Cyperus eragrostis – a new alien species for the Czech flora and the history of its invasion of Europe

***Cyperus eragrostis* – nový adventivní druh české květeny a historie jeho invaze v Evropě**

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Cyperus eragrostis Lam. was first recorded in the Czech Republic in an empty water reservoir at Jablonec nad Nisou (N Bohemia) in 1999. In this study, herbarium specimens of *C. eragrostis* in large herbaria in the Czech Republic were revised and the invasion of Europe by this species was reviewed. A brief description of *C. eragrostis* is given, distribution map of the temporal course of its invasion is presented and the species' ecology in Europe characterized. Accompanying vegetation and results of the analyses of soil from the site are described. How the plant reached this locality remains unknown. The occurrence was only ephemeral as the only tussock was destroyed when the water reservoir was refilled.

K e y w o r d s : *Cyperus eragrostis, Cyperaceae*, alien species, casual, Czech Republic, Central Europe

Introduction

In September 1999, I found a plant of *Cyperus eragrostis* Lam. growing on the exposed bottom of a water reservoir in Jablonec nad Nisou (N Bohemia). It is the first record of this species in the wild in the Czech Republic (Kubát et al. 2002, Pyšek et al. 2002). It consisted of one tussock with about 20 flowering (fruiting) culms. The site is located in an urban area, Mšeno nad Nisou (50°44'19"N, 15°10'28"E, CEBA grid 5256c), in the Lužická kotlina valley, which in the NE borders on the Jizerské hory Mts. The water reservoir consists of three parts with a total area of 42 ha and a capacity of 2.8 mil. m^3 water, and is used for summer recreation. Maximum water depth is 15 m and the reservoir is located at an altitude of 507 m a.s.l.

The herbarium specimen was revised by V. Grulich (Masaryk University, Brno, CR) and G. C. Tucker (Eastern Illinois University, Charleston, USA).

Material and methods

In October 1999, two soil samples were collected from the site at a depth of 0–10 cm. The samples were each placed in an Erlenmeyer flask and mixed with deionized water (ratio 1 : 5). After 30 minutes of shaking, the contents of the flask were filtered and the pH determined using a glass electrode (HI 9321 pH-meter). Conductivity was measured using a GRYF 106, and total carbon and total nitrogen content using a CHN analyser Carlo Erba NC 2500 (see Ehrenberger & Gorbach 1973 for methods). The pH and conductivity of each soil mixture were measured twice.

In May 2002, 264 seeds of *C. eragrostis* were germinated at room temperature on filter paper in a Petri dish.

To obtain information on the occurrence of *C. eragrostis*, five public herbaria (PR, PRC, BRNM, BRNU, and GLM) were examined. Specimens from South and North America, and Europe (Portugal, Spain, France, Italy, Montenegro, Germany, Czech Republic) were seen (see Appendix 1). Nine specimens lacked information on the locality where found and two were incorrectly identified (as *C. brizaeus* or *C. pulcher*). Two specimens were not revised with certainly because seeds were not ripe. This research supplemented the information on the distribution of *C. eragrostis* obtained from the study of herbarium records reported in the literature, which was based on the following sources (only reliable and original sources were used): Portugal (Pereira Coutinho 1939: 121), Spain (Bubani 1901: 191, Lázaro 1920: 64, Merino 1984: 15, Sánchez-Rodríguez 1986: 42, Aparacio & Martín 1987: 239, Fernández-Lopez et al. 1991: 25), France and Belgium (Camus 1888: 282, Nyman 1889: 317, Coste 1906: 463, Bonnier & de Layens 1911: 324, de Litardière 1948: 190, 1953: 131, 1955: 19, 1962: 179, des Abbayes et al. 1971: 947, Guinochet & de Vilmorin 1978: 1057, de Fillips 1980: 286, Corillion 1981: 587, de Langhe et al. 1983: 727, Gamisans 1985: 113, Jeanmonod & Deschâtres 1990: 269, Girerd 1991: 96), England (Ellis 1983: 185, Fitter et al. 1984: 124, Clement & Foster 1994: 372, Wade et al. 1994: 212, Stace 1997: 801), Italy (Pignatti 1982: 696), Germany[1] (Hegi 1909: 10, Bonte 1930: 175, Hegi 1939: 8, Schultze-Motel 1966: 83 & 419, Mang & Walsemann 1984: 101, Caspers 1987: 143 [under name *C. flavescens*], Meierott 1991: 99, Wisskirchen & Haeupler 1998), Switzerland (Camus 1888, Bonnier & de Layens 1911, Lauber & Wagner 1996b: 1266, Brodtbeck et al. 1999: 802), the Netherlands (Heukels 1927: 181, Kloos 1939, van Soest et al. 1956: 40–41), Hungary (Jávorka 1925: 122), Turkey (Kükenthal 1935–1936: 179), and Montenegro (Karaman 1998: 79).

