

## SOME GASTEROMYCETES FROM EASTERN AFRICA

By

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### INTRODUCTION

During recent months a number of collectors have sent gatherings of gasteromycete fungi from E. Africa to the Kew Herbarium. This paper has been written to record the results of their collecting as well as to give them, and other workers in the area, an admittedly incomplete but, it is hoped, useful guide to the puffballs and their allies in the East African region. Recently collected material has been supplemented by studies of the older collections in Kew (K) and elsewhere, particularly the E. African Herbarium (EA).

Though this study is centred on E. Africa in a restricted sense we have also included some material from Malawi, Zambia, Rhodesia and Mozambique where considered appropriate. In a like manner Somalia has also been included. Perhaps, however, it is more important to note that we have also included the rather few gasteromycetes which we have examined from the Mascarene Islands. Though their nearest mainland is the east coast of Africa, these islands are known to have strong floristic affinities with Asia and Australasia rather than with Africa. So that, unless there is evidence to the contrary it should not be assumed that species recorded from these islands will occur on the African mainland.

The colour names used, excepting those describing microscopic characters, are based on Dade, Colour Terminology in Biology ed. II, *Mycol. Pap.* 6, 1949.

### COLLECTING

Gasteromycetes are easy to collect and preserve. All except Clathraceae and Phallaceae should simply be dried quickly and placed in boxes or packets with the usual data on place of collection, date, etc. They should never be pressed. If the collector has the time, inclination and very modest skill required, he should make pencil sketches, or better, water-colour paintings of the fresh material. In the case of phalloids, though dried material is better than none, the best method of preservation is to put at least part of each collection into bottles of spirit, once again making adequate collector's notes and if possible a painting or other indication of the colour of the fresh material.

### GLOSSARY OF TERMS USED

ADAXIAL	towards the axis
ALVEOLUS	small depression or hollow in a surface
AMYGDALIFORM	almond shaped
APICULUS	short projection
APOPHYSIS	swelling at the base of the spore-sac
BALLISTOSPORE	spore which is violently propelled from its mother-cell
BASIDIUM	the spore-mother-cell of basidiomycetes, bearing spores on short spines or sterigmata
CADUCOUS	falling away early
CAESPITOSE	growing from a single point
CAMPANULATE	bell-shaped
CAPILLITIUM	mass of sterile, thread-like hyphae mixed with the spores (cf. paracapillitium)
CLAMP-CONNEXION	characteristic protuberance at the septum in certain hyphae of some basidiomycetes
CLATHRATE	in the form of a lattice
CLATHROID (n)	a member of the Clathraceae
COLLAR	of a phalloid, the pad of tissue at the apex of the cap surrounding the apical perforation, if any; of <i>Tulostoma</i> , that part of the outer peridium which adheres to the head and surrounds the socket
COLUMELLA	a sterile prolongation of the stipe into the gleba (cf. pseudo-columella)
CORTEX	of the peridiole of Nidulariaceae, the dark-coloured layer
CRENULATE	of sterile bases, longitudinally wrinkled

DIAPHRAGM	of Lycoperdaceae, a membrane separating gleba from subgleba and confluent with the endoperidium
ECHINATE	spiny
EGG	of phalloids, the immature fruit-body and its enclosing universal veil
ENDOPERIDIUM	the inner layer of the peridium in Lycoperdales
EVANESCENT	fleeting
EXOPERIDIUM	the outer layer of the peridium in Lycoperdales
FARINA	floury coating
FLOCCOSE, FLOCCULENT	cottony
FUNICULUS	of Nidulariaceae, an elastic cord joining the peridiole to the cup wall
FUSIFORM	spindle-shaped
GLEBA	spore-mass
GLEBIFEROUS	bearing the gleba
HYMENIUM	fertile layer; in basidiomycetes it is composed of basidia
IMBRICATE	overlapping like tiles on a roof
INDUSIUM	of "Dictyophora", the net-like organ hanging from near the stipe apex, under the cap
MAMMOSE	breast-like
MULTISERIATE	of the stipe wall of a phalloid, consisting of more than two layers of chambers
NAKED	of a stoma, without a differentiated peristome
OSTIOLE	stoma, mouth
PARACAPILLITIUM	hyphae resembling those of the true capillitium except that they are hyaline, collapsed, and with frequent septa
PERCURRENT	of a columella, extending right through the gleba
PERIDIAL SUTURE	of clathroids, membrane joining the universal veil (outer peridium) to the receptacle
PERIDIOLE	discrete portion of the gleba, surrounded by its own wall
PERIDIUM	wall or membrane enclosing the fertile part of the fruit-body
PERISTOME	area surrounding the stoma
PHALLOID (n)	a member of the Phallaceae or of the Phallales, according to context
PILEUS	cap of the agaricoid forms
PLACENTA	of Sclerodermatales, tissue which nourishes the spore after its discharge from the badidium
PSEUDOCOLUMELLA	a $\pm$ densely woven, central mass of capillitium
PSEUDOSTEM	stem-like structure with tissues not orientated along the long axis of the fruit-body, usually consisting of $\pm$ spongy tissue
PUNCTATE	having minute warts or depressions
PYRIFORM	pear-shaped
RECEPTACLE	the spongy part of a phalloid
RETICULATE	in the form of a net
REVOLUTE	backwardly curved
RIMOSE	abundantly cracked, "crazed"
RUGULOSE	finely wrinkled
SACCATE	shaped like an open bag
SCABROUS	rough and peeling
SECOTIOID	pertaining to <i>S. cotium</i> and the Secotiaceae
SESSILE	lacking a stalk

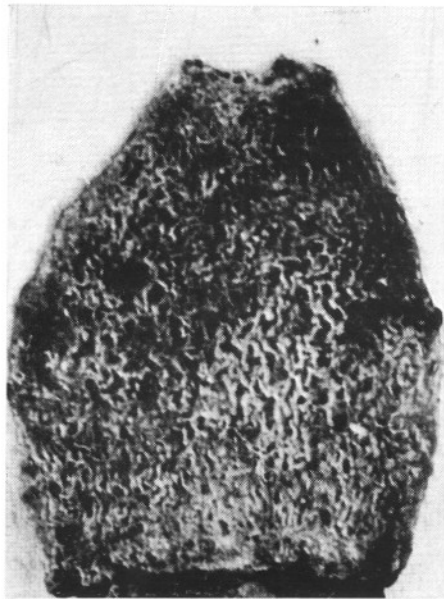
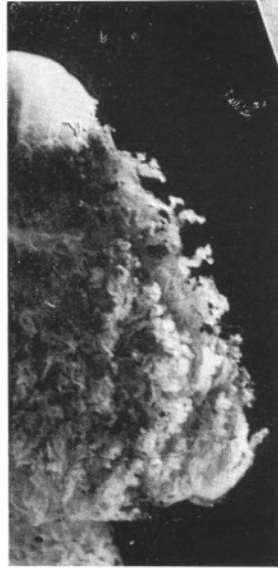


Plate 1

A. *Phallus caliendricus*, spirit material, habit, c.  $\times$  1 (Type); B. *P. caliendricus* cap ornament c.  $\times$  2 (Type); C. *P. caliendricus*, dried material, cap c.  $\times$  4 (BALLY); D. *P. caliendricus*, dried material, habit, c.  $\times$  1 (BALLY).

STERILE BASE	the pseudostem in Lycoperdaceae
STOMA	of a puffball, the apical pore through which the spores are discharged
STRIATE	etched with fine lines
STROMA	compact mass of vegetative hyphae bearing fruit bodies (cf. subiculum)
SUB-BISERIATE	of the stipe wall of a phalloid, consisting mainly of a double layer of chambers
SUBICULUM	a sheet of mycelium covering the substrate and bearing the fruit bodies (cf. stroma)
SULCATE	grooved
TOMENTUM	covering of soft hairs
TRAMAL PLATE	structure supporting the hymenium
TRUNCATE	cut-off short
TUNICA	of the peridiole of Nidulariaceae, the outermost hyaline layer
UNISERIATE	of the stipe-wall of a phalloid, consisting of a single layer of chambers
URCEOLATE	urn-shaped
VOLVA	the cup-like basal remains of the universal veil after expansion of the fruit-body

### THE GASTEROMYCETES

In a popular sense the term gasteromycete implies a basidiomycete in which the spore-mass or *gleba* is enclosed in a sac-like *peridium*. The familiar puff-ball is a typical example. Unfortunately, this conception does not cover the wide range of forms which are conveniently classified as gasteromycetes.

Technically, gasteromycetes are those higher basidiomycetes whose hymenia are enclosed, at least at an early stage of development, and whose basidiospores are not shot-off from the basidium. Thus, some forms very like agarics and boleti are included in the definition of gasteromycete simply because they do not discharge their spores violently from the basidium.

Inability to produce ballistospores has resulted in other means of discharging spores. Ingold (1953) has described the gasteromycetes as "an assorted collection of experiments in spore discharge," and indeed they are. There is, however, at least one other factor which seems to have contributed to this diversity. Since the violent discharge of the ballistospore depends on the hydrostatic pressure within the basidium, the hymenium must be turgid throughout the period of spore-discharge. Gasteromycetes do not have this limitation and are therefore better adapted to fruit in dry conditions than other basidiomycetes. Once again, this has resulted in diversification of both habitat and habit.

In addition to the puffballs and agaricoid forms referred to above there are many other groups. In the birds' nest fungi (Nidulariaceae) the gleba consists of pellets (*peridioles*) which are dispersed from the cup-shaped peridium by raindrops. In several groups the differing water-absorbing capacity of the various layers of the peridium is used as an aid to discharge. In the earth-stars (*Geastrum*) the outer peridium splits into rays which in some species bend backwards on drying, elevating the spore sac to a height more advantageous for spore-discharge. In other species of *Geastrum*, and in the similar *Astraeus*, the rays enclose the spore sac when dry, opening and permitting spore discharge when moist conditions prevail. In *Mycenastrum* the inner peridium behaves in the opposite way, cracking into lobes, bending back and exposing the powdery gleba when dry; closing when wet.

