

Orthotrichum (Orthotrichaceae, Bryopsida) in Pakistan

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Abstract: A first critical survey of the genus *Orthotrichum* in Pakistan is provided. The currently known geographical distributions of the species and their ecologies within Pakistan are discussed. The bryophyte collection from Pakistan contains eight species of the genus *Orthotrichum*. One of these, *O. obtusifolium*, is reported here for the first time from that country, whilst the occurrence of the other seven species is confirmed. *Pseudoleskeella tectorum*, associated with *O. crenulatum*, is also reported here from Pakistan for the first time. Comments on the specimens and a key to allow identification of all eleven species presently known from Pakistan are provided.

Introduction

The bryophyte flora of Pakistan is very poorly known. There are only a few scattered literature reports, such as the checklists of the mosses of Asghar (1957) and Nishimura & Higuchi (1993, 1994), and the bibliography of Pakistan mosses by Townsend (1993). In these reports, listings of *Orthotrichum* species remain incomplete. During field studies in Pakistan in 1998, one of us (J. P. G.) collected bryophyte specimens, among which 14 were samples of the genus *Orthotrichum*. Here we provide a first complete outline of this genus including an annotated key to identification of

species, restricted to those species occurring in Pakistan and some adjacent areas.

In North Pakistan distribution of the genus *Orthotrichum* is restricted to the partly open wooded, mainly northfacing ranges of the Himalaya and Hindu Kush mountains (Waziristan, Kohistan, Swat, Pakistan Northern Areas, Baltistan and Azad Kashmir, fig. 1), from an elevation of 1530 m up to the timberline (c. 3800 m), (epilithic species such as *O. rupestre* up to 5000 m, see tab. 1). At lower altitudes these habitats are characteristically coniferous woodlands intermixed with deciduous trees and

sclerophyllous *Quercus baloot*-wood, and the himalayan birch (*Betula utilis*) at higher altitudes (Hussain & Ilahi 1991).

A number of different field sites were examined (Peer et al 2002), but *Orthotrichum*-species were found at only 2 localities.

These are defined as follows:

(1) Pakistan Northern Areas; Gilgit NW, Naltar valley, Naltar lakes (altitude 3050-3150 m); 2 July 1998. The area consists of moraines of granitic and slaty components and alpine pasture with a glacial creek. The vegetation is predominately *Betula utilis*, although on dry, higher parts relictic *Juniperus semiglobosa*-trees are found and in lower parts of the valley *Pinus wallichiana*-*Picea smithiana*-woodland occurs.

(2) Pakistan Northern Areas; Baltistan, Astor S, Rupal valley, Tarishing S, Chhichi gol; 8 July 1998. The dominant vegetation species are *Pinus wallichiana* and *Picea smithiana* (altitude 2700-3200 m). The *Orthotrichum* specimens were collected from open woodland with alpine pasture (*O. alpestre*, *O. cupulatum*, and *O. laevigatum*).

Key to the species of *Orthotrichum* presently known from Pakistan and some adjacent areas *

- 1 Plants usually with numerous brood bodies on both leaf surfaces; dioicous, most often without capsules; leaves at apex broadly obtuse (if with capsules, these strongly furrowed and stomata superficial) *O. obtusifolium*
- 1' Brood bodies absent or few; plants autoicous, often with capsules; leaves at apex acute or rounded acute, never broadly obtuse 2
- 2 Stomata superficial 3
- 2 Stomata immersed 7
- 3 Exostome teeth erect-spreading when dry (very rarely reflexed in *O. laevigatum*, this species with distinctly exserted capsules); usually found growing on rocks 4
- 3' Exostome teeth recurved or reflexed when

dry; capsules immersed to emergent; usually growing as epiphytes 5

- 4 Capsules immersed to slightly emergent, ovoid to ellipsoid, furrowed at least in upper part when dry; leaves sometimes partly bistratose; hairs of calyptra reaching beyond the top

O. rupestre

- 4' Capsules long exserted, cylindric, smooth (rarely striate) when dry; leaves never bistratose; hairs of calyptra not reaching the top

O. laevigatum [incl. var. *japonicum*]

- 5 Capsules immersed, oblong to ovoid; 16 exostome teeth, lanceolate, strongly recurved; 16 endostome segments, broad lanceolate; calyptra campanulate

