Chromosome numbers of *Carex*

Chromozomové počty druhů rodu *Carex*

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Chromosome numbers were determined for 97 samples of 95 sedge taxa (*Carex*) from the following countries: Austria (6 records), Bulgaria (1), the Canary Islands (Spain, 1), Cape Verde (1), the Czech Republic (51), Hungary (1), Italy (2), Norway (8), Russia (15), Slovakia (1), Sweden (1) and 9 North American plants cultivated in Czech botanical gardens. Chromosome numbers for *Carex argunensis*, *C. callitrichos*, *C. campylorhina*, *C. flavocuspis* subsp. *krascheninnikovii*, *C. paniculata* subsp. *hansenii*, *C. pallida*, *C. quadriflora* and *C. xiphium* are reported here for the first time. The first reports are presented for the European portion of the distribution area of *Carex obtusata* and for the Central European portion of the distributional areas of *C. chordorrhiza, C. otrubae, C. rhizina* and *C. strigosa*. New counts for the Czech Republic fill the gaps in the karyological data for this genus in relation to the Flora project in the Czech Republic.

K e y w o r d s: agmatoploidy, holocentric chromosome, holokinetic chromosome, karyology, polyploidy, symploidy, sedge

Introduction

Cyperaceae is a family with a worldwide distribution and a high species diversity in the Northern Hemisphere, consisting of 121 genera and approximately 5000 species (Bruhl 1995). The genus *Carex*, which includes almost 2000 species, is one of the largest angiosperm genera (Reznicek 1990). The species diversity in this genus is greatest at high latitudes and altitudes in the Northern Hemisphere, where sedges are dominant in many types of vegetation. Sedges are absent in tropical lowlands, except for a few species that are present in southeast Asia and sub-Saharan Africa (Ball & Reznicek 2002). Sedges occur in a wide range of humid to dry habitats (including flooded wetlands, tundra, alpine grasslands, rocky mountain habitats, coniferous woods, mixed or deciduous forests, steppes, meadows, pastures and salt marshes) and have a rather weak affinity with human-made habitats (Egorova 1999, Ball & Reznicek 2002, Waterway et al. 2009). Such ecological diversity is not randomly dispersed across the subgenus *Carex* but is congruent with the phylogeny; a higher frequency of flood-tolerant species is present in the more evolved clades, and shade-tolerant species are clustered in various lineages of the whole genus (Waterway et al. 2009).

The family *Cyperaceae* (order *Poales*) is characterized by holokinetic or holocentric chromosomes that lack a primary constriction (centromere) and have a kinetochore that is localized diffusely along the entire length of the chromatids (Luceño & Guerra 1996). The holokinetic nature of the chromosomes has evolved independently in different phylogenetic lineages of angiosperms. In addition to *Cyperaceae* (where it was first recognized by Heilborn 1924), it occurs in *Juncaceae* (*Poales*), *Chionographis* (*Melanthiaceae*, *Liliales*; Tanaka & Tanaka 1977), *Drosera* (*Droseraceae*, *Caryophyllales*; Sheikh et al. 1995), *Cuscuta* (*Convolvulaceae*, *Solanales*; Pazy & Plitmann 1994) and *Myristica* (*Myristicaceae*, *Magnoliales*; Flach 1966). In most genera with holokinetic chromosomes, an inverted (post-reductional) meiosis is typical (Battaglia & Boyes 1955). In *Cyperaceae*, this process is futher combined with a very rare pseudomonad type of microsporogenesis in which three of the tetrad nuclei (originating from the pollen mother cell) are aborted and only one remains viable and divides into the generative and vegetative nuclei of a pollen grain. Pseudomonad microsporogenesis was first recognized by Juel (1900) in *Carex* and subsequently confirmed in various genera of *Cyperaceae* (but not in the tribe *Hypolytreae*; Strandhede 1973, Furness & Rudall 1999, Hipp et al. 2009).

Two specific mechanisms are responsible for the changes in chromosome number that are usually associated with the holokinetic nature of chromosomes: (i) agmatoploidy, i.e. chromosomal fissions or fragmentations, and (ii) symploidy, i.e. chromosomal fusions without a substantial loss or duplication of genes (Luceño & Guerra 1996). Such variations in the number of holokinetic chromosomes could be further combined with other mechanisms of karyotype evolution, particularly with polyploidy, and sometimes result in contrasting patterns in the variations in chromosome numbers even in closely related families. This phenomenon can be demonstrated by comparing *Cyperaceae* with the genus *Luzula* from the sister family *Juncaceae*, in which the variation in the number of chromosomes is discrete, whereas in the *Cyperaceae* it is almost continuous (Kirschner 1992, Roalson 2008). In the genus *Luzula* it is likely that agmatoploidy operates at the diploid level and agmatoploid chromosome sets are then carried to higher ploidy levels via allopolyploidy (Kirschner 1992). On the other hand, in the genus *Juncus*, the variation in chromosome numbers seems to be almost continuous, as observed in *Cyperaceae* (Goldblatt & Johnson 1979–2003). Consequently, the identification of basic chromosome numbers and recent polyploidy events could be more difficult to recognize in *Cyperaceae* than in *Juncaceae* or in taxa with monocentric chromosomes.

The chromosome number in *Carex* varies almost continually from n = 6 in *C. siderosticta* (Tanaka 1940) to n = 62 in *C. roraimensis* (Hipp et al. 2007). Compared to polyploidy or quantitative aneuploidy, agmatoploidy or symploidy (qualitative aneuploidy; see Luceño & Guerra 1996) are not associated with substantial changes in the nuclear DNA content (Kuta et al. 2004). In contrast to most of the angiosperm genera that exhibit positive correlations between the holoploid genome size (C-value *sensu* Greilhuber et al. 2005) and the ploidy level, the opposite relationship is found in *Carex* (Nishikawa et al. 1984). Considering the almost continual variation in chromosome numbers and the absence of a positive correlation between the DNA content and the chromosome number, a dominant role for agmatoploidy or symploidy relative to polyploidy in karyotype evolution in *Carex* could be expected. Whereas polyploidy is frequent in some other genera of *Cyperaceae* (e.g. *Rhynchospora*: Luceño et al. 1998, Vanzela et al. 2000; *Eleocharis*: Bureš 1998, Da Silva et al. 2008), in *Carex*, it has been confirmed only in *Carex siderosticta*, *C. dolichostachya*, *C. parciflora* and *C. roraimensis* (Hipp et al. 2009).

In order to answer the crucial question regarding karyotype evolution in *Carex*, research based on a combination of flow cytometric measurements of DNA content and quantification of the retroelements in relation to the chromosome number in particular species of *Carex* was initiated. Together with the continuous variation in chromosome numbers in the genus as a whole, considerable intraspecific variation is also observed in many species of *Carex* (Stoeva 1987, Luceño & Castroviejo 1991, 1993, Stoeva & Popova 1991, Hoshino & Waterway 1994, Naczi et al. 1998, Ohkawa et al. 2000, Stoeva et al. 2005). Therefore, the inevitable first step in this research was to identify the chromosome numbers in most of the samples studied, which is the main aim of the present study.

In *Carex*, most of the chromosome counts are for European, Eastern Asian and North American species. However, for 75% of the species in this genus there are no chromosome numbers recorded (cf. Roalson 2008). As in other angiosperms, the chromosome numbers are best known for European species because there are regional chromosomal checklists for many countries (e.g. Löve & Löve 1974, Dobeš & Vitek 2000, Marhold et al. 2007). In the Czech Republic, the chromosome numbers of only a few *Cyperaceae* taxa have been determined (Měsíček & Jarolímová 1992, Jarolímová & Hroudová 1998, Krahulcová 2003, Bureš et al. 2004, Rotreklová et al. 2004). In *Carex*, which comprises 84 taxa that are native to this country (Grulich & Řepka 2002), only the chromosome numbers of eight species have been determined (Stoeva & Štěpánková 1990, Měsíček & Jarolímová 1992, Štěpánková 2008). To fill this gap, the chromosome numbers of most native species in the Czech Republic were analysed.

Materials and methods

Samples, including a portion of the rhizome, were collected in the field from 2006 to 2008. The soil was removed and cuttings temporarily cultivated in pure water in a cultivation room at room temperature and a 16-h day/8-h night regime. Tips of the fresh roots were used to determine the chromosome counts. The tips were pretreated at room temperature in a saturated water solution of p-dichlorobenzene for two hours and then fixed in a cold mixture of ethanol and acetic acid (3 : 1) for 24 hours. The fixed material was processed immediately. The root tips were macerated at room temperature in a mixture of ethanol and hydrochloric acid (1 : 1) for 2 min. Temporary slides were made by squashing the cut and stained meristems in lacto-propionic orcein. If the number of chromosomes agreed with that recorded, invariable count in a particular species, then only one metaphase was examined. In all other cases, at least two metaphases were studied.

Voucher specimens of all of the plants were deposited in the herbarium at the Department of Botany and Zoology of Masaryk University, Brno (BRNU). All of the samples were determined by R. Řepka and the species collected in Russia by A. E. Kozhevnikov (Institute of Biology and Soil Science of the Russian Academy of Science, Vladivostok, Russia).

The records of chromosome numbers published before 2000 were adopted if included in the review written by Roalson (2008). In controversial cases, the original articles were consulted and discussed for particular taxa. The distributional information is that cited by Meusel et al. (1965), Hultén & Fries (1986), Egorova (1999) and Ball & Reznicek (2002). The nomenclature and infrageneric classification follow Egorova (1999) for Eurasian species and Ball & Reznicek (2002) for North American species.

Results

Carex acuta, 2n = 82 (Fig. 1A)

Czech Republic, distr. Žďár nad Sázavou, Hluboká: meadow between village and Řeka pond, alt. 601 m, 49°40'03.3" N, 15°51'15.1" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex acuta is a Eurasian species that occurs in temperate and arctic zones. Counts, including 2n = ca 74 and 2n = 82–86 are published for many European countries (Lövkvist & Hultgård 1999, Stoeva et al. 2005, Roalson 2008), and among them, the 2n = 84 cytotype seems to be the most frequent. Moreover, Roalson (2008) ascribed a chromosome count of 2n = 48 to Dalgaard (1991), but no cytotype of *C. acuta* is reported in that paper. Juel (1900) cites a single, different chromosome count: 2n = 104.

Carex adelostoma see *C. buxbaumii* complex

Carex alba, 2n = 54

Austria, Upper Austria, Hinterstoder: Krumme Steir valley, alt. 636 m, 47°41'48" N, 14°06'10" E, coll. A. Vydrová & V. Grulich 17 Jun 2006.

Carex alba is distributed in European dolomitic and limestone mountains, in the subarctic European part of Russia and the Caucasus Mts. In addition, it occurs sparsely in the Far East of Russia. Roalson (2008) reports for Slovakia, Slovenia and Poland the same chromosome count as was recorded in this study.

Carex aquatilis, 2n = 74 (Fig. 1B)

Norway, distr. Tynset, Stormyra: Østerdalen valley, E bank of the Glomma River, alt. 480 m, 62°14'48.0" N, 10°40'01.6" E, coll. P. Hájková, M. Hájek & D. Dítě 19 Aug 2006.

Carex aquatilis is a widely distributed, circumpolar wetland species that is divided into several subspecies or varieties. Chromosome counts of 2n = 74, 2n = 76 and 2n = 84 (single record for Germany, Dietrich 1972) are published for Europe and NE Asia (Roalson 2008). Karyological variations ranging from 2n = 72 to 2n = 84 have been detected in North American plants (Cayouette & Morisset 1986b). The distribution of *C. aquatilis* cytotypes does not display a clear geographical pattern, and the 2n = 76 cytotype prevails throughout the distribution range (Cayouette & Morisset 1986b, Roalson 2008). In addition, Roalson reports a number of 2n = 44, which was first published by Krogulevich (1976) for the Far East of Russia, but this chromosome count is not cited by later authors (e.g., by Egorova 1999).

Carex argunensis, 2n = 42 (Fig. 1C)

Russia, Republic of Buryatiya, distr. Barguzin, Usť-Barguzin: sandy dunes at Baikal Lake, alt. 490 m, 53°23'52" N, 108°59'43" E, coll. T. Koutecký 13 Aug 2008.

Carex argunensis is distributed from E Siberia and Mongolia to the Far East of Russia and NE China. This is the first chromosome count for this species.

