

NOTES ON THE TAXONOMICAL DELIMITATION IN THE GENERA *CALVATIA*, *GASTROPILA* AND *LANGERMANNIA* (GASTEROMYCETES)

by

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Resumen. CALONGE, F. D. & M. P. MARTÍN (1990). Notas sobre la delimitación taxonómica en los géneros *Calvatia*, *Gastropila* y *Langermannia* (Gasteromycetes). *Bol. Soc. Micol. Madrid* 14: 181-190.

Se realiza un estudio sobre la delimitación taxonómica entre los géneros *Calvatia*, *Gastropila* y *Langermannia*. Una vez concluida la revisión de 23 colecciones de *Calvatia pachyderma* y después del examen minucioso del material tipo de este taxon, se decide incluir a todos los especímenes con esporas lisas y forma ovoide dentro del taxon *Gastropila fragilis*, mientras que los que presentan esporas verrugosas y forma globosa se mantienen dentro del concepto original del taxon *C. pachyderma*, pero transfiriéndolos al género *Langermannia*, por ser en el que mejor encajan actualmente. Se propone una combinación nueva: *Langermannia lepidophora* (Ell. & Ev.) Calonge & Martín.

Palabras clave: *Calvatia*, *Gastropila*, *Langermannia*, *Gasteromycetes*, taxonomía.

Summary. CALONGE, F. D. & M. P. MARTÍN (1990). Notes on the taxonomical delimitation in the genera *Calvatia*, *Gastropila* and *Langermannia* (Gasteromycetes). *Bol. Soc. Micol. Madrid* 14: 181-190.

This article compiles a detailed analysis of the main features which could be considered to define and separate the genera *Calvatia*, *Gastropila* and *Langermannia*. After studying the type collection of *Calvatia pachyderma* and 22 other, previously determined under this name, it was proposed to include all the samples showing ovoid and smooth spores within the taxon *Gastropila fragilis*, while those presenting spores globose, with verrucose ornamentation were transferred into the genus *Langermannia*, which seemed to be the more appropriated. A new combination is proposed: *Langermannia lepidophora* (Ell. & Ev.) Calonge & Martín.

Key words: *Calvatia*, *Gastropila*, *Langermannia*, *Gasteromycetes*, taxonomy.

INTRODUCTION

In a recent publication (DEMOULIN & *al.*, 1988), we showed the possibility of the presence of *Calvatia pachyderma* (Peck) Morgan in Europe. Later investigations on this subject induced us to observe a close relationship between this taxon and *Gastropila fragilis* (Lév.) Homrich & Wright. This fact stimulated us to continue a revision of all the available material named as *Calvatia pachyderma*. Simultaneously, we carried out a critical study of genera *Calvatia*, *Gastropila* and *Langermannia*, in order to find out in which of them the complex "*Calvatia pachyderma*" was belonged.

MATERIAL AND METHODS

On one side, we have re-examined all the specimens from Europe which were published under the name *Calvatia pachyderma* (DEMOULIN & al., 1988). On the other hand, we borrowed the type collection of this taxon deposited in the New York State Museum (NYS), so as 13 other collections, under the same determination, from the University of North Carolina Herbarium (NCU). Within these collections we found an isotype of the original material from Arizona, collected by C. G. Pringle. In total, the number of collections examined were 23, including a sample of *Gastropila fragilis* from Argentina, Buenos Aires (BAFC), kindly sent by Prof. J. E. Wright to be compared with our material.

All samples were first observed under the light microscope and later on carefully examined and photographed in the scanning electron microscope (SEM).

