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ORIGINAL ARTICLE

Aspicilia tibetica, a new terricolous species of the Himalayas and adjacent regions

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Abstract A new species, *Aspicilia tibetica* Sohrabi & Owe-Larss., is described from Tibet, where it grows on soil and plant debris at altitudes between 4,600 and 5,400 m, and where it seems to be rather commonly distributed. It is characterized by a crustose, white thallus, 8-spored asci with small, globose to ellipsoid ascospores, a brown epihymenium, and non-moniliform to submoniliform paraphyses. It lacks secondary substances. The new species is compared with other terricolous *Aspicilia* species. Morphological, chemical, and phytogeographical differences between the non-vagrant terricolous species are summarized.

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Introduction

Aspicilia is a poorly studied genus with many unresolved taxonomic and nomenclatural problems in need of a thorough revision (Clauzade and Roux 1984; Hafellner 1991; Nordin et al. 2007). The genus is characterized by more or less immersed apothecia, asci with a nonamyloid tholus, and simple, hyaline spores. Moniliform or submoniliform paraphyses, with the uppermost cells more or less globose, occur in several but not all species, and the pigment *caesiocinerea*-green (Meyer and Printzen 2000) is usually but not always present in the epihymenium. *Aspicilia* is a morphologically relatively diverse genus, dominated by crustose species, but also including several (sub)fruticose and a few subumbilicate to umbilicate or foliose species. It comprises an estimated number of at least 200 species (Owe-Larsson et al. 2007). Currently, it is placed in the family Megasporaceae (Lumbsch et al. 1994; Schmitt et al. 2006; Lumbsch and Huhndorf 2007). The alternative placement in Pertusariaceae (Miadlikowska et al. 2006) is based on a wide sampling within Lecanoromycetes, resulting in a far too inclusive Pertusariaceae.

The majority of the species in the genus are saxicolous, but several taxa are known to be terricolous, and a few lignicolous or corticolous species have also been described. Among the terricolous *Aspicilia* species, several are vagrant, i.e. obligatory unattached to the soil, while others are erratic, i.e. facultative unattached to the soil (Büdel and Wessels 1986). Some species have only a basal attachment to the soil, for example, *Aspicilia hispida* Mereschk. and *Aspicilia reptans* (Looman) Wetmore (Rosentreter 1993).

Finally, a number of the terricolous species are obligatory and fully attached to the soil or grow entangled among the vegetation.

A number of terricolous species of *Aspicilia* have been described or treated by a number of lichenologists during the last two centuries (for example, Elenkin 1901a, b, c, d, 1907; Eversmann 1831; Hue 1912; Oxner 1971; Link 1848, 1849; Looman 1962; Magnusson 1940; Mereschkowsky 1911, 1921; Steiner 1910, 1919, 1921; Tomin 1930; Werner 1956; Wetmore 1985). During the last two decades, several additional studies on terricolous *Aspicilia* have been presented, by Rosentreter (1993, 1998) on North American species, by Eldridge and Rosentreter (1997) on Australian species, by Rico (1999) on the muscicolous *Aspicilia crespiana* Rico from Spain, by Hafellner et al. (2004) from Southern Europe and mainly from Italy, and by Kulakov (2002, 2003) on *Aspicilia hispida* and other related vagrant species from the lower Volga Region in Russia. Out of a total of 33 *Aspicilia* species from the Greater Sonoran Desert Region, five species are terricolous (Owe-Larsson et al. 2007). The vagrant species in the *Aspicilia esculenta* group is at present under study by the first author.

The morphology in some terricolous *Aspicilia* species is subject to large variation. Several different varieties and forms of vagrant, basally attached or crustose, *Aspicilia* species were described by Mereschkowsky (1911) from the lower Volga region in the Astrakhan region, Russia, including Mt. Bogdo. Also, during later field studies in this region by Kulakov (2002) and the second author, and from Iran by the first author, some terricolous taxa of *Aspicilia* have been found to be extremly heteromorphic. For example, *Aspicilia aspera* (Mereschk.) Tomin seems to have several different morphs (e.g., crustose on rock, crustose on soil, erratic fruticose on soil, or vagrant), and studies using molecular methods are necessary to clarify the taxonomic status ot these different morphs. However, several other terricolous species of *Aspicilia* have typical morphological characters with little variation, making their species identity more easily recognizable. During an expedition to Tibet in West China in 1994, the last author collected several specimens of a distinct, terricolous lichen species, which turned out to be an undescribed species of *Aspicilia*. Here, we formally describe this taxon as new to science.