O. striatum

- 5' Capsules immersed to emergent to slightly exserted, ±cylindric; exostome of 8 pairs of teeth; 8 endostome segments, lanceolate; calyptra conic to conic-oblong 6

- 6 Capsules immersed to emergent, strongly furrowed when dry; calyptra conic-oblong to long conic, naked or with a few hairs; exostome teeth strongly reflexed when dry; leaf apex often broadly acute

O. affine

- 6' Capsules emergent to slightly exserted, smooth or slightly furrowed in upper half when dry; calyptra conic-oblong, often densely hairy, exostome teeth recurved, not reflexed; leaf apex narrowly acute (hitherto not known from Pakistan)

O. speciosum

- 7 Exostome teeth erect-spreading when dry (very rarely reflexed in *O. cupulatum*); endostome rarely present (present in *O. urnigerum*); most often growing on rocks 8

- 7' Exostome teeth recurved or reflexed when dry; endostome always well developed; often growing as epiphytes (*O. alpestre* also on rocks) 10

- 8 Capsules clearly exserted, oblong cylindrical to cylindrical; calyptra conic-oblong

O. anomalum

- 8' Capsules immersed to slightly emergent, ovoid to urceolate; calyptra campanulate 9

- 9 Vaginula naked or with a few hyaline hairs; endostome segments lacking; capsules with 16 striae (normally 8 long and 8 shorter ones)

O. cupulatum

- 9' Vaginula with numerous golden-yellow hairs; 8 or 16 endostome segments, well developed; capsules with 8 strongly developed striae and 8 intermediate striae very weak or lacking (hitherto not known from Pakistan)

O. urnigerum

- 10 Calyptra with scattered to numerous papillose hairs reaching over the top; leaf cells strongly papillose, papillae usually forked; leaf margins sharply crenulate by protruding papillae; stomata almost completely covered; spores 9-16 µm

O. alpestre

- 10' Calyptra naked or with a few smooth hairs; leaf cells smooth or with rather low papillae, leaf margins entire or crenulate only near leaf apex; stomata almost free of or only ½ (to 2/3) covered by subsidiary cells; spores 14-18 µm 11

- 11 Leaves ligulate to oblong-lanceolate; leaf apex partly broadly obtuse, partly rounded acute or acute; leaf margins often crenulate near the apex

O. crenulatum

- 11' Leaves ovate-lanceolate or oblong-lanceolate, never ligulate; leaf margins entire near the apex 12

- 12 Leaves broadly ovate to ovate-lanceolate, often apiculate with a hyaline apical cell; 8 endostome segments; stomata partly nearly uncovered, partly ½-covered or more by subsidiary cells

O. pumilum

- 12' Leaves oblong-lanceolate, acute or narrowly obtuse, not apiculate; 16 (8 +8) endostome segments, the intermediate ones often less well developed; stomata most often uncovered or very slightly covered by subsidiary cells

O. pallens

* In the adjacent areas of Jammu and Kashmir (under Indian administration), two further species have been reported which may also be expected to occur in

Pakistan, *O. speciosum* Nees (in valle Gudhai; Brotherus, 1898) and *O. urnigerum* Myr. (Gulmarg, Liddarwat; Brotherus, 1898; Lewinsky 1992, p.55). These two species are included in the key.

Comments on the specimens

The original specimens are deposited in the private Herbarium of Gruber, in Salzburg, Austria. A set of duplicates is in the Herbarium Schäfer-Verwimp, Germany.

1. *Orthotrichum alpestre* Hornsch. ex B. S. G., Bryol. Eur. 3 (fasc. 2/3), *Orthotrichum* Suppl. 1: 1. 1849.

Specimens examined: Naltar valley, epiphyte on *Betula utilis*, Gruber 2066; admixed to *O. laevigatum* var. *japonicum*, Gruber 2062pp; admixed to *O. striatum*, Gruber 2058. Rupal valley, on rock, mixed with *O. cupulatum*, Gruber 2101.

O. alpestre may be distinguished from related or similar species in the area by emergent or just exerted, strongly furrowed capsules with reflexed exostome and almost completely covered stomata. The leaf cells are often strongly papillose, the leaf margins sharply crenulate from protruding papillae. All specimens are typical for this species.