In the Clathraceae and Phallaceae ("stinkhorns"), the foetid gleba is exposed to the attentions of flies, often on a flower-like receptacle. In the Hymenogastraceae and similar hypogean fungi ("false truffles") the peridium is ruptured and the spores dispersed by burrowing animals. A glance through the illustrations to this paper will give some guide to the range of fungi which go to make up the gasteromycetes.

## Key to the families discussed

- |    |   |                                  |
|----|---|----------------------------------|
|    | Gleba becoming powdery (occasionally granular) at maturity  | 1                                |
|    | Gleba becoming mucilaginous at maturity   | 3                                |
|    | Gleba neither powdery nor mucilaginous  | 4                                |
| 1. | Capillitium of $\pm$ thread-like hyphae not present in gleba  | <i>Sclerodermataceae</i> , p. 18 |
|    | Capillitium abundant  | 2                                |
| 2. | Fruit-body sessile or with a sterile base of $\pm$ spongy tissue not orientated along the long axis of the fruit-body   | <i>Lycoperdaceae</i> , p. 22     |
|    | Fruit-body with a true stipe of hard, orientated tissue. Columella absent   | <i>Tulostomataceae</i> , p. 42   |
|    | Fruit-body with a true, woody stipe prolonged into the gleba as a percurrent columella  | <i>Podaxaceae</i> , p. 11        |
| 3. | Gleba usually borne on the inside of the receptacle, which may be sessile or stipitate and consist of a globose network or of several columns united at the top, or of spreading arms | <i>Clathraceae</i> , p. 15       |
|    | Receptacle a single, unbranched column supporting gleba near its apex   | <i>Phallaceae</i> , p. 11        |
| 4. | Hymenium borne on $\pm$ gill-like plates. Fruit-body usually stipitate  | <i>Secotiaceae</i> , p. 10       |
|    | Hymenium absent, gleba organized into seed-like peridioles. Fruit-body usually cup-shaped, less than c. 1 cm. diam.   | <i>Nidulariaceae</i> , p. 20     |

## SECOTIACEAE

The members of the Secotiaceae are easily recognizable by their gross resemblance to agarics. They have a stipe and an apical pileus which at maturity may spread out like that of a mushroom (e.g. in *Montagnea*) or remain almost closed (e.g. *Galeropsis*). The gleba consists of a true hymenium lining persistent tramal plates. These latter are often radially arranged in the same way as the gills of an agaric (*Montagnea*), or more or less anastomosed but retaining some visible radial orientation (*Galeropsis*), or so anastomosed that their basic orientation is obscured. The spores of the entire group are brown, double-walled, with an apiculus and usually a germ-pore. In the more agaricoid genera they tend to have the same symmetry as a ballistospore; in the more secotioid genera the spores tend to be irregular or globose.

They are typically fungi of arid regions. Only two genera are known to us from E. Africa.

*Montagnea* Fr. (= *Montagnites* Fr.)

This genus consists of *Coprinus*-like plants with radial, non-branched gills and an expanded pileus. It is usually defined as having the apex of the stipe expanded into a small disc, from the margin of which hang the gills. Much material, especially when gathered in an over-ripe condition does appear to fulfil this definition. However, material in good condition clearly shows that the pileus covers the whole of the abaxial edge of the gills but is very thin and splits between them. In older specimens the gills become twisted and the thin backing of pileal tissue may be obscured, the gills appearing to be attached only where they abut onto the disc.

Complete specimens have a well-developed volva. The stipe is hollow in all known *Montagnea* species, and this character, together with the non-branched gills, clearly separates them from the allied genus *Gyrophragmium* Mont.

There is but a single well known species, *M. arenaria* (DC.) Zeller (= *Montagnites candollei* Fr.). One of us (R.W.R.) has collected it in the Rift Valley, nr. Suswa volcano and we are informed by Dr. N. Otieno of its occurrence north of Isiolo, Kenya. The sketch (Fig. 1d) is based on a photograph of Otieno's material.

*Galeropsis* Velen.

Pileus not expanding at maturity but remaining as a subglobose, subvoid or subconic structure, narrowly open at the base. Gills radial but somewhat anastomosed. Stipe well developed, slender, hollow, without volva at base but often with a well-developed, sometimes marginate bulb.

Southern Africa seems to be particularly rich in species of this genus. Two have been recorded for S. Africa: *G. mitraeformis* (Berk.) Heim, and *G. liberatus* (Kalch.) Heim, both of them from the extreme south, another, *G. besseyi* (Pk.) Heim var. *madagascariensis* (Pat.) Heim from several localities in Madagascar. Finally *G. paradoxa* (Matt.) Heim has been recorded from Ethiopia. Heim (1950) expresses the tentative view that all are forms of a single variable species (and cf. the situation in *Podaxis*). Indeed distinctions between the species seem difficult to define. For the moment, however, we shall accept the generally held view that separate taxa are involved.

*G. aff. paradoxa* (Matt.) Heim. (Fig. 1f-h)

Pileus clavate-conic, to about 2×1 cm. pale tan. Gills adnate, frequently anastomosed; basidia 4-spored, waisted, about 25×5 $\mu$ , spores amygdaliform, 10–13×6–7.5 $\mu$ , pale amber, with small but clearly visible germ-pore. Stipe to 8 cm. long with a well-developed basal bulb.

HABITAT: On the ground in pasture at 2–3000 m. alt.

MATERIAL EXAMINED: KENYA: J. K. DEDAN 1233, Forest Dept., Kikuyu, in grass, April, 1965 (K); nr. Limuru, in Kikuyu grass pastures, abundant (R.W.R.'s notes).

NOTES: The material which we have seen, fresh, dried and preserved in spirit, corresponds with that described by Mattiolo (1924) in habit, habitat (including altitude) and in spore size (the last as given by Heim (1950) for Mattiolo's material) but the gills are apparently thinner and rather less frequently anastomosed, and the basidia are apparently all tetrasporous whereas Mattiolo noted both 2- and 4-spored basidia.

The gills are adnate (Fig. 1g), that is to say that if the pileus were to be opened out like that of an agaric the proximal edges of the gills would be confluent with the tissue of the stipe. This is clearly seen in the spirit material and confirmed in transverse sections of the upper 1/3 of the cap. Contrary to the impression to be gained from study of the literature, adnate insertion seems to be usual in this genus. Kotlaba (personal communication) confirms that it is true for *Galeropsis desertorum* Velen. The gills appear to be free in dried material of all species of the genus.

Sectioning of the gills shows them to be of the inaequihymeniiferous type (Buller, 1922) with basidia maturing in succession. The basidium elongates considerably just before maturity, and develops four slightly curved sterigmata on which the spores are borne. The result is that just as in an agaric the spores are held clear of the hymenial surface until they become ripe. In an agaric they would then be forcibly cast off from the sterigmata and the basidium would then collapse. In this case, however, they are not discharged but remain attached to the sterigma whilst the basidium collapses and draws them down again on to the hymenium to which they firmly adhere. As a result of the repetition of this process with the successively maturing basidia the hymenium becomes covered with a thick layer of spores. Basidia can be seen *in situ* only in very thin sections.

The cuticle of the pileus is of ordinary hyphae, not cellular as in the Bolbitiaceae, the family of agarics to which this genus is obviously closely related (Singer, 1962).

## PODAXACEAE

This family shares all the characters of the Secotiaceae, except that the tramal plates break down before maturity and are replaced by capillitium. Thus the gleba is pulverulent as in Lycoperdaceae but the spores resemble secotioid spores.

There is a single genus, *Podaxis* Desv. Morse's (1933) contention that all the forms are referable to a single variable species has not yet been refuted.

*Podaxis pistillaris* (L. ex Pers.) Fr. sensu Morse (Fig. 1a-c)

Sporocarp to 20 cm. high, consisting of an ellipsoid to subcylindric or subconic head supported on a slender stipe. Peridium dirty white to pale fawn, thin, woody, scaly, dehiscing by breaking away from the point of attachment to the stipe, splitting vertically into a small number of rays which bend outward and upward, and finally falling away completely. Stipe tapering upwards, produced into a percurrent columella, bulbous at the base, concolorous with the cap, scaly, longitudinally furrowed, hollow. Gleba copious, ochraceous, blood colour or black, capillitium of spirally thickened, dark hyphae, the spirals sometimes uncoiling to produce ribbons; spores of the basic secotioid type, straw-coloured to dark mahogany, 8–18×7–14 $\mu$ .

HABITAT: On the ground in exposed, dry situations, or on the tops of termitaria.

DISTRIBUTION: Widespread in tropics and subtropics.

MATERIAL EXAMINED: KENYA: W. J. DAWSON, coast nr. Mombasa, rec. 6.8.1914; T. D. MAITLAND 531, Mombasa, rec. 31.1.1921; P. R. O. BALLY B 2185, Garissa, in open country, common, 4.2.1943; BALLY B 3169, Nairobi-Magadi road, nr. Gill's Gulch, 2,400 ft., 20.6.1944; RAYNER 733, Nairobi-Magadi road, nr. Olorgesailie, sandy soil above termites' nest, 1944; BALLY 7778, idem, 23.4.1950; Watamu, nr. Gede (R. W. R.'s notes).

## PHALLACEAE

This family and the closely related Clathraceae are recognizable by their delicate, ephemeral, usually spongy receptacles which develop inside a globose "egg", bursting from it at maturity, exposing the foetid, mucilaginous gleba to the attentions of insects.

In the Phallaceae itself the mature fruit-body consists of the volva, or ruptured remains of the peridium, from which springs a hollow, chambered or spongy stipe holding aloft the gleba.

The Scale in the figures represents 10 microns (0.001 m.m.)

