The taxonomic status of Orthotrichum fastigiatum

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Abstract: *Orthotrichum fastigiatum* has variously been treated as a species or as subscpecies, variety or even as synonym of O. affine. The distinguishing characters between both taxa were studied. An evaluation revealed that some characters such as spore size (different but intergrading), exostome ornamentation, leaf apex, shape of papillae and lid cannot be used for differentiation. Other characters of O. fastigiatum such as smaller size, capsules imbedded in the leaves, a naked calyptra, the width of the ribs of the urn and the extend to which the empty capsule is contracted below the mouth are usable but hardly to quantify. The observation of mixed stands as well an apparent different ecology indicates different genotypes. Therefore O. fastigiatum should be regarded as infraspecific taxon of O. affine.

INTRODUCTION

There is a consistent discussion in taxonomy, whether a taxon deserves recognition and, if yes, on which level. One of the example of doubtful taxonomic status is *Orthotrichum fastigiatum*, which was originally described as a species by Bruch in Bridel already in 1827 but later reduced to the rank of a subspecies or variety and today often no more recognized.

Orthotrichum fastigiatum Bruch ex Brid., Bryol. Univ. 1: 785, 1827.
Orthotrichum affine Schrad. ex Brid., Musc. Rec. 2: 22, 1801
ssp. *fastigiatum* (Brid.) Hartm., Skand. Fl. Ed. 4: 322, 1938
var. *fastigiatum* (Brid.) Hüb.. Musc. Ger, 365, 1833

In the protologue, Bruch admitted that *O. fastigiatum* is not easy distinguishable ("nec facile ab eo dignoscendum") from the most similar ("simillimum") *O. affine*. He differentiated *O. fastigiatum* by
(1) erose-denticulate leaves
(2) lacunose exostome
(3) an articulate endostome consisting of only one cell row, much more robust than in other species of the genus
(4) a calyptra which is smooth or has only few hairs, which is fringed at base.
Already Hübener in 1833 reduced *O. fastigiatum* to the rank of a variety. He wrote that it is even as a variety difficult and critical to distinguish by the form of the peristome teeth, of which the

exostome is irregularly lacunose and the endostome is more robust and stronger articulate. Vegetatively the plants are smaller, the calyptra shorter and less hairy. Interestingly these characters mentioned are different from those which were used later. Mönkemeyer (1927) recognized *O. fastigiatum* as variety, which shall mainly be differentiated by lower plants and broadly ribbed capsules, characters, which hardly allow to separate both taxa.
Nyholm (1954-69) accepted *O. fastigiatum* as a species distinguished from *O. affine* by short setae, broad striae on the capsule, irregularly striate peristome teeth and smooth calyptra and the lid bordered with 3-5 rows of red, much shortened cells. The latter character is not mentioned in the key and seems also to fit *O. affine*. In contrast, *O. affine* shall be characterized by elongate setae, narrow striae, usually papillose peristome teeth and a smooth or hairy calyptra. Because of the wide variation, she did not illustrate *O. affine*. However, in the second edition of her moss flora (Nyholm 1998), she changed her mind and writes under *O. affine*: "It has been sometimes named *O. affine*, sometimes *O. fastigiatum*, or regarded as hybrid between *O. speciosum* and *O. fastigiatum*. I prefer to regard it as one very variable taxon." As illustration of *O. affine* she uses that of *O. fastigiatum* from the first edition.
Vitt (1973) describes *O. fastigiatum* as "a European taxon which has cylindric capsules which are shortly emergent."
Smith (1978) mentions that a shorter more compact form with shorter, more immersed capsule referred by Dixon to var. *fastigiatum* "does not appear to be sufficiently distinct in Britain to warrant recognition", but admits that "the situation clearly requires further investigation", which shall be done here. Nebel & Phillipi (2001) state that a distinction between O. affine and O. fastigiatum is not possible, since the characters are too variable.

TYPE SPECIMENS

For a clarification on a taxonomic basis, a study of the type specimens is obligatory, which has, however, never been undertaken since neither the type of *O. fastigiatum* nor that of *O. affine* are available:

Vitt (1973) mentions that the **type of *O. affine*** (presumably syntypes "Hassiae et prope Goettingam", the protologue says "In asseribus et arborum truncis Hassiae at prope Goettingam Gothamque, ubi a me [Bridel] lectum est) is not present in the Bridel-herbarium in Berlin. However, this concerns the herbarium of Bridel, who published but did not introduce the species. *Orthotrichum affine* was introduced by Schrader. Schrader was professor in Göttingen (Frahm & Eggers 2001), therefore the type locality Göttingen, and it could be that specimens are kept in his herbarium, of which parts shall exist in LE, GOET and KIEL. A search for a possible type specimen in Göttingen by J. Heinrichs and in KIEL by K. Dierßen failed; and a loan request to the herbarium in St. Petersburg was not replied.
According to the protologue, the **type of *O. fastigiatum*** was collected "in cortice Populi circo Bipontium…, Bruchius…" (On bark of poplars around Zweibrücken…"). The Bruch-herbarium is in Lyon and not accessible. Duplicates are in BM, B-Bridel, BR and L (Sayre 1977). There is a specimen in the Bridel Herbarium (B) "Orthotrichum fastigiatum Bruch, An Pappeln, Funck ab Bruch", which could be an isotype if there would not be the confusing addition of Funck´s name. The specimen consists of a small dense semiglobose cushion with ripe capsules without calyptras.