Distribution: *O. alpestre* is known from western N America, Greenland, Europe, North and Central Asia, as well as from the northern parts of India and Pakistan. In Pakistan it appears to be one of most commonly occurring species of the genus, at least in the areas visited (seen in four collections). First and single previous record for Pakistan by Lewinsky (1992). Distribution map in Lewinsky (1993, fig. 28).

2. *Orthotrichum anomalum* Hedw., Spec. Musc. 162. 1801.

Specimen examined: Naltar valley, on rock, Gruber 2061.

Both *O. anomalum* and *O. laevigatum* occur primarily on rocks, have long exerted, ±cylindrical capsules and erect to spreading exostome teeth. However, *O. anomalum* is readily distinguished from the latter as it has immersed stomata and always furrowed capsules.

Distribution: *O. anomalum* is widely

distributed in the northern hemisphere and seems to be common in Pakistan where it was first recorded from a Harriss collection by Brotherus (1898), and consequently by Noguchi (1959), Froehlich (1964), and Nishimura et al. (1993). Distribution map in Lewinsky (1993, fig. 29).

3. *Orthotrichum crenulatum* Mitt., J. Linn. Soc. Bot. Suppl. 1: 48. 1859.

Syn: *O. virens* Vent. in Broth., Acta Soc. Sci. Fenn. 24(2): 18. 1898.

Specimen examined: Naltar valley, epiphytic on old *Juniperus semiglobosa*, growing together with *Pseudoleskeella tectorum* (Funk ex Brid.) Kindb. (new to Pakistan) and *Tortula* spec., Gruber 3193.

O. crenulatum is best recognized by the leaf shape which is ligulate to oblong-lanceolate with obtuse or rounded acute to acute, and often crenulate apex. It is similar to *O. pallens* in having only slightly covered stomata, but is easily distinguished from the latter by its leaf shape and also by having an endostome of only 8 segments. It may be distinguished from *O. pumilum* by leaf shape, partly crenulate leaf apices and less covered stomata.

The specimen Gruber 3193 often has ligulate leaves which are suddenly narrowed below the typical obtuse or rounded acute, crenulate apex. It has a spore size of 14-16 µm and agrees well with the description and figures in Lewinsky (1992). Gemmae have not been seen.

Distribution: Endemic to the area around northeastern Afghanistan, northern India, western Tibet, Turkestan, Kasachstan, and Tadzhikistan (Lewinsky 1992, 1993). First and single previous record by Lewinsky (1993), however, without citing a specimen.

4. *Orthotrichum cupulatum* Brid., Musc. Rec. 2(2): 25. 1801.

Specimens examined: Naltar valley, on rock, Gruber 2064. Rupal valley, on rock, Gruber 2099; admixed to *O. alpestre*, Gruber 2101pp.

O. cupulatum, growing almost exclusively on rocks, is easily recognized by the immersed to emergent, ovoid to urceolate capsules with erect exostome and immersed stomata. From this combination of characteristics it is unmistakable in the area. (For differences to

O. urnigerum Myr., which may also be expected to occur in Pakistan, see the key).

Both specimens lie well within the range of variation of the species. Specimen 2099 deviates by (1) exostome teeth being irregularly striate in the upper two thirds (striae horizontal as well as vertical and oblique, the striae longer and more distinct than those shown in fig. 45k by Lewinsky 1992); (2) the cells of the upper part of leaf are more strongly papillose, with two to three rather high and acute papillae. The reflexed leaf margin is strongly crenulate, similar to that of *O. alpestre*. As in all other Central and South Asian populations of this species, an endostome is absent in both 2099 and 2064.

Distribution: *O. cupulatum* is widely distributed in western North America, southern South America, Europe, North Africa and Central Asia. It is known to occur in Central and South Asia in Afghanistan, Pakistan, northern India, Turkestan, and Uzbekistan. First and single previous record from Pakistan by Blatter & Fernandez (1929). Distribution map in Lewinsky (1993, fig. 29).

5. *Orthotrichum laevigatum* Zett., Oefv. K. Vet. Ak. Foerh. 19: 363. 1862.