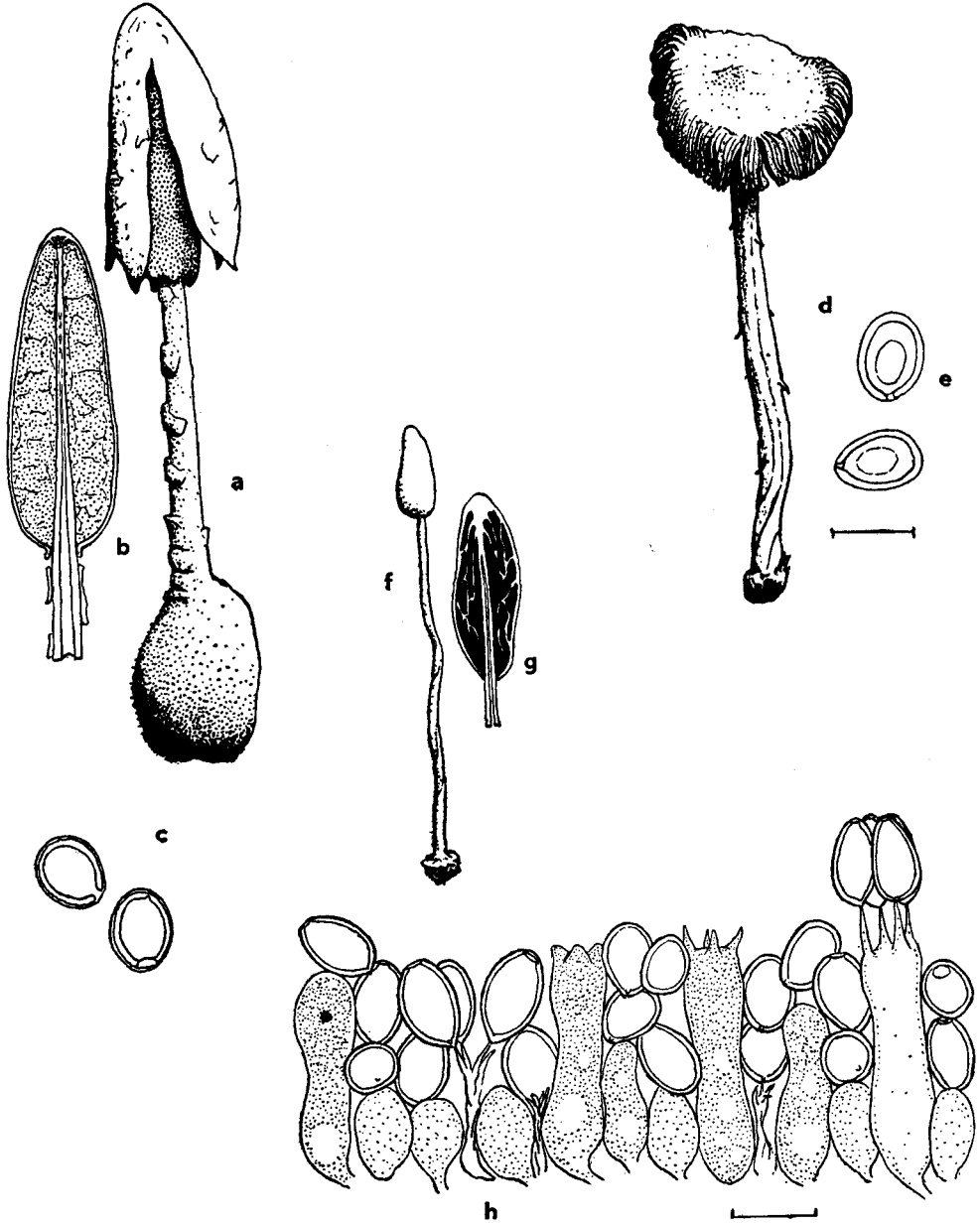


Fig. 1. Podaxaceae and Secotiaceae. a-c, *Podaxis pistillaris*: a, habit  $\times \frac{1}{2}$  (RAYNER 739, from water-colour by E. M. Rayner); b, v.s. upper part; c, spores (RAYNER 739); d-e *Montagnea arenaria*: d, habit  $\times 1$ ; e, spores (from pictures by N. Otieno); f-h *Galeropsis* aff. *paradoxa*: f, habit  $\times \frac{1}{2}$ ; g, v.s. upper part,  $\times 1$ ; h, v.s. hymenium (DEDAN 1233).

In *Mutinus* the gleba is borne directly on the stipe near its apex, but in most other genera, e.g. *Phallus*, it is borne on a more or less campanulate cap which fits over the apex of the stipe. An auxiliary structure, the indusium, is present in some species. It is a conical network suspended from near the apex of the stipe and hanging round it, under the cap.

Variations in the nature of the glebiferous part of the receptacle are the main criteria on which the family is divided into genera and species.

The structure of the egg of *Phallus* is shown in Fig. 2b.

#### **Mutinus Fr.**

Receptacle a hollow, fusiform stipe bearing the gleba directly on the upper part.

A species (almost certainly *M. argentinus* Speg., see Dring, 1964) having a red, acute glebiferous part and a slender, paler stipe has been seen in Kenya on several occasions but no material has been preserved. A similar plant from Tanganyika (Suji Mission, Makanyu, 4,000 ft., Jan. 1945, coll. BALLY) is preserved in Herb. EA, but paucity of the material precludes accurate determination.

#### **Phallus Pers.**

The receptacle, when expanded, consists of a hollow stipe with a volva at the base and a campanulate, glebiferous cap at the apex.

The wall of the stipe may consist of a spongy mass or a more or less clearly defined double layer of chambers, or a single layer of large chambers. We shall therefore refer to the chambers as multi-sub-bi- and uniseriate. The chambers may have holes in their walls opening to the exterior of the stipe or into its hollow exterior, or they may be intercommunicating. The tissue of the stipe may be white or some hue of red or orange.

The cap consists of a thin basal membrane thickened in places by surface ornament. The ornament may be rugulose, papillate, or tuberculate, or consist of a bold network of folds or ridges, in which case it is called reticulate. The cap is white or occasionally orange.

Cap and stipe are usually perforate at their common apex, sometimes barely perceptibly so, sometimes widely. The perforation is surrounded by wide or narrow ring of rather solid, undifferentiated tissue apparently belonging neither to cap nor to stipe. This collar serves as an "egg-tooth", rupturing the peridium when the fruit-body expands.

In some species an indusium hangs down from near the apex of the stipe, under the cap. It is perforated to a greater or a lesser extent, forming a network when fully expanded. It is customary to segregate those species possessing an indusium under two other generic names: *Dictyophora*, in which the cap ornament is reticulate, and *Clautriavia*, in which it is usually described as rugulose. However, the indusium alone is inadequate as a criterion on which to base a genus. In *P. impudicus*, the common European species and type of the genus, an indusium is occasionally present, though other fruit-bodies growing from the same mycelium are without. Closer observation shows that normal fruit-bodies of this species possess the rudiment of an indusium, visible, in microscopic preparations, as a ring of tissue near the apex of the stipe.

#### *P. rubicundus* (Bosc) Fr., (Fig. 2d)

Egg globose to obovoid, strongly rooting, often by a single strand; peridium white to pale brown, dehiscing apically. Receptacle to 15 cm. high, stipe hollow, wall spongy, c. 3 mm. thick, multiseriate, with chambers intercommunicating and often perforated to the exterior, flesh colour. Pileus campanulate, concolorous with stipe or darker, imperforate, surface rugulose, sometimes almost smooth. Gleba olivaceous, mucilaginous, foetid; spores ovoid-cylindrical  $3.5-5 \times 1.5-2.5\mu$  smooth, tinted.

HABITAT: on the ground in forest or in the open.

DISTRIBUTION: Probably throughout tropics and subtropics.

NOTES: The typical form, to which the above description exclusively applies, has a robust, spongy, flesh-coloured stipe. The cap is more or less campanulate and the apex is imperforate. In a previous paper (Dring, 1964) an attempt was made to indicate some of the variation encountered within this so-called species. It seems questionable that such a diversity of plants can profitably be grouped under the same name. As more material is examined a number of well marked types, sometimes of apparently limited geographical distribution, emerge. One of them is dealt with below, in the status of a variety.

Orange, truncate forms with thin cap closely applied to the stipe are often separated, with a good deal of justification, as *P. aurantiacus* Mont. The description suggests that *P. armeniacus* Patouillard (1924), described from Madagascar, would be referable here, but no material of this has been seen.



*P. rubicundus* var. *gracillimus* Dring & Rayner, var. nov. (Fig. 2c)

A typo differt in stipite gracillimos, pariete tenui, e strato unico cubiculorum sistente.  
 TYPUS: BOWKER, Kitale, Kenya, Nov. 1960 (EA).

Egg globose to ovoid, to 2  $\mu$ m wide; peridium light coloured, dehiscence circumscissile or by an apical slit. Receptacle consisting of stipe and cap; stipe red or pink, slender, to  $20 \times 1$  cm., attenuated apically, often curved in an arc, hollow, the wall thin, uniseriate, of large imperforate chambers; cap narrowly campanulate, thin, very finely rugulose to almost smooth. Gleba of the usual type, spores  $3-4 \times 2 \mu$ m. Hab. In turf, presumably ephemeral.

DISTRIBUTION: S. and E. Africa.

MATERIAL EXAMINED: KENYA: BOWKER, Kitale, Nov. 1960 (EA); BALLY 6377, Soy, alt. 6,000 ft., on a Kikuyu-grass lawn, 30.6.1948 (painting by C. Cripps, EA).

NOTES: This variety differs from the type in the extremely slender, long stipe consisting of a single layer of chambers. So far as can be ascertained from the dried material and the coloured drawing at our disposal the cap is thinner than that of *P. rubicundus*, more narrowly campanulate and not pink but yellowish-brown. The cap is also perhaps less rugulose than that of *P. rubicundus* but not too much stress should be placed on this rather variable character.