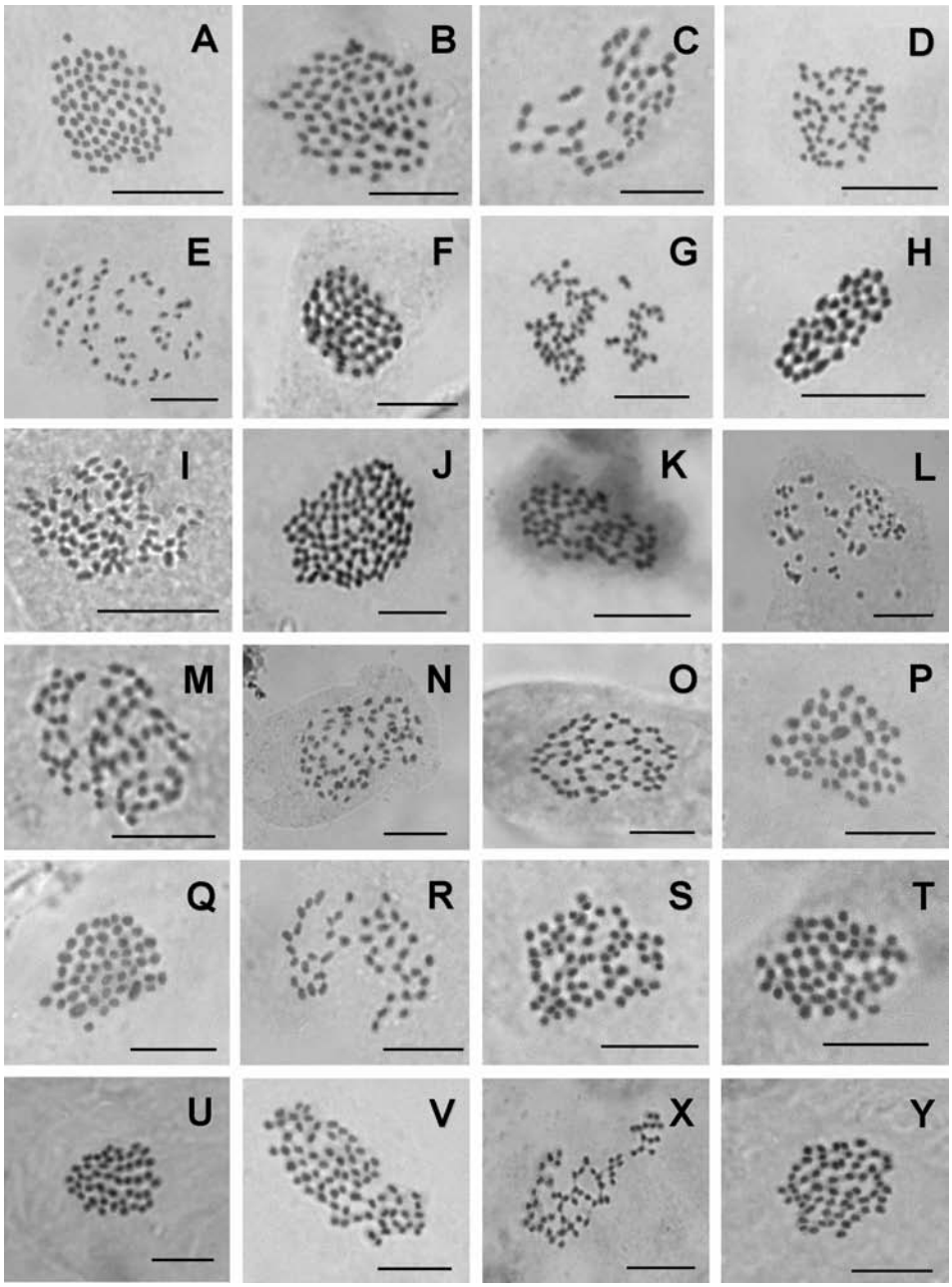

Fig. 1. – Microphotographs of somatic metaphases of twenty-four sedge species. I. **A.** *Carex acuta*, 2n = 82. **B.** *C. aquatilis*, 2n = 74. **C.** *C. argunensis*, 2n = 42 (first record). **D.** *C. aterrima*, 2n = 52. **E.** *C. atrata*, 2n = 54. **F.** *C. aurea*, 2n = 52. **G.** *C. bigelowii* subsp. *rigidoides*, 2n = 70. **H.** *C. blanda*, 2n = 36. **I.** *C. bohemica*, 2n = 80. **J.** *C. adelostoma*, 2n = 106. **K.** *C. campylorhina*, 2n = 58 (first record). **L.** *C. canariensis*, 2n = 58. **M.** *C. caryophyllea*, 2n = 62. **N.** *C. cespitosa*, 2n = 72. **O.** *C. cristatella*, 2n = 64, **P.** *C. davalliana*, female plant, 2n = 46. **Q.** *C. davalliana*, male plant, 2n = 46. **R.** *C. depauperata*, 2n = 44. **S.** *C. diandra*, 2n = 60. **T.** *C. digitata*, 2n = 48. **U.** *C. quadriflora*, 2n = 46 (first record). **V.** *C. distans*, 2n = 70. **X.** *C. disticha*, 2n = 60. **Y.** *C. echinata*, 2n = 58. Scale bars = 10 μm.

Carex atrata complex (*C. aterrima*, *C. atrata*)

Carex aterrima, 2n = 52 (Fig. 1D)

Russia, Republic of Buryatiya, distr. Barguzin, Usť-Barguzin: Pik Markova Mt., alt. 1820 m, 53°38'32" N, 108°49'44" E, coll. T. Koutecký 12 Aug 2008.

Carex aterrima is a mountain species that is widely distributed from C and S Europe to C Asia. Roalson (2008) reports a number of 2n = 54 for Slovakia and E Siberia.

Carex atrata, 2n = 54 (Fig. 1E)

Austria, Carinthia, Hohe Tauern Mts, Goldberg Gruppe, Fraganter Hütte: Ofenspitze Mt., alt. 1973 m, 46°57'02" N, 13°00'52" E; coll. V. Grulich 4 Jul 2006.

Carex atrata occurs in Scandinavia and the European mountains, and has been recorded in W Siberia, Iceland and Greenland. The most common chromosome count for this taxon is 2n = 54, but rare records of 2n = 52 and 2n = 56 are reported by Roalson (2008). Cytotype variations from 2n = 48 to 2n = 52 are recorded for the Altai Mts (Sokolovskaya & Strelkova 1948). Surprisingly low numbers ranging from 2n = 18 (prevailing) to 2n = 26 (rare) are recorded in Slovakia (Hadač & Hašková 1956). Unfortunately, during the preparation of the Slovak karyological checklist, no voucher specimens of this sample were found (Marhold et al. 2007).

Carex aurea, 2n = 52 (Fig. 1F)

Plants of unknown origin cultivated in the Botanical Garden & Arboretum, Mendel University, Brno, Czech Republic, coll. M. Nohelová & P. Bureš 9 Aug 2007.

Carex aurea is a widely distributed North American species that is found in wet meadows. Roalson (2008) reports the same chromosome number for this taxon as was recorded in this study.

Carex bigelowii complex (*C. bigelowii* subsp. *dacica*, *C. bigelowii* subsp. *rigidioides*)

Carex bigelowii subsp. *dacica* (syn. *C. bigelowii* subsp. *rigida*), 2n = 68

Czech Republic, Králický Sněžník Mt.: E of the summit, alt. 1421 m, 50°12'27" N, 16°50'55" E, coll. D. Dvořák 16 Jul 2006.

Carex bigelowii subsp. *dacica* is a central European subspecies that occurs in mountainous to subalpine zones of the E Alps, Harz Mts, Sudetes Mts and Carpathians. The most common chromosome number reported for *C. bigelowii* is 2n = 70 (Roalson 2008), but cytotype variations are recorded in the UK (2n = 68–70) and the cytotype 2n = 71 in Ireland (Faulkner 1972, cit. sec. Brooker et al. 2001).

Carex bigelowii subsp. *rigidioides*, 2n = 70 (Fig. 1G)

Russia, Primorskii Krai, distr. Chuguevsk, Oblachnaya Mt.: mountain pass 0.45 km SSW of the summit, alt. 1700 m, 43°41'28" N, 134°11'53" E, coll. T. Koutecký 14 Jul 2008.

The *Carex bigelowii* subsp. *rigidioides* is an E Asian subspecies that occurs in the Far East of Russia, on Sakhalin Island and in Mongolia. Although there is a single record of 2n = 62 for this species from the Far East of Russia (Zhukova et al. 1973), similarities in the chromosome numbers of the subsp. *dacica* and subsp. *rigidoides* have been independently confirmed based on the similarity of their DNA contents (I. Hralová et al. unpublished).

Carex blanda, 2n = 36 (Fig. 1H)

Plants of unknown origin cultivated in the Botanical Garden & Arboretum, Mendel University, Brno, Czech Republic, coll. M. Nohelová & P. Bureš 9 Aug 2007.

Carex blanda is a wetland species that occurs in the eastern part of North America. Roalson (2008) reports the following chromosome numbers for this taxon: 2n = 34, 2n = 36, 2n = 38 and 2n = 40. However, Naczi (1999) suggests that the two cytotypes with the greatest number of chromosomes are incorrect. He notes that the cytotype 2n = 38, which is cited by Löve & Löve (1981) for Manitoba, must be based on a different taxon because *C. blanda* is not present in this state, and the two cytotypes investigated by Wahl (1940; 2n = 38 and 2n = 40) are either for hybrids of *C. blanda* with other species or misidentified samples of *C. gracilensis*.

Carex bohemica, 2n = 80 (Fig. 1I)

Czech Republic, distr. Rožnov pod Radhoštěm, Horní Bečva: exposed bottom of water reservoir ESE of the village, alt. 570 m, 49°25'21" N, 18°18'59" E, coll. P. Šmarda 26 Jun 2006.

Carex bohemica is a Eurasian species that is distributed disjunctively in regions with suboceanic to subcontinental climates. A cytotype of 2n = 80 is recorded for Germany and Slovenia (Roalson 2008). Cytotypes of 2n = ca 60 and 2n = 62–64 are reported for the Far East of Russia (Probatova & Sokolovskaya 1981, Kozhevnikov et al. 1986, Chepinoga et al. 2009).

Carex brizoides complex (*C. brizoides*, *C. curvata*)

Carex brizoides, 2n = 58

Czech Republic, distr. Žďár nad Sázavou, Cikháj: forest track to Žákova hora Mt., N of the village, alt. 711 m, 49°39'31.4" N, 15°58'43.3" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex brizoides is a European species that occurs in areas with suboceanic climates (separately in the European part of Russia). Roalson (2008) reports the same chromosome numbers for this taxon for Germany, Slovenia and Poland.

Carex curvata, 2n = 58

Czech Republic, distr. Hodonín, Dolní Bojanovice: Hodonínská dúbrava 3.7 km ENE of the church in the village, alt. 173 m, 48°51'49" N, 17°04'42" E, coll. R. Řepka & P. Bureš 25 Jul 2006.

Carex curvata is a central European species that is closely related to *C. brizoides* and occurs on sandy soils with fluctuating water regimes. Roalson (2008) reports the same chromosome number as was found in this study.

Carex brunnescens, 2n = 56

Norway, distr. Røros, Nature Reserve Sølendet: near the car park, alt. 756 m, 62°41' N, 11°50' E, coll. P. Hájková, M. Hájek & D. Dítě 18 Aug 2006.

Carex brunnescens is a circumpolar species that is distributed from boreal to arctic climatic zones and is divided into several subspecies. The most common chromosome number in this taxon is 2n = 56 (Roalson 2008), and a chromosome number of 2n = 54 is recorded once for the Queen Charlotte Islands in W Canada (Taylor & Mulligan 1968). The low chromosome numbers of 2n = ca 44 (Krogulevich 1971) and 2n = 50–52 (Kozhevnikov et

al. 1986) recorded in Russia are not recorded for the other taxa in section *Canescentes* to which *C. brunnescens* belongs (Roalson 2008).

Carex buxbaumii complex (*C. buxbaumii*, *C. adelostoma*)

Carex buxbaumii, 2n = 100

Czech Republic, distr. Hodonín, Dolní Bojanovice: Hodonínská dúbrava 3.7 km ENE of the church in the village, alt. 173 m, 48°51'49" N, 17°04'42" E, coll. R. Řepka & P. Bureš 25 Jul 2006.

Carex buxbaumii is a circumpolar wetland species that occurs most abundantly in areas of Eurasia and North America with suboceanic and boreal climates (separately in Greenland, N Africa, the Caucasus Mts and the C Asian Mts). Cytotypes of 2n = 100, 2n = 105±1 and 2n = 106 are reported by Roalson (2008) for this taxon in Canada and NW Europe. The record of 2n = 74 that is cited by Heilborn (1924) is doubtful because a similar chromosome number is not recorded for the section *Microrhynchae* to which this taxon belongs (see Roalson 2008).

