Ann. Bot. Fennici 36: 33–41
Helsinki 7 April 1999
ISSN 0003-3847

A new columnar form of *Betula pubescens* from Finland: morphological characteristics and micropropagation

Anneli Kauppi, Matti Kauppi & Tauno Ulvinen

Kauppi, A. & Kauppi, M., Department of Biology, University of Oulu, P.O. Box 3000, FIN-90401, Oulu, Finland
Ulvinen, T., Botanical Museum, University of Oulu, P.O. Box 3000, FIN-90401, Oulu, Finland

Received 3 November 1998, accepted 12 January 1999

Kauppi, A., Kauppi, M. & Ulvinen, T. 1999: A new columnar form of *Betula pubescens* from Finland: morphological characteristics and micropropagation. — *Ann. Bot. Fennici* 36: 33–41.

A new form of pubescent birch, *Betula pubescens* Ehrh. f. *columnaris* T. Ulvinen *f. nova* found in Finland, OP, Oulunsalo, in 1992, is introduced and a detailed morphological description including scanning electron microscopy of buds is presented. The birch is characterized by a slender growth habit due to dense ramification and shortness of the branches. Almost all the buds on the distal branches burst and form short twigs. Some of these young shoots die for lack of light and space and dry up during the same summer, but the majority are preserved, giving the tree a compact, pillar-like appearance. The basic cause of this deviant crown architecture is assumed to be a mutation that leads to untimely activation of the axillary meristems, formation of bud clusters and even proleptic branching. The birch has been cloned and has aroused interest in nurseries as a potential decorative tree.

Key words: birches, branching pattern, buds, growth habit

INTRODUCTION

Birches, and especially the two North-European species, the white birch *(Betula pendula* Roth) and the pubescent birch *(B. pubescens* Ehrh.), appear to be genetically very variable. The genetic register of the Finnish Forest Research Institute includes ca. 400 special forms of birch, the majority of which are related to the white birch and only 20 to the pubescent birch (Oskarsson & Nikkanen 1998). Most of the special forms differ from a normal tree in their exceptional leaf form. Well-known examples are the many leaf forms of *B. pendula*, for instance (Kujala & Tuomikoski 1965, Hämet-Ahti *et al.* 1992). Exceptional growth forms have been described in both species, but