Names of taxa and syntaxa follow Moravec et al. (1995), abbreviations of public herbaria follow Holmgren et al. (1990). A voucher herbarium specimen from Jablonec nad Nisou is preserved at PRC.

Nomenclature and description

Cyperus eragrostis Lamarck in J. Lamarck & J. Poiret, Tabl. Encycl. 1: 146. 1791.

S y n o n y m s : *C. declinatus* Moench, Meth.: 317. 1794; *C. vegetus* Willd., Sp. Pl. 1: 283. 1797; *C. monandrus* Roth, Catalecta Bot. 1: 3. 1797; *C. ochrocephalus* Steud. in Flora 25: 601. 1842; *C. prionotropis* Steud. in Flora 25: 601. 1842; *C. glaber* Pourr. ex Willk. & Lange, Prodr. Fl. Hisp. 1: 138. 1870; *C. gracilis* Buchanan in Trans. & Proc. New Zealand Inst. 3: 210. 1871; *C. buchananii* Kirk in Trans. & Proc. New Zealand Inst. 10: app. 41. 1878; *C. serrulatus* Watson in Proc. Amer. Acad. Arts 17: 382. 1882; *C. vegetus* α. *obtusangulus* Kuntze in Rev. Gen. Bot. 3: 334. 1898; *Eucyperus vegetus* Palla in Allg. Bot. Z. Syst. 7: 210. 1901.

Description of *C. eragrostis* (based on Schultze-Motel 1966: 83, Casper & Krausch 1980: 309–310, de Fillips 1980, Sell & Murell 1996: 79): Glabrous, perennial, caespitose, rhizomatous herb with several culms (Fig. 1). Culms (25–) 40–60 (–90) cm high, obtusely trigonous, smooth. Rhizomes short and thick. Leaf-blades dark green, flat or v-shaped, acute, linear, 4–10 mm wide, shorter or longer than inflorescence, margins and keels of

[1] Hoffmann (1994: 66) reported the occurrence of *C. eragrostis* in Germany as a consequence of global climate change.

