

## New sites of *Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zamels in Croatia

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*Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zamels (*Pulsatilla nigricans* Störck) is an endangered species that, according to data from the older botanical literature, grows in the sandy lowlands of north Croatia, where today it is no longer confirmed as existing. So far, it has been found only in two localities. The first is on the eastern foothills of Ravna Gora (northwestern Croatia) and the second is in southern Istria (northern Adriatic coast). In this paper, data about four new, as yet unpublished localities of the *P. pratensis* subsp. *nigricans* are presented, data about its distribution on Žumberak (NW Croatia), as well as pedological conditions in which it grows on Žumberak.

**Key words:** *Pulsatilla pratensis*. flora, distribution, Žumberak, Croatia

### Introduction

Žumberak is a mountainous region of the western part of Central Croatia in which Pannonian, Dinaric and pre-Alpine influences overlap. An average annual temperature of between 8 and 10 °C and an average annual amount of precipitation between 1100 and 1250 mm characterizes the Cfbwx climate according to Köppen's classification. In its geological structure dolomites are predominant, and limestones are much less in evidence. Carbonate skeletal rendzinas (Rendzic leptosols) of various depths have developed on the dolomite bedrock (MAJER and VRBEK 1995), while calcomelanosols (Mollic leptosols) and various kinds of calcocambisol (Calcaric cambisol) have developed on the limestone. These soils retain little moisture, and above them on Žumberak a thermophilous forest developed as well as xerophilous grass communities, in which *P. pratensis* subsp. *nigricans* has found its habitat.

The species *Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zamels (*Pulsatilla nigricans* Störck) (Fig. 1) is distributed in Central and Eastern Europe (TRINAJSTIĆ 1973, TUTIN 1993). It grows in sandy vegetation or on dry grasslands. Until recently (TRINAJSTIĆ 1973), it was considered an almost extinct species, for most of the older data mentioned by SCHLOSSER and VUKOTINOVIĆ (1869) and HIRC (1903–1912) have not been confirmed. An exception is the item about this species existing in the area of the Podravina

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Sands (sandy lowland area of north Croatia) (SOKLIĆ 1943), later confirmed by KRANIČEV (1984). Unfortunately, in this area, which was for a long time the only confirmed find in Croatia, *P. pratensis* subsp. *nigricans* gradually disappeared, for which reason it was put into the Red book of plant species of the Republic of Croatia (ŠUGAR 1994) and into *Flora Croatica: Index florum Croaticae* (NIKOLIĆ 1994) as an endangered species. However, it has been found in two new localities. One on the eastern slopes of Ravna Gora, the area of Vukovoj (north-western Croatia), and the other in southern Istria, near the settlement of Marčana (northern Adriatic coast) (KRANIČEV 1997).

*P. pratensis* subsp. *nigricans* was also noted during research into the flora of Žumberak. First findings date from 1989 but have not been published. However, herbarium specimens exist in the CNHM herbarium collection. After KRANIČEV (1997) published his new findings, more detailed investigations of the distribution on Žumberak and of soil conditions in which *P. pratensis* subsp. *nigricans* grows were undertaken.



**Fig. 1.** *Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zamels at Tomaševci (Žumberak, Croatia).

## Materials and Methods

The new localities in which *P. pratensis* subsp. *nigricans* was found were discovered during botanical field research in Žumberak. Several specimens were taken from each locality for the sake of identification. The usual keys to identification were used (DOMAC 1994, HORVATIĆ and TRINAJSTIĆ 1967–1981, TUTIN et al. 1993). The plants were prepared and deposited in the Herbarium of the Croatian Natural History Museum – CNHM, with the inventory numbers 637:BOB, 638:BOB, 639:BOB and 640:BOB. Distribution was determined according to the map of Žumberak – Gorjanci 1 : 50,000 and the UTM 1 : 500,000 map (10 × 10 km squares), and alongside the UTM square for each new locality are data about the habitat, its exposure and slope, altitude and the time of gathering and re-

new recording. Alongside each find a list of plants that are dominant in the surrounding vegetation is given, and for each species the indicator value of soil humidity (F) according to LANDOLT (1977) is given. The nomenclature of species was correlated with that in the *Flora Europaea* (TUTIN et al. 1964–1980, 1993).