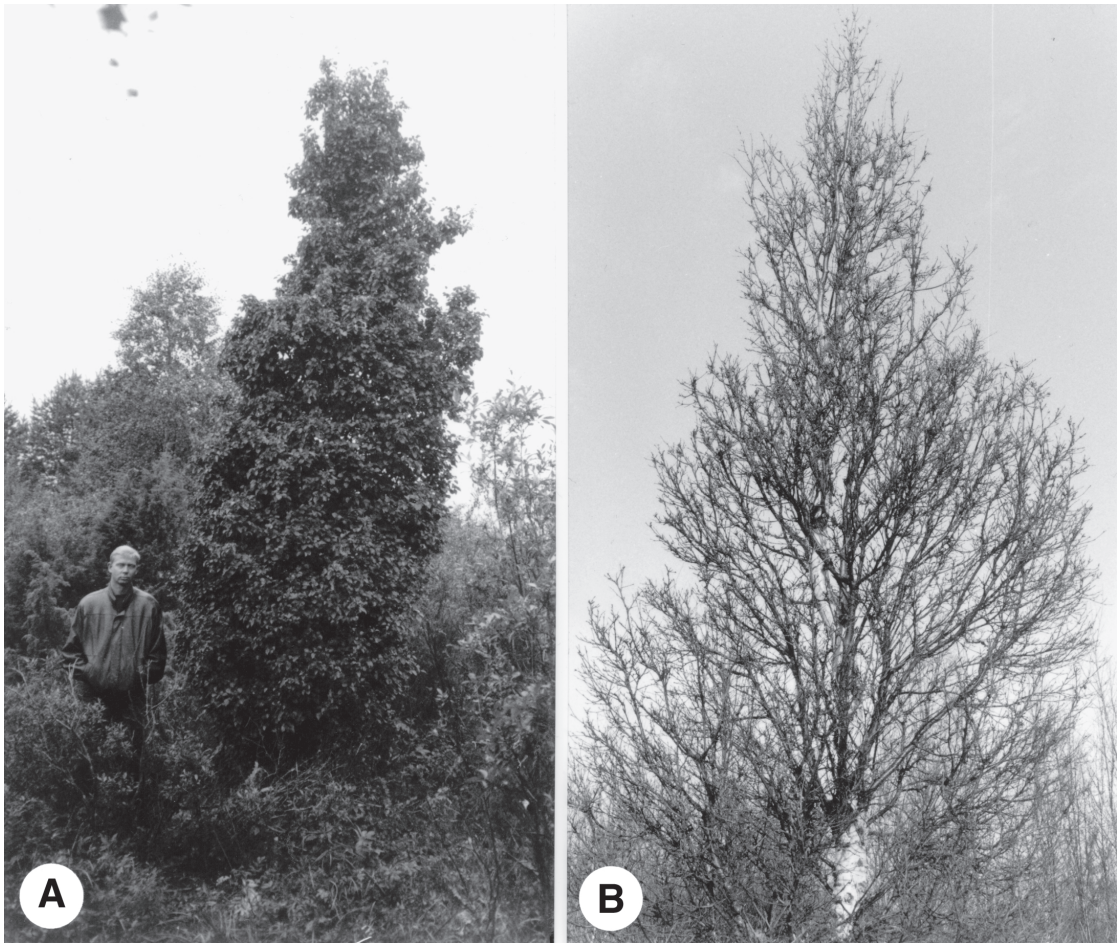

Fig.1. — A: *Betula pubescens* f. *columnaris* photographed at its original site at Koivukari, Oulunsalo, on 27.VIII.1992. The finder, Mr. H. Orava, is present as a scale. — B: The crown of the tree in winter, 5.III.1993.

less frequently. In 1989 we introduced two forms of pubescent birch, *B. pubescens*, f. *hibernifolia* and f. *rubra* (Kauppi & Ulvinen 1989), and in the present paper we describe a new, columnar form of pubescent birch: *Betula pubescens* f. *columnaris* T. Ulvinen *f. nova*. and compare its morphological features in detail with those of the normal form.

Betula pubescens Ehrh. f. ***columnaris*** T. Ulvinen, *f. nova*

Formae typicae similis, sed habitus columnaris, rami brevi, ramuli numerosi.

Holotype: Finland. Oulun Pohjanmaa (Ostrobottnia ouluensis), Oulunsalo, Koivukari, 600 m WNW of the veterans' cottage. 22.VIII.1993 *Anneli Kauppi* (OULU 154616).

We propose the Finnish name *pylväskoivu* for this new form of pubescent birch.

DISCOVERY, SITE DESCRIPTION AND HABITUS

The only specimen of this columniform pubescent birch to be encountered to date is to be found in fairly open forest at Koivukari, Oulunsalo (64°55´N, 25°25´E, Grid 27°E 72017:4234), 100 m from the shore of the Bay of Liminka. It was discovered 25.VII.1992 by Heikki Orava, an environmental officer with the Oulu City Council. The

site belongs to the community group *Cornus-Deschampsia flexuosa* deciduous forests (Havas 1967), which is common along the coast of the Gulf of Bothnia. Low (ca. 5 m) *Betula pubescens, Alnus incana, Sorbus aucuparia,* old dilapidated bushes of *Salix phylicifolia* and solitary specimens of *Juniperus communis* are the most common trees and shrubs at the site. *Deschampsia cespitosa, D. flexuosa, Filipendula ulmaria* and *Cornus suecica* are prominent species in the field layer.

