

Two new species of *Anthracoidea* (*Ustilaginales*) on *Carex* from North America

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Abstract. After a short revision of the genus *Anthracoidea*, two new species, *A. multicaulis* on *C. geyeri* and *C. multicaulis*, and *A. praegracilis* on *C. praegracilis* are described and illustrated.

Key words: *Anthracoidea*, *Anthracoidea multicaulis*, *Anthracoidea praegracilis*, *Carex*, North America, smut fungi, *Ustilaginales*

Introduction

The genus *Anthracoidea* Bref. is a natural group in the *Anthracoideaceae* (Denchev 1997) of the order *Ustilaginales*, parasitising members of *Cyperaceae* in *Carex*, *Carpha*, *Fuirena*, *Kobresia*, *Schoenus*, *Trichophorum* and *Uncinia* (comp. Vánky 2002: 28–29). Sori around the ovaries as black, globose, agglutinated spore masses with powdery surface. Spores single, pigmented (dark brown), usually ornamented with spines, warts or granules, rarely smooth, often with internal swellings or light-refractive areas. Spore germination results in two-celled basidia forming one or more basidiospores on each cell (Kukkonen 1963, 1964). There are nearly one hundred known species (Vánky, in press), most of them morphologically only slightly different “small species”, adapted to one or several host plant species belonging to the same or closely related sections (comp. Nannfeldt 1979; Vánky 1979), rarely to not closely related sections, e.g. *A. fischeri* (P. Karst.) Kukkonen. The taxonomy of the genus *Anthracoidea* is difficult and in need of study by modern, molecular phylogenetic methods (comp. Hendrichs *et al.* 2005), combined with detailed morphological studies of the spores. The obtained results must be interpreted and evaluated on the basis of host plant taxonomy.

Materials and methods

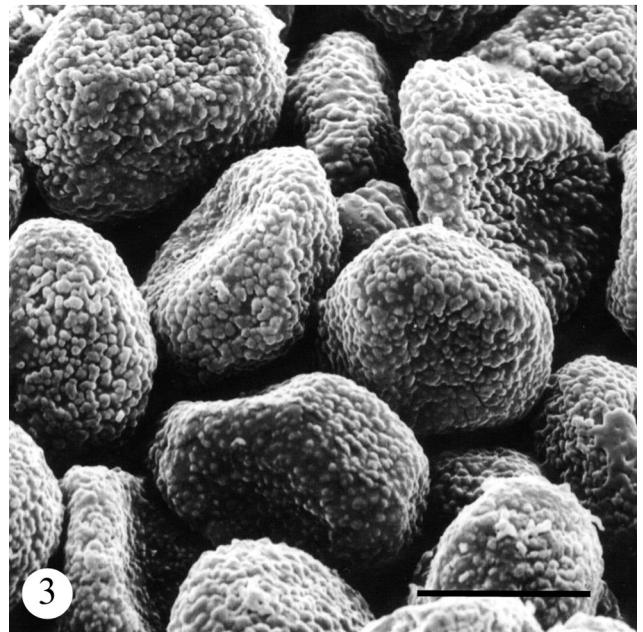
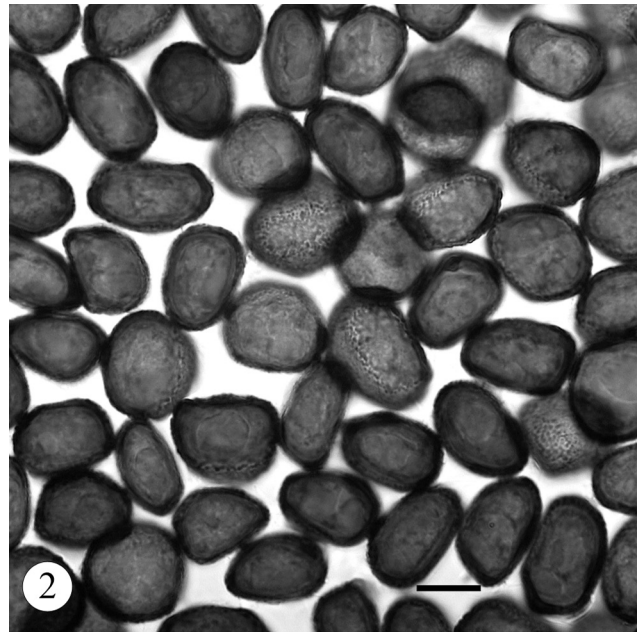
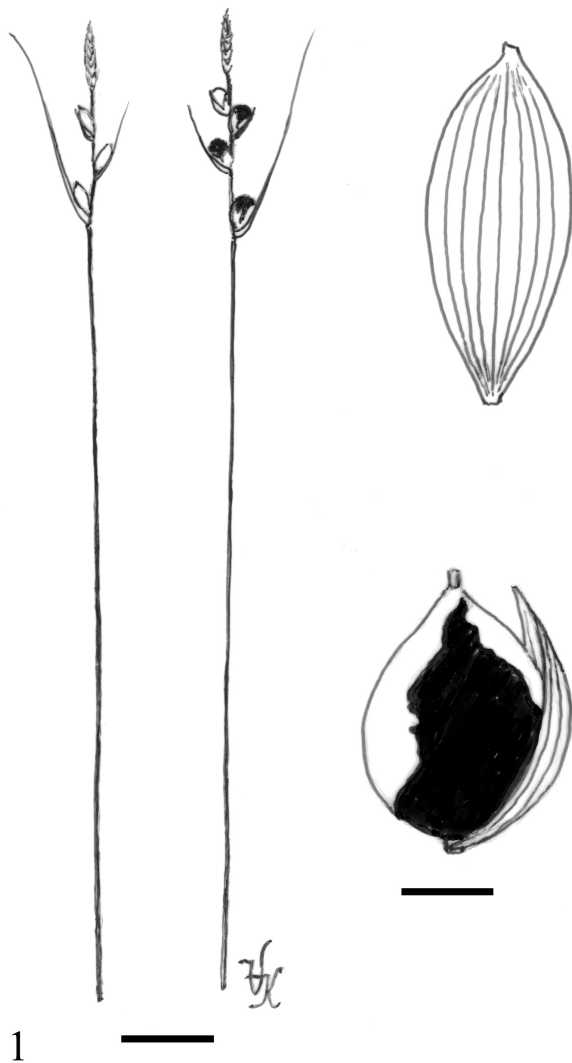
The specimens of *Anthracoidea*, examined in this study are listed in Table 1 and Table 2.

