Arhenia auriscalpium in arctic-alpine habitats: world distribution, ecology, new reports from the southern Rocky Mountains, USA

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Abstract

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During our investigations of alpine agarics in the central and southern Rocky Mountains, *Arrhenia auriscalpium* (Fr.) Fr. was collected several times on high mountain localities in Colorado at elevations of 3,350-3,670 m. *Arrhenia auriscalpium* is a well-known arctic-alpine basidiomycete (Agaricales) with a circumpolar distribution, which has previously been reported only once from the USA (outside Alaska). This is the first formal report of *A. auriscalpium* from Colorado, and is the highest elevation yet recorded for the fungus. This extends the distribution of *A. auriscalpium* deep into the North American cordillera to a latitude of 39° N, which is a southern-most extension for true northern alpine habitat. This new information is added to the global distribution of *A. auriscalpium* which is reported here along with notes on its ecology.

Keywords: alpine, Arctic, *Arrhenia*, Basidiomycetes, fungi, Rocky Mountains.

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Introduction

Arrhenia auriscalpium (Fr.) Fr. is a well-known yet inconspicuous basidiomycete with a circumpolar arctic-alpine distribution (Redhead 1989). It appears to be restricted to cold-dominated habitats, and is considered an indicator of the arctic-alpine biome by mycologists. *Arrhenia auriscalpium* is rarely encountered, possibly because of its small size, but is easily recognized as a gray-brown, laterally-stiped cup (spoon-shaped) with a few anastomosing ridge-like gills (Fig. 1). Efforts at molecular phylogeny with the 25S rDNA (Moncalvo *et al.* 1997) and LSU and ITS rDNA sequences (Redhead *et al.* 2002) place it in the *Omphalinoid* clade and more specifically with gray non-lichenized omphalinas which are now all placed in the genus *Arrhenia* (Redhead *et al.* 2002). This is supported by the presence of chiastic basidia, as opposed to the stichobasidia of the cantharelloid line where it has been placed by some authors (Trog 1844, Pilát and Nannfeldt 1954). The vein-like longitudinally oriented hymenial ridges are considered a type of 'degenerated' gill (likely a derived condition according to molecular data, Redhead *et al.* 2002), and basidia are confined to these areas. The hymenial surface continuously sporulates as it increases in size, an adaptation to habitats where freezing can occur at any time during the fruiting process (Redhead 1984). *Arrhenia auriscalpium* typically occurs on soil with sparse cover associated with minute ground mosses and terrestrial lichens.

During our investigations of alpine Agaricales in the Rocky Mountains (Cripps and Horak, in press), *Arrhenia auriscalpium* was collected several times in

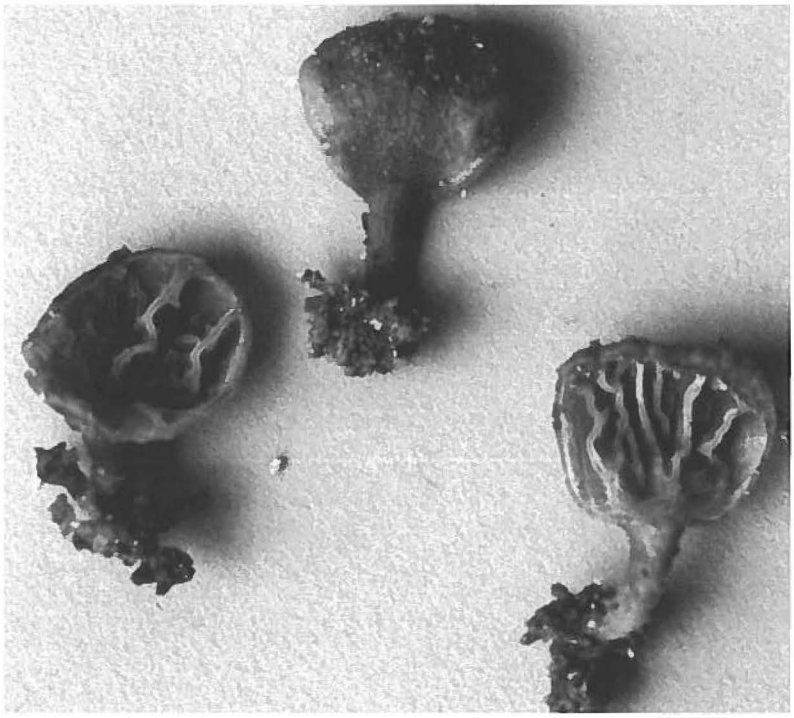


Fig. 1. *Arrhenia auriscalpium* fruiting body, showing ridged hymenium, enlarged 4x.

