

# CHLOROPHYLLUM IN GREAT BRITAIN

Else C. Vellinga

Bruns Lab, 111 Koshland Hall, Berkeley, CA 94720-3102, U.S.A. [ecvellinga@comcast.net](mailto:ecvellinga@comcast.net)

## Introduction

One might expect the systematics of big conspicuous mushrooms would be settled by now, but the genus *Macrolepiota* shows this would be a mistake. This genus, with its showy fruitbodies, has been relatively neglected and mushrooms encountered outside Europe were too readily given a European name. Only recently has it been recognized that *M. procera*, the type species of the genus, occurs exclusively in Europe (it is still not known how far east its distribution reaches), and species known by this name in North, Central and South America, in Australia, and in Japan are all different and good species in their own right. It turns out that the characters to distinguish the species in this genus are often quite subtle and hard to pin down.

Every time a new character was proposed hopes were high that all outstanding questions would be answered. But each had its limitations and only by accumulating data and taking different characters into account is progress possible.

Molecular characters now provide an alternative way to test morphologically-based hypotheses about genera and species. The segments of DNA that have been used are either ones that do not have a coding function, or else code for a gene not involved in development. The simplifying assumption is that these will be unaffected by the evolutionary processes moulding the species and will be subject only to random changes at a more-or-less constant rate.

However, it must be remembered that the outcome and implications of analyses of any data set depend on how extensive it is. This is especially true for the phylogenies that result from molecular work. Let me give you an example. If we compare a cat, an ape and a duck, the closest relative of the ape is the cat, but saying that ape and cat are sister species is not very informative, and nonsense as well, unless we tell the whole story about our

three-organism data set. When a human is added to the data set, it will turn out that ape and human are more closely related to each other than either is to the cat, which starts to make much more sense.

## Genus circumscriptions

I have sampled the whole family of the Agaricaceae to investigate the boundaries of the morphologically recognized genera, and in the process I gathered data for as many *Macrolepiota* species as I could (see Vellinga, 2004 and Vellinga *et al.*, 2003). For the family data set, several genes were sequenced ('sequencing' means that the order of the four different bases, the informational building blocks of the DNA molecule, was determined). For the *Macrolepiota* set only ITS was used; this is a block of DNA which separates two coding regions and whose precise function is not yet known.

The family data set showed in all cases, whatever genes were used, that *Macrolepiota* splits into two different groups, which are not closely related. They are more cousins than siblings. One group is close to the genus *Agaricus* and consists of the species of *Macrolepiota* sect. *Laevistipedes* (*M. rachodes* and its allies) and the green-spored *Chlorophyllum molybdites*. The other contains *Macrolepiota* proper, with *M. procera*, *M. excoriata*, and *M. mastoidea*; this group, is a close relative of *Lepiota*. Figure 1 shows a stylized family tree, based on LSU and ITS data. As the branching structure of the tree is broad rather than deep, more comb than tree, the placement of the groups is not very robust. Specific tests were made to determine whether *Macrolepiota* and the rachodes-group could be merged to restore the old situation. However, the data failed to support such a construction. (Nor, to throw in another solid result, could the united *Leucoagaricus* and *Leucocoprinus* be split asunder.)

