The genus Boubovia (Velen.) Svrček in Norway

Roy Kristiansen
PO Box 32, NO-1650 Sellebakk, Norway

Corresponding author: mykosof@online.no

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Ascomycota, Pezizales, Pyronemataceae, *Boubovia, luteola, vermiphila, ovalispora.*

NØKKELORD
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SAMMENDRAG
Forfatteren beskriver tre arter i slekten *Boubovia* (Velen.) Svrček fra Norge, med spesiell vekt på deres opptreden og økologi. Dette er observasjoner og data innsamlet av forfatteren over en periode på 30 år. Andre mulige potensielle Boubovia-arter er antydet.

ABSTRACT
The author describes three species in the genus Boubovia (Velen.) Svrček from Norway with emphasis on their appearance and ecology. This is observations and collecting of data over a period of 30 years. Other potential *Boubovia* species are indicated.

INTRODUCTION

The genus *Boubovia* was erected by Svrček (1977) based on Velenovsky's *Humaria luteola* (Velenovsky 1934) from Bohemia in the Czech Republic. Less than 15 years ago the genus *Boubovia* was monotypic within Pyronemataceae (Pezizales). However, van Brummelen and Kristiansen (1999) described a new species, *Boubovia vermiphila* from the Hvaler archipelago in Østfold County, SE Norway. About simultaneously Yao and Spooner (1998) transferred several species with ellipsoid spores, previously placed in *Pulvinula,* in to *Boubovia* including the two species *Pulvinula ascoboloides* (Korf and Zhuang 1984) from China and *Pulvinula subprolat*a (Korf and Zhuang 1991) from Tenerife, Canary Islands. Another ellipsoid *Pulvinula* is *P. ovalispora* described by Boudier (1917), and examined by Pfister (1976) and Korf and Zhuang (1984) probably also belongs to Boubovia. Yao and Spooner (loc.cit.) suggested that *P.ovalispora* may be conspecific with their *Boubovia nicholsonii,* described by Massee (1901) as *Humaria nicholsonii*, being an older species epithet. The type of *P.ovalispora* need to be re-evaluated, but the type-material is very scanty according to Korf and Zhuang (1984). However, Perry et al. (2007) showed in their phylogenetic study of Pyronemataceae that *Boubovia luteola* and *Pulvinula ovalispora* are strongly supported sister taxa. Then Hansen et al. (2013) further confirmed by phylogenetic analyses that *Boubovia nicholsonii* (as *Pulvinula ovalispora*) belongs within *Boubovia*, which formed a strongly supported group with the type species *Boubovia luteola.* It also showed for the first time that *Boubovia* is closely related to *Coprotus* and Ascodesamidaceae.

Today Boubovia comprises six species, but if we consider *Pulvinula ovalispora* conspecific with *Boubovia nicholsonii* it is only five.

Boubovia luteola (Velen.) Svrček in Norway
B. vermiphila van Brummelen and Kristiansen in Norway (type)
B. ascoboloides (Korf & Zhuang) Yao & Spooner

B. subprolata (Korf & Zhuang) Yao & Spooner
B .nicholsonii (Masseé) Spooner & Yao
B. ovalispora (Boudier) anon ined. = *B. nicholsonii* ?in Norway

Lindemann et al. (2015) recently erected the new genus *Pseudoboubovia*, for the species *Kotlabaea benkertii* (Peric 2012) previously placed in *Kotlabaea*. Their phylogenetic analyses show that *K. benkertii* is close to the *Boubovia* lineage, which cover *B. luteola*, *B. nicholsonii* and *B. ovalispora*. Based on their observations they proposed *Pseudoboubovia benkertii* (Peric) Lindemann U, Vega M, Peric B. & Tena R. comb. nov. To discuss the characters and relationship to *Boubovia* is outside the scope of this article due to lack of phylogenetic data.

Norwegian records of species of the *Boubovia* are described, with emphasizes on their ecology. All photographs and illustrations are provided by the author, except for the scanning electron micrographs.

MATERIALS AND METHODS

All samples were originally examined on living material in different reagents, as Cotton blue in lactic acid, methyl blue, 3% KOH, Melzer's reagent, water on squashed mounts, and slices cut by a razor blade. Some examinations were also done on dried material soaked in water over night.

History

As already pointed out *Boubovia luteola* was originally described as *Humaria luteola* by Velenovsky (1934), and the diagnosis read as follows:

"H. luteola sp.n. Ap. 3 - 4 mm, solitaria, tota citrina, basi angustata sessila, glabra, discina, integra, crasse carnosa. As. 100 x 12-16, basi modice attanuati, apice angustati et truncati, par, simpl. filif., apice nondilatatae, sed spiraliter contortae. Sp. 25 - 28, ellipticae, laeves, guttulis 3 - 5 donatae, monostichae."

Ad humum silvaticum subfoliis marcidis humidis in silva umbrosa prope Bubova (*Kalstejn*) *maio 1924. – Species mirabilis, facie Helotium revocans. As. jodo lutei."*

Figure 1. Velenovsky's table XXVI, 18

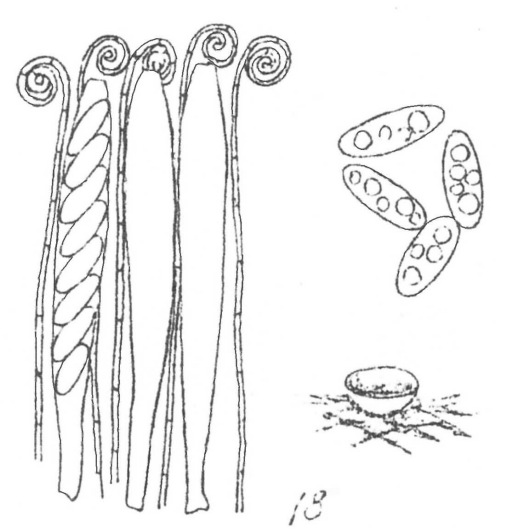

Figure 1. *Humaria luteola* Velenovsky. Original illustration, Velenovsky (1934), table XXVI, 18.