southern Rocky Mountain alpine areas on high mountains above 3,300 m. This is the first formal report of this alpine basidiomycete from Colorado, near the southernmost extent of its known distribution and at the highest elevations yet recorded. Some Colorado collections were from open patches covered with minute ground mosses in association with the lichen *Thamnolia subuliformis* (Ehrh.) Culb., and/or near the arctic-alpine agaric *Psilocybe chionophila* Lamoure. The present records extend the distribution of *A. auriscalpium* deep into the North American cordillera to a latitude of 39° N, the furthest south reported for a true alpine habitat. This new information is added to the global distribution of *A. auriscalpium* which is also reported here.

Description of southern Rocky Mountain collections

Arrhenia auriscalpium (Fr.) Fr., Summa veg. Scand., 312, 1849 (Fig. 1, Fig. 2)
Bas.: *Cantharellus auriscalpium* Fries 1828. Elenchus Fungorum 1: 54.

Fruiting body small, pileus 3-6 (10) mm across, erect, shallowly spoon-shaped, oval to round with distinct sterile margin, at slight to 90° angle from stipe, dry, thin-fleshed, bone brown, gray-brown, smooth (one specimen with fine dark fibrils), somewhat translucent when fresh, hygrophanous and lighter upon drying, margin smooth or more lobed in older specimens. *Hymenium* vertical or facing down towards substrate, with 3-9 (-14) blunt, venose ridges which radiate out from stipe (not coalescing at stipe) and end at sterile margin; ridges with minimal branching and occasional anastomoses; context concolorous, not gelatinized. *Stipe* solid, dry, lateral to eccentric, 2-4 mm long x 1-2 mm wide, equal, more developed in some specimens than others, pale cap color, pale brown, gray, smooth or minutely pruinose, delineated from pileus by distinct line on ventral side or a gradual transition. *Odor* absent.

Spores (6-7-9(-11) x (4.5-5-6.6(-7) µm, on average 8.5-9.5 x 5-5.5 µm, thin-walled, smooth, shape somewhat variable, ovoid, slightly lacrymoid, more rarely subglobose or slightly reniform, hyaline, finely guttulate, with conspicuous apiculus, inamyloid. *Basidia* clavate, 25-40 x 6-9 µm, most 4-spored, a few 2-spored, clamped. *Pileipellis* hyphae cylindric, terminal cells not differentiated, 4-9 µm in diameter, with rough encrustations of pigment, and clamp connections. *Cheilocystidia* absent. *Caulocystidia* not distinct, but as hyphal-

