

***EQUISETUM* × *SERGIJEVSKIANUM*, A HYBRID HORSETAIL FROM SIBERIA****<sup>1</sup>C.N. PAGE & <sup>2</sup>I.I. GUREYEVA**<sup>1</sup>Camborne School of Mines, University of Exeter, Tremough, Penryn, Cornwall TR10 9EZ, United Kingdom<sup>2</sup>Krylov Herbarium, Tomsk State University, Pr. Lenina, Tomsk, 634050, RussiaKey words: *Equisetum*, new hybrid, *Equisetum palustre*, *Equisetum pratense*, Siberia, Russia**ABSTRACT**

A new hybrid of *Equisetum* L. - *Equisetum* × *sergijevskianum* C.N. Page et I.I. Gureyeva (*E. palustre* L. × *E. pratense* Ehrh.) - was described originally from herbarium material found by the authors in 2007 in Krylov Herbarium (TK, Tomsk State University). *E. ×sergijevskianum* is the first new hybrid in *Equisetum* to be first found in Russia. Presented here is an expanded study in English, giving diagnostic features of this hybrid, comparison with parental species and other hybrids in *Equisetum* subgenus *Equisetum*, and discussion of distribution and ecology of the parental species. This hybrid occurrence endorses that this parental combination can exist, and we suggest that this hybrid could consequently occur elsewhere within the widely-sympatric portions of the circum-boreal ranges of the two parent species, which includes northern Europe, and especially perhaps Scandinavia and northern parts of the British Isles.

**INTRODUCTION**

In August 2007, an unusual specimen in *Equisetum* L. subgenus *Equisetum* (the ‘deciduous’ horsetails) was found by the authors in the P.N. Krylov Herbarium (TK) of Tomsk State University (Tomsk, Russia). The specimen in question consisted of two cone-bearing shoots, which had originated from Western Siberia, Russia, collected near Tomsk on 21<sup>st</sup> July 1925 by Lidia Sergiyevskaya, Maria Kuminova and Elena Vandakurova. Identity of this pair of shoots had long been attributed to *E. palustre* L., and in 1971 this diagnosis was further modified by A.E. Bobrov (as an annotation on the herbarium sheet), clearly recognising its unusual appearance, as *E. palustre* L. var. *verticillatum* Milde f. *longiramosum* Klinge. Our new (Page & Gureyeva, 2009) analysis of its morphological and anatomical details showed the specimen to be far from being typical *E. palustre*, and that it bore instead a uniquely strong intermediacy between *E. palustre* and *E. pratense*. Both of these species are frequent within the region. This evidence thus supports a modern diagnosis of this specimen as the first ever known hybrid between these two species. This new hybrid, *E. palustre* L. × *E. pratense* Ehrh. was thus accordingly described and named *E. ×sergijevskianum* C.N. Page & Gureyeva (Page & Gureyeva, 2009). This is the first new hybrid in *Equisetum* to be first found in Russia, and is named after the original finder of the specimen, who was a well-known Siberian botanist and head of the P.N. Krylov Herbarium (TK) at Tomsk State University from 1931 to 1970.

The present paper presents a fuller account of this interesting hybrid, in a more