Then Svrček (1977, 1979) erected a new genus based on the specific characters, and the diagnosis read as follows:

"Apothecia minuta vel mediocria, sessilia, concava, discina, crasse carnosa, margine integro, nuda, luteo-colorata.Excipulum ectale medullareque textura globulosa vel subglobulosa, cellulis ecoloratis, parietibus haud incrassatis. Asci cylindracei, non amyloidei, octospori. Paraphyses tenuiter filiformes, apice non dilatatae, conspecte curvatae et spiraliter contortae. Ascosporae ellipsoideae, verrucosae, hyalinae."

Hab. ad terram.

Etymol. Boubová = hospitium ad marginem silvae prope pagum Bubovice, non procul Karlštejn (Bohemiae centralis), ubi J. Velenovský specimen suam. *Humaria luteola* Velen. legit.

Species typica generis (adhuc unica nota): Boubovia luteola (Velen) Svrček, comb.nov.

– Basionymum: *Humaria luteola* Velenovský. Mon. Disc. Boh. p. 227, tab. 26, fig.18, 1934 (PRM 149745, holotypus).
Figure 2. Svrček 1979, Table V.

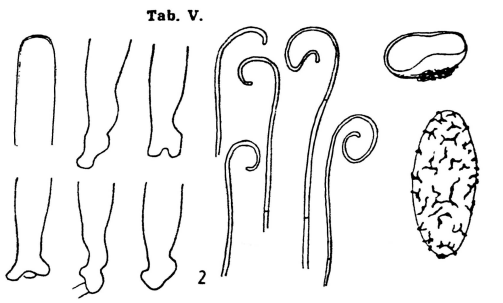

Figure 2. *Boubovia luteola* (Velen.) Svr. Illustrations based on Velenovsky's type. Svrček (1979), table V.

In Svrček (1979) the type material consists of only two apothecia, and there are no additional records in the Czech Republic.

Yao & Spooner (loc. cit.) proposed that the ellipsoid species of *Pulvinula* would better fit in to *Boubovia* based on their microscopical characters, like forked ascus base and apically curved to spirally curled paraphyses, ascus wall thickened in the early stages of development contrary to other species with globose spores, and asci, which remain thin walled throughout development.

DESCRIPTIONS
***Boubovia luteola* (Velen.) Svrček**
Figures 3, 4, 5a, 5b, 6, 7a, 7b.

Basionym
Humaria luteola Vel. Mon.Disc.Bohm. 1934

The first finding was, as noted before done by Velenovsky in the Czech Republic 1924, but first described by him ten years later (Velenovsky 1934). However, Svrček (1979) revised Velenovsky's collection of discomycetes in the herbarium of the National museum in Prague, and erected the new genus *Boubovia* based on the specific characters.

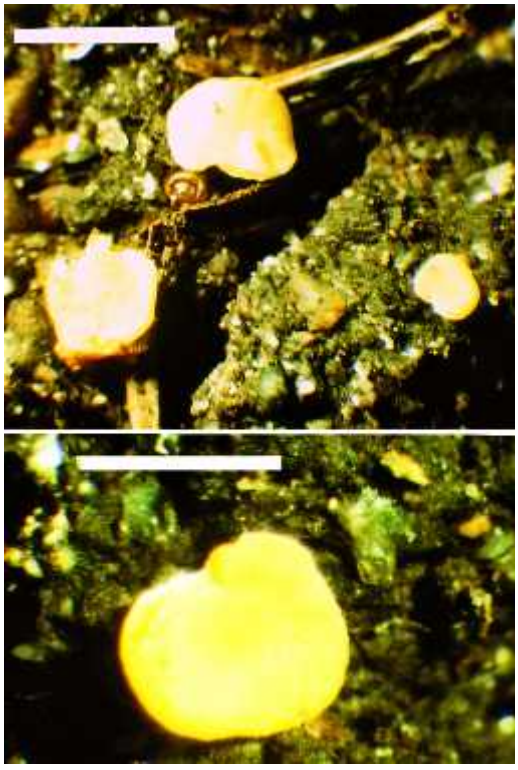

Figure 3. *Boudiera luteola* (Velen.) Svr. Torp, Fredrikstad. Scale bar 2 mm.

Apothecia shallowly cupulate, turbinate to plane discoid, sessile, 1 - 3 mm diameter, lemon yellow to pale yellow. Outside slightly pruinose. Outer and medium excipulum indistinct, consisting of globose to ellipsoid cells 10 - 20 µm in diameter, thin-celled, hyaline. Protruding asci at maturity.

Asci 8-spored, subcylindric, 140 - 180 x 12-18 µm, with a short bifurcate base.

Ascospores, one or two seriate , oblong ellipsoid, 19 - 22 x 8 - 9 µm without ornamentation, with 3 - 5 oildrops (fresh material), deBary–bubbles frequently seen; ornamented with irregular elongated veins and warts, 1.5 - 3.0 µm long and 0.6 - 0.8 µm broad and high. Ornamentation soluble in 3% KOH.

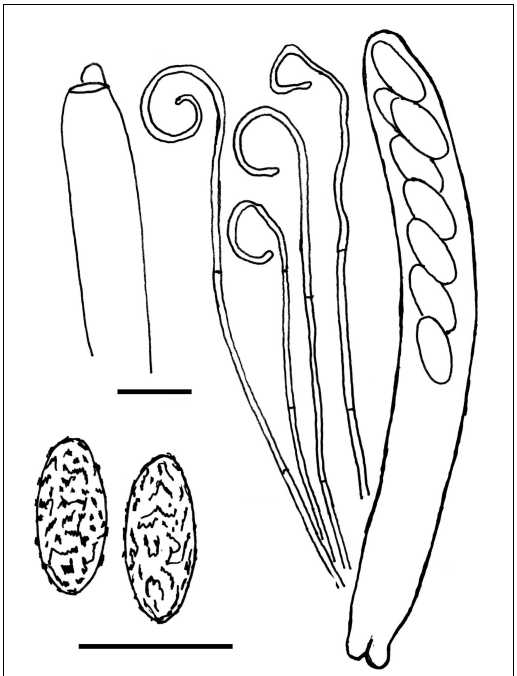

Figure 4. *Boubovia luteola*, Torp, Fredrikstad. Asci, paraphyses, spores in asci, and ascospores. Scale bar a. 15 µm b. 20 µm.

Paraphyses filiforme, 1.5 - 2.0 µm thick, septated, unbranched, distinctly spirally curled apically.