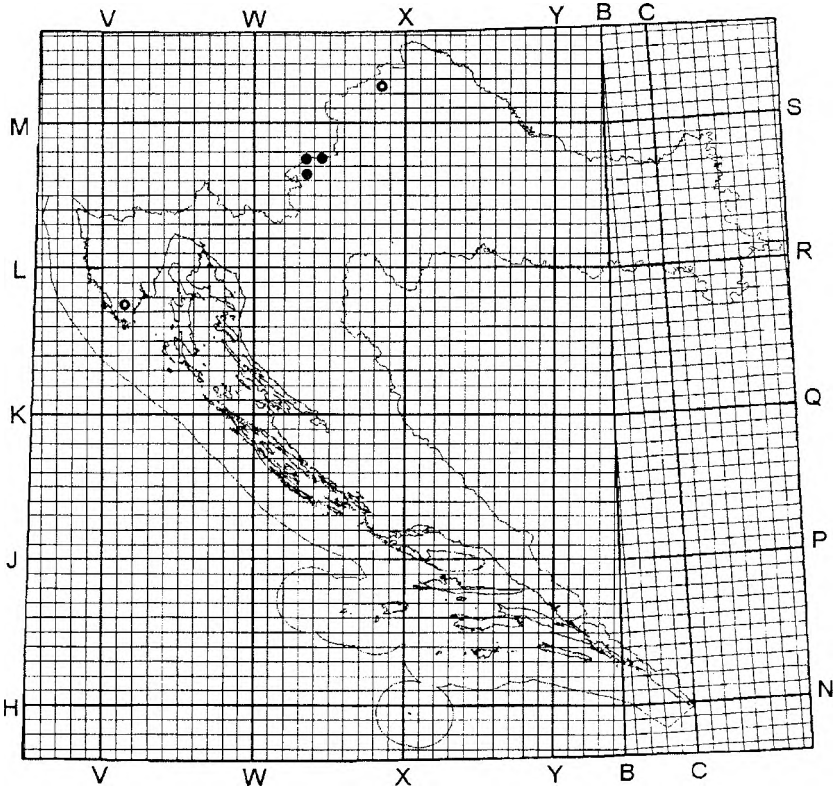
For the sake of determination of the soil and the gathering of samples for laboratory analysis, a soil profile was cut at each locality (Fig. 2). The mechanical composition of the soil in Na-pyrophosphate was determined, the carbonate contents, nutrients ( $P_2O_5$  and  $K_2O$  mg / 100 g of soil), the percentage of N and humus, and the reaction of the soil (in  $H_2O$  and n-KCl). The results of the analysis were interpreted according to ŠKORIĆ (1982) and compared with existing pedological data (MARTINOVIĆ et al. 1986) about the Podravina Sands (Đurđevac Sands), so as to determine any similarity in soil conditions there might be.



Fig. 2. Soil profile at Kumičevac (Žumberak, Croatia) – medium deep brownish calcomelanosol on a limestone.

## Results

During several years of systematic botanical research into Žumberak, the species *P. pratensis* subsp. *nigricans* was discovered at four localities previously unknown: Kičer, Kumičevac, Tomaševci and Osunja (Fig. 3). Numerous populations were shown in grassland vegetation, mainly on dry grassland areas of the class *Festuco-Brometea* Br.-Bl. et Tx. 1943.



**Fig. 3.** Localities of *Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zamels in Croatia (○ – previously known; ● – new localities)

**1. Kičer UTM WL 47, (MTB – 0159): meadow, S 28–32°, 660 m, 8 May 1995, 15 May 1997**

At this site, the plants were scattered in little groups or on their own over the whole southern slope of Kičer. They could be found in coppices as well, but mainly grow on meadows, above medium deep calcomelanosol on limestone (Molic leptosol), neutral reaction, very strong in humus, rich in nitrogen, averagely supplied with potassium, poorly with phosphorous, and containing 5.5% CaCO<sub>3</sub> (Tab. 5). The plants that dominate in the surrounding vegetation are shown in table 1.