*P. rubicundus* var. *gracillimus* is similar to *P. novae-hollandiae* Cda, (= *P. gracilis* Lloyd, nom. invalid., = *Ithyphallus aurantiacus* var. *gracilis* E. Fisch., ? = *P. caleyi* Berk.), which, however has a shorter, biseriate stipe. We have hesitated to give our variety specific rank, or to place it as a variety of *P. novae-hollandiae* until more is known about variation in *P. rubicundus* and its allies.

*Phallus caliendricus* Dring & Rayner sp. nov. (Pl. 1)

Ovum subglobosum, sordide album. Receptaculum stipitatum; stipite incarnatum, usque  $10 \times 2$  cm. fusiforme vel columnare, cavum, pariete spongioso, e stratis c. 4 cubiculorum sistente; cubiculis plus minusve intercommunicantibus. Mitra campanulata, tenuis; reticulis lamellarum lacerarum et tuberculorum dense vestita, apice primo clausa dein perforata. Gleba olivacea, mucilaginoso, foetida; sporis ovoideo-cylindraceis,  $4.5 \times 2 \mu$ m, laevibus, hyalinis. Hab ad terram.

TYPUS: RAYNER 513, Regio Hombe, Mons Kenya, Africa, 15.11.1951 (K).

Egg subglobose, dirty white, strongly rooting by a cord-like mycelial strand. Receptacle stipitate; stipe flesh colour, to  $10 \times 2$  cm. broadly fusiform or columnar, apically attenuate, hollow, the walls about 3 mm. thick, spongy, multiseriate, with up to about 4 layers of more or less intercommunicating chambers. Cap campanulate, 2 cm. long by 1.8 cm. wide at the margin, dull, slightly orangy-red under the olivaceous gleba, surface thrown into very irregular, torn, thin folds, mostly about 1 mm. high but with nodular outgrowths which may attain 2 mm. in length, the whole giving the appearance, after removal of gleba, of a matted wig; margin white, about 1 mm. wide, slightly thickened, formed by the confluence of the folds of the cap; apex at first closed, perforate later; collar prominent, c. 5 mm. diam. Gleba dark olivaceous, mucilaginous, strongly foetid as in *P. impudicus*, spores  $4.5 \times 2 \mu$ m, ovoid-cylindrical, hyaline, smooth.

HABITAT: On the ground.

MATERIAL EXAMINED: KENYA: RAYNER 513, Hombe distr., above River Research Centre, slopes of Mt. Kenya, 6,500 ft., 15.11.1951 (Type, K, with watercolour); BALLY 9722, Nairobi distr., Lukenya, below E. slope, 5,500 ft., 20.5.1954 (EA).

NOTES: This species is distinguishable from *P. rubicundus*, which it resembles in its habit, by the cap ornament being like that of *Itajahya*, though less well developed. Indeed this species may be a link between that genus and *Phallus*.

*P. indusiatus* Vent. ex Pers. (Fig. 2a)

MATERIAL EXAMINED: SEYCHELLES: C. JEFFREY, s.n., Praslin, Vallée de Mai, 1962 (coloured slide only, K); JEFFREY, s.n., without data (K). UGANDA: SIR W. JOHNSTON, Bt., no data, ? 1901 (K); C. B. USSHER 78, Mabira Forest, April 1908 (K); LISTER, Ishanta R., Kigezi, 31.8.1960 (photo only, K). TANGANYIKA: SIR J. KIRK, Newala, Rovuma R. [S. Tanganyika], 1886 (picture only, K); K. BRAUN, 691 [Usambaras] 28.6.1905 (EA); BRAUN 1554, Kiv, nr. Vuga [Usambaras] (EA); BRAUN 8624, Amani (E.A.).

NOTES: This is the common tropical, white "Dictyophora" and is characterized by its well developed, widely spreading indusium and the small reticulations of the cap ornament (up to about 2 mm, diam.). USSHER 78 has particularly narrow reticulations, mostly about 0.5 mm. diam.

The record from Vallée de Mai is of an example with a double stipe and common cap, indusium and volva.

*P. duplicatus* Bosc (Fig. 2b)

Egg subglobose, to about 4 cm. diam., dirty white to brownish, strongly rooting, dehiscing apically. Receptacle consisting of stipe, indusium and cap; stipe white, to 15×3 cm. almost cylindrical, hollow, wall multiseriate, white; indusium short, often scarcely protruding below margin of cap, not widely spreading, the perforations small especially near the margin where they may be absent or hardly perceptible; cap campanulate, deeply reticulate, the primary reticulations up to about 5 mm. across in medium-sized fruit-bodies, collar narrow, often long-elliptical, apical perforation conspicuous, also elliptical. Gleba of the usual phalloid type, smell slightly offensive; spores smooth, elliptical 2.5–3.5×2μ.

HABITAT: On the ground, usually in woodland.

DISTRIBUTION: N. America, E. and S. Africa, W. Europe.

MATERIAL EXAMINED: KENYA: RAYNER, Upper Kiambu, coffee estate, c. 6,200 ft., 1943 (K).

NOTES: This is immediately distinguishable from *P. indusiatus* by the larger reticulations of the cap, the more massive stipe, and the shorter, less widely perforate and narrower indusium. Coker & Couch (1928) state that the indusium of United States examples is light rosy pink and Smith (1951) says "white to pinkish" but the specimen from Kenya had a white indusium.

In the above collection, which is in spirit, the indusium scarcely protrudes below the cap and the perforations, even above, are poorly developed.

From the illustrations in Bottomley (1948) and the single specimen in K (J. MEDLEY WOOD 667, in bush, Inanda, Natal, leg. W. Haygarth, rec. 27.12.1881, with picture) it would seem probable that this, not *P. indusiata*, is the correct name for the S. African examples.

Records of this species in W. Europe are open to suspicion because of confusion between it and indusiate forms of *P. impudicus*. It is tentatively suggested that the main distinction between them lies in the structure and shape of the indusium, which is widely spreading, cobwebby, in the latter. General habit and the character of the reticulations of the cap are important additional distinctions. The difference between the two plants is magnificently demonstrated by Pilát (1958, Fig. 16, p. 74).

*P. hadrianii* Vent. ex Pers. (= *P. imperialis* Schulzer)

MATERIAL EXAMINED: SEYCHELLES: JEFFREY, s.n., Mahé Brilliant, 7.10.1961 (with coloured slide, K).

NOTES: This species differs from *P. impudicus* mainly in its less disagreeable smell, in the pink colour of its volva, volva gel and, often, of its stipe, in the more broadly based egg, and in the more nearly isodiametric reticulation of the cap. The cap is said to be less abruptly conical and the apical perforation consequently wider but this may be of little diagnostic value (Meulenhoff, 1936). It has been argued with some justification that it is merely a variety of *P. impudicus*.

Jeffrey's material conforms with the usual concept of this species, except that the stipe is uniformly pale pink whereas it is usually white or coloured only at the base. Its occurrence in the Seychelles is not so strange as would appear at first sight since many records of *P. impudicus* from Asia are probably referable to this species (Dring & Rayss, 1964). Pearson (1948) records *P. hadrianii* from S. Africa.

## CLATHRACEAE

This group is closely related to the Phallaceae but differs in that the receptacle is more complicated and more variable. It may be sessile or stalked, and consist of a network or of variously united arms or diverging branches. The gleba is borne directly on the adaxial face of the networks, arms, etc., in immediate contrast to the situation in the Phallaceae, where the gleba is always borne externally to the receptacle.

The egg (Fig. 2g) differs from that of the phalloids in that the gelatinous "inner peridium" is not a continuous layer but is divided into segments by peridial sutures. These are membranes which connect the outer peridium with the receptacle, passing approximately radially through the gelatinous layer. A peridial suture corresponds to each arm of the receptacle. The lines of fusion between the peridial suture and the peridium can be seen as slight folds running over the outer surface of the unopened egg.

The genera of Clathraceae are interdistinguishable by the shape of the receptacle. Unfortunately rather few are known to us from this area. In *Clathrus* the receptacle is a hollow network, and all other forms may be considered to be derived from this.

*Ileodictyon* is a close relative of *Clathrus* in which the receptacle, instead of consisting of chambered tissue, is formed of a continuous, intestine-like tube (Reid & Dring, 1964). *I. cibarius* Tul. is recorded from Salisbury (see Bottomley 1948, p. 528).

Loss of all but the vertical arms of the network has resulted in genera like *Linderiella* (Fig. 2e) and *Blumenavia*, both of which have E. African representatives.

Another line of evolution has given rise to stipitate forms represented in the E. African flora by *Simblum* and *Kalchbrennera* (Fig. 2f, i).

#### **Clathrus Mich. ex Pers.**

Receptacle a hollow, more or less spherical lattice. The gleba may cover the whole inner surface of the receptacle or be restricted to the intersections of the arms of the network. The arms consist of a more or less regular arrangement of chambers though this structure may be obscured in the more massive, spongy species.

Only one record is known to us from E. Africa (MAITLAND, without data, Uganda, photograph only, in Herb. K). The fruit-bodies (Fig. 2h) are white or pale-coloured and have rather characteristic flat meshes as in Mme. Goosens-Fontana's illustration (in Dissing & Lange, 1963). Dissing and Lange have taken this to be *C. baumii* P. Henn., with good reason. Though the illustration does not indicate that the gleba is confined to nodular processes at the intersections of the arms as Hennings's (1903) original description specifies, study of the dried material (BR) shows this to be so.

This fungus must be very similar if not identical to that recorded from Jamaica by Dennis (1953) as *C. cf. preussii*, from typical examples of which it differs in the flatter arms, more nearly quadrilateral in section, lacking a fringe along the outer angles (Dring, 1964).

#### **Linderiella G. H. Cunn. (=Linderia Cunn. non Linderia Thumb.)**

Receptacle of vertical, unbranched (exceptionally forked) columns united at the apex but free at the base. The gleba is borne directly on the inside of the apical part of the columns.