The first finding in Norway was by Sigmund Sivertsen (Vitenskapsmuseet, NTNU, Trondheim) in Rana, Nordland county 4. September 1975. This find was included in the work by Kristiansen & Schumacher (1993), where also the first finding in Østfold county was described, done 5. July 1982 on pollutant ground introduced by man, at the village Torp, between Fredrikstad and Sarpsborg, at the eastern side of the Glomma river.

Material examined
Østfold, Fredrikstad, Borge, Torp, just south of the closed paper mill where large deposits of lime (pH 7.5) are stored, which have created a habitat for a large number of discomycetes over the years. 59º 14' 27.01" N, 11º 0'30.17" E.

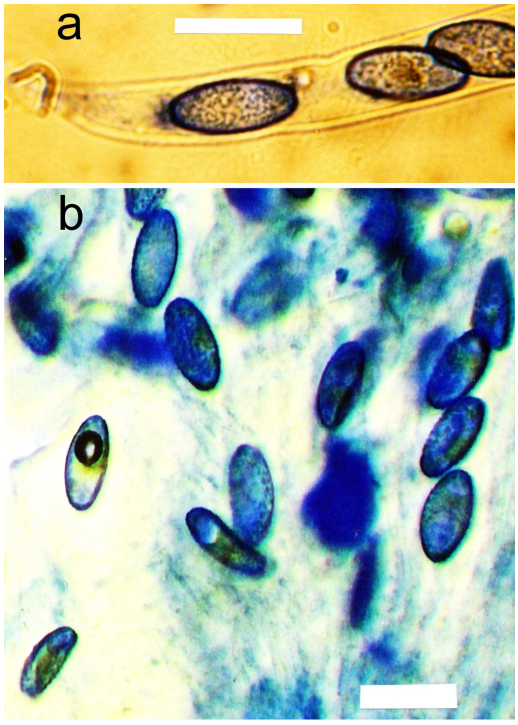

Figure 5. *Boubovia luteola*, Torp, Fredrikstad. a. spores in asci in Cotton blue. Scale bar 20 µm. b. spores in Cotton blue. To the left with deBary bubbles. Scale bar 20 µm.

5. 10. -16. and 31. July 1982 (RK 82.156) (O); ibid.11. June 1983 (O); ibid. 4. July 1983 (RK 83.136) O; duplicates in C, TRH, CUP, PRM and LPS; ibid. 3. July 1983 (RK 83.172).
Østfold, Hvaler, Kirkøy, Ørdal, close to main road 501, in a ditch among tussocks and mosses, *Equisetum* sp., with sticks and branches from the surroundig *Alnus incana*, *Populus tremula*,

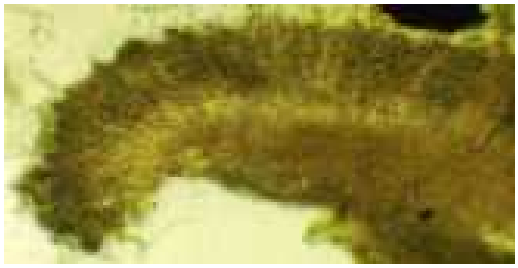

Figure 6. *Boubovia luteola,* Torp Fredrikstad. Thin section of apothecium. Field of view 2 mm.

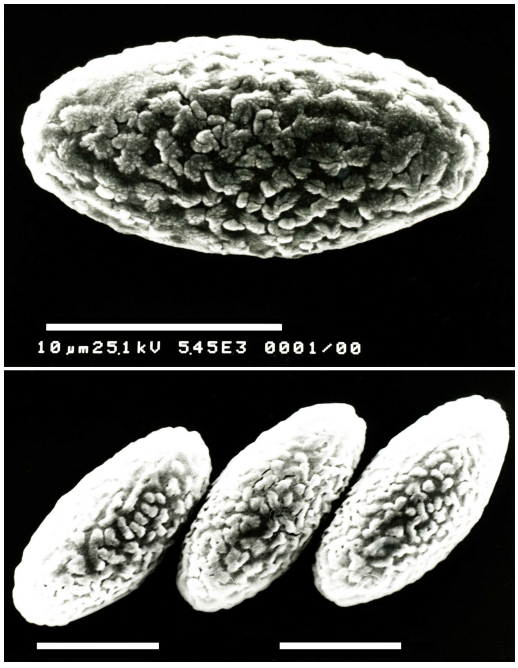

Figure 7. *Boubovia luteola*, Torp, Fredrikstad. Scanning electron micrography. Scale bar 10 µm.

Corylus avellana and *Ulmus glabra,* close to a planted field of young spruces. On humid argillaceous soil (pH 7.1) 59º 3' 4.03 " N 11º 0' 58.70 " E. , 3. July 1983 (RK 83.172) (O); Østfold, Hvaler, Kirkøy, Botne, Hyttekasabakken, close to a track to Botneveten (73 m a.s.l.) on black mold soil (pH 7. 6) in spruce wood. 59º 3' 32.49" N, 11º 3' 24.60" E.
4. and 10. October 1992 (RK 92.57) (O): ibid. 22. August 1993 (RK 93.26); ibid. 6. September 1994 (RK 94.05); ibid. 1. October 1995; (RK 95.74); ibid. 8. August 1998 (RK 98.98); ibid. 20. September 1998 (RK 98.154).

Comments
Unfortunately, the two pristine locations for *Boubovia luteola* at Kirkøy in the Hvaler archipelago is now completely damaged, even the locality in calcarous spruce forest (*Picea alba*), a rather rare nature type in the county of Østfold, where the bedrock mostly consists of granites and gneisses, and calciphile areas are only found on old marine sediments, shell beds or materials introduced by man.

Ecological notes
The locality at Torp, where I first found *Boubovia luteola* is an area of ca. 2 hektar (ha), with introduced materials, a mixture of calcium carbonate, muddy lime-stone, gypsum and sodium salts. Thousands of tons of this waste product from a nearby closed (1972) papermill were dumped here over a period of more than 50 years. Today the area has the shape of a crater with a small lake in the bottom (Figure 8).

This place has been a "goldmine" for operculate discomycetes with over 70 different species. The vegetation is rather sparse and the ground floor consists mainly of mosses and tussocks intermixed with *Tussilago farfara*, shaded by Salix-Alnus vegetation, and *Betula pubescens*.