RESULTS AND DISCUSSION

Calvatia Fr., Summa Veg. Scand. 2: 442 (1849)

Is defined as having carpophores medium to large (5-15 cm), globose to pyriform, with a sterile base (subgleba), rooting from a mycelial strand. Exoperidium thin, evanescent, sometimes reduced to a layer of hyphae, and sometimes scaly. Endoperidium thin, membranous, with apical part breaking away in irregular patches when ripeness takes place. Subgleba chambered or compact, always present, while diaphragm normally develops late, but only in a few cases. Capillitium threads long, "*Lycoperdon*" type, sometimes fragmenting, septate or not. Spores globose to broadly ellipsoid, verruculose to echinulate (DRING, 1964) (Figs. 1-2).

All the specimens studied were without subgleba, which induced us to think they belonged to some other genera, but not *Calvatia*. Among the different possibilities are *Gastropila* and *Langermannia*, two genera related to *Calvatia*.

Regarding *Calvatia* species, KREISEL (1989) has just published a paper trying to clarify what he calls the "*Calvatia* complex". He segregated several species (*C. excipuliformis*, *C. fumosa*, *C. utrififormis*, *C. hesperia*, *C. lloydii*, *C. lycoperdoides*, *C. subcretacea*) proposing the new genus *Handkea*. According to the author, all these species are characterized by having a capillitium without true septa, with elongated slit-like pits and endoperidium not dextrinoid. But he adds that "false septa may be present", so as the possibility of dextrinoid reaction may be "very weakly".

We, personally, think that these characters are somewhat subjective. First of all, the concepts of "true septa" and "false septa" are not easy to be distinguished under the light microscope. It happens frequently that septa are abundant in the centre of the gleba of certain specimens, and absent in other of the same collection. For instance, in *Bovista dermoxantha* (Vitt.) De Toni [= *B. pusilla* (Batsch) Pers.]. Sometimes it is also possible to observe both, true and false septa, in the same carpophore, e.g., *Lycoperdon ericaeum* Bon., *L. molle* Pers.: Pers., etc.

Even the morphology of capillitium may vary greatly, being possible to observe capillitium "*Lycoperdon*" type at the centre of gleba and "*Bovista*" type

in the periphery, or viceversa, e.g., *Bovista aestivalis* (Bon.) Demoulin, *B. limosa* Rostr., *B. heterocapilla* Kreisel, *B. californica* Kreisel, *B. albosquamosa* Kreisel, *B. citrina* (Berk. & Br.) Bottomley, *B. coprophila* (Cooke & Mass.) G. H. Cunn., etc.

On the other hand, the morphology of pits in the capillitium is rather variable. It is common, within the *Lycoperdales*, to observe different kind of pores in the same carpophore. Capillitium with few pores of regular shape in the centre of gleba, and at the same time, other capillitium threads abundantly pitted, with elongated pores, in the periphery. This is the case of *Lycoperdon atropurpureum*, *L. echinatum*, *L. umbrinum*, etc.

Finally, the not dextrinoid reaction could be the main character, but if it can appear as "very weakly", it is sometimes difficult to feel sure of where the limit is.

In conclusion, we think that at moment it should be better to keep unchanged the taxonomy of *Calvatia* Fr. s.l., following the classic systematic works by ZELLER & SMITH (1964), DRING (1964, 1973), until new more stable characters can be found, looking forward to a more natural taxonomy of the genus *Calvatia*.