This deviant form of pubescent birch is similar in height to the other birches (ca. 5–6 m), but stands out because of its very compact pillar-like appearance (Fig. 1A and B). It was estimated to be 15–20 years old. There are three side shoots at the base of the tree, which are similar in appearance to the main tree, two of them being about two metres in height and one 0.5 m. They are located close to the main trunk and have remained slender and fairly sparse because of the scarcity of light. The main trunk is about 15 cm in diameter at the base, but because of the narrow growth habit of the tree it seems quite thick. The bark is typical of the species. A divergence seems to be found only in the crown architecture, and above all in the number and distribution of lateral branches on the long shoots. The tree is exceptionally densely branched from the base upwards, totally obscuring the trunk. The first order branches grow upright, at a more acute angle than usual, and the radius of the crown at breast height is only about 50 cm. Ramification is frequent and the branches are equal in length, which gives the tree a tidy appearance, as if trimmed by a gardener. Decayed or dry brushwood twigs were found only in the shelter of the very dense tips of the main branches. The ramification seems to be vigorous on every branch, not only on certain branches as in the "witches' brooms" of birch (*Taphrina betulina*). The branching is patchy, however, as there are unbranched shoots 5–10 cm or even more in length between the dense ramifications. No disease was found other than leaf rust, *Melampsoridium betulinum*, which is common on pubescent birches in autumn (Fig. 2).

Fig. 2. The holotype of *Betula pubescens* f. *columnaris* (OULU 154616). The black spots on the leaves are caused by a leaf rust fungus.

MICROPROPAGATION

Shoots of the columniform pubescent birch were gathered for reproduction on 22 August 1993 and the first steps of micropropagation were carried out immediately at the Botanical Gardens of the University of Oulu. Shoot tips consisting of an apical meristem with about 1 mm^3 of surrounding tissue were dissected under a preparation microscope and the explants were cultivated on a WPM medium (Lloyd & McCrown 1980) with 0.5 mg l^{-1} BAP and 15 g l^{-1} glucose. A half-strength WPM medium with 0.1 mg l^{-1} IBA was used at the rooting phase. The cultures were maintained in a growth room with a 16:8 photoperiod and day/night temperatures of 25/20°C. The first rooted plantlets took 1.5 months to develop. Five of them were potted in a 3:1 mixture of peat and sand, and cultivation was continued in a greenhouse in spring and summer 1994. The seedlings already showed that the exceptional features of the parent tree had been preserved. In autumn 1994, two of the plants were cut and used for detailed morphological examination and the remaining three were transferred outdoors to acclimatize to open air temperatures. They survived their first winter well,