Sorus and spore characteristics were studied using dried herbarium specimens. Spores were dispersed in a droplet of lactophenol on a microscope slide, covered with a cover glass, gently heated to boiling point to rehydrate the spores, and examined by a light microscope (LM) at 1000x magnification. For scanning electron microscopy (SEM), dry spores were placed on double-sided adhesive tape, mounted on a specimen stub, sputter-coated with gold-palladium, ca 20 nm, and examined in SEM at 10 kV.

Results and discussion

A smutted sedge, *Carex multicaulis*, belonging to the subgen. *Psyllophora*, sect. *Firmiculmes*, was collected during a field trip in California. Examination of herbarium material revealed more infected specimens as well as an additional host, viz. *C. geyeri* Boott from the same section infected by the same *Anthracoidea*.

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Figs 1–3. *Anthracoidea multicaulis* on *Carex multicaulis* (type). Fig. 1. Sori in some ovaries of an inflorescence. Habit, to the left a healthy inflorescence, and enlarged a sorus and a healthy perigynium. Bars = 1 cm for habit, and 1 mm for detail drawings. Figs 2–3. Spores in LM and in SEM. Bars = 10 µm

On members of the subgen. *Psyllophora* eight *Anthracoidea* species are known: 1. *A. caricis-pauciflorae* (Lehtola) Kukkonen, on *C. pauciflora* Lightf. (sect. *Leucoglochin*), 2. *A. caryophylleae* Kukkonen, on *C. obtusata* Lilj. (sect. *Obtusatae*), 3. *A. externa* (Griffiths) Kukkonen, on *C. filifolia* Nutt. (sect. *Filifoliae*), 4. *A. nardinae* (Kukkonen) Nannf., on *C. elynoides* T. Holm (sect. *Filifoliae*) and *C. nardina* Fr. (sect. *Nardinae*), 5. *A. ortegae* Kukkonen, on *C. caduca* Boott (incl. *C. ortegae* Phil.; sect. *Aciculares*), 6. *A. pulicaris* Kukkonen, on *C. pulicaris* L. (sect. *Psyllophora*), 7. *A. rupestris* Kukkonen, on *C. rupestris* All. (sect. *Rupestres*), and 8. *A. scirpoideae* Kukkonen, on *C. scirpoidea* Michx. (sect. *Scirpinae*). The *Anthracoidea* found on *C. multicaulis* and *C. geyeri* differs from all these species, and is described as:

Anthracoidea multicaulis Vánky & Salo, sp. nov.