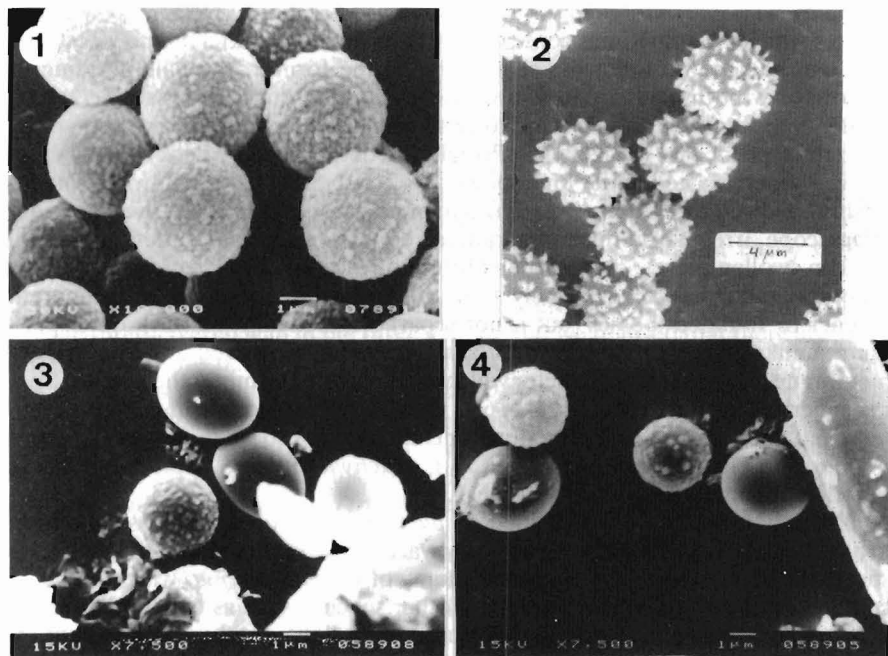


Fig. 1.—*Calvatia utriformis*. Spores showing a verruculose ornamentation (MA-Fungi 5423). Fig. 2.—*Calvatia cysthiformis*. Spores with a well developed ornamentation made up by conical clusters of spines (MA-Fungi 3937). Figs. 3-4.—*Langermannia pachyderma*. Observe the presence of two kind of spores in the type collection, from USA, Arizona, C. G. Pringle, VI-1882, det. G. H. Peck (NYS). The spores ovoid and smooth correspond to *Gastropila fragilis*, while the ones globose and verruculose are of *Langermannia* (= *Calvatia*) *pachyderma*.

THE IDENTITY OF *CALVATIA PACHYDERMA* (PECK) MORGAN

This taxon was originally described as *Lycoperdon pachydermum* by PECK (1882) and later transferred to *Calvatia* by MORGAN (1890). The Peck's original description says: "Subglobose, four to six inches in diameter, the radicating base somewhat pointed, the external peridium thin, smooth, whitish, the upper part cracking into small angular persistent spot-like scales or areas, the inner peridium thick, subcorky, somewhat brittle, the upper part at length breaking up into irregular fragments; capillitium and spores ochraceous-brown, the filaments long, flexuose, somewhat branched, .0003 of an inch thick; spores subglobose or broadly elliptical .0002-.00025 of an inch long. Arizona, June. Pringle".

As it can be seen, he says nothing of the spore ornamentation, which is logical taking in mind that at that time microscopes were unable to distinguish the verruculose ornamentation of such spores. Later, MORGAN (1890) transferred this taxon into the genus *Calvatia*, considering as an important character the opening of peridium; and giving information on the spore ornamentation as follows: "... spores globose, distinctly warted, 5-6 mic. in diameter, sometimes with a minute pedicel".

In 1928, COKER & COUCH, dealing with *Calvatia pachyderma* say: "*Calvatia pachyderma* (Peck) Morgan and *C. lepidophorum* (Ellis) Lloyd are two western species which are sometimes confused. Both have thick peridia but may easily be distinguished by the following characters: In the former, the pale peridium is smooth or whit thin adherent, white patches and there are no separable layers, although the entire peridium is apt to be scissile like a short cake; spores (in plant from the type locality, collected by Pringle and determined by Peck) oval to elliptic, very finely warted under high power ($\times 2160$), $3.5-4 \times 4.2-6 \mu$, with a mucro or short pedicel; capillitium threads fragmented, strongly olivaceous yellow under microscope, irregular in thickness, rather frequently branched, pitted, up to 11μ thick in swollen places; mature gleba bright olivaceous. In *C. lepidophorum* the outer peridium has an extremely thin, glazed surface, marked with inherent patches or rounded 'bosses' but is not separable. Beneath the thick outer peridium, unlike any other American *Calvatia*, the gleba is covered by a thin, papery membrane and this is the character which most easily determines the species. Spores spherical, distinctly warted, $4.2-6 \mu$. Capillitium threads slender, fairly even, up to 5μ thick, brown, occasionally branched, and not so sinuous as in *C. pachyderma*. The plant Morgan described as *C. pachyderma* is *C. lepidophorum*, as noted by Lloyd, and not Peck's species".