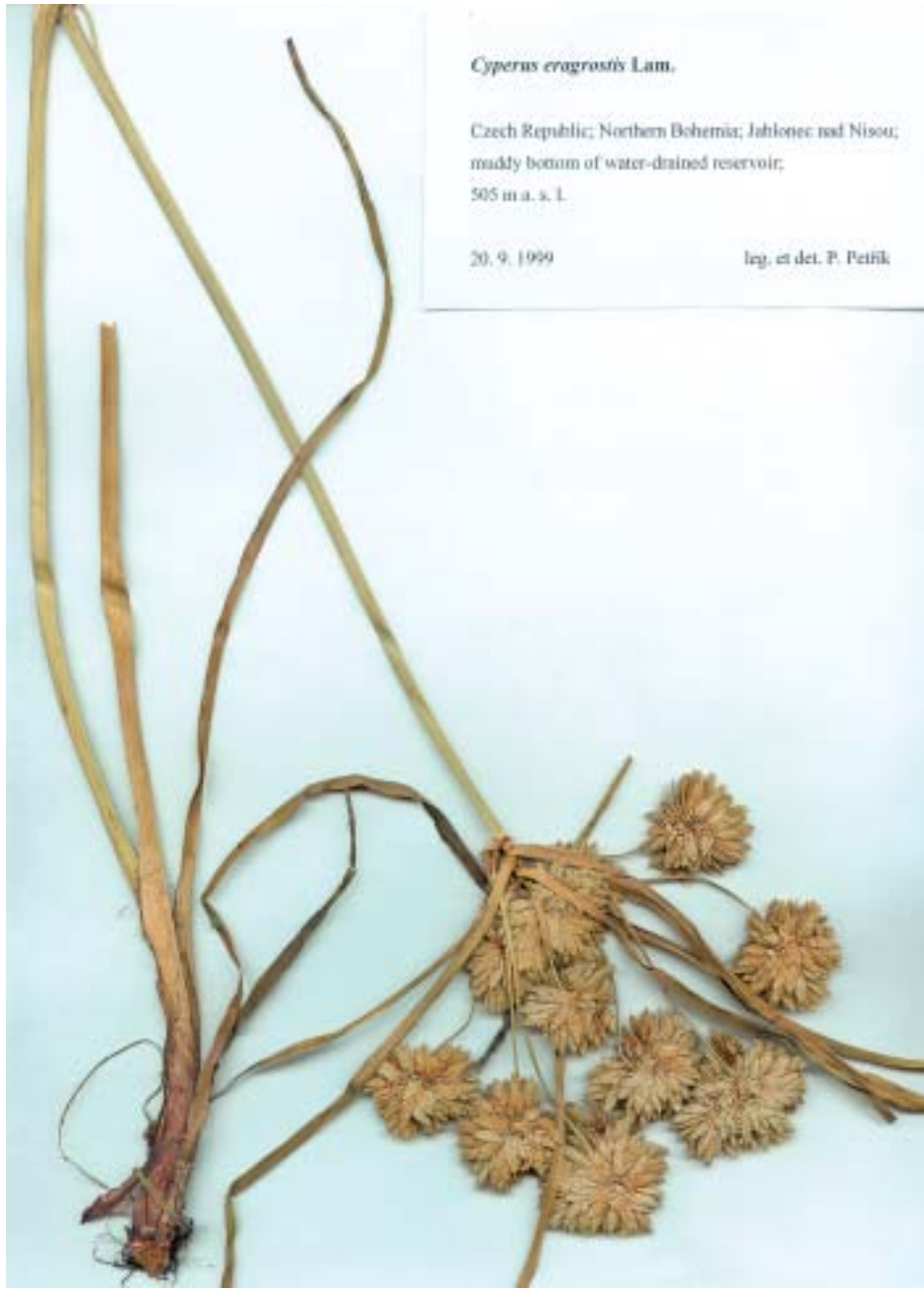

Fig. 1. – Herbarium specimen of *Cyperus eragrostis* from Jablonec nad Nisou (40% of real size).