**2. Kumičevac UTM WL 47, (MTB – 0159): meadow, S 25°, 740 m, 12 April 1989, 15 May 1997**

Individual specimens and smallish groups of *P. pratensis* subsp. *nigricans* are scattered over the southern slopes of Kumičevac. The soil is a medium deep brownish calcomelanosol on limestone (Molic leptosol), with a very acid reaction; it is rich in humus and in nitrogen, but poorly furnished with phosphorus and potassium, and contains no CaCO<sub>3</sub> at all (Tab. 5). The plants that dominate in the surrounding vegetation are shown in table 2.

**Tab. 1.** List of predominant plants among which *P. pratensis* subsp. *nigricans* grows on Kičer and their humidity indicator values according to LANDOLT (1977)

SPECIES	F	SPECIES	F
<i>Anthericum ramosum</i> L.	2	<i>Hieracium proaealtum</i> Vill. Ex Gochnat	2
<i>Anthoxanthum odoratum</i> L.	3	subsp. <i>bauhinii</i> (Besser) Petunn.	
<i>Anthyllis vulneraria</i> L.	1	<i>Hippocrepis comosa</i> L.	2
<i>Asperula cynanchica</i> L.	1	<i>Hypochoeris maculata</i> L.	2
<i>Briza media</i> L.	2	<i>Hypochoeris radicata</i> L.	3
<i>Bromus erectus</i> Huds.	2	<i>Knautia arvensis</i> (L.)Coulter	2
<i>Buphthalmum salicifolium</i> L.	2	<i>Koeleria pyramidata</i> (Lam.)P. Beauv.	2
<i>Campanula patula</i> L.	3	* <i>Laser trilobum</i> (L.)Borkh.	2
<i>Carex caryophyllea</i> Latour.	2	<i>Laserpitium siler</i> L.	2
<i>Carlina acaulis</i> L.	2	* <i>Leucanthemum vulgare</i> Lam.	3
<i>Centaurea scabiosa</i> L.	2	<i>Limodorum abortivum</i> (L.)Sw.	2
<i>Cirsium pannonicum</i> (L.f.)Link	2	* <i>Linum viscosum</i> L.	2
<i>Cruciata glabra</i> (L.)Ehrend.	3	<i>Lotus corniculatus</i> aggr.	2
<i>Cynosurus cristatus</i> L.	3	<i>Orchis militaris</i> L.	2
<i>Dianthus giganteus</i> D'Urv. subsp. <i>croaticus</i> (Borbás)Tutin	3	<i>Orchis tridentata</i> Scop.	3
* <i>Erysimum carnalicum</i> Dolliner	1	<i>Plantago lanceolata</i> L.	2
<i>Euphorbia cyparissias</i> L.	2	<i>Plantago media</i> L.	2
<i>Festuca rubra</i> L.	3	<i>Polygala comosa</i> Schkuhr	1
<i>Filipendula vulgaris</i> Moench	2	<i>Quercus cerris</i> L.	2
<i>Galium verum</i> L.	2	<i>Ranunculus bulbosus</i> L.	2
<i>Globularia punctata</i> Lapeyr.	1	<i>Rhinanthus minor</i> L.	3
<i>Gymnadenia conopsea</i> (L.)R.Br.	3	<i>Salvia pratensis</i> L.	2
<i>Helianthemum nummularium</i> (L.)Mill.	1	<i>Sanguisorba minor</i> Scop.	2
subsp. <i>obscurum</i> (Čelak.) Holub		<i>Scabiosa columbaria</i> aggr.	2
<i>Hieracium pilosella</i> L.	2	<i>Trifolium montanum</i> L.	2
		<i>Trifolium pratense</i> L.	3
		<i>Veronica austriaca</i> aggr.	1

F – Humidity indicator value – indicates the average humidity of the soil during the vegetation period.