MYCOBANK # MB 519197

Typus in matrice *Carex multicaulis* L.H. Bailey, USA, California, Siskiyou Co., Mt. Shasta, south slope, ca 41°21' N, 122°12' W, alt. ca 2500 m.s.m., 9.VIII.1988, leg. M. Berbee & K. Vánky. Holotypus H.U.V. 20646, isotypi in Vánky, Ustilag. exs. no. 1313 (e.g. H 6017358).

Sori circum nuces, globoidei vel ellipsoideales, 2–2,5 × 2,5–3 mm, primo membrana tenui, argenteo-fungali cooperti, qua dissoluta massae sporarum nigrae, agglutinatae, cum superficie pulvereae ostendentes. *Sporae* parum depressae, in visu laterali ellipticae, 11–14,5 µm latae, in visu plano circulares, ovoideae, ellipticae vel subpolygonaliter parum irregulares, raro apice subcutatae, 13–19 × 16–24 (–25)

μm , rubrobrunneae; pariete aequaliter 1–1,5 μm crasso, prominenter dense verrucoso, forte verrucis nonnullis in seriebus irregularibus conjunctis, sine incrassationibus internis, maculae dilute refractivae exceptionaliter tantum, imago obliqua sporarum sinuosa.

Sori (Fig. 1) around the nuts, globoid or ellipsoidal, 2–2.5 $\times$ 2.5–3 mm, at first covered by a thin, silvery fungal membrane which flakes away disclosing the black, agglutinated spore masses with powdery surface. **Spores** (Figs 2–3) slightly flattened, in side view elliptic, 11–14.5 μm wide, in plane view circular, ovoid, elliptic or subpolygonally slightly irregular, only rarely with a subacute tip, 13–19 $\times$ 16–24 (–25) μm , reddish brown; wall evenly 1–1.5 μm thick, prominently, densely verrucose, a few warts may fuse into irregular rows, no internal swellings, light-refractive spots only exceptionally, spore profile wavy.

On *Cyperaceae*, *Carex*, subgen. *Psyllophora*, sect. *Firmiculmes*: *C. geyeri* Boott, *C. multicaulis* L.H. Bailey.

Distribution: North America (USA; see also Table 1).

Carex multicaulis and *C. geyeri* are both woodland species occurring mostly at moderate elevations in western North

America (Cronquist *et al.* 1977; Crins 2002). *C. geyeri* grows also in dry meadows at high altitudes. The smut is likely to be geographically coextensive with its hosts but nevertheless has a preference to high altitudes.

An apparently closely related but controversial section to *Firmiculmes* is the sect. *Phyllostachyae*. It contains ten *Carex* species (Crins *et al.* 2002), of which so far only *C. backii* Boott has been found to be infected by an *Anthracoidea* species, viz. *A. calderi* (Savile) Kukkonen. It has large, 21–32 μm long spores, provided with 0.5–1.5 μm high, subcylindric warts. Consequently, *A. multicaulis* differs also from *A. calderi*.

Another examined smutted sedge, *Carex praegracilis*, belongs to the subgen. *Vignea*, sect. *Divisae*. Two *Anthracoidea* species have been described on North American members of *Divisae*: *A. douglasii* Shear ex Nannf. on *C. douglasii* Boott, and *A. eleocharidis* Kukkonen on *C. duriuscula* C.A. Mey (*C. eleocharis* L.H. Bailey). The smut on *C. praegracilis* is distinctly different from these two species with conspicuous warts, and is described as:

Table 1. Examined specimens of *Anthracoidea multicaulis*

Host plant	Locality, date of collection, collector	Herb.
<i>Carex geyeri</i>	USA, Washington, Yakima Co., Mt. Adams, Wodanthal, 21 Sep 1899, W.N. Suksdorf 554	WSP 33054
	USA, Wash., Mt. Paddo (Adams), alt. ca 2200 m, 14 Jul 1900, W.N. Suksdorf	WS 88982
	USA, Wash., Malaga, B. Roche	WSP 58595
	USA, Montana, Glacier Ntl Park, The Garden Wall, Highline Trail, alt. 2130 m, 27 Jul 1962, W.B. Cooke 33448 & V.G. Cooke	H 6017357
	USA, Wyoming, Yellowstone Ntl Park, 15 mi. NE of West Tumb, 20 Aug 1964, R. Duran & G.W. Fischer	WSP 58970
<i>Carex multicaulis</i>	USA, California, Mt. Shasta, Mud Creek Canyon, alt. 2295 m, 10 Aug 1939, W.B. Cooke 13393 (in Mycobiota of North America no. 64).	H 6017356 WSP 21181
	USA, Calif., Mt. Shasta, 22 Aug 1940, W.B. Cooke (in Mycobiota of North America no. 64A).	BPI 171030 BPI 857980 WSP 21182
	USA, Calif., Mt. Shasta, Lower Panther Creek Meadows, 2295 m, 24 Aug 1949, W.B. Cooke 25636 & V.G. Cooke	WSP 25297
	USA, Calif., Mt. Shasta, south slope, ca 41°21' N, 122°12' W, alt. 2500 m, 9 Aug 1988, M. Berbee & K. Vánky (in Vánky, <i>Ustil.</i> exs. no. 1313)	HUV 20646 H 6017358

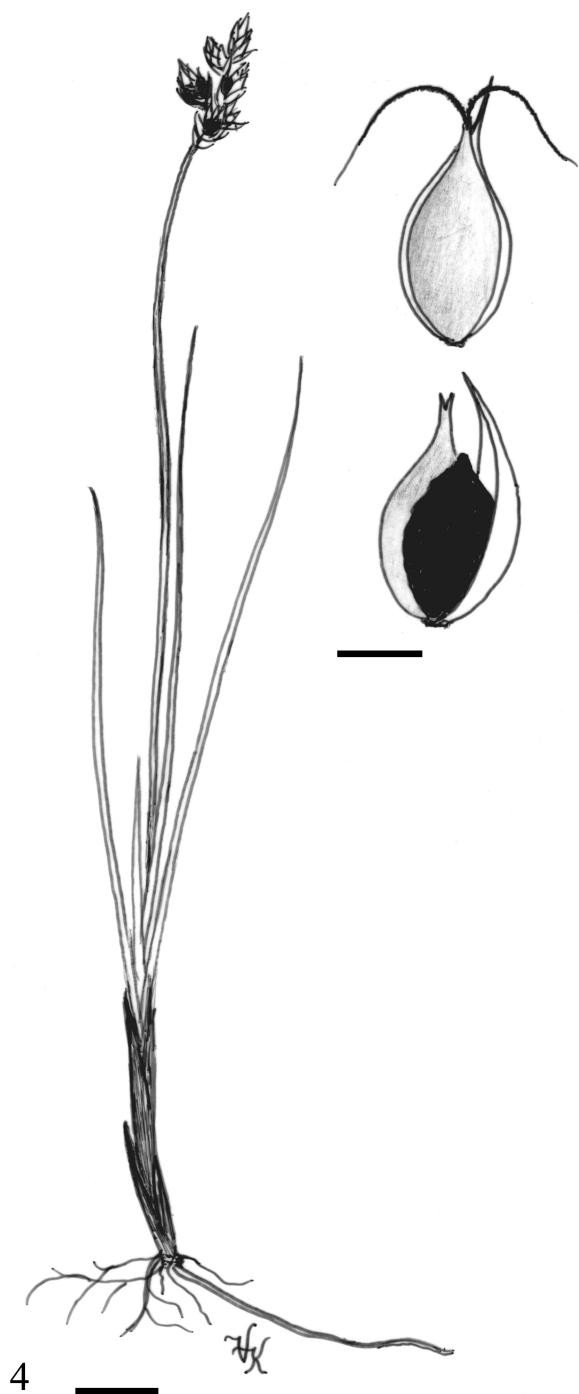
***Anthracoidea praegracilis* Salo & Vánky, sp. nov.**

MYCOBANK # MB 519196

Typus in matrice *Carex praegracilis* W. Boott, Canada, Yukon, Alaska Hwy, mile 945, alkaline lake, 11.VIII.1960, leg. I. Kukkonen 620, holotypus H 7003625, isotypi H 6017355, H.U.V. 21660 et in WSP.