Material and methods

This study is based on morphological studies of all known non-vagrant terricolous species of *Aspicilia*, except for *Aspicilia auricularis* (Werner) S.Y. Kondr., for which only literature data were available. All examined specimens are deposited in the following herbaria: ASU, FH, G, GZU, H, LE, OSC, S, SBBG, SRP, UCR, UPS, WIS, and private herbarium of M. Sohrabi (herb. M. Sohrabi). Morphological studies were performed using a dissecting microscope, and the anatomy of the thallus and apothecia were observed using a Leica Dialux 20 compact light microscope, and photographed by a Leica DFC490 digital camera installed on Leica DM 2500 compact light microscope in Helsinki (H) (Figs. 2 A-C, I-K). Further examination of thallus morphology, including observation and illustration of ascus, ascospore and condiospore characters (Figs. 2 D-H, L-M and 3) were prepared in Graz (GZU), with the aid of stereo microscopes: Leica Wild M3Z and Zeiss Axiocam MRc5. In addition, the software CombineZM ('Public-Domain-Software', developed by Alan Hadley) was utilized for calculating picture stacks. Some microtome sections (16–20 μm thick) from the thallus and apothecia were prepared by using a freezing microtome. Preparations were mounted in lactophenol cotton-blue and water, or in KOH (tips of paraphyses). All microscopy measurements were made on water mounts. As a rule, 30 mature spores were measured from each specimen selected for closer scrutiny. Measurements were done using ×1,000 magnification and oil immersion; an eyepiece scale bar with 1-μm grid was used. Spore and conidia measurements are given as (min.–)M − SD–[M]–M+SD(–max.), rounded to the nearest 0.1 μm, where 'min.' and 'max.' are the extreme values recorded, M the arithmetric mean and SD the corresponding standard deviation. Measurements of other details represent extreme values.

High performance thin layer chromatography (HPTLC) and thin layer chromatography (TLC) were used to screen for secondary substances in selected specimens, and were performed according to standard methods (Arup et al. 1993; Orange et al. 2001).

Taxonomy

Aspicilia tibetica Sohrabi & Owe-Larss. sp. nov.

Type China. Tibet (Xizang): Himalaya Range, 135 km SSW of Lhasa, SSE of Pomo Tso (=Puma Yumco), near the pass into the Kuru valley, way from the pass-road to the glacier, 28º28′N, 090º37′E, alt. 5,100–5,300 m, *Kobresia*-meadows and slopes covered with rock debris, on soil, 18. VII.1994, *Obermayer 04386* (GZU, holotype; H, isotype).

Etymology The epithet refers to the region where the species was first collected.

Description Thallus terricola, crustaceus, rimosus vel areolatus vel irregulariter super substrato evolutus, cretaceus ad cinereus vel cremeus; subtus extensiones rhizomorphae similes praesentes. Apothecia numerosa, immersa ad