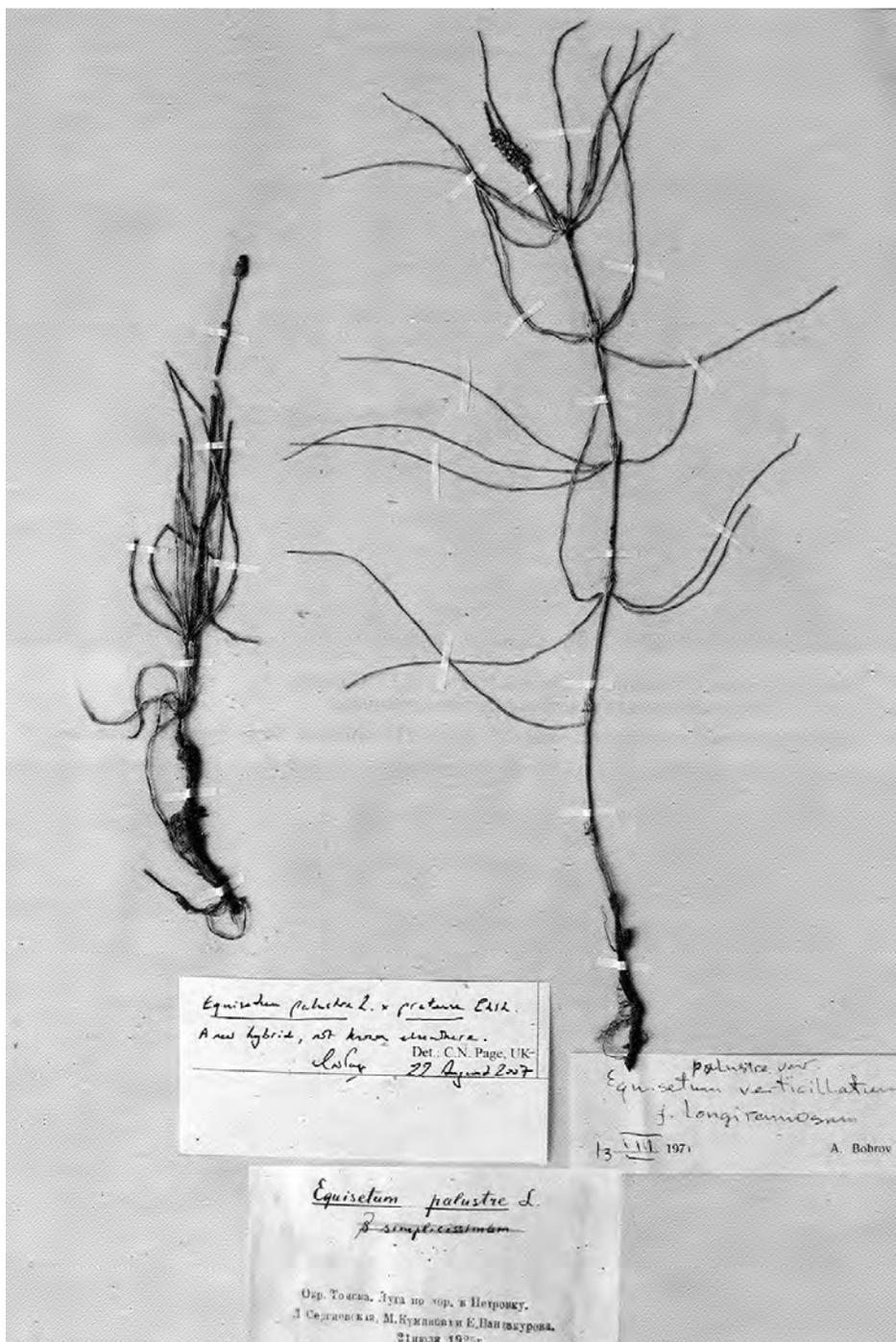


Figure 1. *Equisetum* × *sergijevskianum* C.N. Page et Gureyeva: Whole sheet (holotype, herbarium TK)

accessible form in western literature and to discuss its significance, since, as well as across northern Asia, its two parents are also widespread across both northern Europe and northern North America. This discovery confirms that this hybrid can, indeed, form, and establish sporophyte populations. This hybrid could therefore yet be found elsewhere within the widely-sympatric portions of the circum-boreal ranges of the two parent species, and its description is therefore additionally relevant to studies of both the British and European floras.

### DESCRIPTION AND MORPHOLOGICAL NOTES

*Equisetum* × *sergijevskianum* C.N. Page et Gureyeva (*E. palustre* L. × *E. pratense* Ehrh.), 2009, Sistematičeskie Zametki po Materialam Gerbariâ Imeni P.N. Krylova Tomskogo Gosudarstvennogo Universiteta, 101: 16.

Type description (Page & Gureyeva, 2009): Stems 15-30+ cm, erect, 1.5-2 mm diam., green, with 5-8 grooves and 5-8 ridges; the ridges angular, surface minutely rough; sheaths (excluding teeth) 3.5-5.0 mm, green; teeth 4-5 mm, as many as the ridges, narrowly-triangular, piliferous-acuminate, blackish with wide white scarious margins and acute tips. Branches 1-8 in whorls, spreading to suberect, simple, slender, three angled; ridges acute, the first internode 1.3-2.5 times as short as the corresponding stem sheath; branch sheaths pale, teeth broadly-triangular, acuminate, pale green with narrow scarious margins and top.

Typus: «In the Tomsk adjacents, meadows along the road to Petrovka. 21 July 1925. L.P. Sergijevskaya, M. Kuminova, E. Vandakurova» (Holotypus TK, Figures 1-3).