Carex adelostoma, 2n = 106 (Fig. 1J)

Norway, Dovrefjell Mts, Nature Reserve Haukskardmyrin: between the villages Dombås and Hjerkinn, alt. 1025 m, 62°08'51.9" N, 9°22'24" E, coll. P. Hájková & M. Hájek 22 Aug 2006.

Carex adelostoma is a species with a disjunct, almost circumpolar distribution extending from the boreal to subarctic zones. Roalson (2008) reports the same chromosome counts for this taxon for NW Europe and Canada.

Carex callitrichos see *C. humilis* complex

Carex campylorhina, 2n = 58 (Fig. 1K)

Russia, Primorskii krai, distr. Chuguevsk, Yasnoe: middle part of valley, 6.5 km WSW of the Oblachnaya Mt., alt. 720 m, 43°41'04" N, 134°07'11" E, coll. T. Koutecký 15 Jul 2008.

Carex campylorhina is an E Asian species. This is the first chromosome count for this species. *C. campylorhina* belongs to the section *Depauperatae,* for which there is a similar chromosome number of 2n = 56 for *C. xiphium* (see below). Moreover, both taxa have the same DNA content (I. Hralová et al., unpublished).

Carex canariensis, 2n = 58 (Fig. 1L)

Canary Islands, Tenerife Island, Anaga Mts, Chinobre Mt.: at the road to the Chamorga village, alt. 800 m, 28°33'28.5" N, 16°10'36.4" W, coll. P. Šmarda & B. Kučerová 24 Apr 2007.

This taxon is endemic to the Canary Islands. The same chromosome number is reported for Gran Canaria Island (Dalgaard 1991) and Tenerife Island (Luceño 1994a).

Carex canescens, 2n = 56

Russia, Kamchatka Peninsula, Elizovo: road to the Polovinka River, 2.9 km WNW of the bus station in the town, alt. 67 m, 53°11'31" N, 158°20'45" E, coll. T. Koutecký 3 Aug 2008.

Carex canescens is a Eurasian species that is distributed from temperate to arctic zones (in mountainous areas only in the Mediterranean region and the Southern hemisphere). This study confirmed the most frequent chromosome number reported for various regions of

the species distribution by Roalson (2008). Other chromosome counts are published for the Chukotka Peninsula (2n = 62, Zhukova & Petrovskii 1975) and the Far East of Russia (2n = 52–54 and 2n = 56–58, Kozhevnikov et al. 1986). Toivonen (1980) notes that an earlier report of 2n = 54 (Wahl 1940) is a consequence of inaccurate chromosome counting. The chromosome count of n = 36 reported by Roalson (2008) as cited in an article published by Toivonen (1980) is for a irregular meiosis in the pollen of a hybrid plant of which *C. canescens* was one of the parents.

Carex caryophyllea, 2n = 62 (Fig. 1M)

Czech Republic, distr. Slavkov u Brna, Rašovice: 0.8 km W of the church in he village, alt. 246 m, 49°07'20" N, 16°56'33" E, coll. Z. Lososová & O. Rotreklová 31 May 2006.

Carex caryophyllea is a Eurasian species that occurs in dry grassland and open woodland and whose eastern distribution limit is in W Siberia (introduced into North America). The large variation in chromosome numbers include 2n = 62, 2n = 64 and a range from 2n = 66–69, as reported by Roalson (2008), whereas there is no evident geographical pattern in the distribution of particular cytotypes. Roalson reports chromosome numbers of n = 66–69 based on Stoeva & Popova (1990) who counted chromosomes in root tip tissues and therefore documented the somatic (2n) number.

Carex cespitosa, 2n = 72 (Fig. 1N)

Czech Republic, distr. Žďár nad Sázavou, Radostín: Nature Reserve Padrtiny, S of the village, alt. 625 m, 49°38'35.5" N, 15°52'22.4" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex cespitosa is a Eurasian species. Chromosome numbers ranging from 2n = 68 to 2n = 80 are reported by Roalson (2008). Cytotypes of 2n = 78, 2n = 79 and 2n = 80 are published for N and C Europe (Heilborn 1922, 1924, Tischler 1934, Faulkner 1972) and Bulgaria (Stoeva et al. 2005). Our results are consistent with the records for Austria (Dobeš et al. 1997, 2n = 68–74).

Carex chordorrhiza, 2n = 62

Czech Republic, distr. Telč, Jihlávka: Nature Reserve Kaliště 1.3 km SSE of the village, alt. 653 m, 49°15'01" N, 15°17'47" E, coll. V. Grulich 21 Aug 2006.

Carex chordorrhiza is a circumpolar species that is abundant in boreal and arctic climatic zones with isolated, relict southernmost localities in the temperate zone. Four chromosome numbers are reported: 2n = 60 (Iceland, Löve & Löve 1956); 2n = 60 and 2n = 62 (Canada, Löve & Löve 1965, Löve & Ritchie 1966); 2n = 66 (Scandinavia, Knaben & Engelskjon 1967) and 2n = 70 (Chukotka Peninsula; Zhukova & Petrovskii 1976, Zhukova et al. 1977).

Carex crawfordii, 2n = 68

Plants of unknown origin cultivated in the Botanical Garden & Arboretum, Mendel University, Brno, Czech Republic, coll. M. Nohelová & P. Bureš 9 Aug 2007.

Carex crawfordii is a widely distributed, North American species. Roalson (2008) reports chromosome numbers of 2n = 66, 2n = 68 and 2n = ca 70 for this taxon; 2n = 68 is the most frequently documented number.

Carex cristatella, 2n = 64 (Fig. 1O)

Plants of unknown origin cultivated in the Botanical Garden & Arboretum, Mendel University, Brno, Czech Republic, coll. M. Nohelová & P. Bureš 9 Aug 2007.

Carex cristatella is a species that occurs in the SE part of North America. Roalson (2008) reports a chromosome count of 2n = 70 for this taxon.

Carex curvata see *C. brizoides* complex

Carex davalliana, 2n = 46 (Figs 1P, Q)

Czech Republic, distr. Hlinsko, Vortová: wet meadow near the cemetery, NE of the village, alt. 628 m, 49°42' 56" N, 15°56'20" E, coll. J. Bureš & P. Bureš 18 Jun 2006.

Carex davalliana is a dioecious Central European species of calcareous fens and springs. Roalson (2008) reports the same chromosome numbers for this taxon for several European countries. Both male and female plants were studied and there is one pair of rather long chromosomes in the karyotypes of both sexes. The same pattern, i.e., one large chromosome in the meiotic karyotype, is recorded for this species by Heilborn (1937). The enlargement of particular chromosomes could be associated with the origin or early stages of the evolution of sex chromosomes (Charlesworth 1991, Vyskot & Hobza 2004). However, the sex chromosomes of dioecious species of *Carex* have not been studied. Compared to the species richness of the whole genus, dioecy is a relatively rare breeding strategy in *Carex* occurring in only 12 species, despite its advantages as a means of avoiding inbreeding depression in fragmented habitats (Guibert et al. 2009). Intra-karyotype variations in chromosome size, including the occasional presence of large chromosomes, is not rare in hermaphrodite sedges, as previously reported, e.g. in *Carex buekii* (Stoeva et al. 2005) and documented in the present study in *C. livida* (Fig. 2K), C. *sempervirens* subsp. *laxiflora* (Fig. 2U) and *C. vaginata* (Fig. 2X). Large chromosomes are usually considered to be products of chromosomal fusion (Hoshino & Waterway 1994).

Carex demissa see *C. flava* complex

Carex depauperata, 2n = 44 (Fig. 1R)

Italy, Gargano Peninsula, Foresta Umbra: 0.5 km ESE of the Casa Forestale, alt. 800 m, 41°49'07.1" N, 15°59' 54.9" E, coll. V. Grulich, P. Šmarda & I. Hralová 15 May 2007.

Carex depauperata is a sub-Mediterranean species that is disjunctly distributed from Europe to W Asia. The most frequent cytotype is 2n = 44 (Roalson 2008). The single record of 2n = 74 for Greece (Strid & Franzén 1981) is disputable because of the absence of records of such a high chromosome number in section *Deapauperatae* to which this species belongs (see Roalson 2008).

Carex diandra, 2n = 60 (Fig. 1S)

Czech Republic, Jizerské hory Mts, Nature Reserve Rašeliniště Jizery, alt. 838 m, 50°50'43" N, 15°21'22" E, coll. Š. Králová 17 Jun 2006.

Carex diandra is a circumpolar wetland species that is abundant in temperate to boreal climatic zones. Our findings are consistent with the cytotype reported by Roalson (2008) for N Europe, North America and Slovenia. Other cytotypes are recorded for Alaska (2n = 54,

Packer & Whitkus 1982), the Iberian Peninsula and Mallorca Island (2n = 58, Luceño 1994 a, b).

Carex digitata complex (*C. digitata*, *C. quadrifolia*)

Carex digitata, 2n = 48 (Fig. 1T)

Czech Republic, distr. Brno, Brno-Líšeň: Mariánské údolí valley, 2.3 km NW of the church in the city-part, alt. 288 m, 49°13'15" N, 16°43'09" E, coll. I. Hralová & P. Bureš 24 May 2006.

Carex digitata is a species of broadleaved European forests that occurs in temperate regions of Europe. The cytotype variation (2n = 48, 2n = 50, 2n = 52, 2n = 54, and 2n = 56) for this taxon is reported by Roalson (2008). The most frequent chromosome number throughout the whole natural range of this species appears to be 2n = 52. However, there is no geographical pattern in the distribution of particular cytotypes. The cytotype variation in the *C. digitata* complex may be due to the unresolved taxonomic status of some putative taxa that were recently included in the broad concept of this complex. For instance, a chromosome count of 2n = 54 is cited by Harmaja (1990) for the closely related *C. pallidula*, which is very similar to *C. digitata* in terms of its morphology and distribution.

Carex quadriflora, 2n = 46 (Fig. 1U)

Russia, Primorskii krai, distr. Chuguevsk, Yasnoe: S slope of valley, 3.6 km W of the Oblachnaya Mt., alt. 890 m, 43°41'27" N, 134°09'16" E, coll. T. Koutecký 14 Jul 2008.

Carex quadriflora is an E Asian species that occurs in the Russian Ussuri River basin, N Korea, NE China and Japan (Hokkaido Island). The first karyological record for this species is similar to that of the cytotypes of related taxa in the subsection *Digitatae* (Egorova 1999). Moreover, three taxa belong to this subsection, i.e. *C. digitata*, *C. ornithopoda* and *C. quadrifolia* have a very similar DNA content (Hralová et al., unpublished).

Carex distans, 2n = 70 (Fig. 1V)

Czech Republic, distr. Hodonín, Javorník nad Veličkou: Nature Reserve Machová, 1.4 km NW of Machová Hill, alt. 396 m, 48°49'54" N, 17°31'28" E, coll. K. Fajmon 10 Jun 2006.

Carex distans is a European species whose range includes N Africa. It is particularly abundant on saline and clay soils. A chromosome count of 2n = 74 prevails throughout Europe (Roalson 2008). A single record of 2n = 72 is reported for Italy (Dietrich 1972). A karyological variation from 2n = 68 to 74 is recorded for Iberian and Northern African populations (Luceño & Castroviejo 1993), although there is no clear geographical pattern in the distribution of particular cytotypes. Escudero et al. (2008) record a chromosome number of 2n = 70 for Spain, Greece and Morocco, 2n = 72 for Greece and 2n = 75 for the Island of Crete. In this study a count similar to that for Austria (Dobeš et al. 1997) was recorded.

Carex disticha, 2n = 60 (Fig. 1X)

Czech Republic, distr. Mikulov, Nové Mlýny: Nature Reserve Křivé jezero, alt. 163 m, 48°50'45" N, 16°43'43" E, coll. J. Danihelka & P. Bureš 15 Jun 2006.

Carex disticha is a wetland species that is distributed from Europe to C Asia and E Siberia, it also occurs in Canada. The most frequent cytotype in this taxon is 2n = 62 (Roalson 2008), but 2n = 64 is recorded for Belarus (Dmitrieva 1985). In addition, karyological

variations from 2n = 60 to 65 plus numerous chromosomal fragments are reported by Luceño (1992, 1994b) for the Iberian Peninsula.

Carex echinata, 2n = 58 (Fig. 1Y)

Czech Republic, distr. Žďár nad Sázavou, Radostín: Nature Reserve Padrtiny, S of the village, alt. 625 m, 49°38'35.0" N 15°52'30.6" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex echinata is a wetland species that is abundant in Europe and the eastern part of North America. The most frequent cytotype throghout its distribution is 2n = 58 and 2n = 56 is infrequent (Roalson 2008). Cytotypes with 2n = 50 and 2n = 52 are present in North America (Löve 1954).