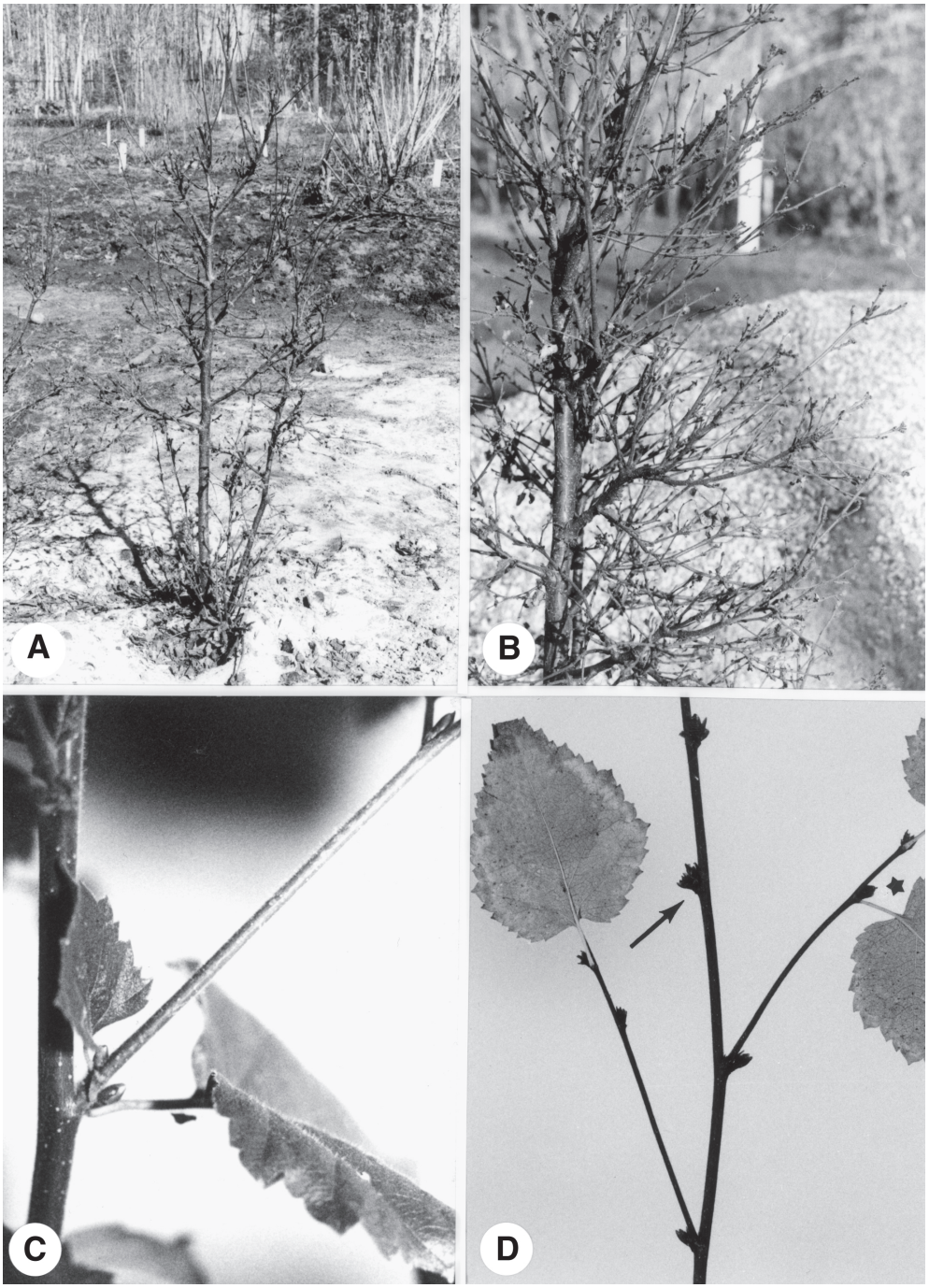

Fig. 3. — A: Habitus of a cloned columniform pubescent birch in May 1998, after four growing seasons. — B: Part of the crown in October 1998. — C: Axillary shoot of the cloned birch at the age of one year, in August 1994, two buds at the base of a proleptic axillary branch are well developed and liable to grow into branches next spring. — D: From a sample grown in a greenhouse and pressed on 7.X.1994, the axillary buds of the current year's foliage leaves (fallen at the time of photographing) are three-tipped because of early enlarging of the axillary buds of their scale leaves. The bud cluster marked with an arrow is also shown in the SEM photograph, Fig. 6C. Two of the first order axillary buds have grown into proleptic long shoot branches. The bud beneath each branching point is of second order. The asterisk marks the bud shown in the SEM photograph in Fig. 6A.

but were still only one metre high in spring 1998 (Fig. 3A) in spite of having spent four growing seasons in well manured garden soil. The peculiar growth habit was well preserved, however, and after the fifth season they began to resemble the parent tree in their pattern of ramification as well (Fig. 3B).

SCANNING ELECTRON MICROSCOPY

Samples of leaf axils from the micropropagated seedlings were dissected out for morphological examination in August 1994. These were fixed in FAA (formalin, glacial acetic acid and ethanol 5:10:85), dehydrated in an alcohol gradient, critical-point dried, attached to a SEM mount and sputtered with gold. The structure of the buds was examined and photographed with a JMS 6300 F field emission scanning electron microscope (FE-SEM).

MORPHOLOGICAL CHARACTERISTICS

The growth pattern of the columniform pubescent birch is sympodial, with long shoots and short shoots, as is characteristic for this species, but the internodes of long shoots are shorter than normal and typical short shoots are very rare. Noteable deviations are also found in the development of the axillary buds and in the branching pattern of the shoots, whereas the leaf morphology seems to be unchanged.