There is only one known species.

#### ***L. columnata* (Bosc) Cunn. (= *Laternea columnata* (Bosc) Lloyd) (Fig. 2e)**

Egg subglobose with longitudinal furrows corresponding to the peridial sutures and hence to the columns of the receptacle, to about 5 cm. diam., white to pale brownish, usually with a single thick rooting strand. Receptacle orange to bright red, at first urceolate to ovate, becoming obovate as the top part expands fully, of 2-4 thick columns which are gradually attenuated toward the apex where they are united, abruptly tapering below where they are free, up to about 2 cm. across at the widest part. Gleba borne in a single large mass initially spherical and pendant from the top of the receptacle, as the latter opens dequescing and forming a more or less even coat over the inner surface of the upper part of the columns. Gleba and spores as usual for the family.

HABITAT: On the ground.

DISTRIBUTION: The Americas, Africa south of the equator, Japan, New Zealand.

MATERIAL EXAMINED: KENYA: E. R. NAPIER, s.n., Kiambu, 5,700 ft., Dec. 1931, coll. MRS. ARMSTRONG (K); RAYNER 736, Scott Laboratories, Nairobi, 6,300 ft. (K); MRS. P. H. IRWIN 613, Peover, Mt. Elgon, 10.6.1962 (watercolours only, K); MRS. W. STEVENS, Nairobi, 30.4.1964 (EA).

NOTES: This is very closely related to a section of the genus *Clathrus* and indeed the tendency of its columns to branch in exceptional cases, makes it very difficult to draw a water-tight distinction between the two genera. (See Coker & Couch (1928), Pl. 1. for an excellent illustration of a *Clathrus*-like specimen. These authors, in fact use the original binomial *Clathrus columnatus* Bosc.). Specimens from Japan with only two columns have been segregated as *L. bicornata* Lloyd. Specimens from the E. Rift valley have only two columns though one of the specimens from Mt. Elgon illustrated by Mrs. Irwin has three.

Specimens of *L. columnata* have sometimes been confused with *Anthurus* but should be immediately recognizable in that the columns of the receptacle are united below into a short stipe in the latter. They are also initially joined at the apex of the receptacle but later become separated and flaring.

Hennings (1904) recorded *Anthurus* sp. from the Usambaras but it was badly damaged. It seems probable that it was *A. archeri* which is known from S. Africa, though only from oakwoods near the S.W. coast, but it cannot be entirely excluded that it was in fact a *Lysurus*.

#### **Blumenavia Möller**

Receptacle of vertical columns, united at the apex, free at the base, the sides of each column fringed by irregular, torn wings which bear the gleba.

The special glebiferous organ is developed from the large adaxial chamber of the arm. The wall of the chamber is specially thickened except on the adaxial side where it is defective. At maturity it ruptures along this vertex and the thickened walls are free to fold sideways and forwards as irregular flaps carrying the greater part of the gleba with them.

In *Laternea* Turpin, another genus of Clathraceae, special glebifers are also developed from modified receptacular chambers. Since they are similar in habit to *Blumenavia* a good case might be

made for uniting the two, though this will not be undertaken here. For an account of two species of *Laternea* and one of *Blumenavia*, see Dennis (1953).

This series of forms with columns discontinuous at the base, including *Linderiella* and *Blumenavia* and ending in *Laternea* is one of the most complete and beautiful in the Clathraceae. It illustrates the loss of all but the vertical arms of the receptacle, and their reduction in number, the vertical displacement of the gleba, development of a special glebiferous organ (cf. the cap of *Phallus*) and reduction in size of the receptacle.

But one species of *Blumenavia* is known from E. Africa.

#### *B. usambarensis* P. Henn.

Egg blotched with brown, subglobose, to 4 cm. diam. opening by a series of large irregular apical lobes. Receptacle white, long-ovoid, to about  $8 \times 3$  cm. consisting of 3–5 vertical columns free below and joined at the apex, to 1 cm. thick at the base, attenuated apically, outer surface strongly transversely ridged, sub-triangular or quadrilateral in section, broadest side outermost. Glebiferous wings raggedly dentate, extending along the whole length of the inner angle of the side of the columns. Gleba of the usual type, probably restricted to the upper part of the receptacle. Spores of the usual type,  $3-3.5 \times 1.5 \mu$ .

NOTES: We have seen no E. African material of this very rare fungus and the description is made up from Hennings's (1902) original and studies of a W. Indian collection in Herb. K (R. W. G. DENNIS, s.n. Noronja, Trinidad, rain forest, 1,800 ft., 2.10.1949, with watercolour). This species would seem to differ from *B. rhacodes* Möll., the type species, in the position of the glebiferous wings, and in the much more fragile construction of the receptacle, which is white instead of red. Hennings does not mention that the gleba is restricted to the upper part of the receptacle but this seems likely.

*Laternea angolensis* Welwitsch & Currey (1870) may be the same according to the original account. There is no type specimen in herb. BM.

#### *Simblum* Klotzsch

Receptacle consisting of a stipe surmounted by a clathrate, fertile network. The copious gleba is borne on all but the flattened outer face of the arms of the network.

Morphologically this may be regarded as a stipitate *Clathrus*.

Although basically globose, the head may be depressed onto the stipe so that it appears hemispherical. The colour of the receptacle may be white or some tint of yellow or red. The gleba may vary in the extent to which it covers the sides and exterior of the arms. The fertile network is usually abruptly differentiated from the stipe but occasionally there is a gradual transition.

The fertile network varies considerably in the number of meshes (about 5 to about 25) and in their size and shape. Conard (1913) reports finding occasional arms of the network embedded deep in the gleba. Ahmad's (1952) implication that the irregularity of the network in some specimens brings them very close to *Lysurus* is interesting and is confirmed by material in K (Varanasi, India, coll. K. B. Khare). The genus does share with *Lysurus* the tendency of the gleba to migrate towards the outside of the arms, a tendency which is even more marked in the next genus, *Kalchbrennera*.

The number of species in the genus is a matter of dispute. The original one, *S. periphragmoides* was yellowish in colour and came from Mauritius. Specimens from the Old World are normally placed in this species and are usually some shade of yellow.

Reddish (occasionally white) species usually come from the New World and are usually called *S. sphaerocephalum* (inappropriately, perhaps, since the "hemispherical" head is commoner in New World than in Old World forms).

There are, however, notable exceptions to the hypothesis that colour depends on distribution. A yellow form from Texas has been described as *S. texense* (Atkinson & Long) Long, and Ahmad's (1952) Pakistani collections are apparently red rather than yellow.

We have seen no substantiated record of a *Simblum* from continental Africa, all supposed examples being referable to *Kalchbrennera*.

#### *S. periphragmoides* Klotz. (Fig. 2i)

MATERIAL EXAMINED: MAURITIUS: MRS. A. TELFAIR, Bois Chéry (K) (TYPE).

ZANZIBAR: MRS. H. FAULKNER, Massazine, among grass in sandy soil, 19.11.1957 (K), and another collection, in spirit, without date (K).

NOTES: The Zanzibar collections comprise rather small fruit-bodies with the "hemispherical" head (Fig. 2i). They are described as having been orange. The stipe wall consists of 2–3 layers of chambers thinning to one layer at the top and bottom. The chambers are arranged in broken vertical columns and many of them communicate with chambers above and below to form vertical tubes. The receptacular network consists of an apparently continuous tube whose walls are rather thicker

than those of the chambers of the stipe. The veil which lined the inside of the hollow stipe before expansion of the fruit-body persists as a short flaccid cylinder hanging down inside the stipe. The anatomical details correspond closely with those described by Long (1907) for *S. texense*.

#### Kalchbrennera Berk.

Receptacle like that of *Simblum* except that the fertile network is less well developed and bears simple or forked processes on its outer side at the point of intersection of the arms. The gleba is borne between these processes, that is on the outside of the network, not inside it as in every other clathroid.

The position of the gleba is surprising. However, the ends of the processes are external to the gleba. A tendency for the gleba to migrate round the sides of the arms and to take up a position more or less exterior to the receptacle has already been noted for *Simblum* and *Lysurus*. Presumably this is an extension of that process.

The genus contains a single species.

#### *K. corallocephala* (Welw. & Curr.) Kalch. (= *Simblum clathratum* Lloyd) (Fig. 2f)

Egg subglobose, becoming obovoid, to about 4 cm. diam. Network of receptacle bright red, hemispherical, to 3 cm. diam., meshes very variable in number, arms transversely rugulose, tubular, to 3 mm. diam., appendages bright red, branched or simple, projecting up to 2 cm. from the network, often smaller. Stipe cream-coloured, often tinged with pink above, cylindrical or attenuated downwards, to 12 × 3 cm., hollow, walls sub-biseriate, the larger chambers internal, often intercommunicating to produce short vertical tubes. Gleba as normal for the Clathraceae, particularly foetid, spores normal.

HABITAT: On the ground, in woodland or in the open.

DISTRIBUTION: Apparently limited to Africa south of the Sahara.

MATERIAL EXAMINED: KENYA: RAYNER 738, Bamboo forest Central Prov., c. 7,000 ft., 1947; BALLY B6349, Karen Estate, Ngong Distr., leaf mould in forest, May 1948 (EA); B9721, Spring Valley, Nairobi, coll. H. STONE, May 1954 (EA); B11575, Karen Estate, Nairobi Distr., coll. MRS. J. PEDFIELD, 19.5.1957 (K, in spirit); L. D. & B. VERDCOURT 2066, Muguga, nr. Nairobi, edge of cultivated field and natural woodland, 16.12.1959 (EA); L. D. VERDCOURT H201/61, Muguga, nr. Nairobi, in grass, 23.5.1961 (EA).