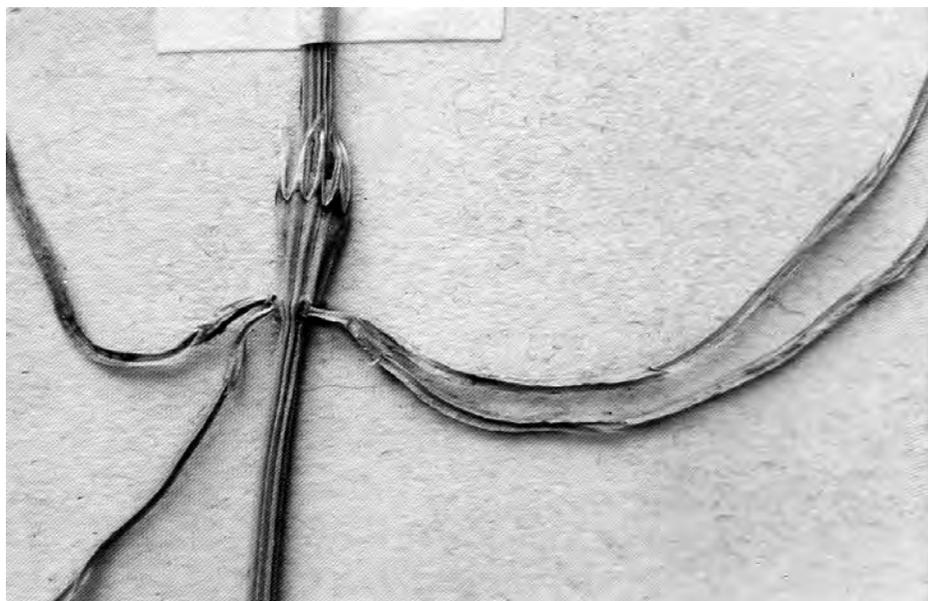
### Morphological notes on the type material

*Equisetum* × *sergijevskianum*, in overall habit, presents a relatively small and slender-structured shoot, with a central, simple, more or less erect stem 15-30 cm in length and a lower-shoot diameter seldom exceeding 1.5-2.0 mm. Approximately the lower two thirds of the stem have nodes each bearing whorls of relatively long (up to 6-10 cm), thin (0.6-0.8 mm in diameter) spreading, ascending to sub-erect simple branches. The number of branches per whorl is (1)4-5(8). Thus incomplete whorls occur mostly on nodes of the lowermost part of the stem. The upper one third of the stem is branch-free, and thus forms a prominent ‘tail-like’ terminal portion to the stem. The resulting general shoot outline of the plant thus varies from narrowly to broadly ovate, and the habit of the plant and the slenderness of both the main shoot and of its long, mostly ascending, branches are prominent initial features, which would be conspicuous and distinctive in the field (Figures 1-3).

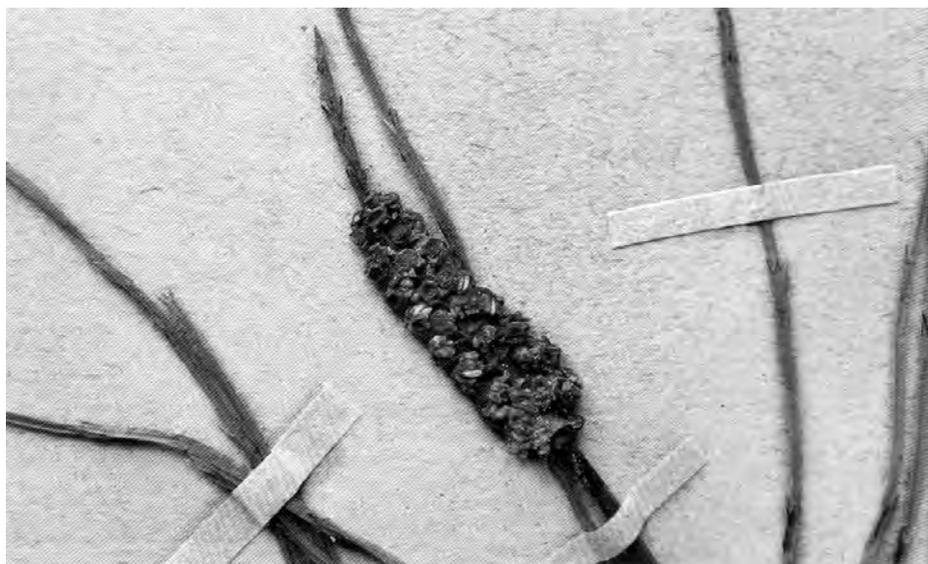
In detail, the main shoot internodes have 5-8 acute ridges and the same number of moderately-deep grooves (notably more so than in *E. palustre*). All of the ridges have a minutely rough surface formed by small erect silica tubercles, which can be seen in low-power (eg. x10) magnification, and are particularly prominent immediately below each node through the lower and middle parts of the main stem. Sheaths are green, slightly bell-shaped (in dried herbarium material) with conspicuous ridges. The numbers of teeth and ridges are the same (5-8) as the number of ridges of the internode below. Sheaths are 2 mm in diameter at the base, 3mm in diameter near the teeth and 3.5-5.0 mm in length (without teeth). The 5-8 teeth to each main-stem sheath are free of one another (ie not conjoined), up to 5 mm in length, from dark brown to blackish, narrowly-triangular, broadest at the base, with wide white filmy margins, narrowing down to a relatively long hair-like acute upper portion with (at least in herbarium material) often a