DISTINGUISHING CHARACTERS

Interestingly, the distinguishing characters between both taxa vary from author to author. Orthotrichum fastigiatum was differentiated by Bruch mainly by peristome characters, mentioned

later only by Nyholm (1959-69), and the calyptra, but later by characters such as the size of plants, the striae on the capsules or the shorter seta, which was not mentioned in the protologue. It cannot be excluded that the later interpretation does not fit the type of O. fastigiatum, and in this respect a neotypification would be desirable, if there would not be the possibility that a type exists in St. Petersburg. So the interpretation of this taxon has changed over the time and finally it has no more been distinguished.

Although not regarded in recent floras, a distinction between *O. fastigiatum* and *O. affine* seems to be necessary for the following reasons:
In the experience of the author, specimens referable to *O. fastigiatum* (by small, slender plants with immersed capsules and almost naked calyptras) were the most common representatives of the genus at the borders of the "epiphyte deserts", in polluted but not too much polluted areas in western Germany. After re-invasion of the epiphytes after the decrease of sulphur-dioxide emissions, this form was among the first Orthotricha in the formerly heavily polluted areas such as the Ruhr-area in Western Germany. This expression remained the only in urban areas as revealed from epiphyte mapping projects in the cities of Bonn (Dilg 1998) or Duisburg (Franzen 2001, in both cases named as *O. affine*).
In the late nineties of the last century, specimens consisting of large plants forming globular balls on twigs of *Corylus* or *Sambucus* showed up in the Rhine-Mosel-area, preferably in humid valleys. These specimens did not differ alone by their larger size but also by emersed, less striate capsules with hairy calyptras. Since *O. affine* was interpreted before in the sense of *O. fastigiatum*, these luxuriant forms were first determined as *O. speciosum*. It was, however, still the question whether these *O. speciosum*-like forms were just expressions of the more humid habitat and the *O. fastigiatum*-like forms accordingly expressions of drier urban areas, thus both expressions of the same species.
During the past years, both expressions existed aside, and it seemed desirable to distinguish both, especially because of the fact that they indicated different habitats and also seemed to have a different toxitolerance. Therefore the recognition of the large form as *O. affine* var. *robustum* was proposed (Frahm 2002). The hypothesis of different toxitolerance was confirmed by the previous experience (*O. fastigiatum* as only expression in slightly polluted areas) as well as by recent observations in the field, which proved that *O. fastigiatum* is found together with toxitolerant or even nitrophilous species such as *O. diaphanum*, whereas "the large" *O. affine* is found together with *Radula complanata, Metzgeria furcata* and other Orthotricha, indicating better air quality. Also, the occurrence of *O. fastigiatum* in alluvial forests indicates a certain nitrophily, which enabled previously the survival in urban or industrial areas.
The discovery of mixed stands of *O. affine* and *O. fastigiatum* drew the attention of the author again on this problem. Such mixed stands were found in 2003 in the Sieg valley E of Bonn on *Salix* in an alluvial forest. This proved that both are not just different expressions of the same species but separate genotypes. In this regard, the hypothesis of Nyholm (1954-69) was remembered, who had interpreted *O. affine* as hybrid between *O. fastigiatum* and *O. speciosum*. In fact, this hypothesis is proved by a evaluation of characters of *O. affine* (table 1), which are intermediate between *O. speciosum* and *O. fastigiatum*. These three species are closely related, being (together with O. lyellii and O. striatum) united in the Sect. Affinae, which is characterized by phaneroporous stomata.

A critical evaluation of the distinguishing characters mentioned in the literature revealed the following:
(1) the **exostome teeth** of the so called *O. fastigiatum* (*O.fastigiatum* auct.) are united in pairs, split to at least the middle and papillose throughout. They are not striate as mentioned by Nyholm (1954-69). Those of *O. speciosum* are also narrowed in pairs and have lacunose teeth for ½ to 2/3