Translated into morphology, the molecular

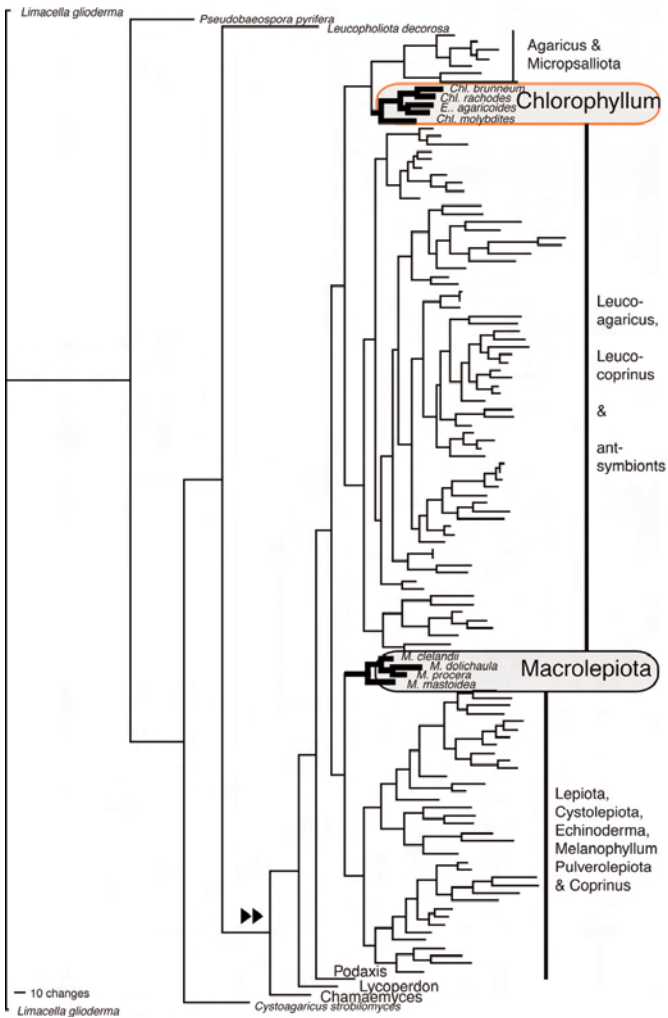


Fig. 1. Phylogenetic tree constructed based on a parsimony analysis of LSU and ITS rDNA sequences from representatives of the family Agaricaceae, with *Limacella glioderma* as outgroup. The double arrow indicates the origin of the family. Species name have been omitted for clarity, except for *Macrolepiota* and *Chlorophyllum*.

data say that *Macrolepiota* is restricted to species with spores having a real germ pore, a trichoderm with loosely arranged cells as pileus covering, and a stipe covering which forms bands on the full grown stipe. Most species do not change colour when scratched on the stipe.

*Chlorophyllum* species are characterized by spores with or (in one tropical species) without a germ pore, but the pore is a depression in the spore wall, as if someone had put a thumb there, a smooth stipe, and a pileus covering made up of tightly packed upright narrow cells (but see below under *C. abruptibulbum* for exception). The spores can be green, or they can be without any colour.

All species I know discolour red or orange red when scratched on the stipe.

The printed version of the British checklist (Legon & Henrici, 2005) does not follow these genus circumscriptions but takes the traditional approach of keeping *C. rachodes* in *Macrolepiota*. However, the on-line version now follows the classification advocated here.

Yet a cautious attitude to the changes demanded by molecular techniques may be reasonable in some cases. For example, the dust has not yet settled completely in the Psathyrellaceae where coprinoid and psathyrelloid species mingle and genus borders have still not been clearly established.

### Species in *Chlorophyllum*

The *C. rachodes* complex has been the setting for much discussion about species, varieties and formae. Again, molecular characters may help to settle the old disputes and, in the process, open our eyes to characters in common or discriminating between the different units. When we know that there are several groups, we can look for morphological differences, which might be overlooked when we think there is only one.

So far, molecular analyses indicate that there are three species in the *C. rachodes* complex in the temperate areas of Europe (Fig. 2). Most workers in the field have recognized only two taxa, but Candusso & Lanzoni (1990) also recognized three taxa in broad agreement with those presented here. Morphologically the three taxa are well characterized:

No.1. Pileus with brown scales on a pale background (with age the background may become darker); stipe gradually broadened at base; annulus double and well-developed (Fig. 4); cheilocystidia broadly clavate, spheropedunculate or clavate; spores 8.8-12.8 x 5.4-7.9  $\mu\text{m}$ , avl x avw