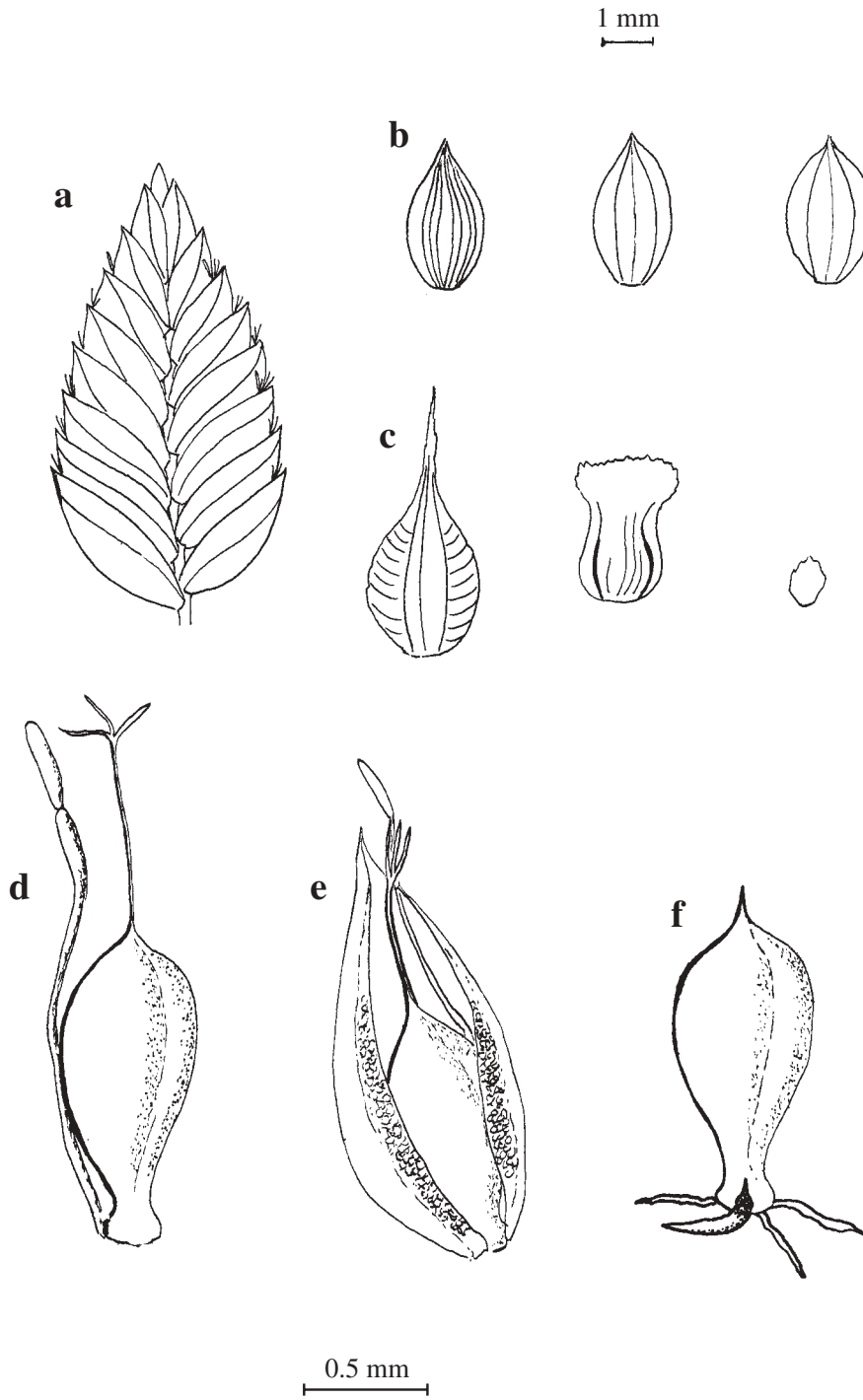

Fig. 2. – Floral organs of *Cyperus eragrostis*: a) spikelet, b) glumes, c) bracts, d) achene with style and stamen, e) achene in glume, f) germinating achene (orig. Petřík).

leaves finely serrate. Leaf-sheaths purple-brown. Inflorescences simple or compound with an umbel composed of 5–10 lateral branches (rays). Each ray bears in the axil a leaf-like sheathless bract and is terminated by one or more yellow-green globose heads, (1–) 2 (–4) cm in diameter. Spikelets densely crowded, compressed, 5–12 mm long and 3 mm wide, ovoid-oblong, subacute, with 14–30 gynaecandrous flowers. Floral scales 2.0–3.3 mm long and 1.0–1.5 mm wide, ovate, membranaceous, light to purple-brown, keel green and tip slightly recurved (Fig. 2). Stamen[2] 1, about 3.5 mm long. Style ± 1.5 mm long, with 3 stigmas. Achenes obtusely trigonous, obovoid, 1.0–1.3 mm long and 0.5–0.8 mm wide, base stipitate and apex apiculate. Achene surface finely ornamented, pale to dark brown.

Native and secondary distribution

Cyperus eragrostis is native to South America. Bryson et al. (1996: 507–508) report the species from Argentina, Bolivia, Brazil, Chile, Peru (cf. also Brako & Zarucchi 1993: 393), Surinam, Uruguay, Juan Fernández Islands and Easter Island (former Isla de Pascua). In North America the species was introduced into Canada (British Columbia), California, Louisiana, Mississippi, New Jersey, Oregon, Pennsylvania, South Carolina, Texas, and Washington, and probably also Alabama (Coste 1906, Munz & Keck 1963: 1425, Shetler & Skog 1978: 180, Bryson & Carter 1994: 174–175, Tucker 1994: 186, Bryson et al. 1996, Kartesz & Meacham 1999). According to Tucker (1992: 1139), it is also present in Mexico. Denton (1978) published the distribution map of *C. eragrostis* in the Americas. Adventive occurrences are recorded for Tahiti and Cape Land (Kükenthal 1935–1936), New Zealand (Healy & Edgar 1980: 186, Johnson & Brooke 1989: 96), Queensland in Australia (Sharpe 1986 sec. Clement & Foster 1994), Canary Islands, Azores and Madeira (Coste 1906, Hohenelster & Welß 1993: 311). Egorova (2000: 10) recently reported it from the W Caucasus.

The mode of introduction of *C. eragrostis* into Europe is unknown. It is included in European handbooks and encyclopaedias on gardening and house plants (Rataj & Hejný 1968: 233, Grounds 1979: 190, Walters et al. 1984: 115). The map of the secondary occurrences of *C. eragrostis* in Europe based on revised specimens and information in the literature is presented in Fig. 3. The earliest recorded occurrence in Europe is for Hamburg (1854), although even older reports exist for the 1840s (Nyman 1889). The species is still present in Hamburg (Mang & Walsemann 1984, Wisskirchen & Haeupler 1998). Earliest records for N Spain (from 1857), W England (1876), Portugal (1877), the Netherlands (1913), Switzerland and Hungary (1914), Montenegro (1915) and NW Italy (1934) followed that for Hamburg. The presence of the species in Montenegro was confirmed in 1994, nearly 80 years after and without knowing it had been previously recorded (V. Karaman, in litt.). However, some early records, such as those for Tahiti, Cape Land and Turkey (Kükenthal 1935–1936) have not been confirmed recently.