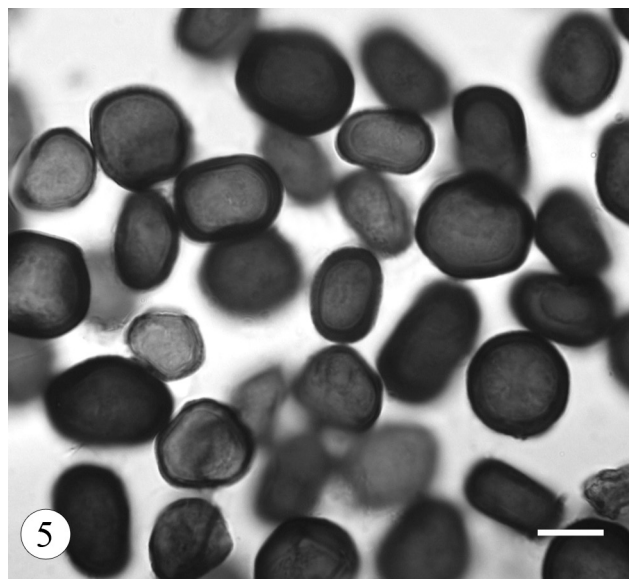
Sori in ovariis nonnullis inflorescentiae eiusdem, circum nuces corpora nigra, globoidea, mature pulverea, 1–1,5 (–2) mm in diametro formantes. **Sporae** forma et magnitudine variae, depressae, complanatae, in visu laterali ellipticae, (8–)

8,5–10,5 (–11) μm latae, in visu plano subcirculares, ellipticae, subpolygonaliter vel polygonaliter irregulares, raro elongatae vel etiam lacrimiformes cum apice uno subcutae, 10,5–18 (–20) $\times$ 12–23 (–28) μm , mediocriter usque atrius rubrobrunneae; pariete parum inaequali, 0,8–2,5 μm crasso, minute, sparse usque dense punctato-verruculoso, imago obliqua sporarum levis, 1–3 intumescitiae internales leniter vel magis aperte praesentibus, maculae refractivae rariae, in SEM verrucae 0,1–0,8 (–1,2) μm diametro, rare conjungentes. **Germinatio sporarum** secundum typum *Anthracoidearum*.

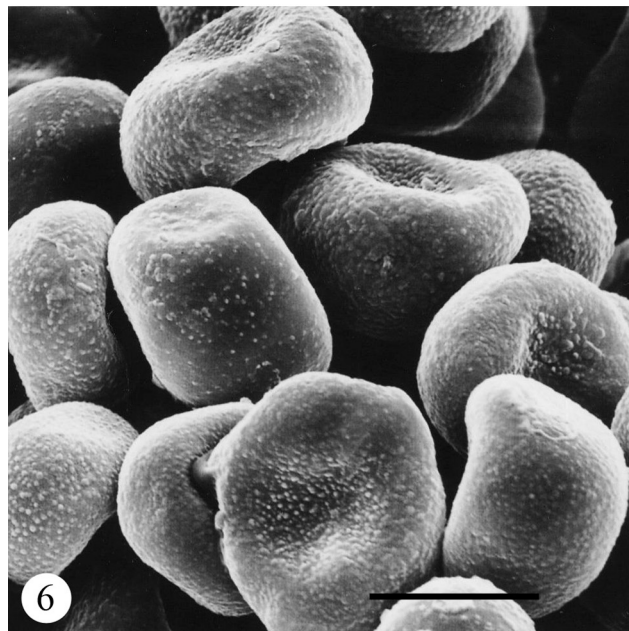


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Sori (Fig. 4) in some ovaries of an inflorescence, forming black, globoid, early powdery bodies around the nuts, 1–1.5 (–2) mm in diameter. **Spores** (Figs 5–6) variable in shape and size, flattened, in side view elliptic, (8–) 8.5–10.5 (–11) μm wide, in plane view subcircular, elliptic, subpolygonally or polygonally irregular, rarely elongate or even tear-shaped, with a subacute tip, 10.5–18 (–20) $\times$ 12–23 (–28) μm , medium to dark reddish brown; wall slightly uneven, 0.8–2.5 μm thick, minutely, sparsely to densely punctate-verruculose, spore profile smooth, 1–3 weakly or well developed internal swellings can be present, light-refractive spots rare, in SEM warts 0.1–0.8