slightly bent tip.

The branches mostly have a 3-fold symmetry, with 3 sharp ridges covered in bead-like tubercles, with narrow grooves between, each with small lengthwise furrows along the base. Branch sheaths are green, with usually 3 erect, thin, forward-pointing (i.e. non-spreading, non-clasping), acute, pale-green teeth, 1-2 mm long, sometimes with thin hyaline scarious margins and brownish-tipped teeth. The first internode of a branch is



**Figure 2.** *Equisetum* × *sergijevskianum* C.N. Page et Gureyeva: detail of stem sheath and branches



**Figure 3.** *Equisetum* × *sergijevskianum* C.N. Page et Gureyeva: detail of cone

variable in length, but usually 1.3-2.5 times shorter than the adjacent stem sheath.

On the herbarium sheet, both mounted shoots are fertile (Figures 1 & 3), each with a terminal cone on the otherwise green shoots. The cones are 9 and 15 mm in length respectively. The cones are of somewhat variable shape, ovate (and probably immature) on the smaller specimen, to cylindrical (and apparently fully mature) on the larger specimen, the latter of which has a peduncle 1.5-2 cm in length. Each cone carries 9 whorls of sporangia. The cone of the larger specimen has somewhat congruent terminal sporangia. The spores in both cones are incomplete, corrugated and misshapen.

## DISCUSSION

### *Equisetum* × *sergijevskianum* in relation to other hybrids in *Equisetum* subgenus *Equisetum*

Hybrids of horsetails, especially within *Equisetum* subgenus *Equisetum* (the deciduous-shooted horsetails) have now been described in a considerable number of different combinations, particularly within Europe (Page, 1963, 1972, 1973, 1988, 1995, 1997, 2001, 2006; Dines & Bonner, 2002; Lubiensky, 2003, 2010; Page *et al.*, 2007; Page & Gureyeva, 2009; Page, 2012). All characteristically bear a strong morphological intermediacy between the shoot structure of their respective individual parents, and most produce only highly abortive spores, as here, or no cones at all. Significantly, the frequency of recognition of these hybrids, and the number of hybrid combinations known, have increased greatly with time, especially over the last 50 years. Indeed, known hybrids, identified on the basis of morphology, have been subsequently independently supported in their diagnosis on the basis of phenolics (Veit *et al* 1995), molecular characteristics (Brune *et al* 2008) and detailed SEM studies (Lubiensky & Doerken 2013).

The present hybrid, *E. × sergijevskianum*, originally described by us from this single specimen from the vicinity of Tomsk, shows a strong morphological intermediacy between *E. palustre* and *E. pratense*, and there is little doubt that it is a hybrid between these taxa. That in the cones of *E. × sergijevskianum* the spores are incomplete, corrugated and mis-shapen, provides further evidence of hybrid diagnosis of this taxon.

*Equisetum × sergijevskianum* is the fourth described hybrid that has *E. palustre* L. as one parent. Previously described hybrids are *E. × font-queri* Rothm. (*E. palustre* × *E. telmatea* Ehrh.), *E. × dycei* C.N. Page (*E. fluviatile* L. × *E. palustre*) and *E. × rothmaleri* C.N. Page (*E. arvense* L. × *E. palustre*), which are known from many places, at least in Britain (Page, 1997). Like all hybrids of *E. palustre*, *E. × sergijevskianum* shows a strongly intermediate form, in this case of a generally oval outline habit, and ascending branch structure. All the previously described hybrids of *E. palustre* have sterile stems that have a relatively long terminal branchless part. The cones for all hybrids are of intermediate form. All hybrids of *E. palustre* inherit a relatively small number of nodes with relatively long (compared with their width) sheaths. The teeth are fairly broad with scarious margins that become pale when dry. The cones, if present, develop in summer, and tend to be borne atop otherwise green summer shoots.