A detailed comparison with a normally growing pubescent birch is presented in Table 1 and Figs. 3–6. The axillary buds of the foliar leaves and even those of the proximal retarded leaves on the annual shoots, are broad-tipped in appearance, or else there appear to be three of them instead of one as in normal birch (Figs. 3C and D, 4B, 5 and 6C). This small cluster of buds will be partly buried in the xylem when the branch thickens. It is usual for these buds not to stay dormant but to increase in size, and many of them burst before the autumn. Proleptic development of the axillary buds is one of the reasons for the shaggy, broom-like appearance of the distal branches (Fig. 5). As a whole, this birch activates more buds to form side shoots than the normal type, although many of the slender ramifications die, dry up before the autumn and usually drop off later. There are plenty of leaves to conceal the dry twigs in summertime, however, so that the external appearance remains compact, as if the tree had been trimmed.

DISCUSSION

A number of exceptional forms of birch have been identified in Northern Finland (Kallio 1978), some of them being deviations from the basic types in terms of leaf form or mode of growth. According to Valanne and Sulkinoja (1991), the variability of *Betula pubescens* is at least in part due to its ease of hybridization with *B. nana* L. in northern Scandinavia. The fact that the morphological characteristics of the columniform pubescent birch described here were preserved in its cloned descendants indicates that it is not a question of site-induced modification, but rather of a mutation in one or more genes.

Although the crown architecture of this columniform birch is exceptional, its growth pattern is sympodial, with long shoots and short shoots, as is characteristic of *Betula pubescens* (cf. Kauppi *et al.* 1988). The long shoots are divergent in their number and distribution, however, and typical short shoots are very rare. The principal distinguishing feature is the heightened tendency of its buds to branch (forming bud clusters), not only the buds of the retarded leaves at the very base of the trunk (cf. Kauppi *et al.* 1987) but also the ordinary axillary buds of the foliage leaves on the aerial shoots. We have previously encountered buds of this type only in cutting-origin stools of *Salix* ‘Aquatica’ (Paukkonen *et al.* 1992). The buds are also inclined to enlarge and even burst proleptically. It is probable that the apical dominance that strictly regulates dormancy or the bursting of buds in plants (Kauppi *et al.* 1987) has been disturbed in this birch. The compact pillarform appearance is principally caused by the deviant development of the buds and shoots, principally the dense ramification and shortness of the branches. These features were encountered here for the first time in *B. pubescens.*

Forms of *Betula pendula* resembling this tree in their crown architecture are known, e.g., that

found in Asikkala (E 4184) and the commercial cultivar 'Fastigiata' (Oskarsson & Nikkanen 1998), but as far as is known, their growth habit and other morphological characteristics have not

Table 1. Comparison of axillary buds and branching patterns of the columniform pubescent birch with a normal form.