Carex elata, 2n = 74

Czech Republic, Hodonín: Hodonínská dúbrava 3.25 km NW of the railway station in the town, alt. 192 m, 48°52'52" N, 17°05'54" E, coll. R. Řepka & P. Bureš 25 Jul 2006.

Carex elata is a wetland species that occurs mainly in temperate Europe (rarely in S Scandinavia, the Caucasus Mts and N Africa and disjunctively in the Far East of Russia). The karyological variation reported by Roalson (2008) ranged most commonly from 2n = 74 to 77. In NW Europe, the prevailing cytotype is 2n = 76 and in Bulgaria the most common value is 2n = 74 (Stoeva et al. 2005). The chromosome number of 2n = 80 is cited by Heilborn (1922, 1924). The two lowest chromosome numbers, 2n = 68 and 2n = 70 (reported for North America) were assigned mistakenly to *C. elata* because they were originally published under *C. stricta* Lam. (Whitkus 1981, Standley 1987) and not under *C. stricta* Good., which is a taxonomic synonym of *C. elata*.

Carex elongata, 2n = 56

Czech Republic, distr. Žďár nad Sázavou, Cikháj: pond SW of the village, alt. 663 m, 49°38'36.8" N, 15°57'43.7" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex elongata is a wetland species that is broadly distributed across temperate and boreal regions of Europe up to W Siberia (separately in the Caucasus Mts). The most frequent cytotype 2n = 56 is found in the European part of the species' natural range (Roalson 2008). A different cytotype of 2n = 60 is recorded occasionally in Belarus (Parfenov & Dmitrieva 1987). Roalson (2008) incorrectly cites cytotypes of 2n = 74–76 from Druskovic (1995), who in fact reports a number of 2n = 56 in his original paper.

Carex enervis, 2n = 60 (Fig. 2A)

Russia, Republic of Buryatiya, distr. Ivolgin, Dacan: damp pasture 0.2 km NW of monastery Dacan, alt. 580 m, 51°45'30" N, 107°11'30" E, coll. T. Koutecký 8 Aug 2008.

Carex enervis is an Asian species that occurs in saline grassland and steppes and is distributed from E Siberia to the Far East of Russia, Mongolia and NE China. Chepinoga et al. (2009) report chromosome numbers for this taxon of 2n = 44–46 in Russia. The present findings are consistent with the records published for other taxa of section *Foetidae* (e.g., 2n = 60 for *C. maritima*, Roalson 2008).

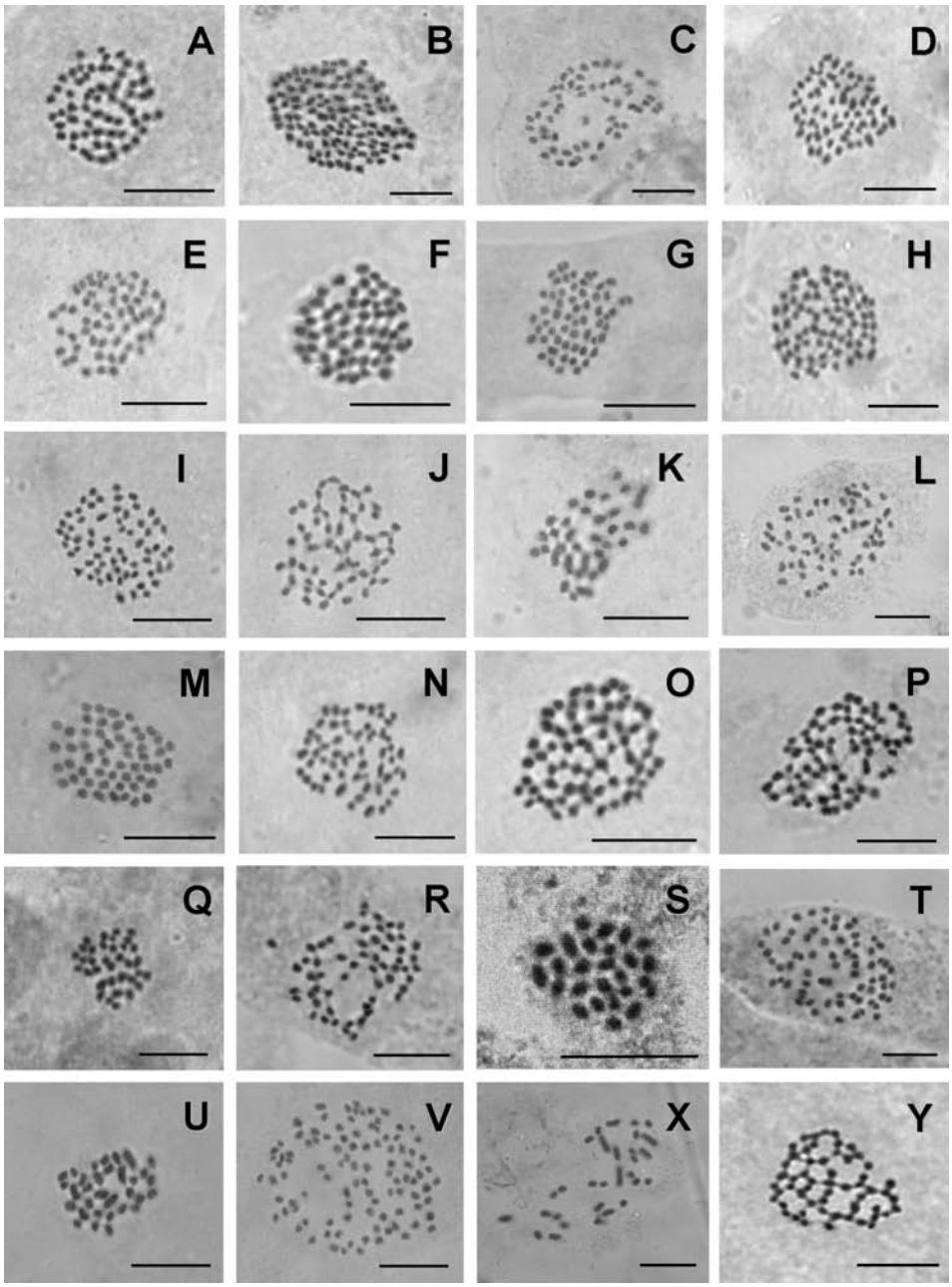

Fig. 2. – Microphotographs of somatic metaphases of twenty-four sedge species. II. **A.** *Carex enervis*, 2n = 60. **B.** *C. cuspidata*, 2n = 108. **C.** *C. flava*, 2n = 56. **D.** *C. flavocuspis* subsp. *krascheninnikovii*, 2n = 64 (first record). **E.** *C. frigida*, 2n = 58. **F.** *C. grayi*, 2n = 52. **G.** *C. hordeistichos*, 2n = 58. **H.** *C. callitrichos*, 2n = 70 (first record). **I.** *C. lachenalii*, 2n = 64. **J.** *C. limosa*, 2n = 58. **K.** *C. livida*, 2n = 32. **L.** *C. lurida*, 2n = 60. **M.** *C. melanostachya*, 2n = 54. **N.** *C. pallida*, 2n = 58 (first record). **O.** *C. paniculata* subsp. *hansenii*, 2n = 64 (first record). **P.** *C. lanceolata*, 2n = 70. **Q.** *C. macroura*, 2n = 35. **R.** *C. pseudobrizoides*, 2n = 58. **S.** *C. riloensis*, 2n = 26. **T.** *C. rostrata*, 2n = 70. **U.** *C. sempervirens* subsp. *laxiflora*, 2n = 32. **V.** *C. sordida*, 2n = 100. **X.** *C. vaginata*, 2n = 30. **Y.** *C. xiphium*, 2n = 56 (first record). Scale bars = 10 μm.

Carex ferruginea subsp. *ferruginea*, 2n = 40

Austria, Upper Austria, distr. Spital am Pyhrn, Wurzeralm, alt. 1402 m, 47°38'48" N, 14°17'17" E, coll. A. Vydrová & V. Grulich 18 Jun 2006.

Carex ferruginea subsp. *ferruginea* is a European species that is distributed from sub-Alpine to Alpine zones on calcareous substrates. Chromosome numbers of 2n = 39 and 2n = 40 are reported by Roalson (2008) for this subspecies, and Stoeva (2000) reports numbers of 2n = 38 and 2n = 40 for Bulgaria.

Carex flacca complex (*C. flacca*, *C. cuspidata*)

Carex flacca, 2n = 76

Czech Republic, distr. Brno, Brno-Líšeň: Mariánské údolí valley, 2.3 km NW of the church in Brno-Líšeň, alt. 288 m, 49°13'15" N, 16°43'09" E, coll. I. Hralová & P. Bureš 24 May 2006.

Carex flacca is a European taxon that occurs mainly on calcareous and clay soils (introduced into North America). The most frequently reported cytotype is 2n = 76 (Roalson 2008). However, three records of 2n = 38 suggest the possible presence of intraspecific polyploidy.

Carex cuspidata, 2n = 108 (Fig. 2B)

Italy, Gargano Peninsula, Vieste: Capo Vieste, 3 km NW of the village, alt. 15 m, 41°54'33" N, 16°09'02" E, coll. V. Grulich 14 May 2007.

Carex cuspidata occurs in S Europe, W Asia and N Africa. For this taxon, three cytotypes are recorded to date: 2n = 90 for Spain (Löve & Kjellqvist 1973), 2n = 114 for Bulgaria (Stoeva 1992) and 2n = 76–80 for Turkey (Hayirlioğlu-Ayaz et al. 2001). In accordance with the chromosome numbers the DNA content of *C. cuspidata* is approximately 1.5-fold greater than in *C. flacca* (I. Hralová et al., unpublished).

Carex flava complex (*C. flava*, *C. demissa*, *C. lepidocarpa*, *C. jemtlandica*)

Carex flava, 2n = 56 (Fig. 2C)

Czech Republic, distr. Polička, Borová u Poličky: wet meadow 0.4 km E of the railway station in the village, alt. 621 m, 49°44'35" N, 16°09'54" E, coll. P. Bureš 29 Jul 2006.

Carex flava occurs in Europe and North America (separately in N Africa, the Caucasus Mts and C Asia). The cytotypes 2n = 58, 2n = 60 (prevailing cytotype), 2n = 64 and 2n = 70 are reported by Roalson (2008) and are most likely due to aneuploidy, which it is suggested occurs in this complex (Hipp et al. 2009). The record of 2n = 30 reported by Roalson (2008) is incorrect because in the original paper by Halkka et al. (1992), a meiotic count (n) is reported. Although 2n = 56 has never been recorded for this taxon, the cytotype 2n = 58 is recorded for plants from Bulgaria and the Czech Republic (Stoeva & Štěpánková 1990).

Carex demissa, 2n = 70

Czech Republic, distr. Hlinsko, Vortová: peat meadow near the cemetery, NE of the village, alt. 626 m, 49°42'57" N, 15°56'19" E, coll. P. Bureš 30 Jul 2006.

Carex demissa is a European wetland species. The same cytotype is reported by Roalson (2008). Chromosome counts of 2n = 68 and 2n = 70 are recorded for plants from the Iberian Peninsula (Luceño 1994b).

Carex lepidocarpa, 2n = 68

Czech Republic, distr. Žďár nad Sázavou, Hluboká: peat meadow near the Řeka pond, alt. 581 m, 49°39'59.6" N, 15°51'10.5" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex lepidocarpa is a wetland species that occurs in temperate zones in Europe and the NE part of North America. A chromosome count of 2n = 68 is reported for the British Isles (Davies 1956), Germany (Dietrich 1972) and Slovakia (Stoeva & Štěpánková 1990). Cytotype variation is reported as occurring in Switzerland (2n = 62 and 2n = 68, Schmid 1982), the Czech Republic (2n = 68 and 2n = 69, Stoeva & Stěpánková 1990) and the Iberian Peninsula (2n = 66, 2n = 68 and 2n = 70, Luceño 1994b). The highest chromosome number, 2n = 72, is reported for Slovenia (Druskovic 1995). Tanaka (1948) and Druskovic (1982) record a number of 2n = 58.

Carex jemtlandica, 2n = 68

Sweden, distr. Jämtland, Hammerdal: 0.5 km E of the Näverkälsbodarna, alt. 330 m, 63°34'48.6" N, 15°13' 52.1" E, coll. P. Hájková, M. Hájek & D. Dítě 15 Aug 2006.