*Equisetum × sergijevskianum* is also the fourth described hybrid that has one *E. pratense* Ehrh. as one parent. The previously described hybrids are *E. × mildeanum* Rothm. (*E. pratense* × *sylvaticum* L.), which is known from several locations in Scotland and the mountains of Central Europe (Rothmaler, 1944; Page, 1988, 1997; Lubiensky, 2003), *E. × montellii* Hiitonen (*E. × suecicum* Rothm. (*nom. nudum*), *E. arvense* × *pratense*), which has a very limited distribution in far northern Europe according to Hiitonen (1933) and in Eurasia according to Rothmaler (1944, without further location

data), and *E. × mchaffieae* C.N. Page (*E. fluviatile × pratense*), known only so-far from one isolated location in Northern Scotland (Page *et al.*, 2007). Like other hybrids of *E. pratense*, *E. × sergijevskianum* has a slender main stem and branches, and detailed stem internode rough micro-structure that clearly indicates the inclusion of *E. pratense* as one parent. Indeed, the obvious roughness of the stem to the touch is a particular character of hybrids with *E. pratense* or *E. sylvaticum* in their parentage. However, *E. × sergijevskianum*, as in other hybrids of *E. pratense*, shows the tops of the teeth in the sheaths of the main stem, at least in its bottom third, to be long, straight, narrow, black, and fully free of one another. The thin branches are angular with a trihedral cross-section, and are simple and unbranched throughout. These characters, and especially the lack of any secondary branching, confirms *E. pratense* is the other parent and not *E. sylvaticum*.

### ***Equisetum × sergijevskianum* in relation to its parental ranges**

The two parents of *E. × sergijevskianum* are each remarkably widespread in the northern hemisphere, especially at high latitudes, and have large areas of geographic overlap.

*Equisetum palustre* has a range which extends southwards from Arctic Circle and is distributed within Eurasia mainly north of the 40° N parallel, in Europe, from the Pyrenees, northern coast of the Mediterranean Sea, around the Black Sea, in the Caucasus up to the Arctic Circle (eg. Hulten, 1962; Dostal, 1984; Derrick *et al.*, 1987). In Siberia, *E. palustre* is widely distributed within the boreal zone in the North to the Anadyr (Ilyin, 1934; Shaulo, 1988, 2000, 2005; Skvortsov, 2006). It is also present from Mongolia eastwards to Korea and Japan, and southwards to northern and western China, in the latter area occurring as the variety *E. palustre* var. *szechuanense* C.N. Page (Page 1974). In North America it occurs across the temperate zone from the Atlantic Ocean to Alaska, as the variety *E. palustre* var. *americanum* Victorin (Schaffner, 1930; Hauke, 1993). Across at least the western Eurasian part of its range, *E. palustre* is found at a wide range of elevations from habitats below sea level in the far west of Europe up to 2500 m above sea level in the mountainous areas of central Europe (Dostal, 1984; Page, 1988). Its ecological preferences are areas of moist, sandy or marshy soil occurring in waterlogged forests, along the shores of lakes, in marshland, shingle, sandy banks of rivers, thickets of coastal scrub, marine coastal sand dunes, wetland communities with grass, oligotrophic, mesotrophic and eutrophic marshes, especially in northern latitudes (Dostal, 1984; Skvortsov, 2006). In Britain, the species occurs especially in base-rich coastal sand-dune slacks to alpine streambanks, and is an important indicator of cool high level basic flushes (Page, 1988, 1997).

*Equisetum pratense* has a range which is also circumboreal. In Europe it is present mainly north of latitude 48°N, from Central Europe and the Alps, north to Iceland, Northern Scandinavia and Russia, and continues eastwards at similar latitudes to the Far East, to the Arctic regions of Siberia and Chukotka, southward to Mongolia and China (Ilyin 1934; Jalas & Suominen, 1972; Dostal, 1984; Shaulo, 1988; 2000; 2005; Skvortsov, 2006). It is also present at similarly high latitudes in North America from Alaska to Labrador (Hulten, 1962). Across this vast range, it grows on rich substrates in sparse forests, meadows used for haymaking, on the outskirts of fields, roadsides, on banks of rivers and streams, within open woodlands, thickets and in mountain pastures (Dostal, 1984; Shaulo, 2005; Skvortsov, 2006). In Britain it is noted to grow at moderate to sub-alpine altitudes on moist mineral-rich substrates in the northern parts of these islands, especially on the sandy-clayey banks of rivers and streams, on damp, lightly shaded slopes of valleys, and particularly on flushed streamside sands where a high calcium plus

silica mineral content combine (Page, 1988; 1997; 2001).