F 1 – Plants of a very dry soil, F 2 – plants of a mainly dry soil, F 3 – plants of mainly medium dry to damp soils.

### 3. Tomaševci UTM WL 36, (MTB – 0258): meadow, S 26°, 600 m, 27 April 1989, 7 April 1991, 6 June 1995, 25 May 1997, 7 May 1999

At this site, very close to a village, and intersected by a forest road, the most numerous, and most beautiful, populations of *P. pratensis* subsp. *nigricans* were noted. From April to May, the meadow, some 50 × 100 m in area, is carpeted with the black-violet flowers and the shaggy heads of the woolly and hairy fruits (Fig. 4). Here the species grows on a very humus-rich, relatively shallow rendzina on a dolomite bedrock (Rendzic leptosol), giving a mild alkaline reaction, and very rich in nitrogen, well supplied with potassium but poorly with phosphorus, and containing 21.99% of CaCO<sub>3</sub> (Tab. 5). That plants that dominate in the surrounding vegetation are shown in table 3.

### 4. Osunja UTM WL 37, (MTB 0158): meadow, W 25°, 630 m, 12 April 1989, 15 May 1997.

At this site about a hundred individual specimens were noted on a meadow with hazel bushes, juniper and turkey oak. The soil it grows on is rich in humus, a shallow rendzina on

**Tab. 2.** List of predominant plants among which *P. pratensis* subsp. *nigricans* grows on Kumičevac and their humidity indicator values according to LANDOLT (1977)

SPECIES	F	SPECIES	F
<i>Antennaria dioica</i> (L.) Gaertn.	2	<i>Helianthemum nummularium</i> (L.) Mill. subsp. <i>obscurum</i> (Čelok.) Holub	1
<i>Anthyllis vulneraria</i> L.	1	<i>Hieracium pilosella</i> L.	2
<i>Asperula cynanchica</i> L.	1	<i>Hieracium proaetium</i> Vill. ex Gochnat subsp. <i>bauginii</i> (Besser) Petunn.	2
<i>Briza media</i> L.	2	<i>Hippocrepis comosa</i> L.	2
<i>Bromus erectus</i> Huds.	2	<i>Hypochoeris maculata</i> L.	2
<i>Buphthalmum salicifolium</i> L.	2	<i>Knautia drymeia</i> Heuff.	3
<i>Carex caryophyllea</i> Latourr.	2	<i>Koeleria pyramidata</i> (Lam.) P. Beauv.	2
<i>Carex flacca</i> Schreb.	3	<i>Linum catharticum</i> L.	3
<i>Centaurea jacea</i> L.	3	<i>Lotus corniculatus</i> aggr.	2
<i>Centaurea scabiosa</i> L.	2	<i>Luzula campestris</i> (L.) DC.	3
<i>Chamaecytisus hirsutus</i> aggr.	2	<i>Nardus stricta</i> L.	3
<i>Cirsium acule</i> Scop.	2	<i>Orchis morio</i> L.	2
<i>Crataegus monogyna</i> Jacq.	3	<i>Dactylofiza sambucina</i> (L.) Soa	2
<i>Cruciata glabra</i> (L.) Ehrend.	3	<i>Plantago media</i> L.	2
<i>Dianthus giganteus</i> D'Urv. subsp. <i>croaticus</i> (Borbás) Tutin	3	<i>Potentilla erecta</i> (L.) Rauschel	3
<i>Euphorbia brittingeri</i> Opiz ex Samp.	2	<i>Prunella laciniata</i> (L.) L.	2
<i>Euphorbia cyparissias</i> L.	2	<i>Salvia pratensis</i> L.	2
<i>Festuca tenuifolia</i> Sibth.	2	<i>Teucrium chamaedrys</i> L.	1
<i>Galium verum</i> aggr.	2	<i>Trifolium montanum</i> L.	2
<i>Genista germanica</i> L.	2		

**Tab. 3.** List of predominant plants among which *P. pratensis* subsp. *nigricans* grows on Tomaševci and their humidity indicator values according to LANDOLT (1977)

