.l., 48°55′32″N, 18°58′45″E (Kočí K. & Kočí M., 29 Oct 2000; H3).

***Festuca valesiaca* Gaudin** ($2n \approx 2x$): **Czech Republic:** Havraníky u Znojma: Havranické vřesoviště Nature Reserve, 600 m NW of the church in the village, dry grassland on siliceous bedrock, abundant, 325 m a.s.l., 48°48′57″N, 16°00′18″E (P. Šmarda, K. Kočí & J. Müller, May 2001; F184). – Praha-Sedlec: 1.1 km N of Praha-Sedlec railway station, foot of E exp. siliceous rocky slopes above the railway road, common, 184 m a.s.l., 50°11′57.0″N, 14°22′19.3″E (P. Šmarda, 5 Oct 2004; F730). – Větrušice: Větrušická rokle Nature Reserve, 550 m E of the Libčice nad Vltavou railway station, foot of SW exp. siliceous rocky slopes, common, 216 m a.s.l., 50°08′30.8″N, 14°23′44.3″E (P. Šmarda, 5 Oct 2004; F729). **Hungary:** Börzsöny hégy Hills, Márianosztra: 2 km SE of the village, thermophilous turkey oak forest on deeper soil on andesite, common, 299 m a.s.l., 47°51′32.5″N, 18°55′12.2″E (P. Šmarda & J. Roleček, 26 Jun 2004; F695). – Zala county, Becehegy: Keszthelyi hegység Nature Reserve, S exp. calcareous steppe slopes above the village, 270 m a.s.l., 46°47′36″N, 17°22′07″E (P. Šmarda, 2 Jun 2002; F338). **Poland:** Kielce region, Skorocice: Skorocicki wawóz Nature Reserve on NE village periphery, steppe vegetation on gypsum (*Bromion*), burnt the year before, abundant, 180 m a.s.l., 50°24′18″N, 20°39′20″E (P. Šmarda, 9 Jun 2001; F201). **Slovakia:** Cerová vrchovina Hills, Blhovce: Steblová skala Nature Reserve, 3.8 km SSE of the church in the village, dry grassland on basalt bedrock, shaded by *Quercus cerris*, 400 m a.s.l., 48°14′44″N, 19°58′47″E (J. Ripka, 2001–2002; H698). – Chotín: Chotínske piesky Nature Reserve, along the road on NW village periphery, overgrown sand dune, large colony, 115 m a.s.l., 47°48′42.9″N, 18°12′51.8″E (P. Šmarda & J. Roleček, 26 Jun 2004; H1324, H1325, H1326). – Ostrôžky Hills, Budiná: Budinská skala rock, 3.5 km WNW of the church in the village, andesite rock, below the bulky beech tree, andesite scree with *Gallium verum* and *Potentilla argentea*, 758 m a.s.l., 48°27′54″N, 19°25′46″E (M. Valachovič & J. Ripka, 28 May 2001; SAV). – Štiavnické vrchy Hills, Žibritov: 1.4 km ESE of the church in the village, orchard near the road, species-rich meadow on andesite, common, 460 m a.s.l., 48°23′12″N, 18°59′58″E (P. Šmarda, 22 May 2002; F259).

***Festuca versicolor* subsp. *pallidula* (Hack.) Markgr.-Dann.** ($2n \approx 2x$): **Austria:** Niederösterreich, Orthof (near Breitenstein): about 0.6 km S of the village, Kalte Rinne valley, rocks near the road, abundant, 900 m a.s.l., 47°39′28″N, 15°47′31″E (K. Kočí, P. Englmaier & P. Šmarda, 30 May 2000; H52).

Festuca versicolor* Tausch subsp. *versicolor ($2n \approx 2x$): **Czech Republic:** Krkonoše Mts, Pec pod Sněžkou: Obří důl cirque, porphyrite rocks called Čertova zahrádka, 1050 m a.s.l., 50°43′36″N, 15°43′29″E (V. Grulich, 4 Aug 2005; H1428). **Slovakia:** Strážovské vrchy Hills, Zliechov:

top of Strážov Hill, about 2 km W of village centre, S exp. limestone rocks, small colony, ±1200 m a.s.l., 48°57′06″N, 18°28′21″E (T. Vymyslický, Jun 2003; F530).

***Festuca violacea* subsp. *puccinellii* (Parl.) Foggi, Gr. Rossi et Signorini** ($2n \approx 2x$): **Italy:** Alpi Apuani Mts, Resceto: about 2.5 km from the village, along the Via Vandelli route, calcareous scree, common, ±1300 m a.s.l., 44°05′39″N, 10°13′55″E (P. Šmarda, 29 May 2003; F471).

***Festuca wagneri* (Degen, Thaisz et Flatt) Degen, Thaisz et Flatt in Degen** ($2n \approx 4x$): **Hungary:** Bács-Kiskun county, Kunpeszér: about 2 km NW of the village, along the asphalt road, base-rich sand steppe with *Alcana tinctoria*, *Koelreia macrantha* s.l., dominant, 115 m a.s.l., 47°05′29.7″N, 19°14′04.9″E (P. Šmarda, 6 Jun 2002; F294). – Pest county, Fót: N town periphery, sand steppe, 190 m a.s.l., 47°37′51″N, 19°12′05″E (M. Chytrý, 19 Oct 2001; F236). – Pest county, Szőt-Csörög: sandbank among gardens in the village, together with *Festuca vaginata*, dominant, 115 m a.s.l., 47°44′00.0″N, 19°11′01.3″E (P. Šmarda, 4 Jun 2002; F329, F330). **Slovakia:** Streda nad Bodrogom: Tarbucka Nature Reserve, 3.3 km SSE of the railway station in the village, S exp. slopes, sand steppe with *Dianthus serotinus*, ?rare, 169 m a.s.l., 48°22′20.2″N, 21°46′58.4″E (P. Šmarda & J. Roleček, 1 Jul 2004; F701).

***Festuca xanthina* Roem. et Schult.** ($2n \approx 2x$): **Bulgaria:** Stara Planina Mts, Jasenovo: moist rocks in calcareous valley beginning at NW village periphery, sparse, 524 m a.s.l., 42°41′40″N, 25°18′46″E (M. Hájek & P. Hájková, 2005; F753).