ZELLER & SMITH (1964) defined *C. pachyderma* spores as: "... subglobose, broadly elliptical to broadly ovate, finely warted to seemingly smooth..." All this shows the chaotic situation of the taxonomy of *C. pachyderma*, which has been confused with *C. lepidophora* and with other species, such as *Gastropila fragilis* until very recently. This fact stimulated us to try to clarify, within our possibilities, the identity of this taxon, examining the type collection and as many specimens as was possible.

The observation of the type, which consists of a collection of angular and irregular fragments (1-6 cm long) of peridium, without any apparent remaining part of gleba, showed us the presence of two kinds of spores; some of them ovoid and smooth, $3.5-4.5 \times 4.5-6 \mu$ m and the rest globose to subglobose and finely verruc-

lose, 4-6 µm diameter (Figs. 3-4). Within the box containing type material there is a note written by Ponce de León saying: "*Calvatia pachyderma* (Peck) Lloyd (Part of the type)".

The globose spores with verruculose ornamentation coincide with those published by KREISEL (1989) for *C. pachyderma* collected in Nepal. On the other hand, the presence of smooth spores could well be the result of a contamination with an apparently close species such as *Gastropila fragilis*, taxon described from South America and also present in the United States, as we have verified in the course of this investigation. Comparing those smooth spores with the ones obtained from a sample of *Gastropila fragilis*, kindly sent to us by Prof. J. E. Wright, we did confirm that both are identical (Figs. 5-8).

Thus, we decided to place within *G. fragilis* all American specimens with ovoid and smooth spores, so as the European ones published by DEMOULIN & *al.* (1988). On the other hand, the rest of specimens showing verruculose and globose to subglobose spores, which fit better within the original concept of *C. pachyderma* (MORGAN, 1890; COKER & COUCH, 1928; KREISEL, 1989), are transferred to the genus *Langermannia*.

Consequently, *Gastropila fragilis* is incorporated to the catalogue of Europe and North America, while *Langermannia (Calvatia) pachyderma* remains mentioned only for western United States (ZELLER & SMITH, 1964), Nepal (KREISEL, 1989) and South Africa (BOTTOMLEY, 1948).

***Gastropila* Homrich & Wright, Mycologia 65: 780 (1973)**

= *Pila* Speg., Revista Chilena Hist. Nat. 25: 77-78 (1921), non *Pila* Bertran & Renault, Bull. Soc. Hist. Nat. Autun 5: 151-253 (1892-93)

Carpophores of 10-20 cm diam., globose, with an irregular opening at the apical part, forming radiate-stellate bodies. Peridium very thick, fragile externally, corky-spongy internally, smooth, sparsely branched, not easily broken (HOMRICH & WRIGHT, 1973).

Concerning the peridium, we have investigated its composition trying to identify the three-layered wall in the three genera, but we realised that there are small differences. It was possible to distinguish two layers in most cases, and three in a few specimens. Within *Lycoperdales*, *Gastropila* seems to be very close to *Calvatia*, but they separate each other by the spore morphology and absence or presence of subgleba. The taxonomy of the genus *Gastropila* has been studied by PONCE DE LEÓN (1976), but this author synonymised *Langermannia pachyderma* (Peck) Kreisel with *Gastropila fragilis* (Lév.) Homrich & Wright.