SPECIES	F	SPECIES	F
<i>Anthericum ramosum</i> L.	2	<i>Geranium sanguineum</i> L.	2
<i>Anthyllis vulneraria</i> L.	1	<i>Globularia punctata</i> Lapeyr.	1
<i>Arabis hirsuta</i> (L.) Scop.	2	<i>Gymnadenia conopsea</i> (L.) R. Br.	3
<i>Arrhenatherum elatius</i> (L.) P. Beauv. ex J. Presl et C. Presl	3	<i>Helianthemum nummularium</i> (L.) Mill. subsp. <i>obscurum</i> (Čelok.) Holub	1
<i>Asperula cynanchica</i> L.	1	<i>Hieracium proaetium</i> Vill. ex Gochnat subsp. <i>bauginii</i> (Besser) Petunn.	2
<i>Brachypodium pinnatum</i> (L.) P. Beauv.	2	<i>Hippocrepis comosa</i> L.	2
<i>Briza media</i> L.	2	<i>Koeleria pyramidata</i> (Lam.) P. Beauv.	2
<i>Bromus erectus</i> Huds.	2	<i>Linum catharticum</i> L.	3
<i>Buphthalmum salicifolium</i> L.	2	<i>Lotus corniculatus</i> aggr.	2
<i>Campanula persicifolia</i> L.	2	<i>Plantago lanceolata</i> L.	2
<i>Centaurea jacea</i> L.	3	<i>Plantago media</i> L.	2
<i>Clematis recta</i> L.	2	<i>Polygala comosa</i> Schkuhr	1
<i>Cruciata glabra</i> (L.) Ehrend.	3	<i>Ranunculus bulbosus</i> L.	2
<i>Dactylis glomerata</i> L.	3	<i>Rhinanthus minor</i> L.	3
<i>Dianthus giganteus</i> D'Urv. subsp. <i>croaticus</i> (Borbás) Tutin	3	<i>Salvia pratensis</i> L.	2
<i>Dorycnium pentaphyllum</i> Scop. subsp. <i>germanicum</i> (Gremli) Gams	1	<i>Sanguisorba minor</i> Scop.	2
* <i>Erysimum carnolicum</i> Dolliner	1	<i>Scabiosa columbaria</i> aggr.	2
<i>Euphorbia brittingeri</i> Opiz ex Samp.	2	<i>Sedum sexangulare</i> L.	2
<i>Euphorbia cyparissias</i> L.	2	<i>Stachys recta</i> L.	1
<i>Festuca rubra</i> L.	3	<i>Teucrium chamaedrys</i> L.	1
<i>Filipendula vulgaris</i> Moench	2	<i>Thymus pulegioides</i> L.	2
<i>Genista germanica</i> L.	2	<i>Trifolium montanum</i> L.	2
		<i>Veronica austriaca</i> aggr.	1

Tab. 4. List of predominant plants among which *P. pratensis* subsp. *nigricans* grows on Osunja and their humidity indicator values according to LANDOLT (1977)