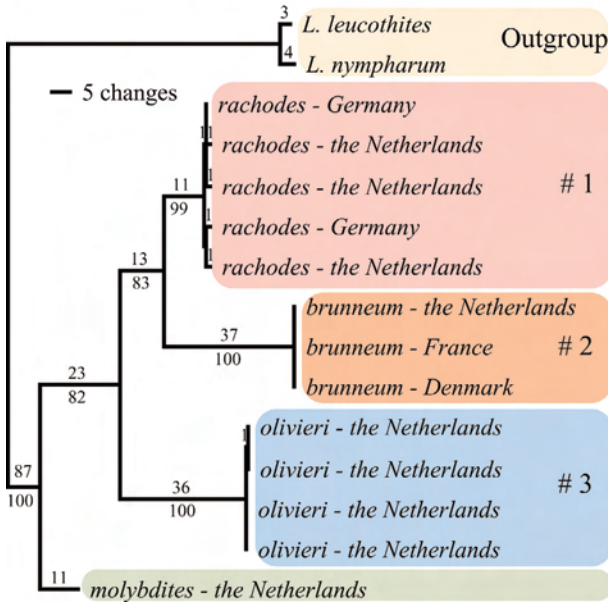


Fig. 2. Phylogenetic tree constructed based on a parsimony analysis of ITS rDNA sequences from European collections of four *Chlorophyllum* species, with two *Leucoagaricus* species as outgroup. Bootstrap values are indicated below the branches.

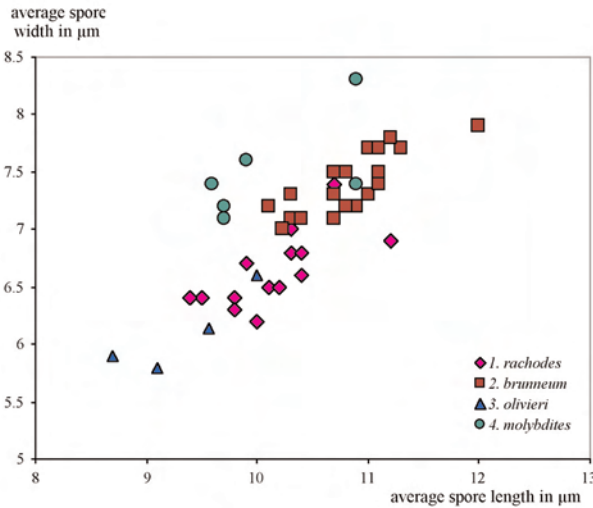


Fig. 3. Scatter diagram of average spore sizes for four *Chlorophyllum* species, *Chl. rachodes*, *Chl. brunneum*, *Chl. olivieri* and *Chl. molybdites*, based on collections from all over the world.

= 9.4-11.2 x 6.2-7.4  $\mu\text{m}$ ,  $Q = 1.3-2.0$ ,  $avQ = 1.4-1.6$  (spore sizes based on 14 collections from Europe and North America; Fig. 3).

No. 2. Pileus also with brown scales on a pale background (again, with age, the background may become a bit darker); the stipe sits on an abrupt

bulbous base, often a bit to one side, and the base may be shared by several specimens; the annulus is often not as elaborate as in no.1, but has a stiff brown patch on the underside; cheilocystidia clavate, narrowly clavate, and spores a bit larger than those of no. 1: 8.8-14.6 x 5.9-8.8  $\mu\text{m}$ ,  $avl \times avw = 10.1-12.0 \times 7.1-7.9 \mu\text{m}$ ,  $Q = 1.25-1.85$ ,  $avQ = 1.4-1.5$  (based on 21 collections from Europe, North America and Australia; Fig. 3)

No. 3. Pileus scales and background are of the same colour, the scales hardly contrasting in colour with the background, greyish, grey-brown to dingy olivaceous brown; the stipe is often bulbous, but not abruptly so; cheilocystidia clavate to broadly clavate and the spores are just a bit smaller than in the other two: 7.9-10.8 x 5.4-6.9  $\mu\text{m}$ ,  $avl \times avw = 8.7-10.0 \times 5.8-6.6 \mu\text{m}$ ,  $Q = 1.3-1.75$ ,  $avQ = 1.5-1.6$  (based on three European collections, and one from western North America; Fig. 3).

For completeness, the green-spored *C. molybdites*, known from one indoor location in Scotland, has been added to the analyses for Figs 2 and 3.

**The name game – what are we going to call them?**

- No. 1 – Vittadini’s original description of *Agaricus rachodes* fits this the best. He consistently used the spelling ‘rachodes’, which has no known etymology, leading some to use ‘rhacodes’ on the assumption that he meant to derive his name from a Greek root meaning ‘ragged’.