Specimens examined: Naltar valley, epiphytic on *Betula utilis*, mixed with a few plants of *O. alpestre*, Gruber 2062. Rupal valley, on rock, Gruber 2100.

O. laevigatum is characterised by the distinctly exserted, cylindrical and (mostly) smooth capsules with erect to spreading exostome and superficial stomata. In the field it may be confused only with *O. anomalum*, although the latter has clearly striate to furrowed capsules and is immediately distinguished under the microscope by the immersed stomata. Another similar species, with superficial stomata, is *O. rupestre*. This species however, is clearly distinguishable from *O. laevigatum* by its oblong-ovoid, immersed to emergent, never distinctly exserted, cylindrical capsules (as seen in *O. laevigatum*) and always splitting exostome teeth when old (remaining paired or only rarely splitting in *O. laevigatum*).

The var. *japonicum* only differs from var. *laevigatum* by the consistently well developed, strongly ornamented endostome

segments and mostly larger spore size (18-22 μm) (Lewinsky 1992: 42f); the spore size of var. *laevigatum* is 12-20 μm . In the specimen Gruber 2100 the capsules are similar to those figured by Lawton (1971, fig. 12 of pl. 121, of *O. laevigatum* var. *laevigatum*), although the peristome is badly preserved and an endostome appears not to be present. A few old capsules have reflexed exostome teeth, and the spore size is mostly 16 μm . In 2062 the capsules are more long cylindrical than in fig. 7, pl. 121, of *O. laevigatum* var. *laevigatum* (Lawton 1971); the peristomes are better preserved, and the typical endostome segments of *O. laevigatum* var. *japonicum* (Iwatsuki) Lewinsky, as described and figured by Lewinsky (1992, fig. 24j), are to be seen. The figure of the capsule in Lewinsky (1992, fig. 24a) shows an intermediate expression which is also present in both collections at hand. Many of the capsules in 2062 are slightly but distinctly striate in the upper half, rarely in the whole length. This is clearly in contradiction to Lewinsky (1992: 42) who describes only smooth capsules (at least in SE Asian material). In European populations this character seems quite common as Venturi (1887: 158) described the capsule "... avec des faibles traces de bandes ...", and Mönkemeyer (1927: 619) found it "... fast glatt, mit sehr schwachen Streifen ...". From North American populations it is said that the capsule is "... usually smooth when dry, sometimes wrinkled, rarely slightly ribbed just below the mouth ..." (Lawton 1971: 222). Comparing these descriptions with the specimen 2062 it is clear to us that "distinctly striate capsules" (at least when old) must be accepted within the range of variation of this species.

It should be noted that the specimen 2062 grew as epiphyte, and the habitat of this species has rarely been reported in literature (Lawton 1971; Ignatov & Lewinsky-Haapasaari 1994).

The specimen Gruber 2062 certainly belongs to *O. laevigatum* var. *japonicum* (Iwats.) Lewinsky. However, the spore size of 16 μm in Gruber 2100 and 16-18 μm in Gruber 2062, is not a useful feature for distinguishing between var. *laevigatum* and var. *japonicum*.

Distribution: *O. laevigatum* var. *japonicum* is known only from Asia in India,

Nepal, Tibet, Southern Siberia (Altai Mountains) and Japan. The var. *laevigatum* is reported from North America and Europe. From Pakistan *O. laevigatum* was first recorded by Brotherus (1898; as *O. schlotthaueri* Vent.) and consequently by Robinson (1965) and Nishimura et al. (1993, as fo. *macounii* (Aust.) Lawt. & Vitt). Distribution map in Lewinsky (1993, fig. 23).

6. *Orthotrichum obtusifolium* Brid., Muscol. Rec. 2(2): 23. 1801.

Specimens examined: Naltar valley, epiphytic, with *Pseudoleskeella tectorum*, *Hypnum cupressiforme*, *Tortula* spec., *Orthotrichum* spec. (sterile, with leaves partly strongly undulate), without sporophytes; Gruber 2060, 3379.

Although *O. obtusifolium* is mostly sterile, it is easily recognized by broadly-ovate-lanceolate leaves with broadly obtuse apex and plane or incurved leaf margins, commonly with numerous brood bodies on both leaf surfaces.