The numbers of other discomycetes are extensive, like *Marcelleina pseudoanthracina*

Figure 8. Overview of the deposit of muddy limestone at Torp (grey area). Locality for *Boubovia luteola* and *Boubovia ovalispora*. Scale bar 50 m.

and *M. persoonii* (Moravec 1989, Hansen et al. 2005), large populations of *Chalazion helveticum* (Kristiansen 1991), *Tricharina ascophanoides* and its anamorph (Kristiansen 2014, Yang and Kristiansen 1989), *Octospora wrightii* (Kristiansen 1985), *Helvella pezizoides*, *Peziza ampelina* (Kristiansen (1982), *Peziza subisabellina* (Hansen 2001, Wergeland Krog 1997) and others, including a few hypogeous fungi. Agaricales are less common in this environment.

In 2016 the owner started looking at opportunities to use the area for residential purposes, implying that this nationally important location is threatened. However, a dialogue with the owner and authorities is initiated with the aim to secure the location for the future.

***Boubovia vermiphila* v. Brumm. & R. Krist.**

Figures 9, 10, 11, 12, 13, 14, 15, 16a, 16b.

This species was first recognized July 1983, and was later collected in 1989, 1990, 1992, 1993, and 1998. Even though the spot is located in a very shaded area this tiny fungus dry out easily, and it was not found in the intervening years. The small size (< 1 mm) and the hyaline colour make it difficult to distinguish the fruitbodies from tiny quartz grains or shell pieces, and in the field it is hard to separate it from the associated *Chalazion sociable*. It is not collected, so far, in the 21. century, but the locality is less visited in the last 15 years. As a type locality (Figure 16), and the only known locality for the species worldwide, I have pointed out the necessity to protect the place against all kinds of intervention (Kristiansen 2000), like cutting of trees, expansion of the road etc.

Because of the unique characters this minute fungi was a puzzle in the beginning and difficult to place, although somewhat reminiscent of *Boubovia luteola*, like the special curled paraphyses, the less developed excipulum and ascospores. These types of paraphyses also appears in *Pulvinula*, and I had almost at the same time found *Pulvinula ovalispora*, which have many characters like a *Boubovia*, but – with the exception of *P. ovalispora* - have spherical ascospores.

At an early stage a collection was sent to Professor Richard P. Korf at the Cornell University, Ithaca, who became very interested and replied with a number of comments, like, quote: *"Your "Boubovia sp. 2" with the spores heavily marked and many with polar caps of cyanophilic material has us somewhat puzzled. In*

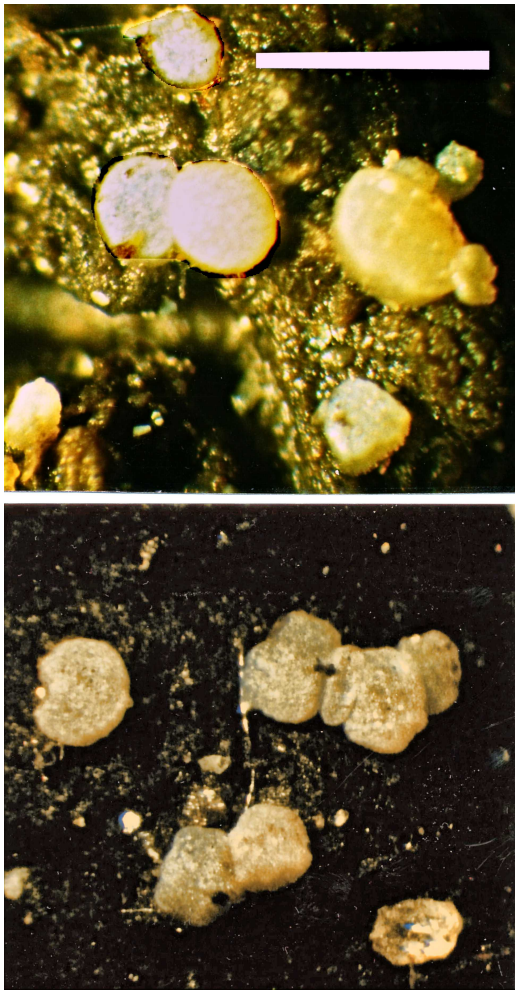

Figure 9. Apothecia of *Boubovia vermiphila*, Kirkøy, Hvaler. Scale bar 1 mm.

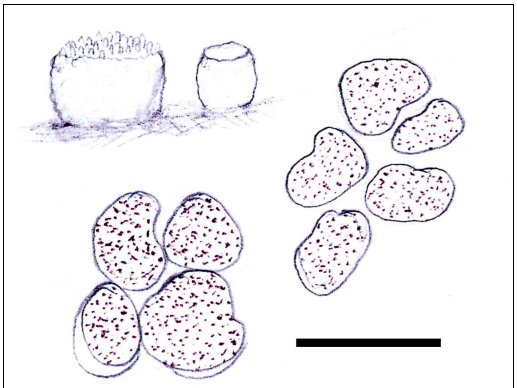

Figure 10. Apothecia of *Boubovia vermiphila*, Kirkøy, Hvaler. Scale bar 1 mm.

some ways the markings look rather like those of P.(ulvinula) ascoboloides, but your never has the spore sheath loosening as ours does, and we lack the obvious isolated warts that are so prominent in your species ... I have never seen anything else like it before! ... could well be a species of Pulvinula, related to P. ascoboloides. ... then possibly your species and P.ascoboloides deserve a genus of their own?"
(pers. comm. 9. August 1984).

Meanwhile, curator Sigmund Sivertsen at Vitenskapsmuseet (NTNU) had examined the fungus as well (1988), and his conclusion was that it is very close and related to *Pulvinula ascoboloides* as described by Korf and Zhuang (1984), - an opinion independent of Korf's statement 1984.

Several years later with still unsolved problems I consulted Dr. J. van Brummelen at the Rjiksherbarium in Leiden, which was the start of a close correspondence on this unique discomycete. Quote: "*I was astonished by the combination of characters. Although there are characters suggesting a relation with Pulvinula, e.g. the very thin, curved paraphysis, there are others, not fitting well with such a position, e.g. the large, clavate, mature asci, the ornamented ascospores, and the probably coprophilous habitat. I have never seen anything like this and would not hesitate to publish it as a new species and probably also a new genus."*
(pers. comm. 24. July 1990).