***Gastropila fragilis* (Lév.) Homrich & Wright, Mycologia 65: 781 (1973)**

≡ *Mycenastrum fragile* Lév., Ann. Sci. Nat. Bot., ser. 3, 2: 221 (1844)

≡ *Pila fragilis* (Lév.) Speg., Revista Chilena Hist. Nat. 25: 77-78 (1921)

= *Calvatia pachyderma* (Peck) Lloyd, Mycol. Writ., Letter 65, 5 (1915), non *C. pachyderma* (Peck) Morgan, J. Cinc. Soc. Nat. Hist. 12: 167 (1890)

The main characters of this genus are: spores smooth, ovoid; subgleba absent and three-layered peridium.

Material studied.—AMÉRICA: Argentina, Buenos Aires, Marcos Paz, leg. J. Sadonet, 27-XI-1988, det. J. E. Wright (BAFC), MA-Fungi 22865. USA, Cali-

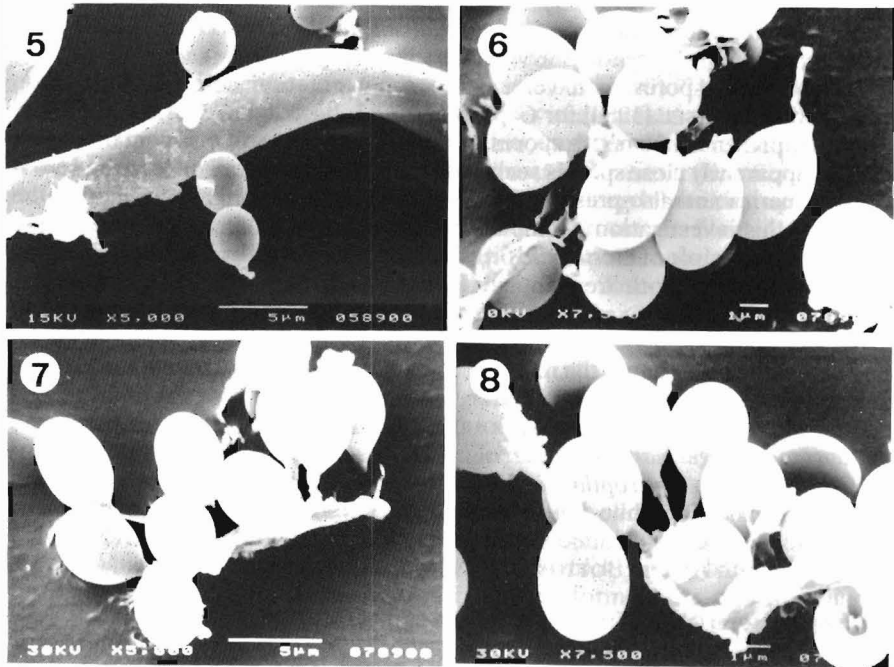


Fig. 5.—*Gastropila fragilis*. Spores and capillitium of a collection from Argentina (BAFC) (MA-Fungi 22865). Fig. 6.—*Gastropila fragilis*. Spores of a collection from USA, California coast, previously named as *Calvatia pachyderma*. Fig. 7.—*Gastropila fragilis*. Spores of a collection from USA, Strawberry Canyon, previously named as *Calvatia pachyderma*. Fig. 8.—*Gastropila fragilis*. Spores of a collection from USA, California, Berkeley, Bay Region, previously named as *C. pachyderma* (all from NCU).

fornia, Strawberry Canyon, Berkeley Hills, *E. Morse*, 26-V-1928. California, Pacific Coast, *E. Morse* (without date). California, Marín, S. F. Bay Region, leg. *E. Parks*, det. *E. Morse*, 4-VI-1932. California, Bay Region, leg. *Mycol. Soc. Life Sc. Berkeley*, 4-XI-1932. California, Point Reyes, leg. *F. F. Barbour*, det. *E. Morse*, 6-V-1932 (NCU). Colorado, Denver, leg. *Bethel* (without date) (Figs. 5-8).