SPECIES	F	SPECIES	F
<i>Anthriscanthum odoratum</i> L.	3	<i>Knautia arvensis</i> (L.)Coulter	2
* <i>Bromus pannonicus</i> Kumm. et Sendtn.	2	<i>Koeleria eriostachya</i> Pančić	1
<i>Buchthalmum salicifolium</i> L.	2	* <i>Lasier trilobum</i> (L.)Borkh.	2
<i>Carex flacca</i> Schreb.	3	<i>Limodorum abortivum</i> (L.)Sw.	2
<i>Cirsium acaule</i> Scop.	2	<i>Linum catharticum</i> L.	3
<i>Corylus avellana</i> L.	3	<i>Lotus corniculatus</i> aggr.	2
<i>Cruciata glabra</i> (L.)Ehrend.	3	<i>Medicago lupulina</i> L.	2
<i>Dactylis glomerata</i> L.	3	<i>Plantago lanceolata</i> L.	2
<i>Dianthus giganteus</i> D'Urv. subsp. <i>croaticus</i> (Borbás)Tutin	3	<i>Plantago media</i> L.	2
<i>Epimedium alpinum</i> L.	3	<i>Polygala comosa</i> Schkuhr	1
<i>Euphorbia brittingeri</i> Opiz ex Samp.	2	<i>Polygonatum odoratum</i> (Mill.)Druce	2
<i>Festuca tenuifolia</i> Sibth.	2	<i>Primula vulgaris</i> Huds.	3
<i>Filipendula vulgaris</i> Moench	2	<i>Quercus cerris</i> L.	2
<i>Galium moluga</i> aggr.	3	<i>Ranunculus bulbosus</i> L.	2
<i>Geranium sanguineum</i> L.	2	<i>Rhinanthus minor</i> L.	3
<i>Helianthemum nummularium</i> (L.)Mill.	1	<i>Rumex acetosa</i> L.	3
subsp. <i>obscurum</i> (Celak.) Holub		<i>Scabiosa columbaria</i> aggr.	2
<i>Hieracium praecaltum</i> Vill. ex Gachnot	2	<i>Silene vulgaris</i> (Moench.)Garcke	2
subsp. <i>bauhini</i> (Besser)Petunn.		<i>Tanacetum corymbosum</i> (L.)Sch.Bip.	2
<i>Hippocrepis comosa</i> L.	2	<i>Thesium linophyllum</i> L.	1
<i>Juniperus communis</i> L.	2	<i>Trifolium montanum</i> L.	2
		<i>Trifolium pratense</i> L.	3

(See explanation on Tab. 1)

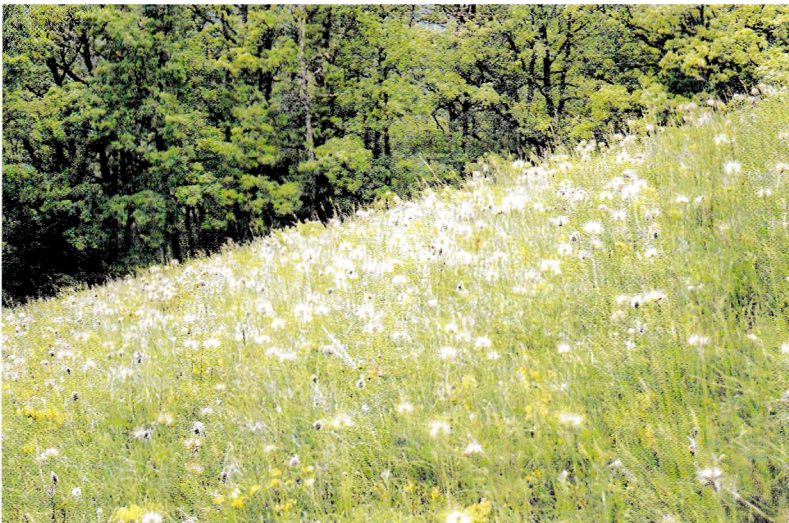


Fig. 4. The meadow at Tomaševci (Žumberak, Croatia) – the most numerous population of *Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zamels on Žumberak.

a dolomite substrate (Rendzic leptosol), with a weak alkaline reaction, very rich in nitrogen, but poorly supplied with phosphorous and potassium, containing 63.02% CaCO<sub>3</sub> (Tab. 5). The plants shown on table 4 dominated the surrounding vegetation.

**Tab. 5.** The results of soil chemistry analysis of samples from the finding sites on Žumberak, compared with existing data for the soil of the Podravina (Đurđevac) Sands.