Normal (Fig. 4A)	Columniform (Fig. 4B)
The terminal bud and one or two lateral buds at the tip of several long shoots each form a staminate catkin that passes the winter.	No overwintering staminate catkins are formed. The topmost buds do not develop, or they die at an early stage.
The first two leaves laterally on the axillary buds, the prophylls, remain as scale leaves that consist only of stipulate leaf bases forming the outermost bracts. The inner bracts are formed by the stipules of the next two leaves. The blades of these leaves are folded under the bracts and open out in spring when the bud opens. The apical meristem of the bud extends only in spring, forming the axis and the next leaves of the axillary shoot.	The basic structure of the axillary buds do not differ from the normal type, but the schedule of their development may be speeded up resulting even in proleptic branching, i.e. the bud bursts to form an axillary shoot without passing the winter (*see* Fig. 3C and D).
The axillary buds of the prophylls and those of two or three somewhat retarded first foliage leaves on the axial branches remain at a primordial or dormant stage. In practice, they never develop branches, not even visible buds.	The axillary buds of the first few juvenile leaves on the branches grow in size, so that they already are easily visible in autumn. Actually, there appear to be a group of buds in the axis of each foliage leaf, usually three in number, two of them being of second order. The second order buds can: a) grow into shoots contemporary with the growth of the main bud (proleptic development of the second order bud), b) form shoots a year later (normal schedule), or c) remain as dormant buds that posses a potential to burst in later years.
In spring the axillary buds of the fallen leaves burst to develop lateral branches: long shoots or short shoots. The long shoots usually have 5–6 foliage leaves in a spiral pattern, and the internodes are 2–4 cm in length, depending on the growth rate of the branch.	Only 2–3 foliage leaves are formed on the long shoots, and the internodes are less than one cm in length. Only occasionally are there more leaves and the internodes are longer.
Two or three lateral buds distally on an annual long shoot are inclined to extend as long shoots (i.e. acrotonic development) or some of them may form a short shoot bearing 1–2 female catkins. The proximal buds remain dormant or grow as vegetative short shoots. These extend very little in each growing season, having only a few short (some mm) internodes. They never branch, and usually abscise in a few seasons.	The acrotony is disturbed, and typical short shoots are rare. It is common for the axillary buds of the first few leaves at the base of an annual shoot to produce long shoots. On the other hand, shoots having short internodes are formed from the topmost preserved lateral buds. These shoots are prone to branch again and again. It is also common for a branch that extends very little in its first season to continue the next year with longer internodes. Usually this happens when a substantial number of distal branches have died, making space for lower branches (typical distal branches in Fig. 5).

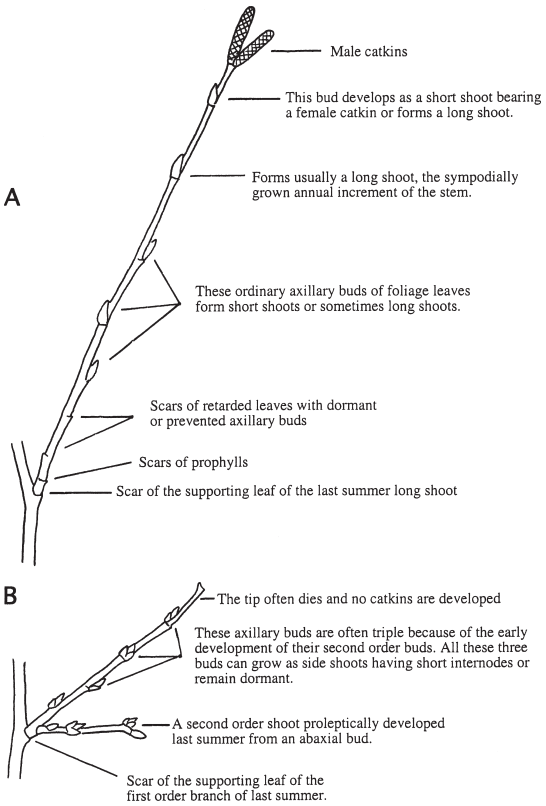

Fig. 4. Semi-schematic drawings of axillary buds and annual shoot development of *Betula pubescens* in its winter habit. — A: Characteristic growth pattern of the species. — B: Model of the columniform tree.

Fig. 5. — A: Drawing of a typical branch, cut late in autumn 1997 from a four-year-old micropropagated descendant of the columniform pubescent birch (OULU E 93322). Because of proleptic development of the axillary buds, it is almost impossible to determine afterwards the year when each side shoot developed. The shoots left unshaded in the drawing had grown in summer 1997, judging by their greenish colour. There is no clear distinction between long shoots and short shoots as is typical of normal pubescent birches. — B: A point of dense ramification on a distal branch of the cloned columnar birch in spring 1998. Some of the short side shoots had developed proleptically from second order buds during the previous summer.

been studied. Slender types of some other trees are also known, e.g., of many species of *Populus* and also *Alnus glutinosa*, *Pinus sylvestris* and *Picea abies* (Hämet-Ahti *et al.* 1992, Oskarsson & Nikkanen 1998). Many of them are valuable as decorative trees. The present columniform pubescent birch is fairly beautiful in summer, but in wintertime it is shaggy and not very attractive. It could be a curiosity, suitable for growing in small gardens in northern regions, where it needs no special care, only light. Together with the mutations of pubescent birch found earlier (Kauppi & Ulvinen 1989), this tree would be of great value genetically. It would be a suitable object for studying hormonal regulation of the bud bursting and branching mechanism and for studying gene expression in these phenomena.