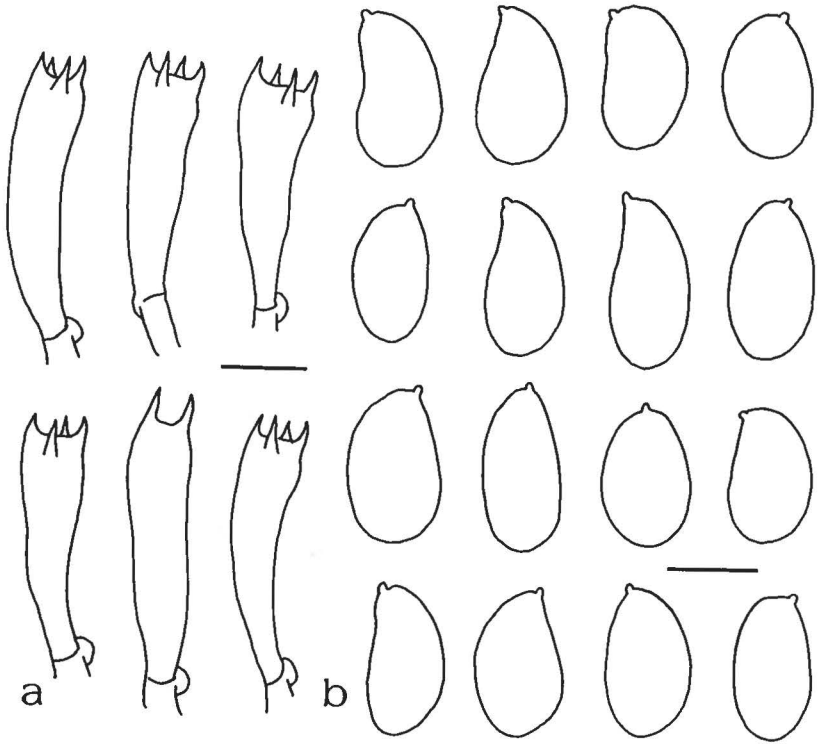


Fig. 2. *Arrhenia auriscalpium* (collection CLC 1140). A. Basidia. Bar = 10 µm. B. Basidiospores. Bar = 5 µm.

like end cells, 90-60 x 4-5 µm, clamped, rounded at apex, can protrude from stipe surface.

Habitat: Alpine life zone, from 3,350-3,650 m in elevation, solitary, on ground near minute ground moss and lichen, or in wind and sun-exposed soil near *Thamnolia subuliformis* (white worm lichen).

Material examined. USA: CO: Pitkin County, Independence Pass, 11 Aug., 1999, C. Cripps, CLC 1336 (MONT); Summit County, Loveland Pass, 14 Aug., 1997, C. Cripps, CLC 1140 (MONT), 14 Aug., 1997, J. Rogers, CLC 1145 (MONT), 9 Aug., 1999, C. Cripps, CLC 1305 (MONT).

World distribution, biogeography

Eurasia

The first record of *Arrhenia auriscalpium* in Europe in the alpine was from Switzerland at the summit of Faulhorn, 2860 m., and it was published under the name *Cantharellus muehlenbeckii* (Trog 1844, Irlet 1984). *Arrhenia auriscalpium* occurs in arctic and alpine areas in Europe (Table 1 and Fig. 3). Most Eurasian records are within or near the 10° C thermocline delineating the arctic biome, or from mountainous sites above timberline in the Alps, Pyrenees, Tatras, Caucasus, and Khibinis. It is reported primarily on bare ground, on glacier forefronts in sandy and silty soil with minute mosses. Exceptions are the type specimen from Sweden and those from Spain collected at lower elevations (Barrasa and Rico 2003).

North America

Arrhenia auriscalpium has been recorded for Alaska (Sprague and Lawrence 1959, Miller 1968, Horak unpublished, Gilbertson and Miller unpublished), Canada (by O. K. Miller and Ohenoja, see Redhead 1984, 1989), and Greenland (Lange 1957, Kobayasi *et al.* 1971, Petersen 1977, Klán and Kubičkova 1979, Lamoure *et al.* 1982, and Gulden unpublished), and Washington (Redhead and Ammirati unpublished) (Table 1, Fig. 3). Elevations for these areas range from sea level in Alaska to alpine areas near Banff and Jasper National Park, around 2210 m. Our collections on Independence and Loveland Pass, in the southern Rocky Mountains (latitude 39° N) are at the southernmost known extension of *A. auriscalpium*'s known range, except for a collection made by J. Haines on the North Rim of the

Table 1. World distribution of Arrhenia auriscalpium (Fr.) Fr. (selected collections)