Locality	Soil type	Depth (cm)		pH		CaCO <sub>3</sub> (%)	Nutrients mg / 100 g soil			Humus (%)	Texture categ. (mech. compos.)
		soil	sample	H <sub>2</sub> O	n-KCl		P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N (%)		
Kičer	Calcomela nosol on a limestone	45	2–25	7.6	7.0	5.50	1.0	14.8	0.81	15.93	Heavy clay
Osunja	Rendzina on a dolomite	15	2–10	7.9	7.4	63.02	5.0	7.5	0.85	13.56	Fine sandy loam
Tomaševci	Rendzina on a dolomite	22	2–10	7.7	7.3	21.99	1.4	23.0	1.00	18.05	Light clay
Kumičevac	Calcomela nosol on a limestone (brownish)	44	3–17	5.6	4.5	–	0.3	8.8	0.29	7.6	Light clay
			28–40	6.7	5.8	–	0.6	15.1	0.11	2.06	Heavy clay
Đurđevac sands	Aeolian sands (arenosol)	90	0–5	4.7	4.4	–	3.3	3.2	0.02	0.30	Loamy fine sand
			20–40	5.1	4.3	–	2.8	1.6	–	0.74	Loamy coarse sand

### Discussion

Although *P. pratensis* subsp. *nigricans* was successfully transplanted into the Botanical Garden of the Forestry Faculty of Zagreb (TRINAJSTIĆ 1994), and the older botanical data show that the plant was more widely distributed, it was considered that in nature it grew mainly in sandy vegetation, simply because for a long time the only known locality was in the area of the Podravina Sands (north Croatia). It was only the data given by KRANJČEV (1997) that proved that *P. pratensis* subsp. *nigricans* grows successfully in other habitats in Croatia, which was also confirmed by new finds from Žumberak.

Laboratory analyses of the soil samples from the four new sites have shown that *P. pratensis* subsp. *nigricans* grows here on two types of soil, rendzinas on dolomite (Rendzic leptosols), and calcomelanosol on limestone (Molic leptosol) (Tab. 5). It is interesting that these soils are highly differentiated in terms of CaCO<sub>3</sub> content, there being no CaCO<sub>3</sub> at all in the Kumičevac soil, while at Osunja the soil has 63.02%. There are also big differences with respect to potassium content and acidity, so that while in Tomaševci and Osunja the soils have a mildly alkaline reaction, on Kičer it is neutral, in Kumičevac the reaction is very acidic. In terms of mechanical characteristics, the soils also vary, from fine sandy loam, through light clay to heavy clay. The common features are a high proportion of humus and a large percentage of nitrogen. The soil in the Đurđevac Sands, which are aeolian sands (Arenosols) (MARTINOVIĆ 2000) is about 40–90 cm deep, with a pronounced acidic reaction, poorly furnished with phosphorus and potassium, poor in nitrogen and only very slightly humus-rich. In mechanical composition, the upper layer is composed of loamy fine sand, the lower of loamy coarse sand (Tab. 5).



Considering the characteristics of the soils on which *P. pratensis* subsp. *nigricans* successfully grows on Žumberak, it might well be concluded that it is tolerant of acidity, CaCO<sub>3</sub> content, potassium and phosphorus, but that it likes a highly humus-rich soil that is also abundantly supplied with nitrogen. However, the fact that large populations of this plant once grew in the area of the Đurđevac Sands, where the soil conditions are quite different, with little humus and nitrogen, suggests the conclusion that these conditions also are not crucial for *P. pratensis* subsp. *nigricans* to grow.

From everything that has been stated, it has to be concluded that *P. pratensis* subsp. *nigricans* is a plant of wider ecological valence than it was considered earlier, and thus it is very hard to say what factor is decisive for its growth. However, one can say that all the soils are very permeable and have little total moisture. This is confirmed by the soil humidity indicator values of plants, from which it is clear that for all four localities the dominant value is F 2, which indicates plants of dry soils. Since the soil of the Đurđevac Sands where a very extensive population of *P. pratensis* subsp. *nigricans* once grew is similar to the soils of the Žumberak region where the plant also grows only in respect of permeability and low total humidity content, the only thing to be concluded is that it thrives in loose, airy soils that have little humidity content.

The new findings, and the results of the analysis of the soils on which *P. pratensis* subsp. *nigricans* grows on Žumberak inevitably lead to the assumption that this plant could be much more widely distributed in Croatia.

### Acknowledgments

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