EUROPE: France, Pyrenees Orientales, Banyuls, Mas de la Serra, among grasses, leg. *V. Demoulin*, 16-VI-1975, MA-Fungi 19746. With the same locality and legit, 21-VI-1975, MA-Fungi 19747. Port-Vendres, *J. Lambinon*, 4-VII-1985, MA-Fungi 19745. With the same locality, *G. Hubin*, V/X-1987 (LG). Spain, Gerona, Roses, Cala Juncols, leg. *M. P. Martín*, 3-V-1985, MA-Fungi 19415. Blanes, Cala Bona, leg. *M. D. Sierra*, 25-V-1985, MA-Fungi 19748.

Observations.—The European collections have recently been published as *Calvatia pachyderma* (DEMOULIN & *al.*, 1988; KREISEL, 1989).

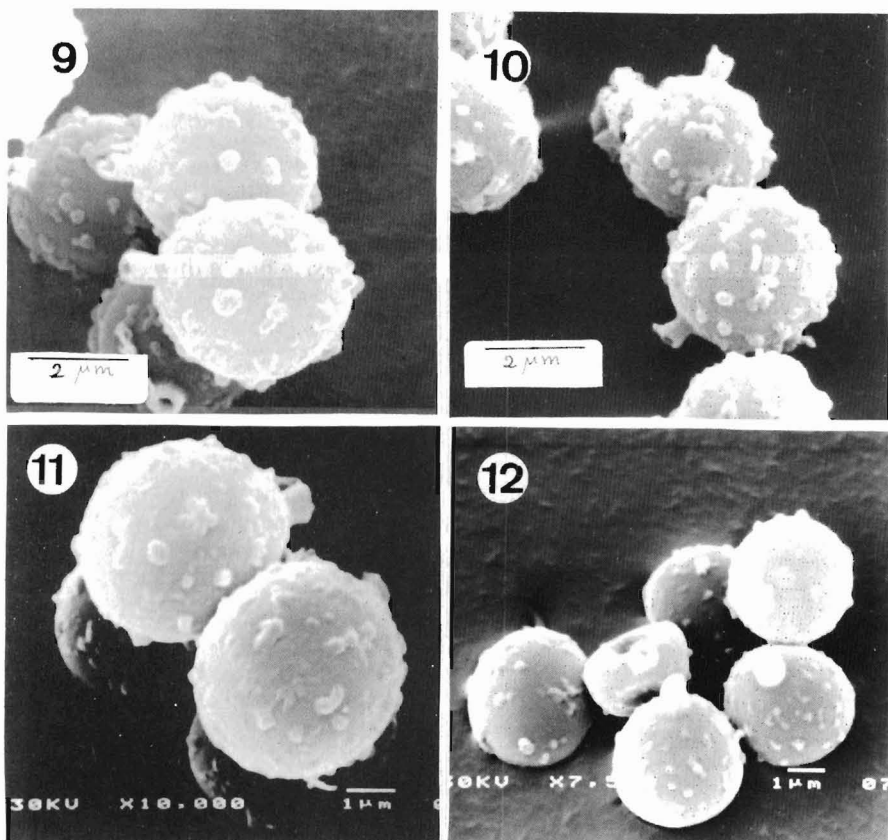
Langermannia Rostkovius in Sturm's Deutschland Flora, Abt. 3, 18: 23 (1844)

= *Lanopila* Fr., Fungi Natalensis p. 151 (1848)