The specimen 2060 appears typical for this species.

Distribution: Widely distributed in the northern hemisphere from North America to Europe and Asia reaching Kashmir in India, China, and Japan. First record for Pakistan. Distribution map in Lewinsky (1993, fig. 25).

7. *Orthotrichum rupestre* Schleich. ex Schwaegr., Spec. Musc. Frond. Suppl. 1, 2: 27. pl. 53. 1816.

Syn.: *Orthotrichum sturmii* Hoppe & Hornsch., Flora 2(1): 89. 1819. *Orthotrichum rupestre* var. *sturmii* (Hoppe & Hornsch.) Jur., Laubmfl. Oest. Ungarn: 201. 1882.

Specimen examined: Naltar valley, on rock; Gruber 2059.

O. rupestre is clearly recognizable by the following characteristics: immersed to emergent, ovoid to ellipsoid capsules with erect-spreading exostome teeth and superficial stomata, and campanulate, hairy calyptra. It is normally found growing on rocks, although more rarely it is epiphytic.

The specimen 2059 is consistent with other collections from South and East Asia by the lack of endostome segments. The lamina is mainly unistratose with occasional bistratose

margins and single striae reaching nearly to the base.

Distribution: *O. rupestre* is rather cosmopolitan, in South and East Asia known from India (Kashmir), Pakistan, and China. Distribution map in Lewinsky (1993, fig. 13, 23). First record from Pakistan by Brotherus (1898), as *O. rupestre* and *O. sturmii*. Further reported by Noguchi (1959), Froehlich (1964), Robinson (1965), and Nishimura et al. (1993).

8. *Orthotrichum striatum* Hedw., Spec. Musc. Frond. 163. 1801.

Specimen examined: Naltar valley, epiphytic on *Betula utilis*, with a few plants of *O. alpestre*, Gruber 2058.

O. striatum is easily recognized in the area by its oblong to ovoid, immersed, smooth capsules (when dry the upper parts are sometimes slightly furrowed) with superficial stomata and the peristome of 16 broad (at least partly two cells wide) endostome segments and 16 lanceolate, yellow or orange exostome teeth which are strongly recurved. *O. affine* is readily distinguished from *O. striatum* by its strongly furrowed capsules and 8 exostome teeth. *O. rupestre* is distinguished by its erect exostome and by its reduced, or absent, endostome.

The spores in Gruber 2058 are 24-28 µm in diameter and are smaller than those reported by Lewinsky (1992) from SE Asia (31-35 µm). However, the spore size lies well within the range of European or North American populations (18-28 µm and 17-31 µm, respectively).

Distribution: *O. striatum* is known from the Pacific Northwest of North America, Europe and North Africa. In South and East Asia, where it is known from India, China and Pakistan, it seems to be a rather rare species and the above cited specimen is only the second from Pakistan (first reported from a Harriss collection by Lewinsky 1992). Distribution map in Lewinsky (1993, fig. 21).

Three species known from Pakistan are not represented in the Gruber collections: *O. affine*, *O. pallens*, and *O. pumilum*.

Orthotrichum affine Brid. is a rather polymorphous epiphyte (very rarely on rocks) and distinguished from other species in the area by immersed to emergent, strongly furrowed capsules with 8 reflexed exostome teeth and superficial stomata, the calyptra is (long) conic with a few scattered hairs. Other species with superficial stomata have either smooth capsules with 16 exostome teeth (*O. striatum*) or distinctly exerted capsules (*O. laevigatum*) or have the exostome teeth erect-spreading, never reflexed (*O. rupestre*). A rare species in SE Asia known only from three collections, two from India, and one last century Harriss collection from Pakistan (Lewinsky 1992; distribution map in Lewinsky 1993, fig. 22).

Immersed but almost uncovered stomata are the most typical feature of *Orthotrichum pallens* Brid. In combination with the reflexed exostome of 8 pairs of teeth, the 16 (8 + 8) endostome segments (the intermediate ones often reduced) and the less papillose leaf cells it can be distinguished from the similar *O. alpestre* which always has nearly completely covered stomata and most often strongly papillose leaf cells. For differences to *O. pumilum* and *O. crenulatum* see the descriptions of those species. *O. pallens* is known from North America, Mexico, Venezuela, Greenland, Europe, and northern Asia. It is rare in SE Asia reaching its southernmost border in Pakistan and India from where it is known only from a very few collections (Lewinsky 1992; distribution map in Lewinsky 1993, fig. 28).