### SCLERODERMATACEAE

This family is characterized by the possession of a more or less globose, sessile or stipitate, usually epigeal fruit-body. The peridium consists of a single layer, being thick or thin, tough or fragile at maturity, continuous with the tramal plates. The gleba is divided into discrete knots of tissue separated by the anastomosing tramal plates. It is not labyrinthine as in the Phallaceae and Lycoperdaceae, nor can it be said to be divided into chambers since there is virtually no hymenium, the basidia and their supporting hyphae forming loosely woven islands of tissue without a central cavity. The basidia apparently become functionless before the spores are fully grown and nutrition of the spore continues through a placenta of hyaline cells which envelopes each spore. The exact nature of the placental cells seems to determine the characteristic ornament of the mature epispore. Mature spores are usually relatively large and strongly ornamented with prominent spines or a deep reticulum, or often a combination of both.

The tramal plates are more or less persistent at maturity, dividing the gleba into distinct pockets, often called peridioles.

The two best known genera are *Scleroderma* and *Pisolithus*. The latter is not represented in the E. African material at our disposal, though its only widespread species *P. arrhizus* Pers. (= *P. tinctorius* (Mont.) Fisch.) may occur in the dryer areas. Its fruit-bodies are dark brown, very hard, stipitate, dehiscing by irregular erosion from the apex. The tramal plates are very prominent and split down the middle so that each peridiole breaks away as a separate grain.

The tramal and other tissue yields a yellowish dye. Pseudomycorrhizal association with *Eucalyptus* and probably other trees has been demonstrated.

#### *Scleroderma* Pers.

Tramal plates breaking down at maturity resulting in a pulverulent gleba consisting of spores plus large quantities of debris derived from the trama, placenta, etc., and often obscuring the ornamentation of the epispore.

The peridium just before it dries out at maturity is always fairly thick (1 mm. to 1 cm.), brittle or tough when dry. Dehiscence is by more or less regular stellate cracking of the peridium and

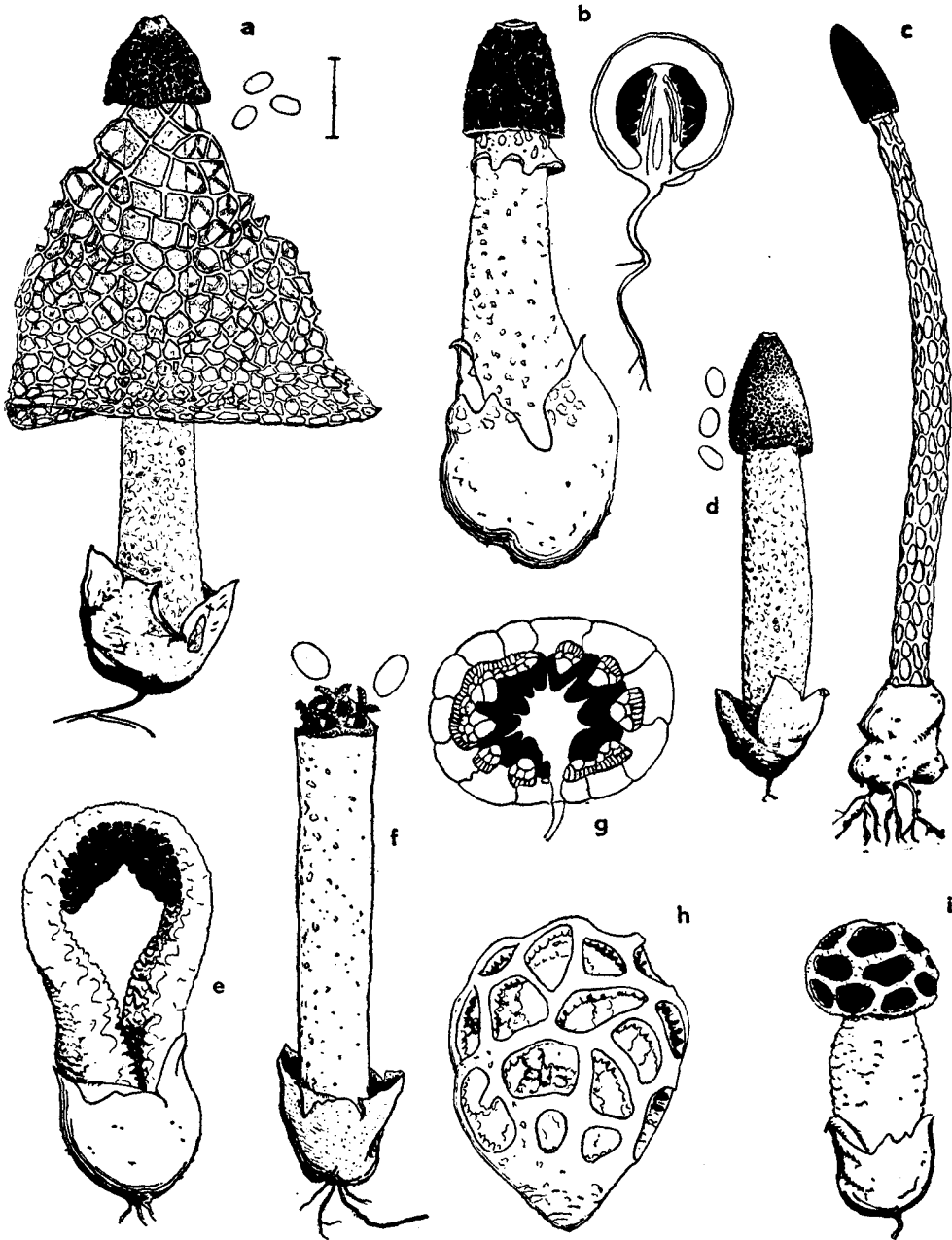


Fig 2. Phallaceae and Clathraceae. a, *Phallus indusiatus*, habit  $\times \frac{1}{2}$  and spores (from W. African material); b, *P. duplicatus*, habit and v.s. egg,  $\times \frac{1}{2}$  (RAYNER 737, from watercolour by E. M. Rayner); c, *P. rubicundus* var. *gracillimus*, habit  $\times \frac{1}{2}$  (from watercolour by C. Cripps); d, *P. rubicundus*, habit  $\times \frac{1}{2}$  and spores (from W. African material); e, *Linderiella columnata*, habit  $\times \frac{1}{2}$  (from watercolour by Mrs. Irwin); f, *Kalchbrennera corallocephala*, habit  $\times \frac{1}{2}$  and spores (from W. African material); g, *Clathrus* sp. v.s. egg  $\times \frac{1}{2}$  (W. Indian material, from watercolour by R. W. G. Dennis); h, *Clathrus* sp., habit  $\times \frac{1}{2}$  (from photo by T. D. Maitland); i, *Simblum periphragmoides*, habit  $\times 1$  (FAULKNER).

recurving of the resulting lobes, or by irregular flaking away of the apex. The most important characters for distinguishing between the species are thickness of the peridium, mode of dehiscence and spore-size and ornament.

*S. verrucosum* Vaill. ex Pers. ssp. *verrucosum* (Fig. 3c)

Fruit-bodies depressed globose, to about 6 cm. diam., usually less, usually with a short stipe but sometimes practically sessile or with a very long stalk. Peridium when dry, less than 1 mm. thick, fragile, with small, brown, angular, firmly attached scales. Spores globose, strongly echinate 7–12 $\mu$  diam., not including the spines, which are up to 2 $\mu$  long, curved and acute.

DISTRIBUTION: Cosmopolitan.

MATERIAL EXAMINED: RHODESIA: EYLES HERB. 7222, Salisbury, Feb. 1932 (as *S. nitidum* Berk.) (K).

NOTES: This subspecies must be relatively common in the area though we have seen only one gathering. Bottomley (1948, p. 538) records it for S. Rhodesia and Lloyd (L. 12, p. 1 (Vol. 2) 1906) for the Usambaras.

The length of the stipe in some collections is extreme. These have often been described as separate species (see Dring, 1964).

*S. verrucosum* ssp. *bovista* (Fr.) Sebek is similar to ssp. *verrucosum* except that specimens with very long stipes are not found, and the ornament on the spores is a coarse reticulum. Intermediates between the two subspecies exist in which the epispore is partly spiny, partly reticulate. Bottomley (1948, p. 540) records ssp. *bovista* from Rhodesia (as *S. bovista*).

*S. flavidum* Ellis & Everhart (Fig. 3a, b)

Fruit-bodies depressed globose to pyriform, to 6 cm. diam. dehiscing by apical lobes which become partly reflexed, usually with a well-developed stem-like base. Peridium buff, up to 5 mm. thick when fresh, usually more than 1 mm. when dry, smooth, or the upper part deeply cracked or areolate. Gleba usually with a yellowish tinge, powdery, often falling away completely leaving the empty star-shaped peridium. Tramal plates often rather persistent. Spores dark brown, echinate, 10–14 $\mu$ .

DISTRIBUTION: N. America, Australasia, E. and S. Africa.

MATERIAL EXAMINED: KENYA: C. LEAKEY, s.n., Nairobi, Apr. 1964 (K, EA); UGANDA: MAITLAND 593, Kampala, Sept. 1922 (as *S. geaster*, K); TANGANYIKA: GIBSON, s.n., Golongolo, nr. Lushoto, profuse under *Pinus radiata* suggesting mycorrhizal association, 6.7.1959 (as *S. bovista*, K).

NOTES: This is rather a variable species recognizable by its stellate dehiscence, spore and peridial characters and sterile base. It differs from *S. geaster* in the thinner peridium and in that the spines on the spores are not reticulately arranged.

Authentic material in Herb. K (ELLIS & EVERHART, N. Amer. Fungi Exs., 2 ser., 1698) has spores with very thin sharp spines but other material shows a great deal of variation in this respect. In Leakey's specimen, the habit of which is absolutely typical of the species, the ornament of the epispore is reduced to warts. MAITLAND 593 has more typical spores but the fruit-bodies are very depressed in shape and most of them lack a sterile base. The upper part of the peridium is deeply cracked after the manner of some N. American specimens (see Coker & Couch, 1928, pl. 88). Gibson's specimen is immature and can therefore only be tentatively placed here.