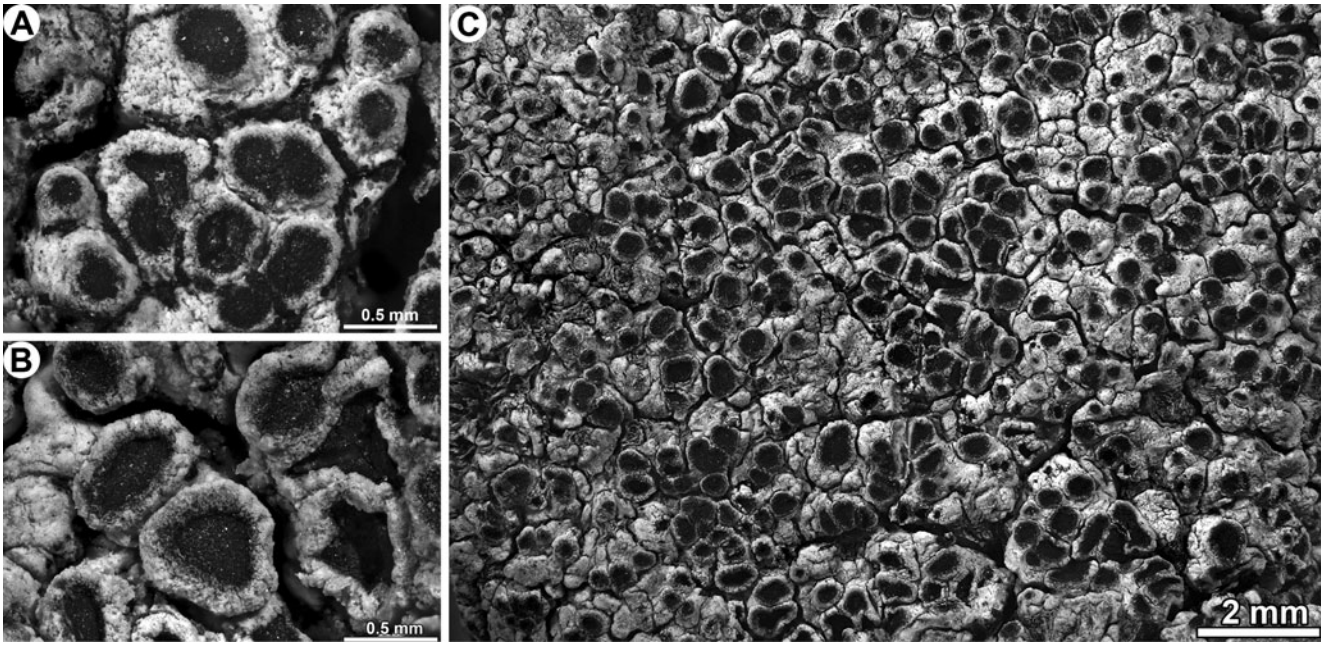

Fig. 1 *Aspicilia tibetica* (holotype). **a** Slightly aggregated, ± immersed apothecia. **b** Detached, marginate apothecia. **c** Thallus with abundant apothecia

interdum plusminusve sessilia, (0.2–)0.3–0.7(–1) mm diametro, 1–6/areola, simplicia et plusminusve orbicularia vel composita et saepe angularia; margo thallinus distinctus, tenuis, planus ad paulo elevatus; epihymenium fuscum vel olivaceofuscum, raro cinereovirens; hymenium hyalinum, (60–)70–80(–100) μm altum; paraphyses non-moniliformes ad submoniliformes; asci clavati, typo *Aspicilia*, 8-spori; ascosporae hyalinae, simplices, ellipsoideae ad globosae, (8.0–)9.8–[11.5]–13.2(–14.2)×(5.5–)6.5–[7.4]–8.4(–9.2) μm. Conidia bacilliformia, (4.8–)5.4–[6.1]–6.7(–6.9) × (1.4–)1.4–[1.5]–1.6(–1.6) μm. Materiae chemicae secundariae a TLC non detectae.

Thallus terricolous, on soil or plant debris, forming small patches up to 3–7 cm wide, crustose, continuous, rimose to areolate to irregularly developed on the substrate, with small cracks or depressions, with tiny rhizomorph-like extensions, prothallus absent. Areoles mostly irregular, sometimes angular to rounded, flat to convex, rarely concave, 0.3–0.9(–1.3) mm in diam., contiguous. Upper surface often smooth to roughened, pruinose, sometimes diffusely granulose, white to whitish gray to pale gray, chalky or cream-colored, dull, occasionally in old thalli margins brown to pale brownish. Upper cortex paraplectenchymatous, (10–)20–60(–80) μm thick, filled with granules and irregular cubic to round cells, uppermost part brown; cortex covered with a very thick epinecral layer, (40–)50–80(–100) μm thick, with crystals.

Photobiont green, chlorococcoid, unicellular, cells 6–14 (–16) μm wide, distributed in regular to irregular layers, often fragmented in small patches 40–60 μm wide.

Medulla ± loose to paraplectenchymatous, variable in thickness, lower parts interrupted by prosoplectenchymatous tissue, originated from the small rhizomorph-like extensions. Lower surface white to yellow, sometimes brownish to ochraceous, without cortex, basally with 1–3 ±isodiametric cells, some partly belonging to rhizomorph-like extensions. Rhizomorph-like extensions from the lower surface, short, up to 1 mm long, delicate, lacking algal cells, pale, white to yellowish, sometimes yellow-brown, usually attached to plant debris, occasionally visible at the margins.

Apothecia immersed, numerous, (0.2–)0.3–0.7(–1) mm in diam., 1–6 per areole, single and rounded to orbicular, or composite, then usually somewhat angular, immersed in the areoles, sometimes becoming±sessile and appearing lecanorine. Disc concave to flat, sometimes slightly convex, brown-black to dark black, sometimes whitish to gray pruinose. Thalline margin distinct, thin, usually leveled with the thallus or±elevated, usually concolorous with the thallus, sometimes somewhat darker closer to the disc or with a thin white rim. Proper exciple indiscrete, paraplectenchymatous, (20–)30–70(–95) μm wide, I-or sometimes in part weakly I±blue; uppermost cells brown to olive brown, ±globose to subcylindrical, 4–5(–7) μm in diam. Epihymenium brown, sometimes olive-brown, rarely gray-green, N+olive to green, K+brownish to green-brown; often with a thin, uneven crystal layer (up to 5–10 μm thick; crystals dissolving in N and K). Hymenium hyaline, (60–)70–80(–100) μm tall, weakly I+blue, turning partly yellow to yellow-green or rarely copper-red. Paraphyses non-moniliform to submoniliform, rarely moniliform,