The increase in the cumulative number of herbarium specimens in Europe gives an indication the dynamics of the invasion (Fig. 4). Several periods of acceleration occurred after an initial slow increase that lasted until the end of 19th century; the first was from 1906 to 1938, the second started in the 1970s and is still continuing. Most records are from 1916 (6), 1915 and 1913 (5), 1925 and 1998 (4). There were several longer periods when no re-

[2] That it has three stamens cited by Lauber & Wagner (1996a: 158) is wrong.

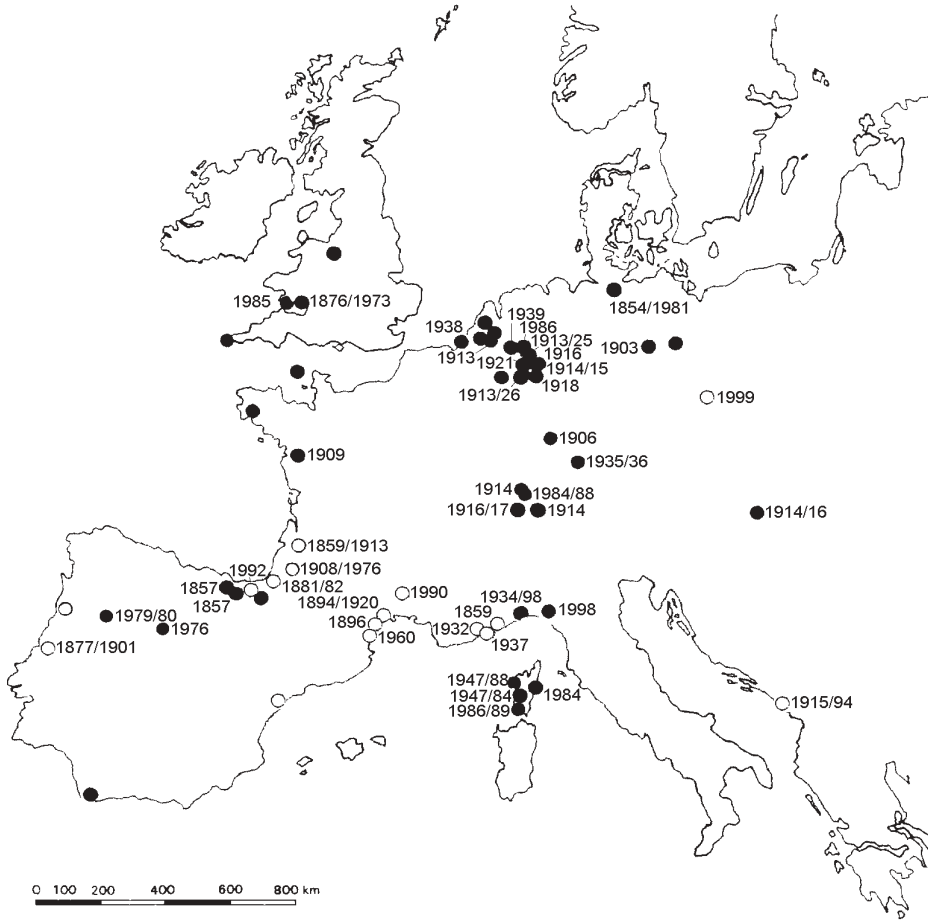

Fig. 3. – Map of the distribution of *Cyperus eragrostis* in Europe based on references cited in text. The complete points are for published data and the open ones are for documented voucher herbarium specimen. The first number indicates the year when it was first found, the second the year it was last observed. The points without a number are of uncertain date.

cords were reported: 1859–1876 (18 years), 1938–1947 (10 years) and 1960–1973 (14 years). The second period is associated with the 2nd World War, but the other two cannot be easily explained.

Occurrence in the Czech Republic

Cyperus eragrostis was first recorded from the present territory of the Czech Republic in the list of plants growing in the botanical garden at Smíchov, Prague (Kosteletzky 1844: 44). The plant was grown in a greenhouse in winter and outdoors in summer. The list of herbarium specimens of plants collected in Bohemia is given in Appendix 1. Nowadays the plant is cultivated in the Botanical Garden of Charles University, Prague.