Carex jemtlandica is a Scandinavian species, that is closely related to *C. lepidocarpa* and has a range that extends to Estonia. The same chromosome number is recorded for Finland (Halkka et al. 1992).

Carex flavocuspis subsp. *krascheninnikovii*, 2n = 64 (Fig. 2D)

Russia, Kamchatka Peninsula, Elizovo, Termal'nii: Dvugorbaya Hill, 7.3 km SW of the power station, alt. 960 m, 52°30'30" N, 158°07'30" E, coll. T. Koutecký 25 Jul 2008.

Carex flavocuspis subsp. *krascheninnikovii* is an E Asian taxon that occurs in the Far East of Russia, on the Kamchatka Peninsula and the Kurile Islands. This is the first chromosome count for this species.

Carex frigida, 2n = 58 (Fig. 2E)

Austria, Carinthia, Hohe Tauern Mts, Sadnik Hill: 1.8 km NE of the summit, alt. 2062 m, 46°56'47" N, 13°00'43" E, coll. P. Šmarda 4 Jul 2006.

Carex frigida occurs on S and C European mountains. Roalson (2008) reports chromosome numbers for this taxon of 2n = 56 for Switzerland, France and Austria, and 2n = 58 for Slovenia.

Carex fritschii, 2n = 30

Czech Republic, distr. Břeclav, Valtice: hunting-lodge Rendez-vous, 5.7 km S-SSW of the church in the village, alt. 205 m, 48°45'01" N, 16°47'26" E, coll. J. Danihelka & P. Bureš 15 Jun 2006.

This central European species grows in sandy and gravelly soils in open oak forests. The current findings are consistent with the cytotypes reported by Roalson (2008) for Switzerland and Austria and by Verlague & Reduron (2008) for France.

Carex grayi, 2n = 52 (Fig. 2F)

Plants of unknown origin cultivated in the Botanical Garden, Masaryk University Brno, Czech Republic, coll. I. Hralová 2007.

Carex grayi occurs in the SE part of North America and is frequently cultivated as an ornamental plant. The cytotypes 2n = 52 and 2n = 54 are reported for this taxon by Roalson (2008).

Carex halleriana, 2n = 52

Hungary, Budai Hegység Mts, Budakeszi: forest NW of the village, alt. 337 m, 47°31'44" N, 18°53'50" E, coll. J. Roleček & B. Zemanová 19 Jul 2006.

Carex halleriana is distributed from Europe to W Asia (separately in N Africa). The most frequent cytotype is 2n = 52 and is reported for the S European region of the species' natural range, i.e. Italy, Spain and Slovenia (Roalson 2008). In addition to the most frequent cytotype, variations including 2n = 50, 2n = 54 and 2n = 56 are recorded for Spain (Kjellqvist & Löve 1963, Luceño 1992) and the number of 2n = 50 for Bulgaria (Stoeva 2000).

Carex hordeistichos, 2n = 58 (Fig. 2G)

Czech Republic, distr. Hodonín, Javorník nad Veličkou: Nature Reserve Machová, ca 0.8 km NE of the Machová Hill, alt. 442 m, 48°49'38" N, 17°32'31" E, coll. K. Fajmon 9 Jun 2006.

Carex hordeistichos is a Eurasian species with a disjunct range extending from the Iberian Peninsula to the Caucasus Mts (rarely in N Africa). The prevailing cytotype is 2n = 56 (Roalson 2008), but Tarnavschi (1948) records variations ranging from 2n = 54 to 60 in Romanian populations and Stoeva (2000) the number of 2n = 54 for Bulgaria.

Carex hostiana, 2n = 56

Czech Republic, distr. Hlinsko, Trhová Kamenice: Nature Reserve Buchtovka, 1.4 km SSW of the village, alt. 558 m, 49°46'26" N, 15°48'37" E, coll. J. Bureš & P. Bureš 18 Jun 2006.

Carex hostiana occurs in W and C Europe and in New Foundland (with separate localities in Asia Minor and the Caucasus Mts). The present findings are consistent with those reported by Roalson (2008) for Scandinavia, the British Isles, Slovakia and Slovenia.

Carex humilis complex (*C. callitrichos*, *C. humilis*)

Carex callitrichos, 2n = 70 (Fig. 2H)

Russia, Primorskii Krai, distr. Chuguevsk, Yasnoe: S slope of the valley, 3.6 km W of the Oblachnaya Mt., alt. 890 m, 43°41'27" N, 134°09'16" E, coll. T. Koutecký 14 Jul 2008.

Carex callitrichos is an E Asian species that is distributed from W Siberia to the Far East of Russia, NE China, the Korean Peninsula and Kyushu Island. This is the first chromosome count for this species. This species has a two-fold larger genome than the closely related *C. humilis,* with 2n = 36 (I. Hralová et al., unpublished).

Carex humilis, 2n = 36

Czech Republic, distr. Bučovice, Marefy: Nature Reserve Ševy, alt. 240 m, 49°08'09" N, 16°58'24" E, coll. Z. Lososová & O. Rotreklová 31 May 2006.

Carex humilis is a Eurasian species that has a disjunct distribution occuring in steppe habitats in Europe, the Caucasus Mts and in Siberia. The cytotype 2n = 36 prevails in Europe, including the Czech Republic (Roalson 2008). A single different chromosome count of 2n = 38 is reported for Slovenia (Druskovic 1995). A cytotype of 2n = 56 is incorrectly cited by Roalson (2008) from the article published by Davies (1956), in which a value of 2n = 36 is reported. The chromosome count of 2n = 72 recorded by Tanaka (1948) may be for another taxon in the *C. humilis* complex, i.e. *C. nanella* (2n = 72, Egorova 1999) or *C. callitrichos* (2n = 70, see above).

Carex jemtlandica see *C. flava* complex

Carex lachenalii, 2n = 64 (Fig. 2I)

Norway, Jotunheimen Mts, Krossbu: quarry on the NW slope of Galdhøpiggen Hill near the village, alt. 1372 m, 61°34'16.3" N, 8°03'07.7" E, coll. P. Hájková & M. Hájek 23 Aug 2006.

Carex lachenalii is a circumpolar species that has a disjunct distribution occurring in the arctic and in the higher European mountains. Besides the most frequent cytotype of 2n = 64, chromosome numbers of 2n = 50, 2n = 58, 2n = ca 60 and 2n = 62 are reported (Roalson 2008). The distribution of the particular cytotypes does not appear to have a specific geographical pattern.

Carex lanceolata see *C. pediformis* complex

Carex lepidocarpa see *C. flava* complex

Carex leporina, 2n = 68

Czech Republic, distr. Žďár nad Sázavou, Cikháj: pond SW of the village, alt. 663 m, 49°38'36.8" N, 15°57'43.7" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex leporina occurs mostly in temperate zones from Europe to W Siberia (separately in N Africa, Palestine and the Caucasus Mts, and is introduced into N America). Chromosome numbers of 2n = 60, 2n = 62, 2n = 64, 2n = 66 and 2n = 68 are reported by Roalson (2008) and the most frequent values are 2n = 64 and 2n = 68. The cytotypes 2n = 73, 2n = 74 and 2n = 76 are recorded for the Iberian Peninsula and Morocco (Luceño 1994 a, b).

Carex limosa, 2n = 58 (Fig. 2J)

Czech Republic, Jizerské hory Mts, Nature Reserve Rašeliniště Jizery, alt. 342 m, 50°50'48" N, 15°20'59" E, coll. Š. Králová 17 Jun 2006.

Carex limosa is a circumpolar wetland species that occurs in boreal and arctic zones mainly growing in peat bogs. A chromosome number of 2n = 56 is recorded for E Asia (Tanaka 1948, Zhukova & Petrovskii 1975, 1976). Cytotypes ranging from 2n = 61-64 are reported for Slovenia, NW Europe and North America (Roalson 2008) and the most frequent cytotype is 2n = 64.

Carex livida, 2n = 32 (Fig. 2K)

Norway, distr. Verdal, Buran: Nature Reserve Kaldvassmyra, alt. 200 m, 63°43'21.0" N, 11°34'53.6" E, coll. P. Hájková, M. Hájek & D. Dítě 17 Aug 2006.

Carex livida is a circumpolar species that has a disjunct distribution occurring on the Korean Peninsula and in Japan. Roalson (2008) reports a chromosome number of 2n = 32 for Canada, Iceland and Scandinavia. Taylor & Mulligan (1968) record values of 2n = 50 and 2n = 52 for this species from the Queen Charlotte Islands in western Canada.

Carex lurida, 2n = 60 (Fig. 2L)

Plants of unknown origin cultivated in the Botanical Garden & Arboretum, Mendel University, Brno, Czech Republic, coll. M. Nohelová & P. Bureš 9 Aug 2007.

Carex lurida occurs in the eastern part of North America, Mexico, South America and the West Indies. Cytotypes of 2n = 64 and 2n = 66 are reported by Roalson (2008).

Carex macroura see *C. pediformis* complex

Carex melanostachya, 2n = 54 (Fig. 2M)

Czech Republic, distr. Mikulov, Bulhary: meadow N of the village, alt. 161 m, 48°50'36" N, 16°45'12" E, coll. J. Danihelka & P. Bureš 15 Jun 2006.

Carex melanostachya is a continental Eurasian species whose distribution extends from France to W China. Karyological data for this species are rare and variable. Chebotar' et al. (1977, cit. sec. Agapova et al. 1990, p. 333) and Egorova (1999) record a chromosome number of 2n = 48 for Moldova and Stoeva (2000) a value of 2n = 76 for Bulgaria. The origin of the numbers cited in national floras (Dostál 1989: 2n = 56; Grulich & Řepka 2002: 2n = 30) is unknown.

Carex montana, 2n = 38

Czech Republic, distr. Bučovice, Marefy: Nature Reserve Ševy, alt. 240 m, 49°08'09" N, 16°58'24" E, coll. Z. Lososová & O. Rotreklová 31 May 2006.

Carex montana occurs mainly in Europe and disjunctively in W Siberia. Roalson (2008) reports the same chromosome number as recorded in this study.

Carex mucronata, 2n = 36

Austria, Tirolia, Lienzer Dolomiten Mts, Laserzwand Mt.: 0.5 km NNW of the summit, alt. 2046 m, 46°46'37" N 12°47'58" E, coll. P. Šmarda 6 Jul 2006.

Carex mucronata is a European species that grows in soils derived from calcareous bedrock in subalpine and alpine zones of the Alps, the Appenines and the mountains on the Balkan Peninsula. Roalson (2008) reports chromosome numbers of 2n = 34 and 2n = 36 for this taxon.

Carex muskingumensis, 2n = 80

Plants of unknown origin cultivated in the Botanical Garden, Masaryk University Brno, Czech Republic, coll. I. Hralová 2007.

Carex muskingumensis occurs in the eastern part of North America, mainly in the USA, and its range extends northwards to Canada (Ontario). It is often cultivated as an ornamental plant. Roalson (2008) reports the same chromosome number as was recorded in this study for this species.

Carex nigra, 2n = 84

Czech Republic, distr. Žďár nad Sázavou, Cikháj: meadow on the NW margin of the village, alt. 688 m, 49°38'53.1" N, 15°57'39.5" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex nigra is a widely distributed Euro-Siberian species (occurs in Greenland and N Africa, and was introduced into North America). A large cytotype variation, including single marginal chromosome counts of 2n = ca 74 and 2n = 88, and prevalent continuous variation of 2n = 80–86 are reported by Roalson (2008). The most frequent chromosome number is 2n = 84. Recently, Stoeva et al. (2005) records karyological variation with a prevailing chromosome number of 2n = 84 but no geographical pattern, for plants from Bulgaria. Chromosome numbers of 2n = 50–52 are recorded by Sokolovskaya & Strelkova (1948) for the Caucasus (cit. sec. Agapova et al. 1990, p. 334).

Carex norvegica, 2n = 54

Norway, Dovrefjell Mts., Kongsvoll: SW slope near of the village, alt. 950 m, 62°18' 01.9" N, 9°36'22.7" E, coll. P. Hájková, M. Hájek & D. Dítě 20 Aug 2006.

Carex norvegica has a disjunct distribution occurring in Scandinavia, Iceland, Greenland, E Canada, Alaska and on the Chukotka Peninsula with isolated southern localities in the British Isles, the Alps and Mongolia. The most frequent (2n = 56) and rare (2n = 54) cytotypes are reported by Roalson (2008) for N Europe and North America and by Zhukova (1969) and Zhukova & Petrovskii (1980) for NE Asia. Tanaka (1948) records a chromosome number of 2n = 66.