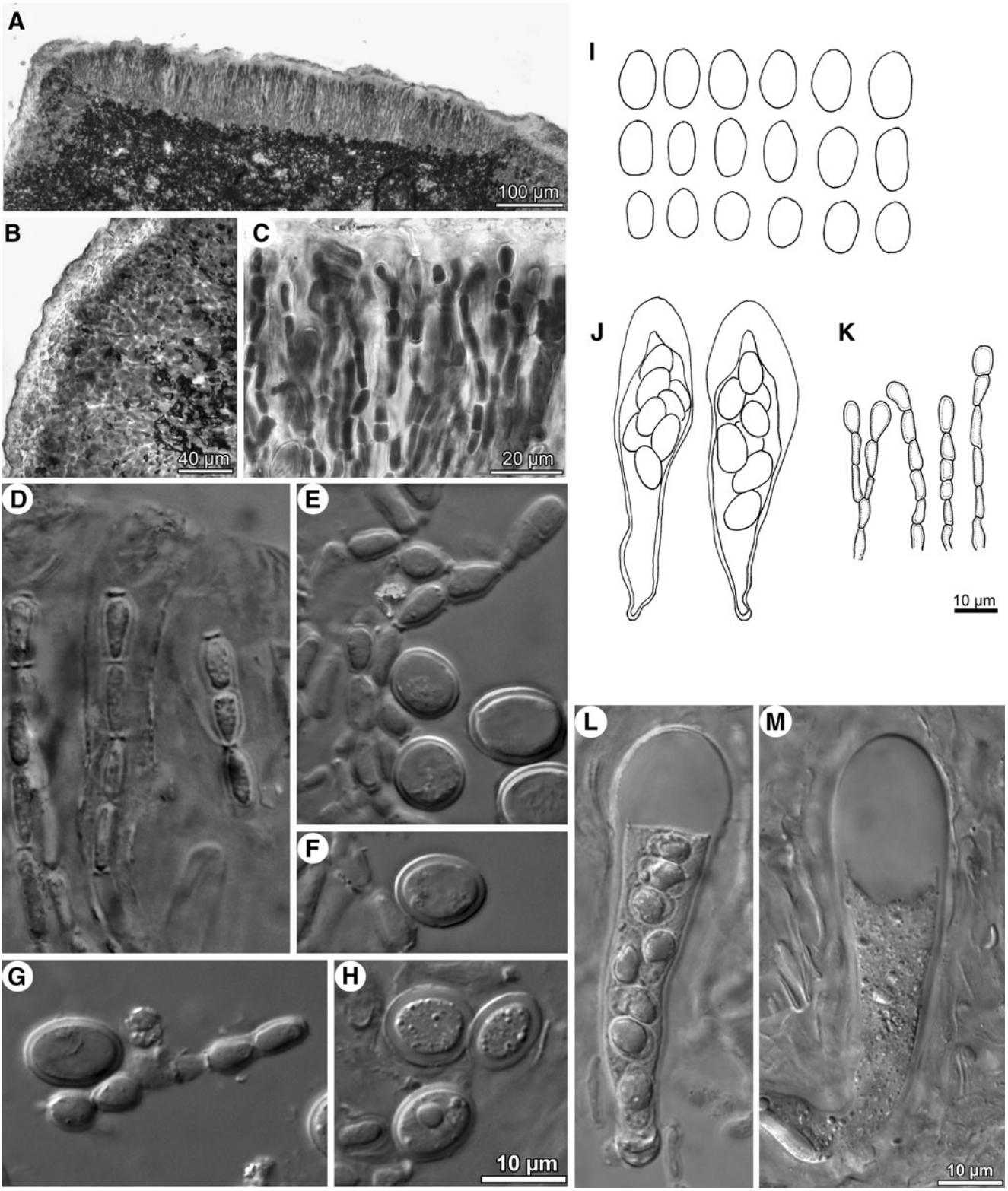

Fig. 2 *Aspicilia tibetica* (**a–c**, **i–k** isotype; **d–h**, **l,m** Obermayer 3567, GZU). **a** Section of areole with apothecium. **b** Cortex and medulla of thalline margin of apothecium. **c** Hymenium with paraphyses. **d** Paraphyses. **e–i** Spores. **j** Asci. **k** Paraphyses. **l** Ascus with immature spores. **m** Immature ascus without spores. *Scale bar* of **h** also applies to **d–g**, that of **k** to **i** and **j**, and that of **m** to **l**