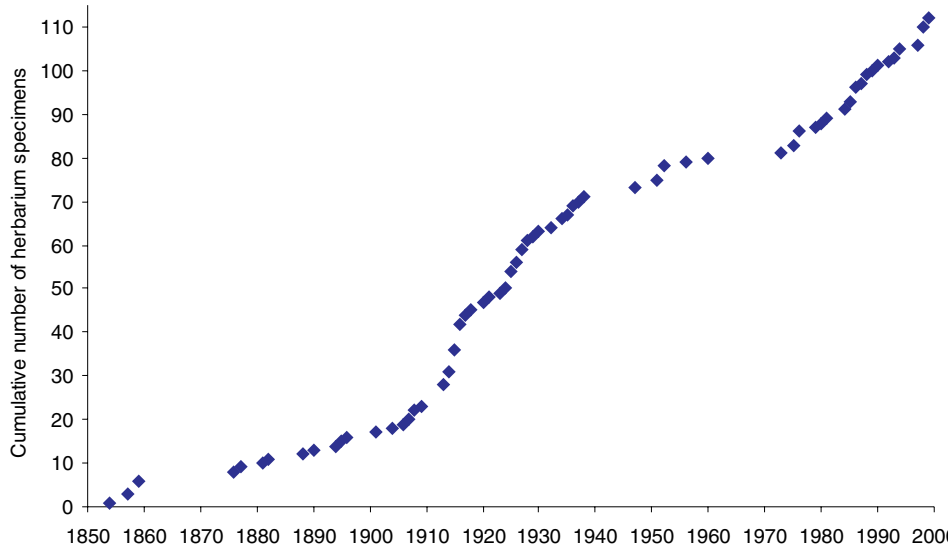

Fig. 4. – Historical trends in the invasion of Europe by *Cyperus eragrostis* (112 records were used, for explanation see text).

Ecology

In its primary distribution, *C. eragrostis* is reported from various habitats. In the Amazonian region, it grows in muddy and disturbed sites along rivers (Brako & Zarucchi 1993). Similar habitat conditions are typical of many adventive localities, which are mostly temporary. This species is also reported from seashores, riverbanks, ponds, roadsides and ditches, rough and wet grounds, muddy savannahs, moist open fields, drainage ditches, stone-pits, edges of railtracks, etc. In Europe, it is mostly found in the oceanic and SW parts, along the lower courses of rivers from 0 to 500 (–550) m a.s.l., in estuaries and on the banks of large rivers (18 reports), roadsides or rail tracks (11), wet meadows (5), and one report is from a stone-pit in serpentine (V. Karaman, in litt.). Some authors describe the communities in which it occurs as *Phragmito-Magnocaricetea* (Guinochet & de Vilmorin 1978, Merino 1984, Sánchez-Rodríguez 1986) and *Bidentetea tripartitae* (Mang & Walsemann 1984, Sánchez-Rodríguez 1986) on muddy or sandy fluvisols.

At Jablonec nad Nisou, Bohemia, one tussock was found growing in badly drained black-grey clayish mud smelling of H_2S (indicating anoxic processes) on the exposed bottom of a water reservoir at 505 m a.s.l. The pH was 5.3 and conductivity ± 700 µS/cm. The total content of carbon was 6.7% and nitrogen 0.5%. That is, the sediment was slightly acidic, with a high amount of free ions, low C/N ratio, and well supplied with nitrogen. Surrounding vegetation consisted of species of the *Agropyro-Rumicion crispi*, *Bidention tripartitae*, *Eleocharition ovatae*, *Littorellion uniflorae*, *Nanocyperion flavescentis*, *Oenanthion aquaticae*, and *Phragmition communis* alliances, including *Alisma lanceolatum*, *A. plantago-aquatica*, *Alopecurus geniculatus*, *Bidens cernua*, *B. frondosa*,

B. radiata, *B. tripartita*, *Carex bohemica*, *C. hirta*, *Chenopodium polyspermum*, *C. rubrum*, *Echinochloa crus-galli*, *Eleocharis acicularis*, *E. ovata*, *E. palustris*, *Gnaphalium uliginosum*, *Juncus articulatus*, *J. bufonius*, *J. bulbosus*, *J. compressus*, *Limosella aquatica*, *Peplis portula*, *Phragmites australis*, *Plantago major* subsp. *intermedia*, *Potentilla norvegica*, *Ranunculus flammula*, *R. repens*, *R. sceleratus*, *Rorippa palustris*, *R. sylvestris*, *Rumex crispus*, *Sagina procumbens*, *Sparganium erectum*, *Stellaria uliginosa*, and *Typha latifolia* (see Petřík 2002 for a more detailed information on flora and vegetation of the dam). This is similar to the ecological conditions in Elbe estuary in Hamburg (Mang & Walsemann 1984).