Carex obtusata, 2n = 52

Czech Republic, distr. Prostějov, Vícov: Malá horka Hill 1.4 km ENE of the church in the village, alt. 339 m, 49°29'20" N, 16°58'44" E, coll. R. Řepka & P. Bureš 25 Jul 2006.

Carex obtusata has disjunct distribution occuring on the continental steppes of Eurasia and North America. Roalson (2008) reports the same chromosome number for this taxon from Wrangel Island (Russia) and the USA. The chromosome count cited here is the first for the European region of this species' distribution.

Carex otrubae, 2n = 60

Czech Republic, Velká nad Veličkou: 1.6 km S of the church in the village, alt. 317 m, 48°52'08" N, 17°31'09" E, coll. K. Fajmon 10 Jun 2006.

The distribution of this Eurasian species extends from W Europe to C Asia. Most of the chromosome counts reported by Roalson (2008, 2n = 58 and 2n = 60) are based on plants from the Mediterranean. Chromosome numbers of 2n = 58, 2n = 62 and 2n = 64 are recorded by Toderash (1979, cit. sec. Agapova 1990, p. 334) for Moldova. The chromosome count cited is the first for the C European part of this species' range.

Carex pallescens, 2n = 64

Czech Republic, distr. Žďár nad Sázavou, Cikháj: meadow on the NW margin of the village, alt. 688 m, 49°38'53.1" N, 15°57'39.5" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex pallescens is distributed from Europe to W Siberia (and separately in the Caucasus Mts, S Siberia and C Asia; a different subspecies is present in the Atlantic region of North America). Chromosome numbers of 2n = 62 and 2n = 64 (prevailing) are reported by

Roalson (2008) for Europe. A single cytotype, with a low 2n = 58, is recorded by Rath & Patnaik (1978).

Carex pallida, 2n = 58 (Fig. 2N)

Russia, Primorskii krai, distr. Chuguevo, Yasnoe: S slope 0.6 km SW of Oblachnaya Mt., alt. 1610 m, 43°41'25" N, 134°11'38" E, coll. T. Koutecký 13 Jul 2008.

Carex pallida is an E Asian species that is distributed from E Siberia to the Far East of Russia, N Mongolia, NE China and the Korean Peninsula. This is the first chromosome count for this species. In the present study, a value of 2n = 58 was determined for the closely related *C. praecox* (see below).

Carex panicea, 2n = 32

Czech Republic, distr. Žďár nad Sázavou, Cikháj: meadow on the NW margin of the village, alt. 688 m, 49°38'53.1" N, 15°57'39.5" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex panicea occurs mainly in Europe, Siberia and the NE part of North America (and separately in the Caucasus Mts, Iceland and S Greenland). Roalson (2008) reports the same chromosome number for the European region of this species' range.

Carex paniculata s.l.

Carex paniculata subsp. *paniculata*, 2n = 60

Czech Republic, distr. Brno, Útěchov: along the Melatínský Brook, 2 km S of the chapel in the village; alt. 373 m, 49°16'04" N, 16°38'13" E, coll. R. Řepka 1 Aug 2006.

Carex paniculata subsp. *paniculata* is a European species that occurs mainly in temperate zones. Roalson (2008) reports three chromosome numbers for this taxon: 2n = 60 for Spain, Slovakia and Italy; 2n = 62 for Germany and 2n = 64 for Slovenia. Stoeva (2000) records a value of 2n = 60 for plants from Bulgaria.

Carex paniculata subsp. *hansenii*, 2n = 64 (Fig. 2O)

Cape Verde, Santo Antão Island, distr. Ribeira Grande: between settlements of Losna and Xoxo, alt. 675 m, 17°07'45" N, 25°04'09" W, coll. V. Grulich & A. Vydrová 5 Nov 2006.

This subspecies is endemic to the Cape Verde Islands. This is the first chromosome count for this species. The DNA content of both subspecies is similar, i.e. subsp. *paniculata* and subsp. *hansenii* (I. Hralová et al., unpublished).

Carex parviflora, 2n = 54

Austria, Carinthia, Hohe Tauern Mts, Goldberg Gruppe: Bretterach, alt. 2270 m, 46°57'40" N, 13°00'24" E, coll. V. Grulich 5 Jul 2006.

Carex parviflora is distributed disjunctively in the alpine zone of European mountains. The same chromosome number is reported by Roalson (2008) and 2n = 52 recorded for plants from the Altai Mts (Sokolovskaya & Strelkova 1948, cit. sec. Agapova et al. 1990, p. 334).

Carex pediformis complex (*C. lanceolata*, *C. macroura*, *C. rhizina*)

Carex lanceolata, 2n = 70 (Fig. 2P)

Russia, Republic of Buryatiya, distr. Barguzin, Usť-Barguzin: Pik Markova Mt., 26.6 km NNW of the ferry in the village, alt. 1610 m, 53°38'09" N, 108°49'33" E, coll. T. Koutecký 13 Aug 2008.

Carex lanceolata is distributed from E Siberia to Japan. Roalson (2008) reports a large range of chromosome numbers: 2n = 26, 2n = 68, 2n = 70, 2n = 72, 2n = 74, 2n = 76, 2n = 78 and 2n = 80.

Carex macroura, 2n = 35, 70

2n = 35: Russia, Irkutsk, Slyudyanka: middle part of valley, alt. 600 m, 51°37'52" N, 103°38'53" E, coll. T. Koutecký 17 Aug 2008 (Fig. 2Q).
2n = 70: Czech Republic, distr. Mimoň, Vranov: pine wood on the S foothill of the Ralsko hill, alt. 360 m, 50°40'04"N, 14°45'23"E, coll. V. Grulich 4 Jun 2008.

Carex macroura is a widely distributed Eurasian species. A single chromosome count of 2n = ca 50 is recorded by Murín et al. (1980) for Mongolia but a similar cytotype has not been found to date in the *C. pediformis* complex (see Roalson 2008). The chromosome number of 2n = 35 from the Far East of Russia is half of that of the cytotype 2n = 70, which prevails within the *C. pediformis* complex. Moreover, the DNA content of *C. macroura* from the Far East of Russia is half that of *C. macroura* from the Czech Republic and *C. lanceolata* (both 2n = 70, I. Hralová et al., unpublished).

Carex rhizina, 2n = 70

Czech Republic, distr. Brno, Horákov: forest road to Mariánské údolí valley 2 km W-WNW of the church in the village, alt. 300 m, 49°12'34" N, 16°43'21" E, coll. R. Řepka, 25 Jul 2006.

Carex rhizina is distributed from W Siberia to E Europe in broadleaved and mixed forests, and occurs in isolated localities in C and N Europe. The chromosome number recorded here is consistent with the karyological data reported by Roalson (2008) for *C. pediformis*, which is the name that was commonly used for this taxon in the past. This record is the first value determined for this species in the C Europaean region of its distribution area.

Carex pendula, 2n = 58

Czech Republic, distr. Hlinsko, Staré Ransko: E slope of the Ranský Babylon Hill, alt. 603 m, 49°40'25.8" N, 15°50'06.3" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex pendula is a European mountain species that is distributed from the Atlantic coast to the Balkan Peninsula (and disjunctively in the Mediterranean, N Africa and the Caucasus Mts). In addition to the most frequent cytotype 2n = 58, two rare chromosome numbers of 2n = 60 and 2n = 62 are recorded (Stoeva 2000, Roalson 2008, Chebotar' et al. 1977, cit. sec. Agapova 1990, p. 335).

Carex pensylvanica, 2n = 36

Plants of unknown origin cultivated in the Botanical Garden & Arboretum, Mendel University, Brno, Czech Republic, coll. M. Nohelová & P. Bureš 9 Aug 2007.

Carex pensylvanica is distributed in the eastern part of North America. Roalson (2008) reports the same chromosome number as was recorded in this study.

Carex pilulifera, 2n = 18

Czech Republic, distr. Žďár nad Sázavou, Cikháj: meadow on the NW margin of the village, alt. 688 m, 49°38'53.1" N, 15°57'39.5" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex pilulifera is a European suboceanic species (also occurs in the Azores and Iceland). In addition to the most frequent chromosome number of 2n = 18 (Roalson 2008), one rare cytotype of 2n = 16 is recorded by Heilborn (1918). Roalson (2008) incorrectly reported a chromosome number of 2n = 35 for *C. pilulifera*, recorded for *C. bergrothii* Palmgr., which actually belongs to the *C. flava* complex. Moreover, this is a haploid not a diploid number (cf. Halkka et al. 1992).

Carex plantaginea, 2n = 50

Plants cultivated in the Botanical Garden & Arboretum, Mendel University, Brno, Czech Republic, coll. M. Nohelová & P. Bureš 9 Aug 2007. Seeds originated from North America, but location is unknown.

Carex plantaginea is distributed in the eastern part of North America. Chromosome numbers of 2n = 50 (Wahl 1940) and 2n = 52 (Manhart 1987) are recorded for North America.

Carex praecox, 2n = 58

Czech Republic, Pavlovské vrchy Hills, Nature Reserve Děvín-Kotel-Soutěska, Děvín Hill, alt. 490 m, 48°52'01" N, 16°38'41" E, coll. J. Danihelka & P. Bureš 15 Jun 2006.

Carex praecox is a Eurasian continental species. Roalson (2008) reports the same chromosome number as recorded in this study. Chromosome numbers ranging from 2n = 48 to 56 are recorded for Moldova (Chebotar' et al. 1977, cit. sec. Agapova 1990, p. 335).

Carex pseudobrizoides, 2n = 58 (Fig. 2R)

Czech Republic, distr. Pardubice, Zminný: pine wood 0.2 km NW of the Malolánské setlement, alt. 241 m, 50°01'57" N, 15°52'18" E, coll. R. Řepka Aug 2006.

Carex pseudobrizoides is a European suboceanic psamophilous species with its eastern distribution limits in the Czech Republic, Poland and Lithuania. Roalson (2008) reports the same chromosome number as recorded in this study.

Carex pseudocyperus, 2n = 66

Czech Republic, distr. Hlinsko, Staré Ransko: Ranský pond in the village, alt. 547 m, 49°41'02" N, 15°49'56" E, coll. J. Bureš & P. Bureš 18 Jun 2006.

This wetland species is widely distributed in Europe and ranges to S Siberia and Kazakhstan, Japan and the NE part of North America. Roalson (2008) and Stoeva (2000) report the same chromosome number as was recorded in this study.

Carex quadriflora see *C. digitata* complex

Carex remota, 2n = 62

Czech Republic, distr. Brno, Brno-Líšeň: Mariánské údolí valley near the Muchova bouda restaurant, alt. 288 m, 49°13'15" N, 16°43'09" E, coll. I. Hralová & P. Bureš 24 May 2006.

Carex remota is a European species with its eastern distribution limits at the Caspian Sea (occurs also in N Africa, the Caucasus Mts and Kazakhstan). Roalson (2008) reports a chromosome number of 2n = 62 as the most frequent cytotype.

Carex rhizina see *C. pediformis* complex

Carex riloensis Stoeva & E. D. Popova, 2n = 26 (Fig. 2S)

Bulgaria, Stara Planina Mts, Kalofer: alpine meadows on the S slope SE ridge of Botev Mt., alt. 2103 m, 42°42'92.9" N, 24°57'07.3" E, coll. R. Řepka 24 Jun 2009.

In this taxon, which is endemic to Bulgaria (Rila Mts and W Rodopi Mts) the same chromosome number as recorded in this study is also recorded by Stoeva & Popova (1993).

Carex riparia, 2n = 72

Czech Republic, distr. Mikulov, Nové Mlýny: Nature Reserve Křivé jezero, alt. 163 m, 48°50'45" N, 16°43'43" E, coll. J. Danihelka & P. Bureš 15 Jun 2006.

This wetland species is widely distributed from the British Isles to C Asia, S Siberia and N China. A chromosome number of 2n = 72 is reported by Roalson (2008) for Slovakia and Slovenia, and recorded by Chebotar' et al. (1977, cit. sec. Agapova 1990, p. 336) for Moldova.

Carex rostrata, 2n = 70 (Fig. 2T)

Czech Republic, distr. Žďár nad Sázavou, Radostín: Nature Reserve Padrtiny, S of the village, alt. 627 m, 49°38'34.7" N, 15°52'35.2" E, coll. P. Bureš & K. Helánová 2 Jun 2006.