*S. capense* Lloyd (Fig. 3d)

Sporocarp small, to almost 1.5 cm. diam., more or less subterranean, sessile, rooting by a mass of fine basal strands. Peridium smooth to minutely cracked, often finely wrinkled on drying, dull ochraceous, very thin and brittle when dry. Gleba reddish-brown; tramal plates yellow, not persistent; spores globose, (7.5)–9–14 $\mu$ , strongly echinulate with warts grouped together, almost free from debris. DISTRIBUTION: Southern Africa.

MATERIAL EXAMINED: KENYA: THOROLD T36, Njoro, 7,000 ft., July 1932 (K).

NOTES: The specimen corresponds with the description given by Lloyd and Bottomley (1945, p. 540–1) except that the material is caespitose. Neither Lloyd nor Bottomley mention that the spines of the epispore are grouped together in clumps.

Bottomley suggests that the species may be the same as *S. cepa* but the peridium is far too thin for that species, and the colours are wrong. The reddish tinge of the gleba at least in the stage immediately before it becomes powdery, is striking.

#### NIDULARIACEAE

Members of this family are characterized by the small (never much exceeding 1 cm. diam.) cup-shaped peridium containing a gleba composed of seed-like peridioles, of which there are usually

more than one per fruit-body. They are held in place in the cup until maturity by mucilage or anchored to its wall by a cord, the funicle. Spores are large, pale, thick-walled, smooth and subspherical to ovoid.

The peculiar habit of these fungi gives them the name "birds'-nest" fungi. They have been provisionally placed next to the Sclerodermataceae in this paper because of the similarity of organization in which the gleba is divided into discrete peridioles. In addition, a true hymenium is absent and the spores are nourished by placentae as in *Scleroderma*.

The more advanced, funiculate genera are best known, both taxonomically and developmentally, but more detailed study of the simpler members of the group may lead to a better understanding of their relationship to the rest of the gasteromycetes.

There is a closely related family, the Sphaerobolaceae, containing only one accepted species *Sphaerobolus stellatus* Tode ex Pers. The fruit-bodies are up to about 2 mm. diam., cup-shaped, and the single peridiole is discharged explosively by the inner layer of the peridium suddenly turning inside-out. *S. stellatus* is cosmopolitan, occurring on decayed wood, dung, etc., but it is easily overlooked, and apparently not yet recorded for E. Africa.

#### Cyathus Haller ex Pers.

Cup obconical with a compound wall to which the peridioles are attached by a complex funiculus. Peridioles dark-coloured, covered by a dark cortex which is sometimes overlain by a thin translucent tunica. They are dispersed by rain-drops falling asymmetrically into the cup, ejecting the peridiole.

As seen in transverse section the cup wall consists of an outer layer of narrow, branched, densely woven hyphae orientated more or less parallel to the surface and bearing the tomentum, if any, on the outside, a middle layer of pseudoparenchymatous tissue, and an inner layer of loosely woven hyphae bounded internally by a cuticle.

There has been much confusion about the anatomy of the peridiole, which is regrettable since its various features are used as taxonomic criteria. For the moment, following Brodie & Dennis (1954), the appearance of the walls of the peridiole as seen in relatively thick sections such as are usually obtained by cutting the soaked-up peridiole with a razor-blade has been used as a means of separating species. The terminology introduced by Lloyd (1906a) and accepted by Brodie & Dennis (1954) has been used, namely *tunica* for the outermost, hyaline layer, if any, and *cortex* for the dark-coloured layer or layers. This system is unsatisfactory, however, and stands in need of drastic revision.

#### *C. microsporus* Tul. (Fig. 3g)

Cups obconical or slightly flaring with very small mycelial emplacement at the base, 5-7 mm. high × up to 6 mm. wide at mouth, externally non-plicate, with a covering of shaggy to adpressed hairs, amber; inside rather greyer, smooth to very faintly plicate. Peridioles 1-2 mm. diam., dark brown, sometimes becoming silvery on drying, tunica thin, cortex single-layered, spores 6.5-5-9.5 × 4.5-6μ.

HABITAT: On rotten wood or soil associated with rotten wood.

DISTRIBUTION: Florida, W. Indies and tropical S. America, Southern Africa.

MATERIAL EXAMINED: KENYA: GIBSON 779, Kimothu Nursery, Mt. Elgon, soil close to rotten timber, Sept. 1961.

NOTES: The species is recognized by the combination of small spores and non-plicate cups. The published accounts differ in the size and shape given for the spores. Those of the above collections correspond with the figures given by Palmer (1961) for the type and other material. To judge by the various American collections in K, the outer surface of the cups usually has longer hairs than is the case with the African specimen.

Mattirolo (1924) records this species from near Meru Mission, Kenya, coll. Rev. Padre G. Balbo.

#### *C. poeppigii* Tul. (Fig. 3e)

Cups dark amber, obconical, to 8 mm. high and 8 mm. wide, fluted to shaggy on exterior, both inner and outer surfaces deeply fluted but fluting sometimes obscured on the outside by the hairs, ridges about 0.5 mm. apart. Peridioles black, shiny, to 2 mm. diam., tunica absent, cortex two layered, dull brown in section; spores ellipsoid, usually about 20-30 × 30-40μ but sometimes rather smaller in African material.

HABITAT: On wood or soil in contact with wood.

DISTRIBUTION: Widespread in tropics and subtropics.

MATERIAL EXAMINED: KENYA: BALLY 10446, Nairobi, 25.10.1955 (K); VERDCOURT 1894, Mrima Hill Forest, 6.9.1957 (K, as *C. limbatu*); UGANDA: W. SMALL 143, 1915; R. DUEMMER 2112, Kipayo, 4,000 ft., on log in forest, April 1915 (K).

NOTES: In addition to the above examples Lloyd (1906b) received it from Braun, Amani, Tanganyika.



This species greatly resembles *C. limbatus* in macroscopic features though the ridges are usually rather closer together. The spores of typical *C. poeppigii* are, however, twice the size of those of typical *C. limbatus*, and the cortex of the peridiole is composed of dull brown, not red brown hyphae as in the latter species.

SMALL 143, noted above, lacks mature spores but is probably this species.

*C. limbatus* Tul. (Fig. 3i)

Cups obconic, to 10 mm. high and 7 mm. wide, usually with prominent basal emplacement; outer surface dark rust colour, shaggy, fluted, the flutes about 0.75–1 mm. wide; inner surface greyish, fluted. Peridioles dark and shiny, with two-layered cortex, spores usually about 10–15 × 15–20 $\mu$ .

DISTRIBUTION: Widespread in the tropics and subtropics.

MATERIAL EXAMINED: KENYA: R. M. NATTRASS, Nairobi, 5,700 ft., on bamboo trash (K, ex Herb H. J. BRODIE 1244); RAYNER 734, Karura Forest, nr. Nairobi, 5,700 ft., 1942; RAYNER 740, without data. UGANDA: A. FRENCH 29, Katonga Forest, Spring 1957 (K). TANGANYIKA: E. MILNE-REDHEAD & P. TAYLOR 9746, Kitai, Songea District, 880 m., on bare earth, probably associated with rotten wood, 17.4.1956 (K). ZAMBIA: ANGUS M68, Kawambwa, N. Prov., dead branch on forest floor, 30.10.1952 (K). MAURITIUS: AYRES, Pouce Rouge, 1861 (K).

NOTES: This species closely resembles the previous one except in spore-size. The cups are usually rather larger and more elongated with wider fluting.

The usual description of the cortex of the peridiole as being "two-layered" needs some qualification. The outer layer of the cortex is very thin, often consisting of a single layer of red-brown hyphae. In all but the very thinnest sections this layer usually becomes partly detached and tilted so as to appear thicker; in the very thin sections it usually becomes detached altogether.

FRENCH 29 has unusually narrow spores 14–6 × 6–7 $\mu$ ; RAYNER 734 very large ones, up to 30 $\mu$  long.

*C. triplex* Lloyd (Fig. 3f)

Cups obconic, not fluted, externally coarsely felted, pale umber; internally light greyish-brown. Peridioles to 2 mm. diam., in dried specimens silvery on the upper surface where the tunica persists, dull grey below where it does not; cortex two-layered; spores narrowly to broadly ellipsoid, 13–20 $\mu$  in major diam., smooth, often very thick-walled.

HABITAT: On dead wood.

DISTRIBUTION: Central or S. America, Ceylon, Mauritius, W. Africa.

MATERIAL EXAMINED: MAURITIUS: Suite des grandes pluies de mars (K, ex Herb. Berk. and Herb. Hooker, as *C. intermedius*).

NOTES: *C. triplex* differs from *C. pallidus* Berk. & Curt. in its darker cups with margin hardly or not reflexed, coarser tomentum, double peridiolar cortex and larger spores. *C. pallidus* is recorded from S. Africa (BORTOMLEY, 1948 and a specimen in K, N. J. G. SMITH, Grahamstown, Jan. 1931).

*C. rudis* Pat. (Fig. 3h)

Cups campanulate, to 10 mm. high, 8 mm. diam., narrowly fluted, exterior dark reddish brown, strongly tomentose-scaly, the scales obscuring the flutes, interior pale silvery grey, the fluting emphasized by dark-brown striae on the upper half. Peridioles brown-black, spores ellipsoid 10–12 × 5.7 $\mu$ .

HABITAT: On manure.

DISTRIBUTION: Madagascar, ? New Zealand.

MATERIAL EXAMINED: MADAGASCAR: Collector and locality unknown, Dec. 1932 (K, ex Herb. H. J. BRODIE 1118).

NOTES: The part of the collection in K consists of only one fruit-body, without peridioles. Brodie has annotated it: "seems to fit very well, few collections known".