- No. 2 – This species has long been known from Great Britain: Berkeley (1860) depicted it already under the name *Agaricus rachodes*. Phillips (1981) called it *Lepiota rhacodes* var. *hortensis* and it is listed in the British Checklist and by Candusso & Lanzoni (1990) as *M. rhacodes* var. *bohemica*. The bad news is that neither ‘horten-



Fig. 4. *Chlorophyllum rachodes* s.str. Note the pileus with its brown scales, contrasting with the background, the bulbous, but not abruptly bulbous, base, and the double annulus.

*sis*' nor '*bohemica*' are names that were published according to the laws of botanical nomenclature, laws which also reign over the fungi. The good news is that a much older name is available, having been published correctly, viz *brunneum*, described from North America. Accordingly this name has been adopted for no. 2 (Vellinga, 2003). This species has the characteristic narrow cheilocystidia and the appropriate relatively simple ring, though the stipe base of the type specimens lack the abrupt bulb which often characterizes this species. The type collection of *C. brunneum* and the collections originally used to erect the name '*bohemica*' have been described by Vellinga (2003).

In the past, the width of the bulb, the width of the germ pore and the size of the scales on the pileus were the main characters used to distinguish this taxon from *C. rachodes*, but as De Kok & Vellinga (1998) showed, there is considerable overlap of the characters and even co-occurrence of incompatible ones in one specimen. It appears now, that there are better, more discriminating characters to distinguish the two. But, if you come across specimens you cannot identify, please contact me!

- No. 3 has not often been recognized as separate from *C. rachodes* itself. Phillips (1981) and Breitenbach & Kränzlin (1995) depicted it, under the names *Lepiota* and *Macrolepiota rhacodes* var. *rhacodes* respectively, while it is *Lepiota brunnea* in Candusso & Lanzoni's treatment. We have been using Barla's name *olivieri* (De Kok & Vellinga, 1998).

*Macrolepiota venenata*, described by Bon from France (Bon et al., 1979), is another name in this complex, but it is a bit of a conundrum. All the material originally or tentatively identified as this species (characterized by the absence of clamp connections) turned out to be *C. brunneum* (no. 2 above). Clamp connections were always found in some part of the fruitbodies. It was also described as a toxic species, but this is hardly a surprise as adverse reactions to other *Chlorophyllum* species are quite common, especially in people who eat them often. Adverse effects of *C. brunneum* (as *M. rachodes* var. *bohemica*) have often been described. So I'm inclined to include *M. venenata* in the synonymy of *C. brunneum*.

#### Where they occur

*Chlorophyllum rachodes* is widespread, but perhaps

less common than the other two species. It is recorded from Europe and North America, and it is often found in disturbed and slightly nitrogen enriched environments. One unusual habitat is the nest of wood ants (Sagara, 1992).

*Chlorophyllum brunneum* is also widespread and known from Europe, North America and Australia. It grows often on compost heaps, in gardens, and other nitrogen-enriched areas.

*Chlorophyllum olivieri* is common and widespread, not only in *Picea* plantations but also in deciduous woodlands. It occurs in Europe, and in western North America (state of Washington).

The records of *C. rachodes* in the British species database represent all three species.

### Other species

Two other *Chlorophyllum* species are occasionally found in artificial environments, such as greenhouses, in Great Britain.

*Chlorophyllum molybdites* has green spores which are a bit wider than those of the outdoor species (see Fig. 3), but for the rest looks very much like *C. rachodes*. It has been found in a recreation centre in Edinburgh (Watling 1991), and its main distribution is (sub)tropical. It is a common species in the eastern states of North America, where it fruits in watered lawns during the summer. In Europe it was found once in a garden in València, Spain (Mahiques 1996). With continuing high summer temperatures it might well spread northwards in Europe.

*Chlorophyllum abruptibulbum* is a palaeotropical species and has been found in a greenhouse at Kew (Pegler et al. 1998). This species differs from the other *Chlorophyllum* species in the dark purple-brown colours of the pileus patch, the lilac discoloration of the background, and the sphaeropedunculate cells of the pileus covering. The outdoor record in the British database is, unfortunately, based on an error (pers. comm. G.G. Kibby) – it would be great to see this lilac beauty in the wild!

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