Carex rostrata is a widely distributed, circumpolar wetland species. A large cytotype variation, including 2n = 60, 2n = 70, 2n = 72, 2n = 74 and 2n = 76, is reported by Roalson (2008), and the most frequent chromosome numbers are 2n = 60 and 2n = 76. The count of 2n = 82 for North American plants is possibly for *C. utriculata* as: (i) the same chromosome number (2n = 82) is recorded for this taxon, (ii) it occurs in North America more frequently than *C. rostrata* and (iii) many authors confuse *C. rostrata* and *C. utriculata* (Ball & Reznicek 2002). The single record of 2n = 42 recorded for Anatolia (Hayirlioğlu-Ayaz et al. 2001) is questionable because such a low chromosome number has not been reported for the section *Vesicariae* (Roalson 2008).

Carex rufina, 2n = 86

Norway, Geiranger Fjord, Dalsnibba Mt.: SW slope near the road no. 58, alt. 1037 m, 62°01'48.5" N, 7°16'17.4" E, coll. P. Hájková, M. Hájek & D. Dítě 23 Aug 2006.

Carex rufina is an arctic species that occurs in Scandinavia, Greenland, Iceland and E Canada. Roalson (2008) reports the same chromosome number for Scandinavia, Greenland and Canada. A single different count of 2n = 60 is recorded by Löve & Löve (1956) for Iceland.

Carex saxatilis, 2n = 80

Norway, Dovrefjell Mts, Kongsvoll: SW slope near the village, alt. 950 m, 62°18'01.9" N, 9°36'22.7" E, coll. P. Hájková, M. Hájek & D. Dítě 20 Aug 2006.

This circumpolar arctic species is divided into several subspecies and varieties. A cytotype of 2n = 40 is recorded for North America (Löve 1954, Löve & Löve 1981). A cytotype of 2n = 60 is recorded for *C. saxatilis* subsp. *laxa* from North America (Löve & Löve 1965, Löve & Ritchie 1966) and from the Baikal region of Russia (Krogulevich 1971). The most frequent chromosome number of 2n = 80 is recorded for Iceland (Löve & Löve 1956),

Greenland (Jörgensen et al. 1958), Scandinavia (Knaben & Engelskjon 1967), the Chukotka Peninsula (Zhukova & Tikhonova 1971, Zhukova & Petrovskii 1976), the Far East of Russia (Krogulevich 1976, Zhukova et al. 1977) and Alaska (Johnson & Packer 1968). In addition to these euploid chromosome numbers, two other cytotypes are recorded for the Far East of Russia (2n = 52, Zhukova et al. 1973) and Alaska (2n = 78, Knaben 1968). The chromosome numbers reported for this taxon by Roalson (2008: based on data for North America) suggest the presence of a polyploid series (2n = 40, 60, 80). However, because of the holokinetic nature of the chromosomes, a numerical comparison of mitotic chromosome numbers is not a reliable way of confirming that polyploidy occurs in sedges (Hipp et al. 2009).

Carex sempervirens subsp. *laxiflora*, 2n = 32 (Fig. 2U)

Slovakia, Veľká Fatra Mts, Borišov Mt., alt. 1270 m, 48°56'18.6" N, 19°06'15.1" E, coll. P. Šmarda 25 Jun 2006.

This subspecies grows in areas with calcareous soils in the W Carpathians. Chromosome numbers ranging from 2n = 30 to 34 are reported for *C. sempervirens* by Roalson (2008). Cytotypes of n = 17 and n = 34 attributed to *C. sempervirens* based on the synonymous *C. granitica* Braun-Blanq., are not recorded by Hindáková & Májovský (1976 in Löve 1976, p. 491) for Slovakia (where subsp. *laxiflora* is native), as stated by Roalson (2008), but they are recorded by Lazare (1976 in Löve 1976: 483) for France. Therefore, Lazare's record refers to another infraspecific taxon that differs from the subsp. *laxiflora*. The single chromosome number record for this subspecies (2n = ca 30) by Májovský (1978: 20) is erroneously ascribed by Roalson (2008: 294) to Hindáková.

Carex sordida, 2n = 100 (Fig. 2V)

Russia, Kamchatka Peninsula, Elizovo: by the road to Moroznaya, 3 km WNW from the bus station in the town, alt. 72 m, 53°11'31" N, 158°20'45" E, coll. T. Koutecký 27 Jul 2008.

Carex sordida is an E Asian species. A cytotype of 2n = 72 is reported for *C. sordida* by Roalson (2008).

Carex stenophylla, 2n = 60

Czech Republic, distr. Brno, Brno-Medlánky: Medlánecký kopec Hill, alt. 306 m, 49°14'17" N, 16°34'06" E, coll. J. Roleček & D. Dvořák 10 Jul 2006.

This Eurasian continental species is widely distributed in steppe habitats from C Europe to C Asia. In addition to the chromosome number of 2n = 60 reported by Roalson (2008), a single chromosome count of 2n = 62 is recorded by Tanaka (1948).

Carex strigosa, 2n = 66

Czech Republic, distr. Břeclav, Lanžhot: floodplain forest 1.6 km E of the church in the village, alt. 158 m, 48°43'25" N, 16°59'22" E, coll. R. Řepka & P. Bureš 25 Jul 2006.

Carex strigosa is a European suboceanic species with its eastern distribution limits in Moldova, the Caucasus Mts and N Iran. Roalson (2008) reports the same chromosome number for this taxon in suboceanic Europe. The same chromosome number is also recorded for Moldova (Toderash & Chebotar' 1978, cit. sec. Agapova 1990, p. 337). Our record is the first chromosome count for the C European region of this species' distribution range.

Carex sylvatica, 2n = 58

Czech Republic, distr. Brno, Brno-Líšeň: Mariánské údolí valley near the Muchova bouda restaurant, alt. 288 m, 49°13'15" N, 16°43'09" E, coll. I. Hralová & P. Bureš 24 May 2006.

Carex sylvatica occurs in woodlands from Europe to W Asia (introduced into North America). The same chromosome count is reported by Roalson (2008) for several European countries.

Carex tomentosa, 2n = 48

Czech Republic, distr. Bučovice, Marefy: Nature Reserve Ševy, alt. 240 m, 49°08'09" N, 16°58'24" E, coll. Z. Lososová & O. Rotreklová 31 May 2006.

Carex tomentosa is a Eurasian continental species with its eastern distribution limits in E Siberia and Mongolia (also occurs in Turkey and N Iran). A chromosome count of 2n = 48 is reported by Roalson (2008) for several European countries. The chromosome count of 2n = 46 reported by Roalson (2008) from the abstract of the paper published by Hayirlioğlu-Ayaz et al. (2001: 381) is erroneous because, according to the text and the figure, the count is 2n = 48 (Hayirlioğlu-Ayaz et al. 2001: 384, 385).

Carex umbrosa, 2n = 62

Czech Republic, distr. Český Krumlov, Chvalšiny: meadow near the pond 2 km WSW of the village, alt. 585 m, 48°50'57" N, 14°10'59" E, coll. V. Grulich 30 Jul 2006.

Carex umbrosa is a European species that is found in humid regions. Its eastern distribution limit is in the European region of Russia. Two different cytotypes are recorded: 2n = 62 for Bulgaria (Stoeva 1987) and Slovenia (Druskovic 1995), and 2n = 66 for Germany (Dietrich 1972) and the Iberian Peninsula (Luceño 1993).

Carex vaginata, 2n = 30, 32

2n = 32: Czech Republic, Hrubý Jeseník Mts, Karlov pod Pradědem: NW slope of Velká kotlina glacial cirque, 4.8 km NW of the village, alt. 1400 m, 50°03'21" N, 17°14'58" E, coll. R. Řepka 5 Aug 2006.
2n = 30: Russia, Kamchatka Peninsula, Elizovo: by the road to Moroznaya, 3 km WNW from the bus station in the town, alt. 72 m, 53°11'40" N, 158°20'47" E, coll. T. Koutecký 27 Jul 2008 (Fig. 2X).

Carex vaginata is a circumpolar species that occurs in boreal and arctic zones and only in the subalpine zone of the highest mountains in C Europe. A chromosome number of 2n = 32 is reported by Roalson (2008) for North America, E Asia and N Europe. Chromosome numbers ranging from 2n = 26 to 32 are recorded for populations from Austria (Dobeš et al. 1997).

Carex xiphium, 2n = 56 (Fig. 2Y)

Russia, Primorskii krai, distr. Chuguevsk, Yasnoe: middle part of valley, 6.5 km WSW of the Oblachnaya Mt., alt. 720 m, 43°41'04" N, 134°07'11" E, coll. T. Koutecký 15 Jul 2008.

Carex xiphium is an E Asian species (the Far East of Russia, N Korea and NE China). This is the first chromosome count for this species. In most of the taxa in the section *Depauperatae*, which includes this taxon, low chromosome numbers prevail, e.g. 2n = 40 in *C. michelii* and 2n = 44 in *C. pilosa* and *C. depauperata* (Roalson 2008). However, Tanaka (1948) records a value of 2n = 56 for the closely related *C. brevicollis*, and 2n = 58 is recorded here for the related *C. campylorhina*. Moreover, the DNA content of *C. xiphium* and *C. campylorhina* is similar (I. Hralová et al., unpublished).

Discussion

List of the taxa investigated is given in Table 1. In eight of the taxa studied, chromosome numbers were counted for the first time (*Carex argunensis*, *C. callitrichos*, *C. campylorhina*, *C. flavocuspis* subsp. *krascheninnikovii*, *C. paniculata* subsp. *hansenii*, *C. pallida*, *C. quadriflora* and *C. xiphium*). These are the first reports for the European part of the distribution of *Carex obtusata* and the Central European part of the distribution of *C. chordorrhiza, C. otrubae, C. rhizina* and *C. strigosa*. Fifty new counts for the Czech Republic fill a considerable gap in the karyological data for this genus (approximatelly 60% of the 84 sedge taxa are native to this country; Grulich & Řepka 2002).

Table 1. – List of species of *Carex* included in this study and their chromosome numbers. The most frequent published chromosome numbers are given in bold (for details see Results and discussion for particular taxa). Sectional placement follows Egorova (1999) for Eurasian species and Ball & Reznicek (2002) for North American species. Taxa with chromosome numbers cited for the first time are marked by an asterisk.

Subgenus	Section	Species	2n	Literature data
Vignea	*Ammoglochin*	*C. brizoides*	58	**58**
		C. curvata	58	**58**
		*C. pallida**	58	
		C. praecox	58	**58**
		C. pseudobrizoides	58	58
	Boernera	*C. stenophylla*	60	**60**, 62
	Canescentes	*C. brunnescens*	56	44, 50, 51, 52, 54, **56**
		C. canescens	56	52, 53, 54, **56**, 57, 58, 62
		C. lachenalii	64	50, 58, 60, 62, **64**
	Cyperoideae	*C. bohemica*	80	60, 62, 63, 64, **80**
	Divisae	*C. chordorrhiza*	62	60, 62, 66, 70
	Elongatae	*C. elongata*	56	**56**, 60
	Heleoglochin	*C. canariensis*	58	58
		C. diandra	60	54, 58, **60**
		C. otrubae	60	58, 60
		C. paniculata subsp. *hansenii**	64	
		C. paniculata subsp. *paniculata*	60	60, 62, 64
	Holarrhaenae	*C. disticha*	60	60, 61, **62**, 63, 64, 65
	Ovales	*C. crawfordii*	68	66, **68**, 70
		C. cristatella	64	70
		C. muskingumensis	80	80
		C. leporina	68	60, 62, **64**, 66, **68,** 73, 74, 76
	Physoglochin	*C. davalliana*	46	**46**
	Remotae	*C. remota*	62	**62**
	Stellulatae	*C. echinata*	58	50, 52, 56, **58**
Carex	*Acrocystis*	*C. fritschii*	30	**30**
		C. montana	38	**38**
		C. pilulifera	18	16, **18**
		C. riloensis	26	26
		C. tomentosa	48	**48**
	Albae	*C. alba*	54	54
	Aulocystis	*C. ferruginea* subsp. *ferruginea*	40	38, 39, 40
		C. frigida	58	56, 58
		C. mucronata	36	34, 36
		C. sempervirens subsp. *laxiflora*	32	30, 31, 32, 33, 34
	Bicolores	*C. aurea*	52	52
	Carex	*C. sordida*	100	72
	Careyanae	*C. plantaginea*	50	50, 52