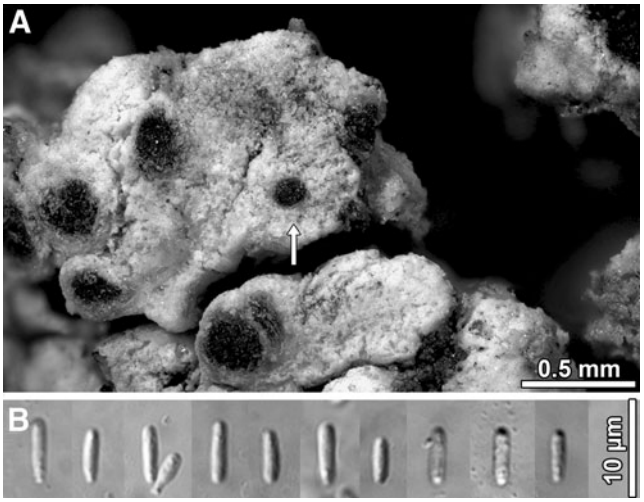

Fig. 3 *Aspicilia tibetica* (holotype). **a** Pycnidium (*arrow*). **b** Conidia from the pictured pycnidium

uppermost part with cylindrical to subcylindrical cells or with 1–2(–4)±globose cells, (2–)2.5–4(–5) µm wide, in lower part cells rectangular, 5–7x1.5–2 µm wide, simple to slightly branched and anastomosing. Subhymenium and hypothecium: pale, I+blue, together (20–)30–35(–45) µm thick, without algal layer underneath. Asci clavate, *Aspicilia*-type, (45–)50–70(–80) × 13–22(–26) µm, 8-spored. Ascospores hyaline, simple, variable, globose to subglobose to ellipsoid, (8.0–)9.8–[11.5]–13.2(–14.2)×(5.5–)6.5–[7.4]–8.4(–9.2) µm (n=40).

Pycnidia rare, immersed, rounded, with black ostiole. Conidia bacilliform, straight, (4.8–)5.4–[6.1]–6.7(–6.9)× (1.4–)1.4–[1.5]–1.6(–1.6) µm (n = 10).

Chemistry No secondary lichen substances detected by HPTLC or TLC.

Distribution and ecology Aspicilia tibetica is a high alpine species, and is found in Tibet at altitudes above 4,600 m. It grows on soil and plant debris (amongst species of *Kobresia*, e.g., *K. pygmaea*) together with other crustose terricolous species such as *Acarospora schleicheri* (Ach.) A.Massal., *Arthrorhaphis alpina* (Schaer.) R. Sant., *Caloplaca cerina* v. *chloroleuca* (Sm.) Th.Fr., *C. cerina* v. *muscorum* (A.Massal.) Jatta, *C. exsecuta* (Nyl.) Dalla Torre & Sarnth., *C. jungermanniae* (Vahl) Th.Fr., *Candelariella* spp., *Diploschistes* spp., *Megaspora verrucosa* (Ach.) Hafellner & V.Wirth, *Phaeorrhiza* ssp., *Rinodina* spp., and *Solorina bispora* Nyl. (many of which show a somewhat Ca-influenced habitat). Accompanying foliose or fruticose lichens include *Allocetraria ambigua* (Bab.) Kurok. & M.J.Lai, *A. flavonigrescens* A.Thell & Randlane, *A. stracheyi* (Bab.) Kurok. & M.J.Lai, *Bryoria* spp., *Cetraria laevigata* Rass., *Lethariella flexuosa* (Nyl.) J.C. Wei, *Thamnolia vermicularis* (Sw.) Schaer., and *T. vermicularis* v. *subuliformis* (Ehrh.) Schaer. Many of the mentioned taxa were already listed in Obermayer (2004) and Randlane et al. (2001).

Remarks Aspicilia tibetica has a well-defined ecology and is characterized by a crustose, white to pale gray thallus, a lower surface with pale rhizomorph-like extensions, small, globose to ellipsoid ascospores, 8-spored asci of the *Aspicilia*-type, a brown epihymenium, a short hymenium, non-moniliform to submoniliform paraphyses, and the lack of secondary substances.