Years passed by, but in 1999 the first concept was ready, and van Brummelen wrote, quote:

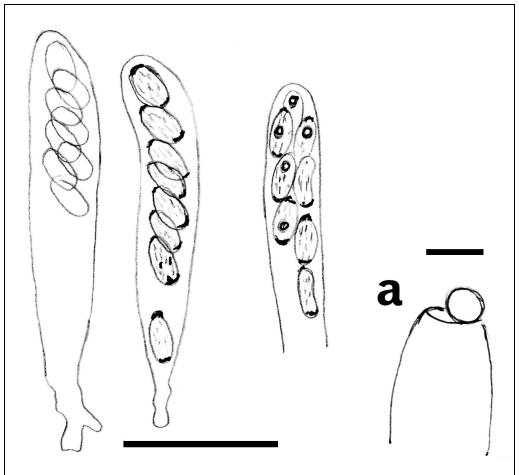

Figure 11. *Boubovia vermiphila*. Spores in asci. Scale bar 50 µm. a. Operculum Scale bar 10 µm.

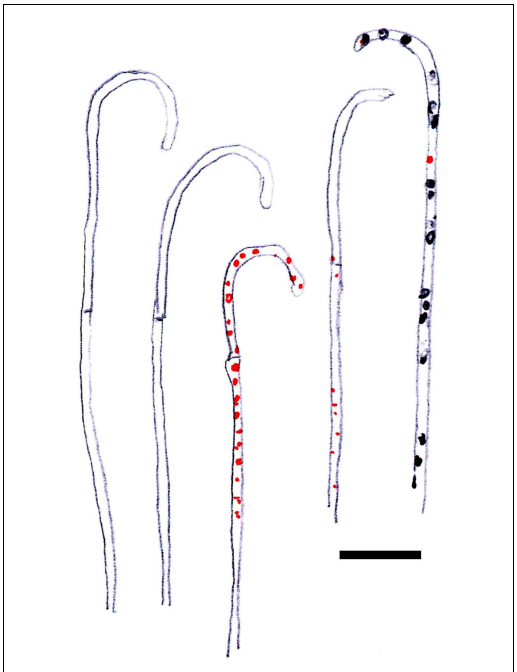

Figure 12. *Boubovia vermiphila*. Paraphyses. Scale bar 5 µm.

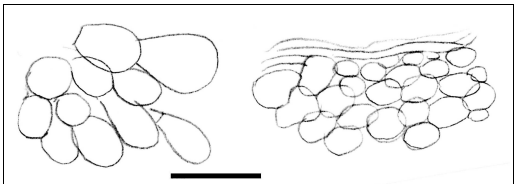

Figure 13. *Boubovia vermiphila*. Cells of outer excipulum. Scale bar 20 µm.

"Rather long I felt somewhat uncertain about the taxonomic position of this species. The material was very delicate and rather brittle. So it was good you made so many drawings and photographs. ... Now I am convinced that the best place is in Boubovia. There are too few good differential characters to create a new genus for this species."
The final description was published in 1999 (van Brummelen and Kristiansen 1999).

Apothecia solitary or in small groups, or caespitose, sessile, 0.2 - 0.5 (1.0) mm diam., up to 0.5 mm high. Receptacle first subglobular, cylindric to barrel-shaped, becoming pulvinate, smooth, whitish-hyaline; yellowish on drying. Rather fragile, margin not differentiated. Disc flat to convex, roughening by protruding asci, hyaline. Not with carotenes.

Hymenium 150 – 160 µm thick. Outer cells of globular and subglobular thin-walled cells 10 - 25 x 6 - 20 µm, without hairs or hyphae.

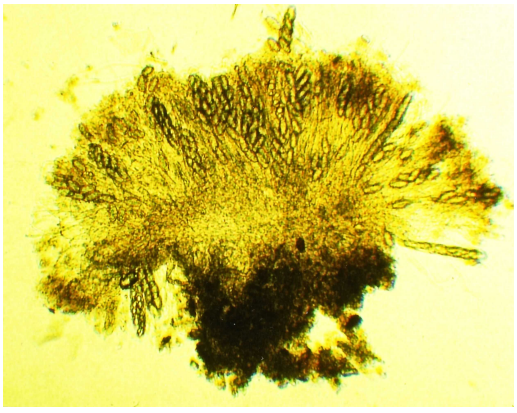

Figure 14. *Boubovia vermiphila*. Thin section of apothecium. Field of view, 1 mm.

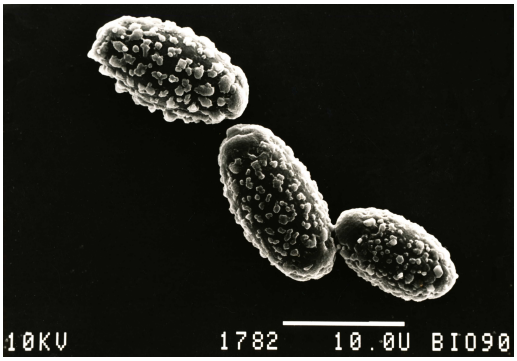

Figure 15. *Boubovia vermiphila*. Scanning electron micrography. Scale bar 10.µm.

Asci broadly clavate, attenuated at base, rounded above, with a large operculum, 8 µm across. 130 - 160 x 20 - 26 µm, 8-spored, but sometimes with only some spores developed.

Ascospores, uni-or biseriate, ellipsoid, 18 - 20 (22) x 9 - 11 µm (without ornamentation) with one or two oil globules, ornamented with large small irregularly shaped warts staining with methyl blue, and usually with large apical caps. The ornamentation is soluble in 3% KOH, first the warts then the caps.

Paraphyses frequent, septate, filiform, rarely branched, hyaline 2.0 - 2.5 µm thick with strongly spirally curved, not enlarged ends, containing small colourless vacuoles and granules staining red in Meltzer reagent.

Material examined
Østfold, Hvaler community, Kirkøy, close to Putten farm, roadside at mainroad 501 (Figure 16 A & B) sheltered by dense vegetation of deciduous wood, on black calcareous soil mixed with excrements of earthworms, and associated with *Chalazion sociabile* and *Ascobolous denudatus*, 18. and 22. July 1983 (RK 83.145 & RK 83.155) (L); ibid. 12. and 17. July 1989 (RK 89.18), holotype (L), isotype (O) (TRH); ibid. 19. and 24. June 1990 (RK 90.15) (L); ibid. 27. August 1992 (RK 92.10); ibid. 22.June 1993 (RK 93.12);

Figure 16. Type localty of *Boubovia vermiphila*, Putten, Kirkøy, Hvaler archipelago.
A. early spring, B. summer.

ibid. 13.June 1998 (RK 98.30) (L); ibid. 6. July 1998 (RK 98.45).