AUSTRIA			
Tirol, Obergurgl, 2100 m	Klán & Kubičková 1979:40	moss	47° N
Tirol, Obergurgl, 2300 m	Horak, E, unpublished: ZT 65-292	glacier forefront	47° N
CANADA			
NW Territory, Rankin Inlet, 20-40 m	(Ohenoja) in Redhead 1984:870	ground moss	63° N
Alberta, Banff, Jasper, Kananaskis, 2210 m	(Miller, OK) in Redhead 1984:871		51° N
CZECH REPUBLIC			
Higher Tatra Mts, 1550 m	Svrček 1957:172	humus	51° N
Higher Tatra Mts, 1940 m	Klán & Kubičková 1979:40	moss	51° N
FINLAND			
Finnish Lapland, 50-300 m	Kallio and Kankainen 1966: 192		69° N
South-central Lapland, 10-280 m	Ohenoja (unpublished)		66° N
FRANCE			
Iseran, 2650 m	Kühner & Lamoure 1972:17	Salix herbacea	45° N
Iseran	Kühner & Lamoure 1986:108		45° N
GREENLAND			
West, 400 m	Lange 1957: 63		66° N
Angmagssalik region	Kobayasi et al. 1971:65		
West	Petersen 1977: 11		66° N
Disko Island, Godhavn	Klán & Kubičková 1979:40	moss	70° N
West	Lamoure, Lange & Petersen 1982:86		66° N
–	Gulden (unpub report)		
Kangerlussuag, Sisimiut, 200 m	Cripps, CLC 1524, CLC 1528 (MONT)		67° N
ICELAND			
Kaldbakur, 600 m	Hallgrimsson & Kristinsson 1965:68	moss & lichen	65° N
several localities	Hallgrimsson 1980:29		
NORWAY			
Finse, 1460 m & other localities	Elven 1975 & Høiland, K 1976:208	terrestrial	61° N
RUSSIA			
Kola Peninsula, Khibini Mts	Mikhailovski 1975		68° N
Kola Peninsula, Khibini Mts	Klán & Kubičková 1979:40	moss	68° N
Caucasus Mts., 3200 m	Klán & Kubičková 1979:40	moss	43° N
SPAIN			
Pyrenees, Andorra, 2260 m	Vila et al. 1996:33	moss	42° N
Madrid, Toledo, Segovia	Barrasa & Rico 2003:704	moss	41° N
SVALBARD (whole island group)			
Ny-Ålesund	Kobayasi et al. 1968:46	ground moss	78° N
South of Ny- Ålesund	Ohenoja 1971:133	ground moss	78° N
South of Ny- Ålesund	Hoiland 1976:208		78° N
Ny- Ålesund	Skifte 1979:32		78° N
Ny- Ålesund	Gulden & Jenssen 1988:23		78° N
Spitsbergen 200-600 m	Jalink & Nauta 1989:8		78° N
Ny- Ålesund	Gulden, G & Torkelsen, E 1996:180	terrestrial	78° N
SWEDEN			
Abisko	Pilát & Nannfeldt 1954:33	moss, terrestrial	68° N
Abisko, 700 m	Kühner & Lamoure 1972:17		68° N
SWITZERLAND			
Swiss National Park 2200 m	Favre 1955:36		46.5° N
Kt. Bern, Faulhorn, 2860 m	Trog 1844	on *Meesia alpina*	46.5° N
Kt. Bern, Steingletscher, 1942 m	Senn-Irlet 1988:125	on sandy soil, moss	47° N
Kt. Graubünden, Parsenn, 2040 m	Senn-Irlet 1992:49	on gravelly soil, near *Dryas*	47° N
Kt. Graubünden, Val Tavrü, 2000 m	Horak unpublished ZT 1749 (1982)	moss & lichen	46° N

Table 1. Continued.

Kt. Graubünden, Surlej, 2430 m	Horak unpublished ZT 3316 (1986)	moss & lichen	46° N
UNITED STATES			
Arizona, N Rim, Grand Canyon	see Redhead 1984:871 Haines 681(K), 1952		36° N
Alaska, Barrow, sealevel	Laursen & Ammirati 1982:542		71°
Alaska, Glacier Bay 1952 m	Sprague & Lawrence 1959:216		58° N
Alaska, Skolai Pass, 1524 m	Miller 1968:1193-4		61° N
Alaska, Barrow, sea level	Horak unpublished ZT 31 (1980)	tundra	71° N
SE Alaska, Tongass National Forest	Gilbertson & Miller, unpub OKM 7686 (in Redhead 84)		57° N
Colorado, Loveland Pass; 3567 m	Cripps CLC 1140 (MONT) 1997	minute moss	40° N
Colorado, Independence Pass, 3658 m	Cripps CLC 1336 (MONT) 1999	minute moss	39° N
Colorado, Loveland Pass, 3353 m	Cripps CLC 1140 (MONT) 1999	ground, near *Thamnolia*	40° N
Washington, near Slate Peak & Hart Pass, Okanogen Nat. Forest, 2100 m	Redhead and Ammirati, unpublished, DAOM 208786 (1993)	on peaty soil with small mosses	48°