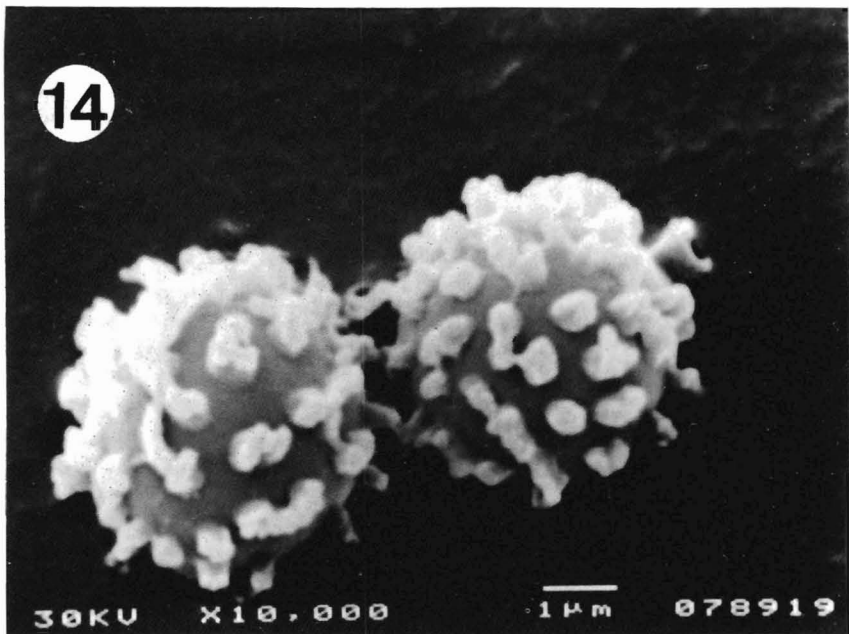
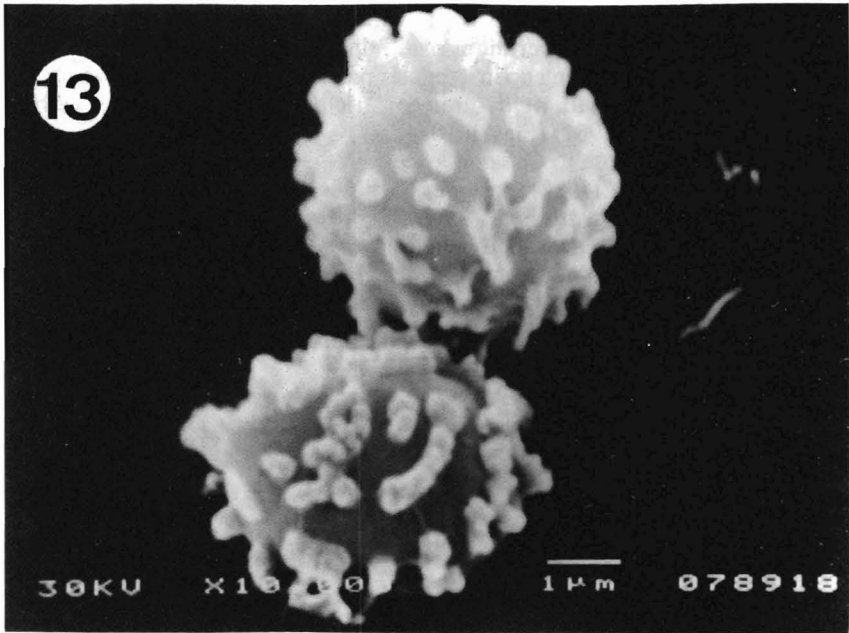
= *Lasiosphaera* Reichardt in Fenzl's Reise Austr. Fregatte Novara 1: 135 (1870)

Carpophores globose, 5-150 cm diam., without subgleba, often detached from the ground at maturity. Exoperidium pale falling away; endoperidium papery, brittle at maturity and breaking up in irregular patches. Gleba homogeneous, with capillitium brown, branched, rigid, often constricted at the septa; spores globose, warty or spiny (DRING, 1964) (Figs. 9-10).

This genus is very close to *Calvatia*, except in the fruit bodies, which lack subgleba. Besides, KREISEL (1962), considers that while *Langermannia* has a single-layered exoperidium, *Calvatia* is two-layered. But this feature is not always easily distinguished, thinking in the facility and quickness of disappearance of the exoperidium. On the other hand, we agree with HOMRICH & WRIGHT (1973) on the difficulty of delimitations between exo and endoperidium.