Ecological notes
The ground floor consists of damp black soil, pH 8.0 - 8.3, mixed with tiny crushed fragments of seashells, and the fungi was found growing on the rounded surface and in the crevices of worm casts often covered by fallen leaves of *Populus tremula*. The area is densely shaded by *Populus tremula, Ulmus glabra, Quercus glabra, Prunus spinosa, Berberis vulgaris, Malus silvestris, Fraxinus excelsior,* and less abundant with *Juniperus communis* and *Sorbus aucuparia*. The vegetation was dominated by a dense cover of *Viola collina*, besides less frequent of *Meruciralis perennis, Primula veris, Melica nutans, Fragaria vesca, Veronica chamaedrys, Geranium sanguineum, Lathyrus pratensis, Ranunculus acris,* besides some ferns (Kristiansen 1990).

Comments
The associated *Chalazion sociabile* is difficult to distinguish in the field from *B. vermiphila*, but is very different microscopically. The fungus shows great similarity and structure with species of *Pulvinula* and *Boudiera luteola*.

We (van Brummelen & Kristiansen 1999) discussed the relationship between the genera *Boudiera* (s. str.) and *Pulvinula*, and were reluctant to accept Pulvinulas as conspecific as both *B. luteola* and *B. vermiphila* have complex and very distinct ascospore ornamentation as the development of the secondary wall undergoes a complex process. *Pulvinulas* are devoid of a secondary wall, while *Boubovia* should accommodate species with only ornamented spores (cfr. van Brummelen and Kristiansen 1999).

But as stated before Perry et al. (2007) shows that *Boubovia luteola* and *Pulvinula ovalispora* are strongly supported sister taxa, and Yao and Spooner (1998) emphasize the asci with thickened in the early stage.

Less than 100 meters east of the *B. vermiphila* spot I also found *Boubovia luteola* about the same time at Ørdal, see above.

***Boubovia ovalispora* (Boud.) anon. ined.**
Figures 17a, 18, 19, 20a, 20b.

Figure 17. Apothecia. Torp, Fredrikstad. Scale bar 5 mm.

Icones: Boudier 1917, plate V, figure III
Beyer et al. 1985, Pilzfarbtafeln nr.44, 160

Basionym
Pulvinula ovalispora Boud.
This species was originally described by me as *Pulvinula ovalispora* (Kristiansen 1985), which at that time was still placed in the genus Pulvinula. So the following description is partly based on the old observations from 1982-1984.

Apothecia solitary 1 - 2 mm in diameter, 1 mm high, distinct plane-discoid, rarely turbinate, or somewhat irregular caused by mutual pressure, sessile, distinct margin. Greyish orange, pale reddish yellow to pinkish yellow; outside paler.

Asci 8-spored, clavate, attenuated to a smaller base, often bifurcate, 130 - 160 x 12 - 13 µm, with protruding asci at maturity.

Ascospores, uni-seriate, ellipsoid, smooth, somewhat inequilateral in shape, with small oildrops near the poles, often with irregular deBary bubbles (2 -3) confluent, 12.6 - 14.4 x 7.4 - 8.8 µm.

Figure 18. *Boubovia ovalispora*. Torp, Fredrikstad. Spores in asci with deBary bubbles in Cotton blue. Immature spores to the right. Scale bar 15 µm.

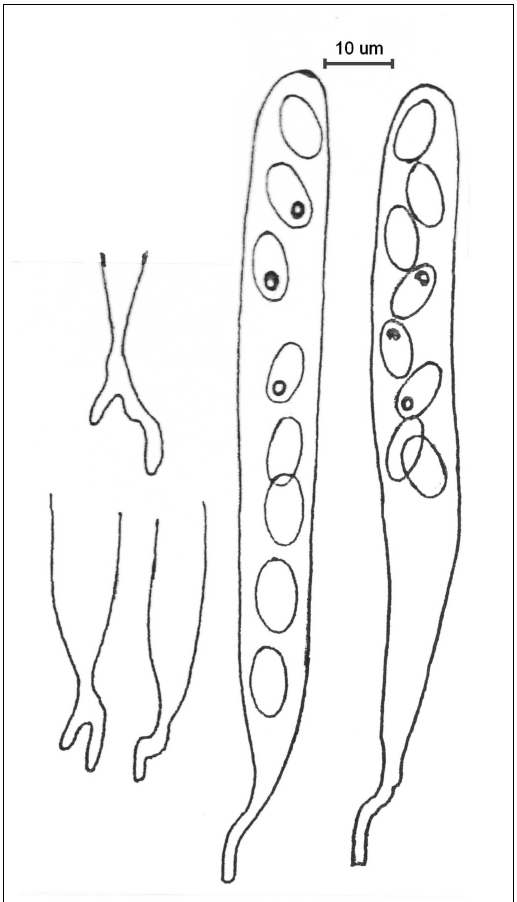

Figure 19. *Boubovia ovalispora*. Torp, Fredrikstad. Spores in asci and asci base. Scale bar 10 µm.

Paraphyses filiform, strongly spirally curled apically, equally thick 1.0 - 1.5 µm.
Outer excipulum consists of globular - subglobular (textura globosa - angularis), 7 x 8 to 12 x 14 µm in diameter

Material examined
Østfold, Fredrikstad, Borge, Torp, near Kreutzgate just south of the closed papermill, where large deposits of muddy calcareous clay (pH 7.5) are stored, which have created a habitat

Figure 20. *Boubovia ovalispora*, Torp. Fredrikstad. Paraphyses. Scale bar 5 µm

for a large number of discomycetes over the years. The spot is ca.100 meter south of the *Boubovia luteola* locality.

The apothecia were found among dense populations of *Melilotus officinalis*, *Tussilago farfara*, and *Vicia sp*., associated with *Lamprospora miniata* and *Ascobolus behnitziensis* (Kristiansen 2013). 7. July 1984 (RK 84.40); ibid. 11. August 1984 (RK 84.99); ibid. 31. July 1996 (RK 96.48) Herb. CUP, TRH, J.Mor. ; ibid. 27.July 1997 (RK 97.12). 59° 14' 23.56" N, 11° 0' 23.22"

Portugal, Madeira, close to Restaurante Estrele, Nuns valley, close to Eucalyptus trees, on solid brownish soil, 20. November 1994 (MA-18-RK).