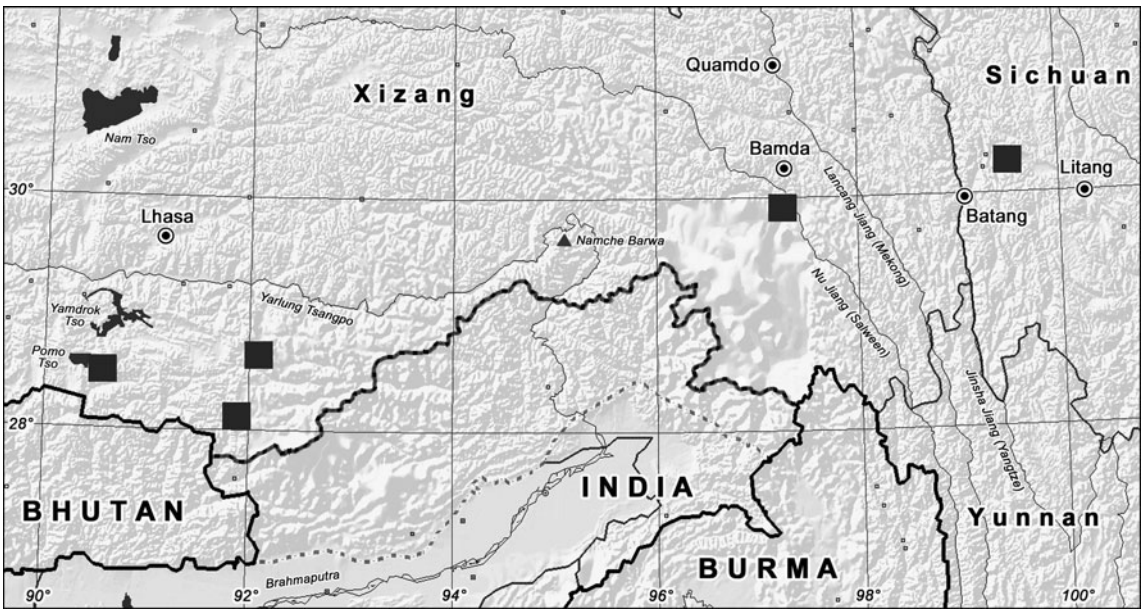

Fig. 4 Distribution of *Aspicilia tibetica*

Several terricolous, non-vagrant *Aspicilia* species have been described. Table 1 lists these species and gives some data on morphology, spore number and size, substrate, known distribution, and secondary chemistry for comparison with *Aspicilia tibetica*. Several of the species are characterized by asci with 2–4(–6) globose to subglobose spores, belonging to the *Aspicilia contorta/calcarea* group in the broad sense. Examples of such species are *Aspicilia aspera*, *A. crespiana*, *A. filiformis* Rosentr., *A. praecrenata* (Nyl.) Hue, *A. reptans* (Looman) Wetmore, and *A. tortuosa* (H. Magn.) N.S. Golubk.

One of few terricolous *Aspicilia* species with 8-spored asci is *Aspicilia californica* Rosentr. It is evident that *A. californica* is very different from *A. tibetica* by its subfruticose thallus, as well as by containing norstictic acid (Rosentreter 1998). The spore number and the secondary chemistry also distinguish *A. californica* from morphological rather similar species, such as *A. filiformis* and *A. reptans*.

Aspicilia glaucopsina (Nyl.) Hue is another terricolous species in California with 8 spores per ascus. *Aspicilia glaucopsina* differs from *A. tibetica* in the thallus color, by having a green epihymenium and moniliform paraphyses, and by the larger spores and longer conidia. *Aspicilia glaucopsina* is related to saxicolous species as *Aspicilia confusa* Owe-Larss. & A. Nordin and *A. phaea* Owe-Larss. & A. Nordin (Owe-Larsson et al. 2007).

Aspicilia subgenus *Pachyothallia* Clauzade & Cl. Roux, with saxicolous species, such as *A. cheresina* (Müll.Arg.) Hue, *Aspicilia determinata* (H. Magn.) N.S. Golubk., *A. farinosa* (Flörke) Hue, *Aspicilia recedens* (Taylor) Arnold, and two species with papillate thallus, *A. cernohorskyana* (Clauzade & Vězda) Cl. Roux and *A. chadefaudiana* Cl. Roux are characterized by 8-spored asci, small spores, a brown epihymenium, and short conidia, but in contrast to *A. tibetica*, also exhibit an algal layer below the hypothecium (Clauzade and Roux 1984; Owe-Larsson et al. 2007).