Possible modes of introduction

The closest occurrence of *C. eragrostis* to the Czech locality ever reported is Berlin, i.e. 260 km from Jablonec nad Nisou (Hegi 1939); the most recent one is Hamburg, almost 500 km away (Mang & Walsemann 1984). Possible explanations for the occurrence of *C. eragrostis* near Jablonec nad Nisou are: (1) escape from cultivation; (2) epizoochory; and (3) other means, e.g. with building material, fishery or as a weed. The first seems to be the most likely as this species is often planted for its decorative value and the reservoir is located close to an urban area. According to Tucker (1992) some occurrences in North America are of this origin. Recently, it is also cultivated in the Czech Republic, in the Botanical Garden of Charles University, Prague (for historical data see Appendix 1). However, no cultivated specimens were found in the surroundings of the reservoir but seed of *C. eragrostis* is available (sold under the wrong name *C. glaber*) from the Černý garden centre in Jaroměř, E Bohemia. Epizoochory is not likely as the reservoir is not a migration route for birds. The only birds regularly seen are a few mute swans (*Cygnus olor* Gmelin) and mallards (*Anas platyrhynchos* L.). The fruits of *C. eragrostis* are not adaptated for transportation by birds. Nonetheless, long-distance dispersal by birds would explain the occurrence of some other rare species at this locality, such as *Bidens radiata* and *Limosella aquatica*. The possibility of introduction of this species by birds into the Channel Islands from N France is mentioned by Clement & Foster (1994). Intentional plantation is also unlikely as the site is not easily accessible. Introduction with special building materials imported from Germany during the construction of the dam at the beginning of the 20th century (Simm et al. 2001: 30) cannot be excluded. *C. eragrostis* is often mentioned as a weed introduced with oil plants, wool or grass seed (Jávorka 1925, Bonte 1930, Stace 1997). This cannot be excluded, as there is a well developed industry in the region. The reservoir is also used as a fishery, which may have been important in facilitating the transport of the seeds of wetland plants.

The plant found at Jablonec nad Nisou was very vigorous and fertile and produced ca. 1460 spikelets, i.e. ca. 15 000 seeds. The germination rate of these seeds sown after more than two years, was 48%. Rataj & Hejný (1968) reported a high germination rate and the plentiful production of vegetative organs. Despite its high vitality and fertility, a successful invasion of the Czech Republic by *C. eragrostis* is unlikely as at other European localities this species only has persisted for a short time. In autumn 2000, the reservoir was again filled with water, which made further observations impossible.

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Souhrn

Na obnaženém dně přehradní nádrže v Jablonci nad Nisou jsem v roce 1999 nalezl jediný trs druhu *Cyperus eragrostis*. Je to první známý a dočasný výskyt tohoto druhu v České republice (Kubát et al. 2002, Pyšek et al. 2002). Původní je *C. eragrostis* v Jižní Americe, odkud byl zavlečen i na jiné kontinenty: mimo Severní Ameriku také do Afriky, Austrálie a Nový Zéland, Ruska a konečně i do Evropy. Druh byl zaznamenán (ať v minulosti, či recentně) především v atlantské, jihovýchodní, méně již ve střední Evropě a výjimečně dále na východ na území celkem 13 států (nyní včetně Česka). Obr. 3 přináší orientační mapu známých výskytů druhu *C. eragrostis* v Evropě. Odtud je znám s jistotou od roku 1854 z Hamburku. Na některých evropských lokalitách byl nalézán opakovaně a např. v okolí hamburského přístaviště se udržuje až do současnosti. Ve svém přirozeném areálu je *C. eragrostis* vázán především na bahnitá místa v okolí větších řek a pobřeží. Podobný charakter mají i nepůvodní stanoviště, kde se může šířit např. v bahnitých silničních příkopech. Jako hlavní způsob zavlečení se v literatuře udává kromě avichorie také člověkem zajišťovaný transport společně s olejninami, vlnou či travním osivem, nebo zplanění z kultur.

S jinými druhy lze *Cyperus eragrostis* jen stěží zaměnit díky jeho vytrvalosti (má krátce plazivý oddenek) a charakteristickému květenství, které na konci svých větévek nese 1 až několik zelenožlutých (1–) 2 (–4) cm širokých kulovitých klubek četných, výrazně smáčknutých klásků. Také tvar nažky je dobrým znakem: je 3hranná, obvejcovitá, 1,0–1,3 mm dlouhá a 0,5–0,8 mm široká, s krátkým zobánkem a stopkatou bází.

Vzhledem k většinou dočasné povaze výskytu tohoto druhu jinde a rovněž z důvodu zániku české lokality opětovným zatopením, není další šíření druhu *C. eragrostis* v České republice pravděpodobné.