Grand Canyon and identified by Rolf Singer (as reported in Klán and Kubičkova 1979; Redhead 1984). Parts of the North Rim are high in elevation, with Mount Turnbull reaching to 2,447 m, but true alpine certainly does not exist in this area. At a latitude of 36° N, treeline in northern New Mexico is between 3,200-3,660 m, to give the broadest range possible (Fig. 4, Arno and Hammerly 1984), and suggests the collection was made below treeline. Similarly, Fries' type collection was found in southern Sweden in a beech forest where the fungus has not been subsequently recorded (Klán and Kubičkova 1979), and it is therefore not included in Table 1. Both records are outliers of the typical arctic-alpine distribution of *A. auriscalpium,* however, a new report suggests the fungus is not restricted to the alpine in Spain (Barrasa and Rico 2003). Our Colorado collections are the highest elevation records for *A. auriscalpium,* at 3,660 m on Independence Pass and 3,350-3,570 m in southwest Colorado, with a treeline between 3,000-3,200 m in these areas. This is the first official report of *Arrhenia auriscalpium* for Colorado, and the first records from the alpine of the southern Rocky Mountains other than a previous notation in Cripps and Horak (1999). The macroscopic and micro-

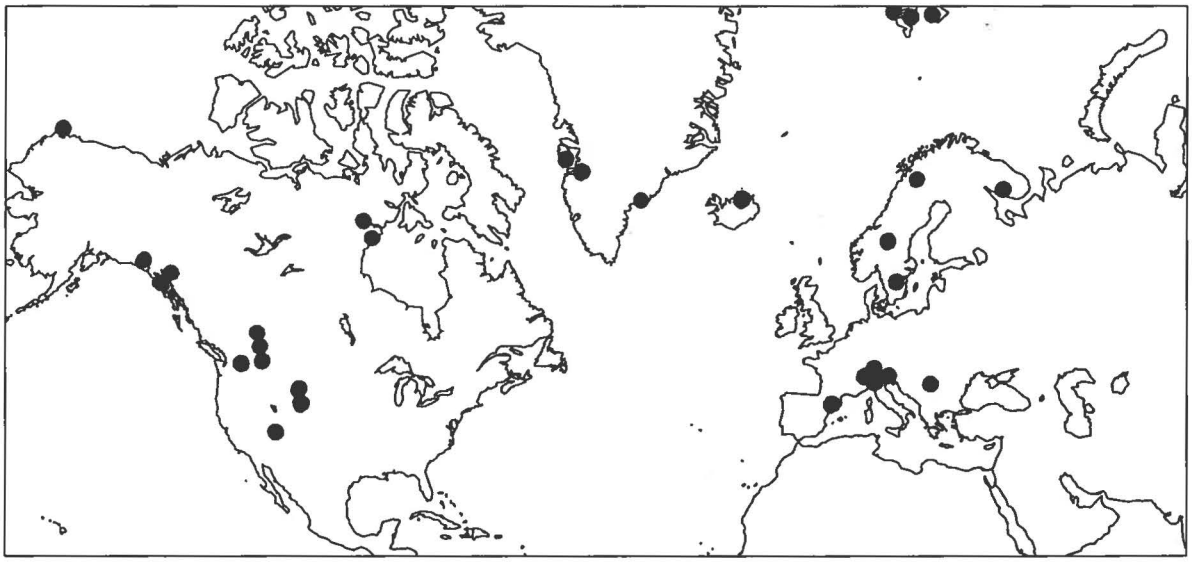
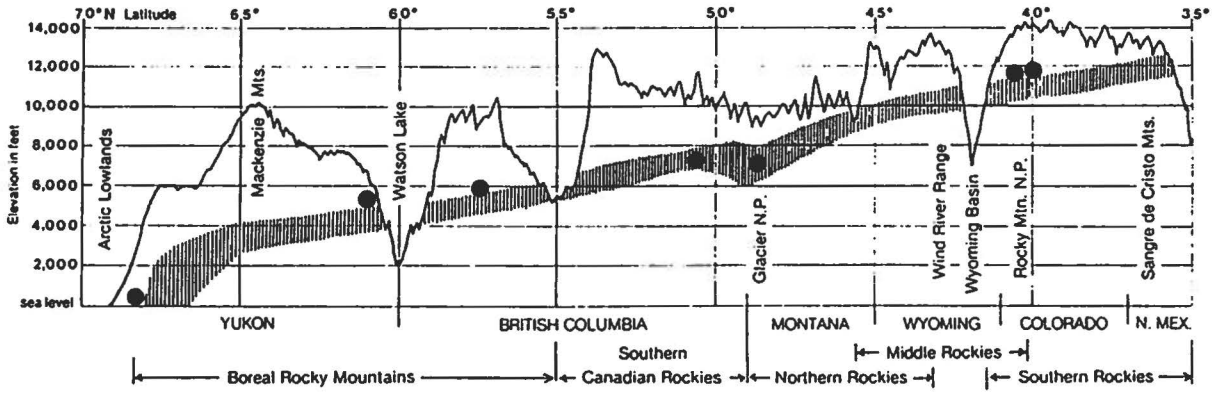


Fig. 3. Map of world distribution of *Arrhenia auriscalpium,* data from Table 1.