O. pumilum Sw. is best recognized and distinguished from *O. pallens* and *O. alpestre* by the leaf shape being broadly ovate to ovate lanceolate with sometimes obtuse, sometimes acute and partly apiculate apex with a hyalin apical cell. Hardly covered stomata and more strongly covered ones are often found on the same capsule which has a peristome of 8 reflexed exostome teeth when dry and 8 lanceolate endostome segments. Further differences to *O. pallens* and *O. alpestre* are included in the key. *O. pumilum* is widely distributed in the northern hemisphere, in Asia reaching Pakistan and eastern China. First record for Pakistan by Blatter & Fernandez (1929).

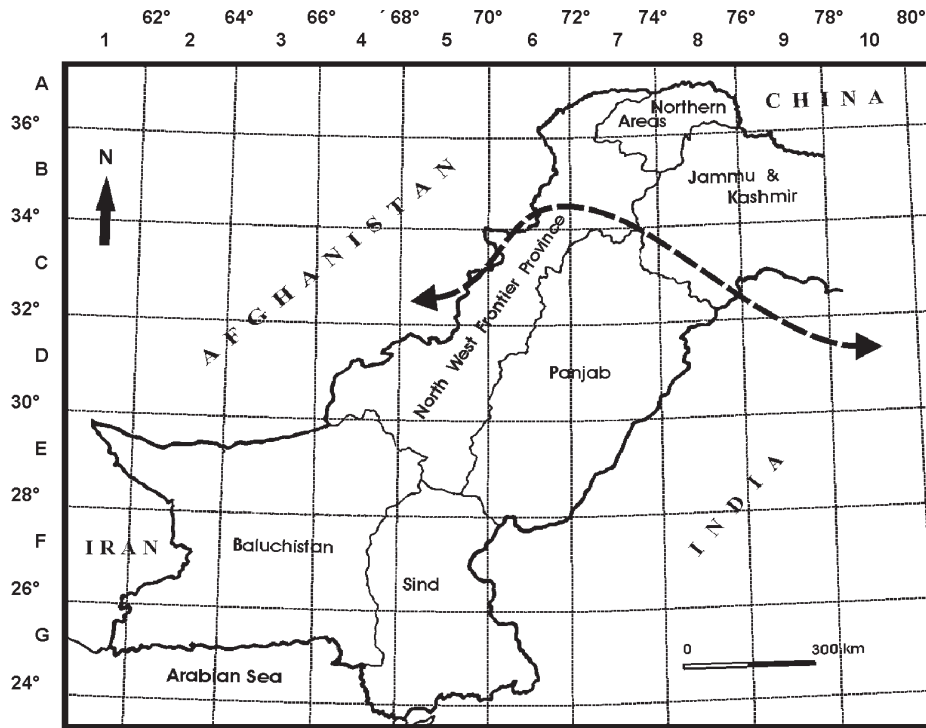


Fig. 1: Dashed line marks the southern border of *Orthotrichum*-occurrence in Pakistan, which is nearly equivalent to the southern border of the Himalaya and Hindu Kush mountain-chains (after Nasir & Ali 1970, modified).

Tab. 1: Distribution grid squares (2° in square) of the genus *Orthotrichum* and the known altitudinal range in Pakistan

| Species | grid squares | altitudinal range |
|--------------------------|----------------|-------------------|
| <i>O. affine</i> : | B6, B8 | 2330 m – 3660 m* |
| <i>O. alpestre</i> : | B7, B8 | 2700 m – 4000 m |
| <i>O. anomalum</i> : | B6, B7, B8, B9 | 1530 m – 4000 m |
| <i>O. crenulatum</i> : | B8, C7* | 3150 m – 3670 m* |
| <i>O. cupulatum</i> : | B8, C6 | 2150 m – 3050 m |
| <i>O. laevigatum</i> : | B8 | 3100 m – 4300 m |
| <i>O. obtusifolium</i> : | B8 | 3050 m – 3100 m |
| <i>O. pumilum</i> : | B7, B8, C6 | 1530 m – 3230 m |
| <i>O. pallens</i> : | B6 | 1600 m – 2000 m* |
| <i>O. rupestre</i> : | B7, B8, B9 | 2200 m – 5000 m |
| <i>O. striatum</i> : | B6 | 2660 m – 3330 m* |