Aspicilia boykinii Owe-Larss. & A. Nordin is a saxicolous species found in the Grand Canyon area in Arizona and Colorado, USA. It agrees with *A. tibetica* by the small spores, and by lacking an algal layer below the hypothecium, but otherwise differs in several characters, such as a subradiate thallus, a green epihymenium, moniliform

Table 1 Some data on morphology, ecology, distribution and secondary chemistry for non-vagrant terricolous *Aspicilia* and allied species. Some of the species listed are facultative saxicolous

Species	Thallus mophology	Spores per ascus	Spore size (μm)	Substrate	Distribution	Spot test (secondary substance where known)
A. aspera	Crustose to subsquamulose to fruticose	2–4	c. 22–26 × 21–25	Soil or pebbles, rock	Russia, Central Asia	K− (no substance)
A. auricularis	Crustose to subsquamulose	No information	No information	Mosses and rock	Lebanon	No information
A. californica	Fruticose to appressed fruticose	6–8	(5.5–)10–18(–24)× (4–)7–11	Soil, organic duller, mosses, litter , rock	California, USA	K+red, P+orange (norstictic acid)
A. crespiana	Squamulose to subfruticose, with rhizomorphs	(2–)4(–6)	(11–)15–32(–45)× (8–)11–20(–31)	Mosses on siliceous rock	Spain, Italy	K− (no substance)
A. filiformis	Appressed fruticose	2–4	12–26 × 11–24	Soil, organic duff, mosses, dead grass	USA	K− or K±yellow (no substance or unknown subst.)
A. glaucopsina	Crustose	(6–)8	(16–) 18–22 (–24) × 10–14(–15)	Soil, mosses, disintegrated granite	California, USA	K− (no substance)
A. praecrenata	Crustose to squamulose	(2–)3–6	(16–) 18–23 (–27) × 15–21	Soil, disintegrated granite	California, USA	K− (aspicilin)
A. reptans	Squamulose with lobes to appressed fruticose	2	10 in diam.	Soil	North America	K−
A. tibetica	Crustose	8	10–14×6–9	On soil, humus, detritus	China	K− (no substance)
A. tortuosa	Crustose to partly appressed fruticose	3–4	17–25 in diam.(var. *simplicior*)	Soil or pebbles	Central Asia	K−
Megaspora verrucosa	Crustose	(4–)8	(30–)37–43(–63)× (16–)21–30(–32)	Soil, humus, mosses on calciferous soil, or on bark or lignum	Eurasia, North America	K− (no substance)

paraphyses, rather long conidia, and by having three chemotypes, two including norstictic acid (Owe-Larsson et al. 2007). *Aspicilia polychroma* Anzi has rather small, ellipsoid ascospores and is K−, but differs from *A. tibetica* by having much longer conidia (16–20 μm) (Hue 1912) and by being saxicolous.

Magnusson (1940) described several *Aspicilia* species from central Asia. However, none of these resembles *A. tibetica*.

Aspicilia uxoris (Werner) V.J. Rico, Aragón & Esnault shows similarities to *A. tibetica* regarding the bacilliform conidia, and by the absence of secondary substances as well as a subhypothecial algal layer (Rico et al. 2007). However, *A. uxoris* differs by somewhat larger spores, by having mostly moniliform paraphyses and pruinose apothecia, and by always being lignicolous, usually on conifer trees (mainly on *Juniperus* spp.), and by having a Mesogean distribution (sensu Quézel 1978), including the Mediterranean, the Irano-Turanian, and the Sahara-Sandian phytogeographical regions, (Sohrabi, unpublished data). Further studies using molecular methods are needed to identify the most related species of *A. tibetica* within the genus *Aspicilia*.

The external appearance of *A. tibetica* might resemble a 'bleached' *Phaeorrhiza nimbosa* (Fr.) H.Mayrhofer & Poelt, an alpine species that has also been recorded from Central Asia (Mayrhofer and Poelt 1978). However, *Phaeorrhiza nimbosa* has a sublobate to lobate thallus edge and a±brown color, a dark lower surface with brown to blackish rhizomorph-like extensions ("Rhizohyphen"), and is easily distinguished under the microscope by the brown, 2-celled spores.

Considering the great variation in choice of substrate and morphology in several *Aspicilia* species, it cannot be ruled out that *A. tibetica* might represent a terricolous modification of a normally saxicolous and/or lignicolous species, modified by the extreme conditions of the alpine zone. However, so far only terricolous specimens have been found, and no possibly conspecific specimens growing on other substrates at lower altitudes in the vicinity or from other areas are known.