Comments

It seems that *B.ovalispora* is an almost cosmopolitan species, which is now found at the Canary Islands, Algerie (type locality), Madeira, Mallorca, USA, Jamaica, and several places in Europe, like Denmark, Germany and United Kingdom.

Korf and Zhuang (1984) stated that there are large variations of the ascospore size from one locality to the other of the specimens they had examined, so it is still an open question whether *B. ovalispora* is one species only or two different ones. More work is needed to clarify this question.

Simultaneously with the finding of *Boubovia ovalispora* at Torp in 1984, I found, a similar species, but with more red-orange pigment, close by (ca. 50 m). A subsequent microscopical examination, however, showed 4-spored asci, but still ellipsoid spores as for *B.ovalispora*, same anatomy, but with less curled paraphyses.

***Boubovia ovalispora* 4-spored**

Figures 21a, 21b, 21c, 21F, 22a, 22b, 23
Table1.

Description

Apothecia up to 1.5 mm in diameter, plane-discoid, rarely turbinate; reddish orange, outside paler, distinct margin.

Table1. Comparison of ascopore- and ascus size of 8- and 4-spored *Boubovia ovalispora*

Samples	ascus µm	ascospores µm	average ascospores
8-spored RK 84.40	130-160 x 12.0-12.5	12.6-14.4 x 7.4-8.8	13.7 x 8.1
4-spored RK 84.100	143-157 x 12.0-13.7	12.6-13.7 x 7.6-8.4	13.5 x 8.1

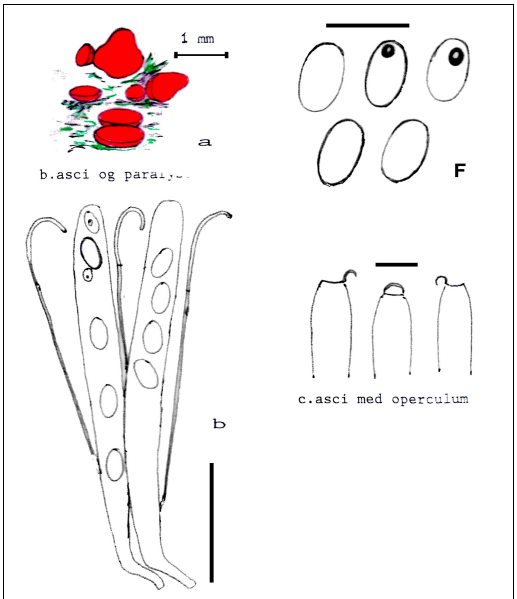

Figure 21. *Boubovia ovalispora* 4-spored, Torp, Fredrikstad. a. apothecia 1 mm. b. asci and spores in asci, paraphyses. Scale bar, 50 µm. c. operculum at asci tip. Scale bar; 15 µm. F. Spores. Scale bar: 15 µm.

Asci 4-spored, some with two aborted spores in addition, clavate, attenuated against base, rarely bifurcate, 142.5 -157.5 x 12.0 - 13.7 (15.0) µm, protruding 25 - 30 µm above the hymenium.
Ascospores uni-seriate, broad ellipsoid, smooth, rarely with deBary bubbles, 12.6 - 13.7 x 7.6 - 8.4 µm.

Paraphyses filiforme, more or less curved or bent apically less than *B. ovalispora*, 1.0 - 1.5 µm.
Outer excipulum consists of subglobular to angular cells 5 x 7 to 10 x 15 µm.

Material examined
Østfold, Fredrikstad, Borge, Torp, close to Kreutzgate, on naken muddy calcareous ground beneath a population of *Tussilago farfara*, 11. August 1984, (RK 84.100).

Comments
Often 4-spored asci develop larger spores than 8-spored, within the same taxon, and will not be considered as a separate species, but as a 4-spored forma.

However, in the present 4-spored species both asci and spores seem to be of the same magnitude as 8-spored. Besides, the colour is more intensified, and the paraphyses are less curved apically. A new collection is necessary if we are to find out if we are speaking of a new species or not.

Distribution, edaphic factors and discussions
All my Boubovia samples from Norway are collected in the low temperate zone less than 50 meters above sea level. The map shows locations in the county of Østfold (Figure 24). All are taken on calcareous ground, which means either marine sediments, shell beds, or locations created by man, and in both deciduous forest and spruce wood. Measurements of pH of soil samples from Torp, which is an artificial location, show small variations, 7.5/7.6. The locations at Hvaler varies more, from 7.1 to 7.6 (*B. luteola*), and 8.3 to 8.6 for

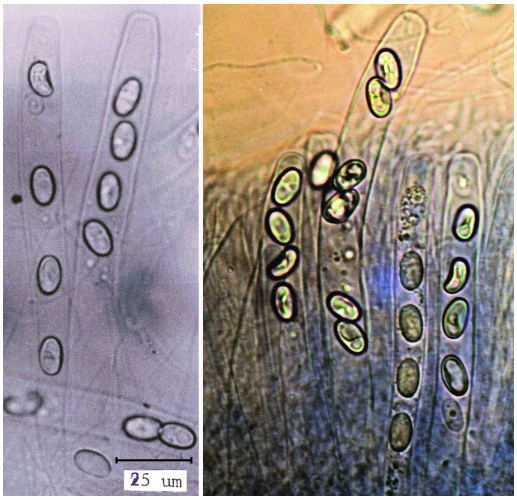

Figure 22. *Boubovia ovalispora* 4-spored. Four spores in asci. Scale bar 25 mm.