That the single sheet of *E. × sergijevskianum* was recognised amongst the herbarium sheets of very many (several hundred) of each of these (above) two parent species examined in the herbarium holding the main plant collections for Siberia, seems to attest to it having a reasonable rarity. That this hybrid has not been previously found, would thus seem not to be a result of lack of frequency of its parent species, nor their areas of overlap, which are hence extremely large in northerly latitudes.

### **Possible reasons for rarity of *Equisetum* × *sergijevskianum***

Taking an overview of all hybrids in *Equisetum* subgenus *Equisetum*, some hybrid combinations are considerably vigorous, some are about equivalent in vigour to their respective parents, and a few appear to lack any enhanced vigour. Although, in the field, secondary spread of hybrid material by vegetative means has been reported in some hybrid taxa in sites such as along streams and around lakes (Page, 1987; 2001; Page *et al.*, 2007), most newly-occurring hybrid plants, especially where occurring in great isolation, must certainly represent independent *de-novo* hybridisation events (Page & Barker, 1985; Page 2002; Murphy *et al.* 2012). From the frequency of known individuals of some hybrid combinations (eg. *E. × litorale* in Britain and Ireland) these are clearly multiple, though for this hybrid, both numerous *de-novo* occurrences plus additional vegetative spread, appear to exist, and compound to achieve its comparative abundance (Page 1987; 1997). There seems little doubt that, although there may have been some local spread, that the most likely formation of this new Russian hybrid was from a new, *de novo* hybridisation event, involving local outcrossing between gametes from prothalli of each of the two parents identified.

Furthermore, for a great majority of such hybrid combinations, considerable longevity of the resultant offspring, which as judged by the sizes of colonies sometimes formed, probably varies from decades to centuries. This longevity enables such hybrids to often spread and persist long-enough for them to eventually come to botanical notice and analysis (eg Page, 1973; 1995; 2001). We have no direct evidence of the longevity of this particular hybrid. However, impressions in both the herbarium and in the field made by the authors across large swathes of southern Siberia, are that species of *Equisetum*, including the present parents, are widespread and abundant through a great range of forested, woodland, river margin, streamside and lakeside habitats. In the case of the parents of *E. × sergijevskianum*, fieldwork, both within Britain and Russia, shows that they are moderately ecologically separated in more northern and upland regions in particular, and both *E. palustre* and *E. pratense* can occur nearby along margins of streams, each often spreading into streamside sandy gravels. As established sporophyte plants, both species compete well, and appear to have a high longevity, even within relatively dense vegetation, which can rapidly close around them along streambank habitats.

At present, the further ecology of *E. × sergijevskianum* can only be judged by the description on the known herbarium label “meadows along the road”. However it can be expected that the hybrid grows within these in wet, possibly disturbed, patches of intermediate environmental conditions to those of the parental species. In a wider perspective in relation to the parental ecology, knowing that this hybrid can occur, other sites in which it might be especially sought include, we suggest, especially recently-eroded faces of streambanks (even of small rills) and in periodically stream-washed gravel and shingle surfaces. For such sites can provide necessary

recently-disturbed, temporarily opened, adequately wet and irrigated surfaces, for successful prothallial colonisation. Against this background, it is relevant to ask, why this hybrid appears, so-far, to be so scarce. It may have had, or lacked, individual vigour, judging from the relatively small size shoots on the type specimen, when compared with typical sizes of shoots of its parents from the same region, and this may be the cause of its rarity, and possible failure of it to survive long-term.

### CONCLUSIONS

This discovery in Siberia is first record of a hybrid between *E. palustre* × *E. pratense*. We suggest that this hybrid could occur elsewhere, perhaps almost anywhere, within the widely-sympatric portions of the circumboreal ranges of its parent species. It is also clearly possible that further study may reveal other hybrids in *Equisetum* from either the Siberian region or across Russia more generally.

### ACKNOWLEDGEMENTS

C.N. Page thanks the authorities of Tomsk State University for the invitation and financial support which made possible his visit to the P.N. Krylov Herbarium, and fieldwork in Siberia, in 2007. Grateful thanks are due to comments from two referees.

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