Subgenus	Section	Species	2n	Literature data
Carex	*Ceratocystis*	*C. demissa*	70	68, 70
		C. flava	56	58, **60**, 64, 70
		C. hostiana	56	56
		C. jemtlandica	68	68
		C. lepidocarpa	68	58, 62, 66, **68, 69,** 70, 72
	Depauperatae	*C. campylorhina**	58	
		C. depauperata	44	44
		*C. xiphium**	56	
	Digitatae	*C. callitrichos**	70	
		C. digitata	48	48, 50, **52**, 54, 56
		C. humilis	36	**36**, 38, 72
		C. lanceolata	70	26, 68, 70, 72, 74, 76, 78, 80
		C. macroura	35, 70	50
		*C. quadriflora**	46	
		C. rhizina	70	**70**
	Glaucae	*C. flacca*	76	38, **76**
		C. cuspidata	108	76, 77, 78, 79, 80, 90, 114
	Foetidae	*C. enervis*	60	44, 45, 46
	Hallerianae	*C. halleriana*	52	50, **52**, 54, 56
	Laxiflorae	*C. blanda*	36	34, 36
	Limosae	*C. limosa*	58	56, 61, **64**
	Lupulinae	*C. grayi*	52	52, 64
	Microrhynchae	*C. aterrima*	52	54
		C. atrata	54	52, **54**, 56, 48, 49, 50, 51, 52
		C. norvegica	54	54, **56**, 66
		C. parviflora	54	54
		C. buxbaumii	100	100, 105, 106
		C. adelostoma	106	106
	Mitratae	*C. caryophyllea*	62	62, 64, 66, 67, 68, 69
		C. umbrosa	62	62, 66
	Montanae	*C. pensylvanica*	36	36
	Obtusatae	*C. obtusata*	52	52
	Paniceae	*C. livida*	32	**32**, 50, 52
		C. panicea	32	32
		C. vaginata	30, 32	26, 27, 287, 29, 30, 31, **32**
	Petraeae	*C. argunensis**	42	
	Phacocystis	*C. acuta*	82	74, 82, 83, 84, 85, 86, 86, 104
		C. aquatilis	74	74, **76**, 84
		C. bigelowii subsp. *dacica*	68	68, 69, **70**, 71
		C. bigelowii subsp. *rigidioides*	70	62
		C. cespitosa	72	68–74, 78, 79, 80
		C. elata	74	74, 75, **76**, 77, 80
		C nigra	84	74, 80, **84**, 86, 88
		C. rufina	86	60, **86**
	Porocystis	*C. pallescens*	64	58, 62, **64**
	Rhynchocystis	*C. pendula*	58	**58**, 60, 62
	Scitae	*C. flavocuspis* subsp. *krascheninnikovii**	64	
	Secalinae	*C. hordeistichos*	58	54, 55, 56, 57, 58, 59, 60
	Spirostachyae	*C. distans*	70	68, 69, 70, 71, 72, 73, **74**
	Sylvaticae	*C. strigosa*	66	**66**
		C. sylvatica	58	**58**
	Tumidae	*C. melanostachya*	54	48, 76
		C. riparia	72	72
	Vesicariae	*C. lurida*	60	64, 66
		C. pseudocyperus	66	66
		C. rostrata	70	**60**, 70, 72, 74, **76**
		C. saxatilis	80	40, 52, 60, 78, **80**

Chromosome number stability is typical of some species of the subgenus *Vignea*, e.g. *Carex brizoides* (2n = 58), *C. capitata* (2n = 50), *C. davalliana* (2n = 46), *C. dioica* (2n = 52), *C. disperma* (2n = 70), *C. maritima* (2n = 60), *C. pauciflora* (2n = 76), *C. praecox* (2n = 58) and *C. remota* (2n = 62) and in those of the subgenus *Carex*, e.g. *C. adelostoma* (2n = 106), *C. alba* (2n = 54), *C. depauperata* (2n = 44), *C. extensa* (2n = 60), *C. fuliginosa* (2n = 40), *C. hostiana* (2n = 56), *C. panicea* (2n = 32), *C. pseudocyperus* (2n = 66) and *C. tomentosa* (2n = 48, see Roalson 2008). Unstable chromosome numbers (more than five cytotypes) are recorded for some species, e.g. *Carex acuta*, *C. aquatilis*, *C. arenaria*, *C. bigelowii*, *C. bohemica*, *C. brunnescens*, *C. canescens*, *C. conica*, *C. elata*, *C. flava*, *C. lasiocarpa*, *C. limosa*, *C. nigra*, *C. ovalis*, *C. pallescens*, *C. rostrata*, *C. rupestris* and *C. vesicaria*. Regardless of the changes in chromosome number commonly associated with the fission or fusion of holokinetic chromosomes, which are typical of the whole genus, cytotype variations in particular infrageneric taxa differ significantly. Taxa with invariable cytotypes are present in the sections *Ammoglochin*, *Paniceae* and *Acrocystis*, whereas taxa with large intraspecific cytotype variations belong to the sections *Ovales*, *Phacocystis* and *Vesicariae* (Roalson 2008, Table 1). Some of the karyological variation in the sections *Phacocystis* and *Vesicariae* may be due to frequent interspecific hybridization, whereas in the karyologically invariable sections, *Acrocystis*, *Ammoglochin* and *Paniceae,* interspecific hybridization does not occur (cf. Egorova 1999). In the section *Ovales*, where hybridization is not reported, changes in chromosome numbers are generated via chromosomal rearrangement (Hipp et al. 2010). In karyologically variable species, new cytotypes may be generated by the hybridization of cytotypes within a species, as documented by Cayouette & Morisset (1985) for *Carex subspathacea* (section *Cryptocarpae*) and by Escudero et al. (2008) for *C. laevigata* (section *Spirostachyae*). Moreover, intermediate chromosome numbers are recorded by Cayouette & Morisset (1985) for some interspecific hybrids within the sections *Phacocystis* and *Cryptocarpae*.

The range of variation in chromosome numbers detected in the taxa studied (2n = 18–108) encompasses almost all of the known variation of 2n = 12–124 within this genus (Roalson 2008). However, the variation in chromosome numbers differs between the subgenera *Vignea* (majority of records are for 2n = 56 to 2n = 68, Roalson 2008) and *Carex* (Table 1, Fig. 3), as described previously by, e.g., Tanaka (1949) and Hendrichs (2004a, b). The variation in chromosome numbers corresponds with that of the DNA content of these subgenera (Hralová et al. 2007). The cytotypes in which 2n is higher than 124 in *Carex* are not based on individual plants but on occasional karyological irregularities that occur in individual cells. The highest chromosome number reported by Roalson (2008: 213) is based on an unreduced pollen grain of *C. aquatilis* (n = 83, Cayouette & Morisset 1986b). Similarly, unreduced pollen is recorded for *C. podogyna* (n = 76, Tanaka 1941), *C. recta* (n = ca 72, Cayouette & Morisset 1986a) and the hybrid *C. canescens* × *C. lachenalii* (n = 58, Toivonen 1981). In addition to the meiotic chromosome counts, a chromosome number of 2n = 148 was recorded in a tetraploid cell of the "regular" diploid (2n = 74) hybrid *Carex aquatilis* × *C. paleacea* by Cayouette & Morisset (1985). The origin of the number n = 68 (Tanaka 1949: 27) in the subgenus *Vignea* remains unclear (cf. Bolkovskikh et al. 1969).

The genome sizes of species of *Carex* are very small relative to that of other angiosperms (Bennett & Leitch 2005) and the C_x values (Greilhuber et al. 2005: monoploid genome size) encompass a 7.7-fold range between 0.15 pg and 1.18 pg (Nishikawa et al.

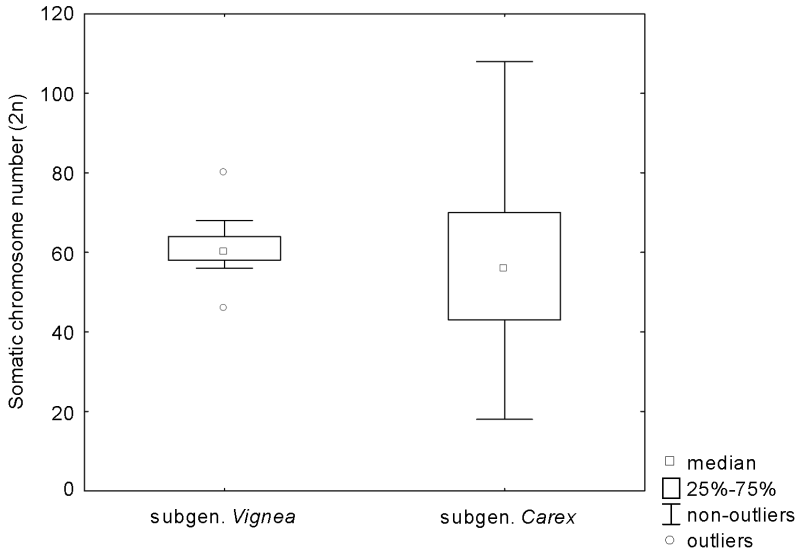

Fig. 3. – Comparison of the variation in chromosome numbers between the subgenera *Vignea* and *Carex* based on the samples analysed in the present study.

1984). However, variation in the ranges in genome sizes differ strongly between the subgenera, whereas in the subgenera *Vignea* and *Carex*, they vary 1.5-fold and 6.85-fold, respectively (Hralová et al. 2007). These findings suggest that either polyploidy and/or amplification of repetitive DNA may be involved in karyotype evolution, particularly in the type subgenus (i.e. in the core *Carex* clade *sensu* Waterway et al. 2009).

Polyploidization is very rare in *Carex*. The chromosome data, which are supported by estimates of the DNA content (I. Hralová et al., unpublished), indicate that polyploidy occurs within the section *Digitatae*; species with a chromosome number of 2n = 70 (*C. macroura* from the Czech Republic, *C. callitrichos*, *C. lanceolata*, and *C. rhizina*) have twice the DNA content of those with 2n = 35 (*C. humilis* and *C. macroura* from the Far East of Russia). Other evidence of polyploidy in the section *Digitatae* is provided by Tyler (2003), who found an isozyme pattern in *C. rhizina* that could be interpreted as fixed heterozygozity and thus supports the allopolyploid origin of this species (with respect to the absence of apomixis in the genus as a whole). In other species of the section *Digitatae* (sensu Egorova 1999), incongruent numbers of 2n = 48 were recorded in *C. digitata* and 2n = 46 in *C. quadriflora*. The results for these two "karyologically delimited" groups are consistent with those obtained for two of the three separated clades by Hendrichs et al. (2004b) within the polyphyletic section *Digitatae* (sensu Egorova 1999, see Table 1).

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Souhrn

Chromozomové počty byly zjištěny u 95 druhů ostřic (*Carex*) pocházejících ze 42 sekcí (Egorova 1999, Ball & Reznicek 2002) převážně z České republiky, dále z Rakouska, Bulharska, Kanárských ostrovů, Kapverd, Maďarska, Itálie, Norska, Ruska, Slovenska, Švédska. Kolekce byla doplněna o severoamerické druhy ostřic pěstované v botanických zahradách v České republice. První údaje o počtu chromozomů byly zjištěny u taxonů *Carex argunensis* (2n = 42), *C. callitrichos* (2n = 70), *C. campylorhina* (2n = 58), *C. flavocuspis* subsp. *krascheninnikovii* (2n = 64), *C. paniculata* subsp. *hansenii* (2n = 64), *C. pallida* (2n = 58), *C. quadriflora* (2n = 46) a *C. xiphium* (2n = 56). Poprvé byly také zjištěny počty chromozomů z evropské části areálu druhu *Carex obtusata* a ze středovevropské části areálů druhů *C. chordorrhiza*, *C. otrubae*, *C. rhizina* a *C. strigosa.* V souladu s dříve publikovanými počty chromozomů byla potvrzena stabilita chromozomových počtů druhů ze sekcí *Ammoglochin*, *Paniceae* a *Acrocystis.* Naopak variabilní počty chromozomů jsou časté u druhů ze sekcí *Ovales*, *Phacocystis* a *Vesicariae* a mohou být výsledkem časté hybridizace. Zjištěný rozsah chromozomových počtů (2n = 18–108) pokrývá téměř celou karyologickou variabilitu v rodu publikovanou dosud v literatuře (2n = 12–124), přičemž rozsah karyologické variability je v podrodu *Carex* mnohem větší než v podrodu *Vignea*, v němž většina chromozomových počtů leží mezi hodnotami 56 a 68. Polyploidizace je v evoluci rodu *Carex* poměrně vzácným jevem. Na základě námi zjištěných chromozomových počtů a dosud nepublikovaných měření obsahu jaderné DNA diskutujeme její roli v evoluci taxonů ze sekce *Digitatae*. U dvoudomého druhu *Carex davalliana* byl v karyotypu samčích i samičích rostlin zjištěn jeden pár výrazně větších chromozomů, které by mohly představovat předstupeň vzniku pohlavních chromozomů. 51 druhů ostřic, pro které byly zjištěny počty chromozomů, reprezentuje 60% druhového bohatství rodu v rámci České republiky.

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