Acknowledgements: We wish to thank the environment officer Heikki Orava, who informed us about the unusual birch in Oulunsalo and guided us to the place. Thanks are also due to Aino Hämäläinen, who reproduced the birch by a micropropagation method, to the gardeners at the Botanical Gardens of the University of Oulu and to other collaborators who helped us. We also thank Mr. Malcolm Hicks, M.A., for revising the English of the manuscript, and Dr. Annikki Palmén for revising the Latin description.

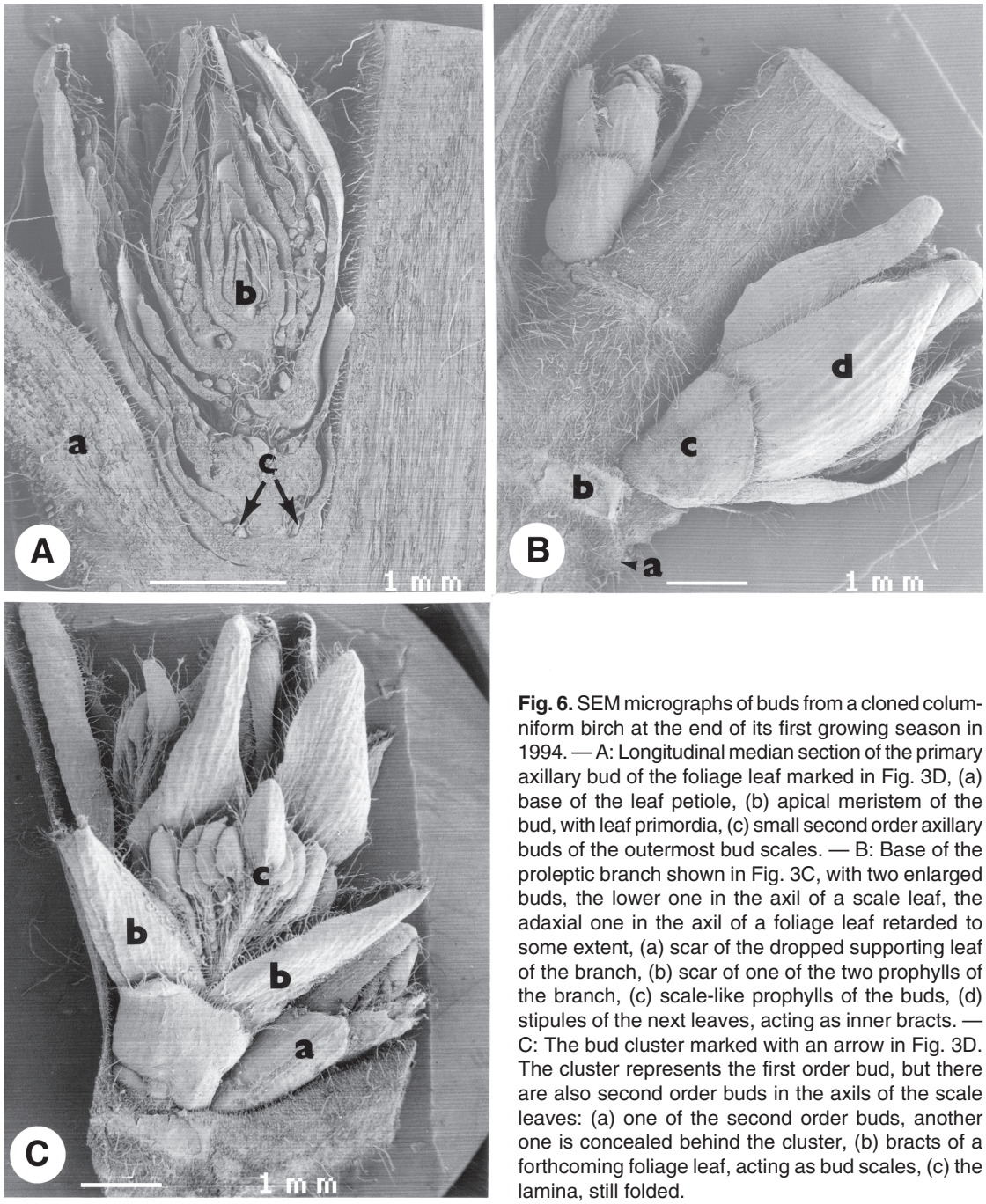

Fig. 6. SEM micrographs of buds from a cloned columniform birch at the end of its first growing season in 1994. — A: Longitudinal median section of the primary axillary bud of the foliage leaf marked in Fig. 3D, (a) base of the leaf petiole, (b) apical meristem of the bud, with leaf primordia, (c) small second order axillary buds of the outermost bud scales. — B: Base of the proleptic branch shown in Fig. 3C, with two enlarged buds, the lower one in the axil of a scale leaf, the adaxial one in the axil of a foliage leaf retarded to some extent, (a) scar of the dropped supporting leaf of the branch, (b) scar of one of the two prophylls of the branch, (c) scale-like prophylls of the buds, (d) stipules of the next leaves, acting as inner bracts. — C: The bud cluster marked with an arrow in Fig. 3D. The cluster represents the first order bud, but there are also second order buds in the axils of the scale leaves: (a) one of the second order buds, another one is concealed behind the cluster, (b) bracts of a forthcoming foliage leaf, acting as bud scales, (c) the lamina, still folded.