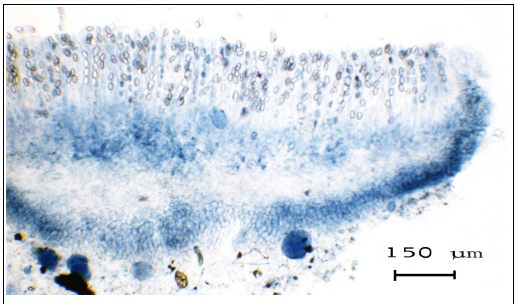

Figure 23. *Boubovia ovalispora* 4-spored. Thin section of apothecium. Scale bar 150 µm.

the *B. vermiphila* locality. These are natural habitats. The populations of these fungi vary in number from year to year. The number of *Boubovia luteola* accounts to several hundreds, but varies from 5-6 species and up to approx. 100 in each finding. They appeared from 1982 to 1998. *B. vermiphila* was found in 1983, 1989, 1990, 1992, 1993 and 1998, and several hundreds were collected these years, although some were richer than others. *B.ovalispora* is less abundant than the others, and appeared only in 1984, 1996 and 1997, and few in numbers. The collection of *Boubovia luteola* from Rana in Nordland County was collected in the boreal zone about 100 meters asl, but not included here.

These fungi are not easy to find because of their small sizes, but the genus *Boubovia* itself are rarely collected, and the aim of the present paper is to focus on the different species and their characters and habitats. There are few mycologists who have found or collected these tiny fungi, but if we look at unusual habitats, like old industrial areas, overgrown heaps of trash, ditches, etc. there are chances for surprises as many of the smaller discomycetes are weak competitors in relation to Agaricales.

There is no existence of phylogenetic data for *B. vermiphila, B. ascoboloides* and *B. subprolata,* to confirm the combinations made by Yao and Spooner (1998). These species need to be re-examined to verify their taxonomic position.

Other potensial Boubovia-candidates

There are at least 2 or 3 potential candidates from Japan and India. Geographically it may sound controversial to consider species from Japan and India in this connection, but quite many operculate discomycetes turn out to have a cosmopolitan distribution; consult *Boubovia ovalispora* herein, and according to Sigmund Sivertsen (pers. comm.) 60% of all discomycetes at Tierra del Fuego (Southern Hemisphere) occurs in Norway!

Japan: From Prof. Richard P. Korf (Cornell University, Ithaca, NY) sent me a slide with six mounted thin sections (20 µm) of a discomycete, which was found during the IMC3 workshop in Japan 1983.
R.P.K. wrote: "*...Henry Dissing thought that one of the collections we took in Japan on the 1983 IMC3 foray was a Boubovia, but it was a very much larger fungus than the one you have."*

The following note accompanied the slide:
ex-CUP-JA 3557 Aleuria (field det. R.P:K.)
Boubovia cfr. luteola (field det. H. Dissing).
On bare sandy soil orange" to orange- "luteus" (Rayner).
Spores grossly warted, non-guttulate. fide Dissing not an Aleuria, not an Octospora, not a Melastiza, not a Cheilymenia. What is it?
Phographed by M. Izawa.
Woods around Marunuma-ko, gumma Pref., Honshu, Japan. 20. VIII. 1983
Leg. IMC workshop workers. Sectioned by W. Y-Zhuang. Date 10.VIII 1984

Comments

Unfortunately I know nothing about the macroscopical features, like size or color of the apothecia. An microscopical examination by me shows oblong ellipsoid ascospores, 19 - 21 x 10 - 12 µm, ornamented by isolated warts about 1 µm, but I cannot observe curved paraphyses, but the excipulum is less

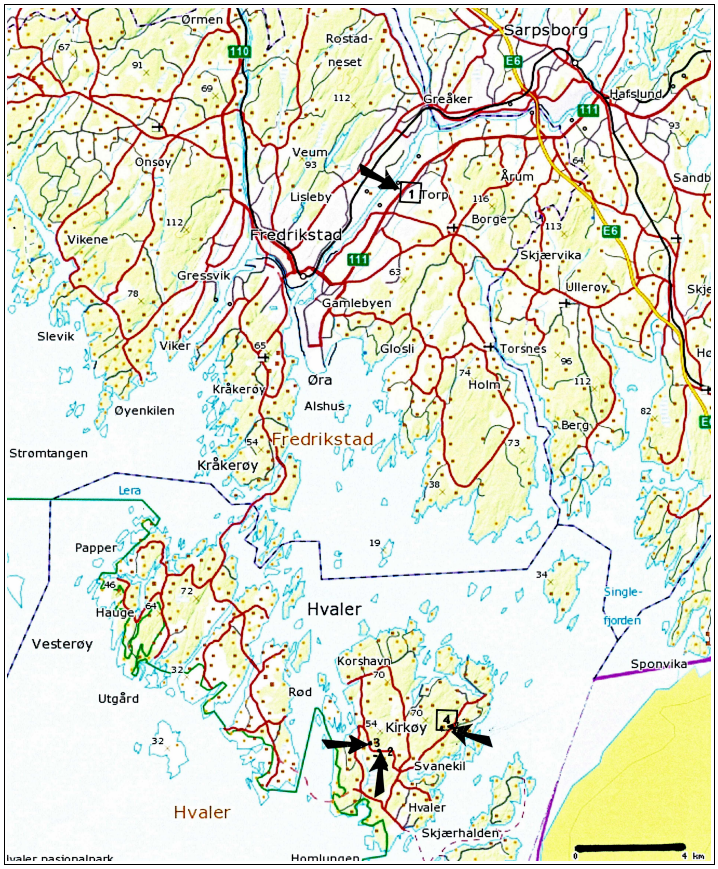

Figure 24. Distribution map of Boubovia species in the Østfold county. 1. Torp, Fredrikstad, 2. Ørdal, Hvaler, 3. Putten, Hvaler og 4. Botneveten, Hvaler.

developed as in *Boubovia*. The ornamentation on the spores is different from the known *Boubovia* species described herein. The sample should be traced and re-examined (by someone in Japan, who joined the IMC3).

India: In 1975 Khare published the description of four new species in the bryophilous genus *Octospora*, from locations in India (Khare 1975), although I cannot imagine that these samples belongs to *Octospora*, since none of them are connected to mosses, viz. not bryophilous, based on their habitats, which are described as decaying woods, on leaves, rotten leaves, and on soil.

There are especially two species that could be potential *Boubovia* species, viz. *Octospora spaniosa* and *O. decalvata*. They have both curved or hooked paraphyses, the spores are ornamented and they are hardly bryophilous. Especially the former have thick-walled asci in youth.

Richard P. Korf agreed to that in a letter 9. August 1984, quote:

"I must admit that we did not consider the two species described by Khare in NJB, Octospora spaniosa and O. decalvata. You are quite right that they are suspicious. The thick-walled young spores of the former make us suspect it is in the same alliance, but the latter I'm not sure about at all."

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