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Figs 4–6. *Anthracoidea praegracilis* on *Carex praegracilis* (type). **Fig. 4.** Sori in some ovaries of an inflorescence. Habit, and enlarged a sorus and a healthy perigynium. Bars = 1 cm for habit, and 1 mm for detail drawings. **Figs 5–6.** Spores in LM and in SEM. Bars = 10 μm

(–1.2) μm in diameter, seldom fusing. **Spore germination** of *Anthracoidea* type (Kukkonen 1964: 275).

On *Cyperaceae*, *Carex*, subgen. *Vigneae*, sect. *Divisae*: *C. praegracilis* W. Boott.

Distribution: North America (Canada, USA; see also Table 2).

There can be rather big differences in spore measurements not only between specimens from geographically distant areas but also from geographically close areas and even between spores from the same sorus. Such a specimen is, e.g., the type, with a relatively great number of small-sized spores. Because other morphological characters are similar, the differences

in spore measurements are considered variations within the same species. Taking into consideration several collections, a combined, more typical spore measurement for this species would be in side view (8–) 10–13 µm, in plane view 11–20 × (13.5–) 15–24 (–25.5) µm.

Anthracoidea praegracilis morphologically is close to the Eurasian *A. arenaria* (Sydow) Nannf. on sedges of the sect. *Ammoglochin*, subgen. *Vignea*.

Carex praegracilis is very widespread in North America and grows in diverse habitats and altitudes (Reznicek & Catling 2002). The sedge is native to western North America and occurs as an invasive species in the east. *A. praegracilis* seems to be common in its host's native area, especially in the north. According to the literature (Savile 1952; Fischer 1953) it also occurs in Saskatchewan and in more southern areas of the USA, in Utah and Colorado.

Table 2. Examined specimens of *Anthracoidea praegracilis*

Host plant	Locality, date of collection, collector	Herb.
<i>Carex praegracilis</i>	CANADA, Yukon, Alaska Hwy, mile 945, alkaline lake, 11 Aug 1960, I. Kukkonen 620	H 7003625 H 6017355 HUV 21660
	CAN., Yukon, Alaska Hwy, mile 985 alt. 2650 m, 14. Aug 1960, I. Kukkonen 643	H 6017345 HUV 21810
	CAN., Yukon, Whitehorse – Carcross, mile 23.5 on Carcross rd, 15. Aug 1960, I. Kukkonen 651	H 6017346 HUV 21812
	CAN., British Columbia, 3 mi. N of Vernon, near Goose Lake, 6. Jul 1953, J.A. Calder 10141 & D.B.O. Savile	H 6017347
	CAN., B.C., 6 mi. WSW of Kamloops, Iron Mask Lake, 10. Jul 1953, J.A. Calder 10309 & D.B.O. Savile	H 6017348
	CAN., B.C., Big Gang Ranch Road, W end of White Lake, 51°23' N, 121°54' W, 23. Jun 1956, J.A. Calder, J.A. Parmelee & R.L. Taylor	H 6017349
	CAN., B.C., on rd to Bridge Lake, 8.5 mi. E of 70 Mile House, ca 1280 m, 11. Aug 1956, J.A. Calder 19945, J.A. Parmelee & R.L. Taylor	H 6017350
	USA, Montana, Kalispell, Aug 1900, D. Griffiths & Lange (in West American Fungi no. 210)	H 6017351 WSP 1010
	USA, Wyoming, Yellowstone Ntl Park, Lamar River, 30. Jul 1939, J.F. Brenckle & O.A. Stevens (in Mycoflora Saximontanensis Exsiccata no. 437)	WSP 33937

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