REFERENCES

Havas, P. 1967: Zur Ökologie der Laubwälder, insbesondere der Grauerlenwälder, an der Küste der Bottenwiek. — *Aquilo Ser. Bot*. 6: 314–346.

Hämet-Ahti, L., Palmén, A., Alanko, P. & Tigerstedt, P. M. A. 1992: Suomen puu- ja pensaskasvio. 2, uudistettu painos. — *Publ. Finnish Dendrol. Soc*. 6: 1–373.

Kallio, P. 1978: Lapin koivut. — *Acta Lapponica Fennica* 10: 78–83.

Kauppi, A., Rinne, P. & Ferm, A. 1987: Initiation, structure and sprouting of dormant basal buds in *Betula pubescens* Ehrh. — *Flora* 179: 55–83.

Kauppi, A., Kiviniitty, M. & Ferm, A. 1988: Growth habits

and crown architecture of *Betula pubescens* Ehrh. of seed and sprout origin. — *Can. J. For. Res*. 18: 1603–1613.

Kauppi, A. & Ulvinen, T. 1989: Two new forms of *Betula pubescens* from Finland. — *Memoranda Soc. Fauna Flora Fennica* 65: 133–136.

Kujala, V. & Tuomikoski, R. 1965: *Betula* L. — Koivun suku. — In: Jalas, J. (ed.), *Suuri kasvikirja* 2: 73–90. Otava, Helsinki.

Lloyd, G. & McCrown, B. 1980: Commercially feasible micropropagation of mountain laurel, *Kalmia latifolia* by use of shoot tip culture. — *Proc. Int. Plant Propagators Soc*. 30: 421–427.

Oskarsson, O. & Nikkanen, T. 1998: Metsäpuiden erikoismuotoja kultakuusesta luutakoivuun. — *Metsäntutkimuslaitoksen Tiedonantoja* 640: 1–54.

Paukkonen, K., Kauppi, A. & Ferm, A. 1992: Origin, structure and shoot-formation ability of buds in cutting-origin stools of *Salix* ‘Aquatica’. — *Flora* 186: 53–65.

Valanne, T. & Sulkinoja, M. 1991: Lapin koivujen risteytymisestä [Hybridization of birches in Lapland]. — *Luonnon Tutkija* 95: 83–87. [In Finnish with English abstract].