Figs. 9-10.—*Langermannia gigantea*. Spores from two different collections showing similar aspect (MA-Fungi 2481, 7966). Fig. 11.—*Langermannia pachyderma*. Spores with verruculose ornamentation, of a collection from USA, California (NYS 309), previously named *C. pachyderma*. Fig. 12.—*Langermannia pachyderma*. Verruculose spores of a collection from USA, Salt Lake, previously named *C. pachyderma* (NCU).



Figs. 13-14.—*Langermannia lepidophora*. Spores showing a distinctly well developed ornamentation, of a collection from USA, Dakota, Huron, previously named *C. pachyderma*, leg. N. Crouch, 1885 (NCU).

Langermannia pachyderma (Peck) Kreisel, The genus *Bovista*, Beih. zur Nova Hedwigia Heft. 25: 202 (1967) (Figs. 11-12)

≡ *Lycoperdon pachydermum* Peck, Bot. Gas. 7: 54 (1882)

≡ *Calvatia pachyderma* (Peck) Morgan, J. Cinc. Soc. Nat. Hist. 12: 167 (1890), non *C. pachyderma* (Peck) Lloyd, Mycol. Writ., Letter 65, 5 (1915)

Material studied.—USA: Arizona, leg. C. G. Pringle, VI-1882, det. C. H. Peck, Typus (NYS). From the same locality and collector, probably part of the type (NCU). California, Utah, Salt Lake, leg. A. O. Jarret (without date) (NCU). Oregon, North Benton, leg. S. M. Zeller, 1962 (NCU). California, leg. R. Dudley, no. 309 (NCU).

Observations.—This taxon has also been mentioned in South Africa (Bottomley, 1948) and Nepal (KREISEL, 1989).

Langermannia lepidophora (Ell. & Ev.) Calonge & Martín, **comb. nov.**

≡ *Lycoperdon lepidophorum* Ell. & Ev., J. Mycol. 1: 89-93 (1885)

≡ *Calvatia lepidophora* (Ell. & Ev.) Coker & Couch, Gast. Eastern United States and Canada, p. 60 (1928)

≡ *Hypoblema lepidophorum* (Ell. & Ev.) Lloyd, Mycol. Writ. 1: 140 (1903)

≡ *Bovista lepidophora* (Ell. & Ev.) De Toni, in Sacc., Syll. Fung. 7: 1033 (1888)

This taxon is very close to *Langermannia pachyderma*, but differs in having spores with a much more developed ornamentation (Figs. 13-14), exoperidium of 1-2 mm tick, with a thin glazed surface marked with patches, and mainly for its very thin papery membranous endoperidium, almost unique in the *Lycoperdales*.

Material studied.—USA: Huron, Dakota, leg. N. Crouch, 1885 (NCU). This specimen is possibly part of the type.

CONCLUSIONS

A critical study of the taxonomical delimitation among the genera *Calvatia*, *Gastropila* and *Langermannia* is presented in this article. As a consequence of this investigation we can conclude:

1. The examination on type material of *Calvatia pachyderma* (Peck) Morgan, both by light and SEM, shows the presence of two kind of spores; some of them completely smooth and mainly ovoid, and the rest always globose and verruculose.
2. We interpret the dimorphic spores of type material in the way of a possible contamination with *Gastropila fragilis* (Lév.) Homrich & Wright, a taxon also frequent in western United States, previously described from South America.
3. The revision of different collections of the complex "*Calvatia pachyderma*", both from Europe and North America, induced us to reclassify them in two groups: one formed by the specimens showing smooth spores and ovoid shape, which is identified with *Gastropila fragilis*, and the second one keeping the specimens with globose spores and verruculose ornamentation, which is recombined into the genus *Langermannia*.

4. We propose the new combination *Langermannia lepidophora* (Ell. & Ev.) Calonge & Martín.

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