The examined specimens of *Aspicilia tibetica* were 15 years old, and it is usually difficult to extract DNA from old herbarium material (Cubero et al. 1999). However, we managed to obtain an ITS1-5.8-ITS2 sequence (GenBank GU289915) from one of the specimens (*Obermayer* 04386). The sequence was compared with sequences available in GenBank and a great number of unpublished sequences that will be submitted in connection with other publications. Preliminary analyses indicated that *A. tibetica* is most closely related to the corticolous and lignicolous *A. uxoris,* known from Algeria, Morocco, and Spain (Rico et al. 2007), and the widespread *A. recedens* appeared as the closest related saxicolous species. None of the terricolous species discussed seemed to be closely related to *A. uxoris*. Additional molecular information will be presented in subsequent publications.

Additional specimens examined of Aspicilia tibetica China. Tibet (Xizang): 120 km SSW of Quamdo (=Changtu), 10 km S of Bamda, 30º09′N, 097º17′E, alt. 4,600–4,800 m, alpine meadows with *Kobresia*, on soil, 5.VII.1994, Obermayer 3897 (GZU), Obermayer 3947 (UPS); Himalaya Range, 130 km SSW of Lhasa, eastside of Puma Yumco (=Pomo Tso), way to the nearest mountain east of Pomo Tso, 28º31′N, 90º37′E, alt. 5,200–5,400 m, alpine meadows with *Kobresia*, on soil, 15.VII.1994, Obermayer 4255 (GZU); Himalaya Range, 190 km SSE of Lhase, 125 km S of Tsetang (Nedong), 20 km S of Nera Tso (=Ni la Hu), on way to Cona (=Tsona), 28º07′N, 91º55′E, alt. 4,650–4,800 m, alpine meadows, on rocks (near ground), 30.VII.1994, Obermayer 5095 (GZU); Ibid., on soil, Obermayer 5105 (GZU), Obermayer 5054 (herb. M. Sohrabi); Himalaya Range, 170 km SE of Lhasa, 80 km SE of Tsetang (Nedong), 2nd pass on way from Tsetang to Lhünze, 28º38′N, 92º14′E, alt. 5,000 m, alpine meadows and debrise cones, on ground, 25.VII.1994, Obermayer 4927 (GZU). Sichuan: Shalui Shan Mts., 40 km NNE of Batang, SE of Yidun, 30º14′N, 99º34′E, alt. 4,700–4,850 m, alpine meadows with *Kobresia* and *Rhododendron* shrubs, on soil, 28.VI.1994, Obermayer 3567 (GZU).

Additional specimens examined of other non-vagrant terricolous Aspicilia species (Table 1) Aspicilia aspera: Russia. Astrakhan: berg Bogdo, Mereschkowsky, 1910 (G, H). *Aspicilia californica*: U.S.A. California: San Benito Co., Pinnacles National Monument, San Benito Range, dry gravelly wash along Chalone Creek, 36º29′N, 121º10′W, alt. 293 m, June 1991, Rosentreter 7267 (ASU). *A. crespiana* Rico: Spain. Madrid: San Martin de Valdeiglesias, km. 3 de la carretera de Cadalso de los Vidrios a Pelayos de la Presa orcobada, alt. 740 m, V.J. Rico (1249/1) & M. A. Florido, 12.II.1988, (H). *A. filiformis*: USA: Idaho, Ada Co., Red Tie Site, T1 S R 3 E section 200, 43˚18′11″N, 116˚06′32″W, 19.V.2004, Rosentreter 15683 (SRP). *A. glaucopsina*: U.S.A. California: Los Angeles Co., Santa Monica Mts., alt. 340 m, on disintegrated granite, 1897, Hasse 192 (holotype, H-NYL 2965). *A. praecrenata*: U.S.A. California: Los Angeles Co., Santa Monica Mountains, "Barton's Peak", alt. 300 m, on clay and disintegrated granite, H.E. Hasse, February 1898 (holotype, H-NYL 25559). *A. reptans*: Canada. Saskatchewan: Webb, alt. 2,600 ft., 12 April 1959, Looman 596114_ (holotype, WIS). *A. tortuosa*: China. Kansu: Ehr-tao-ch'uan (Nan-shan), alt. 3,000 m, 18.XII.1931, Bohlin 53 (S). *Megaspora verrucosa*: Sweden. Jämtland: Åre par., Skurdalsbergen, N part, c. 200 m S of

Skurdalsporten, 63º21′17.8″N 12º04′59.9″E (WGS84), alt. 780 m, on mossy rock below calciferous overhanging rock, 7.IX.2007, Nordin 6495 (UPS).

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