(*data from Kashmir are included)

O. suburnigerum Herz. is a nomen nudum (see comments in Nishimura & Higuchi 1993).

Currently knowledge of the distribution of *Orthotrichum* in Pakistan

The general patterns of distribution of the genus *Orthotrichum* in Pakistan have been described in the introduction. More detailed data are given in grid squares (tab. 1.), in a format similar to that used in the Flora of West Pakistan (Nasir & Ali 1970, fig. 1.).

Discussion

The mountainous regions of Asia do not lend themselves to field research, partly because of the inhospitable terrain, and partly because of socio-economic problems within the countries concerned. Thus any new contributions to our knowledge of the biology and ecology of the areas are useful. In the present work we have summarised the information available in the (often inaccessible) literature and combined this with new findings from our own field work to provide an up-to-date account of the distributions, ecology and phytosociological associations of species of the genus *Orthotrichum* in Pakistan.

In common with Central European mosses (Düll 1992) populations of *Orthotrichum* found at the edges of their ranges in Pakistan are subjected to less suitable development conditions and fewer suitable locations (Frahm 2001). Dryness phases and drying resistance of the species are particularly relevant here.

Notable examples include the two "rarest" species *O. crenulatum* and *O. obtusifolium* (more rare than most rarest vascular plants!). The population of both species within the area of Naltar lakes are confined to separate microhabitats. *Pseudeskeella tectorum*, which is known to be associated with *Orthotrichum* species, and which is recorded from Pakistan for the first time, is associated with both species of *Orthotrichum*.

In the ancient near-natural *Juniperus semiglobosa*-forest stands surrounding Naltar

lakes, the environment is characteristically harsh, and has a relictic character. The trees have reacted by developing a longevity strategy (Klötzli 1991). In this habitat *O. crenulatum* occurs on the trunks of these trees, which may be up to 1 m in diameter. These (rare) specimens are bearing sporophytes almost continuously. The spore size of 14-16µm indicates a long dispersal strategy with a conceivable spread radius of more than 300 km (Frahm 2001). Hard, but "semiconservative" ecological conditions of the location explain the existence of the small epiphytic population on *Juniperus semiglobosa*. Further finds in such rare positions are to be expected, as implied by "Pakistan" in Lewinsky (1992, 1993) but without further specification. Increasing occurrence may be expected in the border area to Kashmir and Afghanistan (Brotherus 1898, Lewinsky 1993) because of the favorable climatic conditions.

O. obtusifolium requires somewhat different conditions in the area. Sporophytes were not to be found, the propagation effected by breeding bodies, which form well developed cushions at the bases of *Betula utilis*-trunks. Populations are found in humid conditions on the valley floor and the lower slopes of the glaciated valley. The rarity of the species – despite the occurrence of *Betula utilis* in almost all valley streams in the region, may be explained by the higher requirements for the air-humidity and the localised dispersal strategy using breeding bodies.

In contrast to the previous species, the epiphytic and saxicole *O. pumilum* is of most frequent occurrence in Pakistan and is associated with coniferous forests of higher altitudes. The species also has the largest altitudinal range. It regularly forms sporophytes. With spore size of 14-17µm it is a long distance wind dispersal strategist.

The epiphytic representatives of *Orthotrichum* at the subtropical edge of the high Asian region are particularly noteworthy. Their habitat is relatively uninfluenced by pollutants, so monitoring studies, particularly in comparison to Central Europe and the alpine region would be a valuable avenue for future research, also in regard to climate change. The rare woodland-habitats are

extremely vulnerable to human influences and may disappear in the next decades. The previously untouched *Juniperus semiglobosa*-woodland is already subject to local destruction. In comparable areas in Afghanistan Podlech (2000, pers. comm.) evaluates the situation even more pessimistically. However, this does not detract from the scientific value of the identification key to *Orthotrichum* presented here.

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