A north-to-south section along the crest of the Rocky Mountains, showing the southward rise in the alpine timberline (shaded zone). Sectioned distance is about 2300 miles.

Fig. 4. 1984. Graph reproduced with permission of publisher from Timberline: Mountain and Arctic Forest Frontiers by S. F. Arno and R. P. Hammerly. The Mountaineers, Seattle, WA. Locations added from N to S: Barrow (AK), Skolai Pass (AK), Glacier Bay ((AK), Banff-Jasper (Alta-B.C.), Okanogen Nat. For. (WA), Loveland Pass (CO), and Independence Pass (CO).

scopic features of the southern Rocky Mountain collections fit well into the circumscription of the species given by Redhead (1984) for other North American collections, and for the lectotype specified by Redhead (1984) from the original mixed type collection of Fries (also see Barrasa and Rico 2003).

Conclusions

The distribution of *Arrhenia auriscalpium* is mainly limited to arctic and alpine habitats as shown in Fig. 3, and has a circumboreal distribution. Treeline declines on high mountains as latitudes increase towards the North Pole, finally merging with the northernmost extent of trees near the arctic boundary. The elevational distribution of *A. auriscalpium* follows the same trend, being found at higher elevations in the lower latitudes in alpine habitats such as the Alps, Caucasus, Pyrenees, and the Rocky Mountains (Fig. 5). However, while there are records for Washington and northern Montana, intensive collecting in alpine areas of southern Montana and Wyoming has yet to turn up this species in the middle Rocky Mountains. An explana-

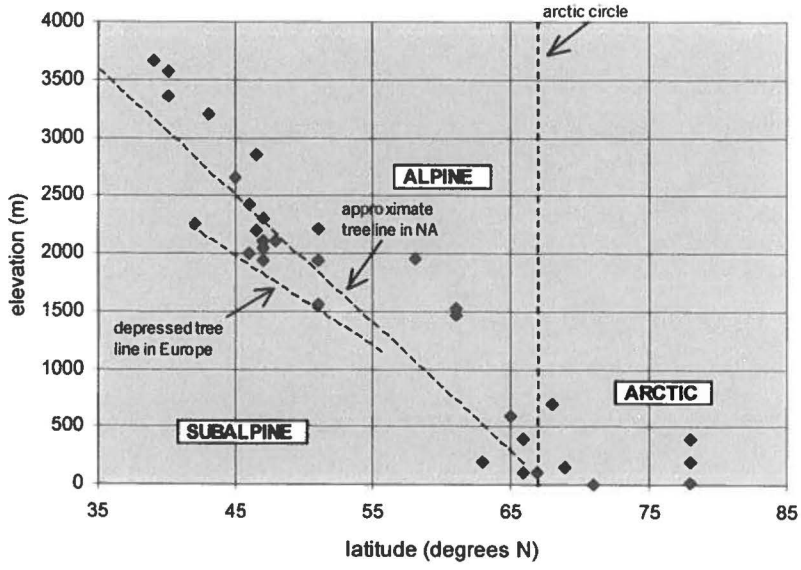


Fig. 5. Distribution of *Arrhenia auriscalpium* by elevation and latitude.

tion for the North American distribution of *Arrhenia auriscalpium* could be the presence of potential refugia for arctic-alpine fungi in the southern Rocky mountains such as the San Juans during periods of glaciation. Just as nunataks acted as high-elevation havens for plants (Körner 1995), they could likewise be refugia for fungi, and function as areas from which fungi could migrate back into the surrounding mountain ranges when glaciers receded, although there is presently much controversy surrounding the veracity of this topic. To date, there are no records from Antarctic and subantarctic habitats (Horak 1966, 1982).

Acknowledgement

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