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Appendix 1. – Specimens revised. Note: uncertain reading is marked by a question mark.

California. Burlingame, San Mateo County, moist open fields, 30 feet (= 9 m a. s. l.) (Rose 1965 BRNM). – California (Černoch 1965 BRNU). **Chile.** Valdivia, in Sümpfen (Buchtien 1888 PR, PRC). – **Peru.** "Peruvia" (PR). **Argentina.** Quilmes (Rodriguez 1912 PR). **Brasil.** Pôrto Alegre, Rio Grande do Sul, am Graben bei Saõ Zoaõ (Reineck 1897 PRC). **France.** Gironde, fossés des marècages de la rive gauche de la Garrone á Bacalan près Bordeaux (Motelay 1859 PRC) [two sheets]. – Hérault (Coste 1859 PRC). – Gironde, chemin de la borde près de Bordeaux, dans les fossés voisins de la Gironde (Clavaud & Motelay 1859 PRC). – Bayonne, parties marécageuses de l'ancien arsenal maritime près de l'Adour (Blanchet 1881 PRC). – Bayonne (Blanchet & Pontarlier 1882 PRC). – Lattes Hérault, dans une fossé, près la route de Palavas (Mandon 1894 BRNM). – Sérignan, bords de la bęt (Jorinus 1896 PRC). – Gironde, environs de Bordeaux (Pitard 1904 PR). – Landes ad margines pratorum prope Dax (Neyraut 1908 BRNU, PR). – Bordeaux, fossés de la route de Labarthe (Jeanjean 1913 BRNM, GLM). – Hérault (Neyraut 1920 BRNU). – Cannes, in paludosis prope Théoule (Skřivánek 1932 BRNM). – Alpes maritimes: collines de Juper Cannes (Callé 1937 BRNM). – Pyrénées Orientales, Canet-Plage bei Perpignan, am Gran de Canet, Sumpf am Ufer (Simon 1960 BRNM). – Landes: Vorgelände des Flusses Adour in der Stadt Dax, sumpfiges Oedland, 10 m a. s. l. (Simon 1976 BRNU). – Pied-de-Borne, river Chassezac, muddy shore of artificial river basin with fluctuating water level ± 1.5 m, 550 m a. s. l. (Goetghebeur 1990 BRNM). – Bordeaux (BRNU). **Germany.** Cult. Botanischer Garten zu Görlitz (Barber 1909 GLM). **Spain.** Donostia [San Sebastian], Miramon, zonas encharcadas en pistas forestales, 100 m a. s. l. (Garin 1992 BRNM). – Pamplona (PR). **Portugal.** Coimbra (Abotter 1877 BRNM). – Coimbra, valla da Geria (Moller 1888 BRNM). – Coimbra, auf alluvialen Böden (Ferreira 1901 BRNU, PR, PRC). – Porto (Buchtien BRNM). **Italy.** Varazze, ad viam inter Pero et Stella (Gzesisa? 1934 BRNU). **Montenegro.** Bocche [Boka Kotorska, Gulf of Kotor], Castelnuovo, im Wasserfurchen (Latzel 1915 BRNU). [Probably the earliest find for this country.] **Czech Republic (Bohemia).** Kačina [Castle near the town of Kutná Hora], cult. (Peyl 1846 PR, Peyl 1890? BRNU). – Ex horto botanico (1853 PR). – Čechy, cult. (Veselský 1854 PR).

Revised specimens without locality or incorrectly determined. **PR:** *C. pulcher* [correctly revised as *C. vegetus* by Ph. M. Opiz; J. Chrtek sen. pers. comm.]. – *C. vegetus*, cult., leg. ? – *C. brizaeus* [= *C. eragrostis*], Wichann? – *C. vegetus*, leg. Thermidov? **PRC:** *C. monandrus*. – *C. vegetus* [collected probably by K. B. Presl; J. Hadinec pers. comm.]. – *C. vegetus* [probably cultivated in the old botanical garden in Smíchov, Prague; J. Hadinec pers. comm.]. – *C. vegetus*, in hort. Palemut Heket? [herbarium of J. B. Zahlbruckner, probably from Vienna; J. Hadinec pers. comm.]. – Cunersdorf 25 (Walter). **BRNU:** *C. monandrus* (Petrak). **GLM:** *C. vegetus*, cult. (Steudner).

Not surely revised as *Cyperus eragrostis*. **GLM:** Hort. botan. Gorlic. (GLM) [not matured]. – Hort. botan. Berolin. (GLM) [not matured].