of its length. They are also papillose. *Orthotrichum affine* has similar teeth which are split to the half or fenestrate in the upper part.
(2) With regard to the **spore size**, the measurements vary much between the authors. Nyholm (1954-69) indicates a spore size of 18-20 µm for *O. fastigiatum*, 20-24 µm for *O. affine* and 24-28 µm for *O. speciosum*. Vitt (1973) gives a spore size of 13-26 µm for *O. speciosum* and 15-18 µm for *O. affin*e (*O. fastigiatum* is not treated). In Smith (1978), *O. speciosum* has spores 34-36 µm large and *O. affine* 18-24 µm. According to Nebel & Philippi (2001), *O. affine* has spore sizes of (16-)18-24(-26) µm, which shall be brownish, and *O. speciosum* almost the same size with (16-)18-24(-28). So the spore size of *O. speciosum* in the literature ranges between 13 and 36 µm! One reason is that the spores of Orthotrichum-species start to germinate in the capsule which causes an increase of the diameter. According to own measurements, the spore size of *O. fastigiatum* and *O. affine* is 16-18 and that of *O. speciosum* is 18-20 µm, and all of them are greenish.
(3) The red ring at the base of the **lid** consisting from 3-5 rows of cells (mentioned as typical for *O. fastigiatum* by Nyholm 1956-59) is also present in *O. affine* and *O. speciosum*.
(4) The **striae** on the capsule shall be broad in *O. fastigiatum* (consisting of 4 rows of cells) but smaller in *O. affine* (and lacking in *O. speciosum*). However, *O. affine* seems to have also striae consisting of 4 rows of cells (which are not so pronounced since the capsule is wider). Those of *O. affine*, however, have thickened longitudinal walls. Jensen (1952) mentions that *O. affine* shall have 8-12 striae but *O. fastigiatum* 12 and more, which could not be confirmed.
(4) The **leaf apex** is sharply acute in *O. speciosum* but broadly lanceolate to even blunt in *O. affine* and *fastigiatum*, which is also visible from the illustrations in Nyholm (1954-69) and Smith (1978).
(5) There are 1-2 **papillae** per cell in all species, but these are are sharply acute in *O. speciosum* but low and blunt in *O. fastigiatum* and *O. affine*.
(6) The **upper laminal** cells are more or less equally thickened in *O. fastigiatum* but incrassate, collenchymatose and often with thicker longitudinal walls in *O. affine* and *O. speciosum*.
(7) The **calyptra** of O. speciosum is very hairy, that of O. fastigiatum naked or almost so und that of O. affine is intermediate.
(8) According to Jensen (1952), the **spores** of *O. fastigiatum* are **ripe** in May but those of *O. affine* from June to August. A study of herbarium revealed, however, no differences. There seem to be no differences in the development of sporophytes in almost all species of Orthotrichum in Central Europe. Fertilisation takes place in autumn and young sporophytes are developed over the winter. The calyptras fall off in late spring and the capsules open in summer time. The only noteworthy exception is *O. pulchellum*, which has ripe capsules in winter.

DISCUSSION

A critical evaluation of the distinguishing characters reveals usuable as well as unusuable characters and also differences, which cannot really be quantified.
Character states of spore size (different but intergrading), exostome ornamentation, leaf apex, shape of papillae and lid cannot be used with success to separate O. fastigiatum from O. affine.
The size of the plants and the emergence of the capsules reveal differences in the way that plants attributable to O. fastigiatum have
- a smaller size and
- capsules imbedded in the leaves, whereas O. affine is larger and has emergent capsules (fig. 2).
- width of the ribs and the extend to which the
- empty capsule is contracted below the mouth (fig. 3)
- a calyptra which is naked or almost so.

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All these characters are, however, difficult to quantify. Insofar, O. fastigiatum can be differentiated, but not easily, as Bruch already stated when he described the species. Apparent ecological differences and mixed tufts indicate that O. fastigatum is a genotype and not only an extreme expression of the variation of O. affine. As a consequence, it should perhaps be distinguished at a infraspecific level, whether as variety or subspecies is a matter of taste.

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Fig. 1: Cushions of Orthotrichum fastigiatum (left) and O. affine (right).

Table 1: Differences between Orthotrichum fastigiatum, O. affine and O. speciosum

	O. fastigiatum	O. affine	O. speciosum
Plants	Low, slender, growing distant	Large, in dense tufts	Large, in dense tufts
Capsule position	Fully or half immersed in the leaves	exserted above the leaves	exserted above the leaves
Capsule shape	contracted below the mouth when dry	cylindric or contracted towards the apex	cylindric or contracted towards the apex
Ribs	Dry with 8 ribs, 4-6 cells wide,	Dry with narrow ribs	Dry with ribs only in the upper parts
Calyptra	Yellowish green, sparsely hairy or smooth	Straw coloured, moderately hairy	densely hairy
Lid	With 3-5 rows of red short cells	With rows of red cells	without rows of red cells
Peristome (Exostome)	papillose	papillose	papillose
Spore size	16-18 µm	18-20 µm	24-28 µm

Fig. 2: Single plants (from left to right) of *Orthotrichum fastigiatum*, *O. affine* and *O. speciosum*.

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Fig. 3: Capsules of (from left to right) *Orthotrichum speciosum, O. affine* and *O. fastigiatum*.

Fig. 4: Calyptras of (from left to right) *Orthotrichum speciosum, O. affine* and *O. fastigiatum*.