The description of the spores is taken from Patouillard's original description and from New Zealand material in K which Brodie has annotated: "This is what New Zealand mycologists send me as *C. novae-zealandiae*. To me it is close to *C. rudis*". It is indeed strikingly similar to the Malagash material, the nature of the tomentum being a most distinctive character.

#### LYCOPERDACEAE

Sporocarps more or less spherical, sessile or carried on a pseudostem, that is a basal cylinder or inverted cone of spongy tissue whose elements are not orientated in the direction of the long axis of the fruit-body as is the case in the tissue of a true stipe. Peridium divided into two distinct layers, the exo- and endoperidia. Gleba pulverulent at maturity, consisting of globose or ellipsoid, usually ornamented spores, and, almost always of well-developed capillitium.

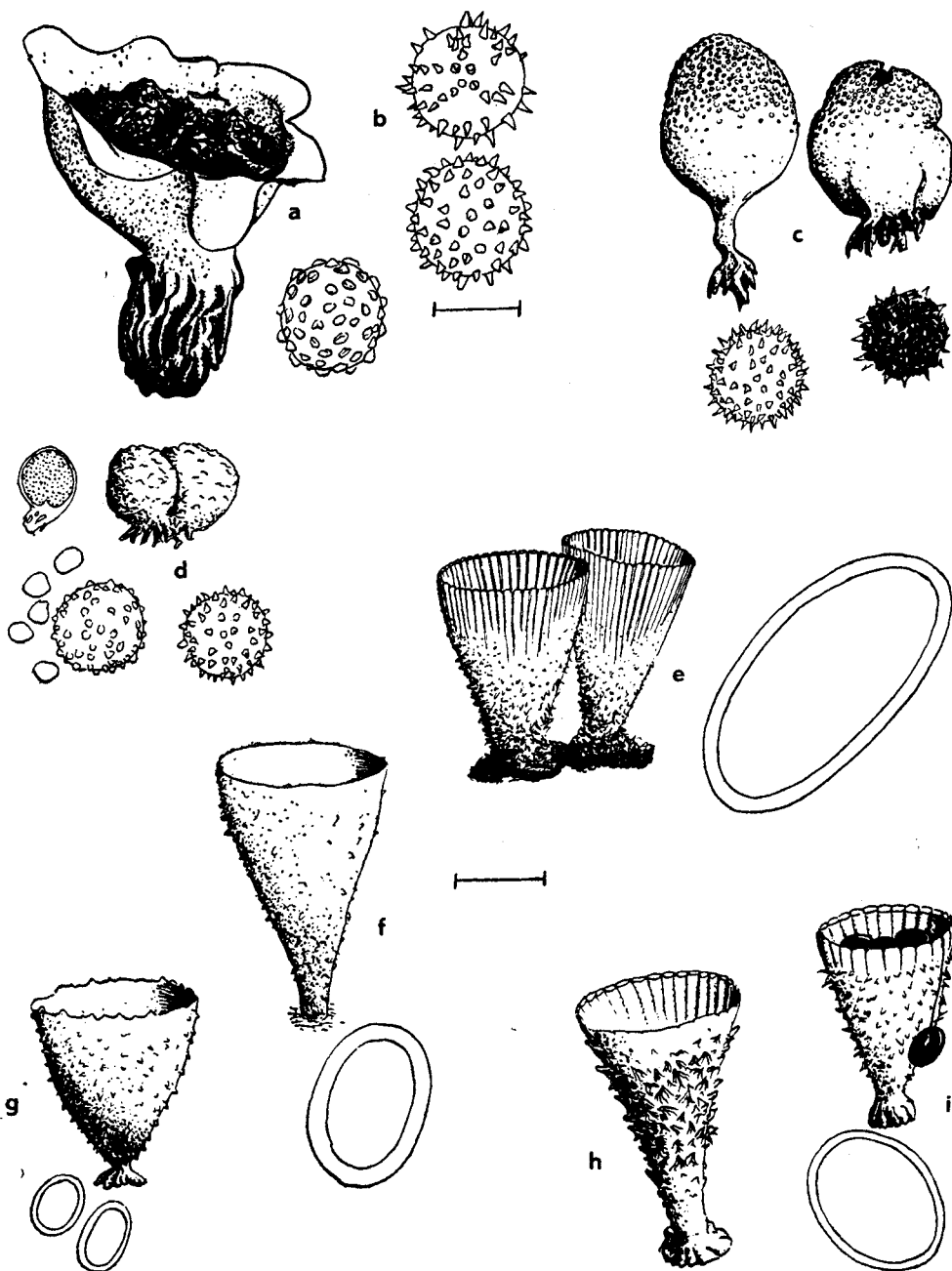


Fig 3. Sclerodermataceae and Nidulariaceae. a-b, *Scleroderma flavidum*: a, habit  $\times \frac{1}{2}$  and spore (LEAKEY); b, spores (MAITLAND 593); c, *S. verrucosum* ssp. *verrucosum*, habit  $\times \frac{1}{2}$  and spores, one with debris (EYLES 1222); d, *S. capensis* habit and v.s.,  $\times \frac{1}{2}$ , spores and nurse cells (THOROLD); e, *Cyathus poeppigii*, habit  $\times 2$  and spore (BALLY 1046); f, *C. triplex*, habit  $\times 2$  (Mauritius); g, *C. microsporus*, and spores (GIBSON 779); h, *C. rudis*, habit  $\times 2$  (Madagascar); i, *C. limbatus*, habit  $\times 2$  and spore (RAYNER 734).

This family, as defined here, includes the familiar and successful puffballs (*Lycoperdon* and related genera), and the earth-stars (*Geastrum*).

A number of important organs are characteristic of this family, though none of them is absolutely diagnostic. Perhaps the most important of these is the capillitium. In the narrow sense in which it is used here, the word denotes the thread-like, thick-walled, tinted to dark-coloured mycelium which permeates the gleba. It is admitted that capillitium is not strictly limited to the Lycoperdaceae, and that there are a few species of Lycoperdaceae which lack true capillitium. Nevertheless, the presence of capillitium is the hallmark of the family.

Tramal remains which have not developed into true capillitium may also be present in the mature gleba. They are usually hyaline, collapsed, septate hyphae, often clinging together in bundles, or they may be less like ordinary tramal cells and more like immature capillitial hyphae. Such structures comprise the paracapillitium (Kreisel, 1962).

In members of the Lycoperdaceae and some other families capillitium is replaced by abundant paracapillitium. In some other cases paracapillitium is mixed with true capillitium in the same gleba. The significance of the various forms of capillitium and the various combinations of true capillitium and paracapillitium both taxonomically and as agents in the process of spore discharge is largely unknown and well worthy of investigation.

Knowledge of peridia is equally limited. Little is known about the relationship between the peridia in various families. Certainly wide homologies must not be drawn between the layers of the peridium of different families. The exoperidium of *Lycoperdon* should not, for example, be assumed to be the homologue of the outer peridium of *Tulostoma*. In this paper the terms exoperidium and endoperidium have been used only for the peridial layers of *Lycoperdaceae*. Where a double peridial layer is present in other groups the layers are called inner and outer peridia.

The pseudostem is an additional organ frequently found in the puffballs. It consists of glebal tissue which has become sterile and modified to fulfill a supporting function. Its glebal origin is reflected in its usually chambered structure. The absence of the true stipe in the Lycoperdaceae (and in the Phallaceae and Clathraceae) is interesting as it strongly suggests an origin from a sessile, probably hypogean ancestor.

#### *Lycoperdon* Pers.

Sporocarp sessile or with pseudostem, dehiscing by an apical pore. Capillitium simple or branched, often arising in a central tuft or pseudocolumella and in any case attached to the inner surface of the endoperidium, sometimes undeveloped (paracapillitium). Exoperidium of simple or compound spines or of branny or scurfy particles, often caducous.

*L. pratense* Pers. emend. Quélet (= *L. hiemale* Vitt., *L. depressum* Bon.) (Fig. 4b)

Exoperidial spines compound, pale. Endoperidium ochraceous to buff or grey, areolate after fall of spines. Subgleba chambered, separated from gleba by a diaphragm confluent with the endoperidium. Gleba without pseudocolumella, Capillitium almost absent except at periphery of gleba where it is represented by a few straight, occasionally branched and occasionally septate hyphae without pits; paracapillitium of septate, hyaline hyphae; spores 3.5–5.5µ diam., almost smooth to finely spiny.

**HABITAT:** On the ground.

**MATERIAL EXAMINED:** KENYA: VERDCOURT 3951, 12 miles S. of Mombasa, on path, coastal bush, 19.1.1964 (K). UGANDA: CALDER 28, Makerere Hill, exposed mown sward, common after rain, 1964 (K). MAURITIUS: TELFAIR, Pouce Rouge, Jan. 1863 (K, as *L. gemmatum* var.).

**NOTES:** This species is recognizable by its diaphragm and capillitium. The latter seems to vary, according to the collection, from almost "mature" capillitium to completely collapsed, almost amorphous paracapillitium; most specimens fall between the two extremes, in fact most show considerable range within the same fruit-body. It is possible that African material will be separable into a number of taxa on capillitial and other characters when more collections are known. Large, caespitose, pyriform to obconical, dark-olivaceous specimens with purplish gleba are known from S. Africa, the Congo and Ghana under the name *L. djurense* sensu Bottomley and are probably specifically distinct.

Those species of *Lycoperdon* with a diaphragm are sometimes placed in a separate genus, *Vascellum* Smarda. Thus, this species is often called *V. pratense* (Pers.) Kreisel. On its own the diaphragm is perhaps insufficient as a generic distinction, and other characters, particularly the proportion of capillitium to paracapillitium, are variable. (See also Dissing & Lange, 1962.)

*L. perlatum* Pers. (Fig. 4d)

Sporocarp depressed to subtrubinate. Pseudostem present. Exoperidium of closely grouped, usually simple warts, often so arranged that one large wart is surrounded by a ring of smaller ones, the

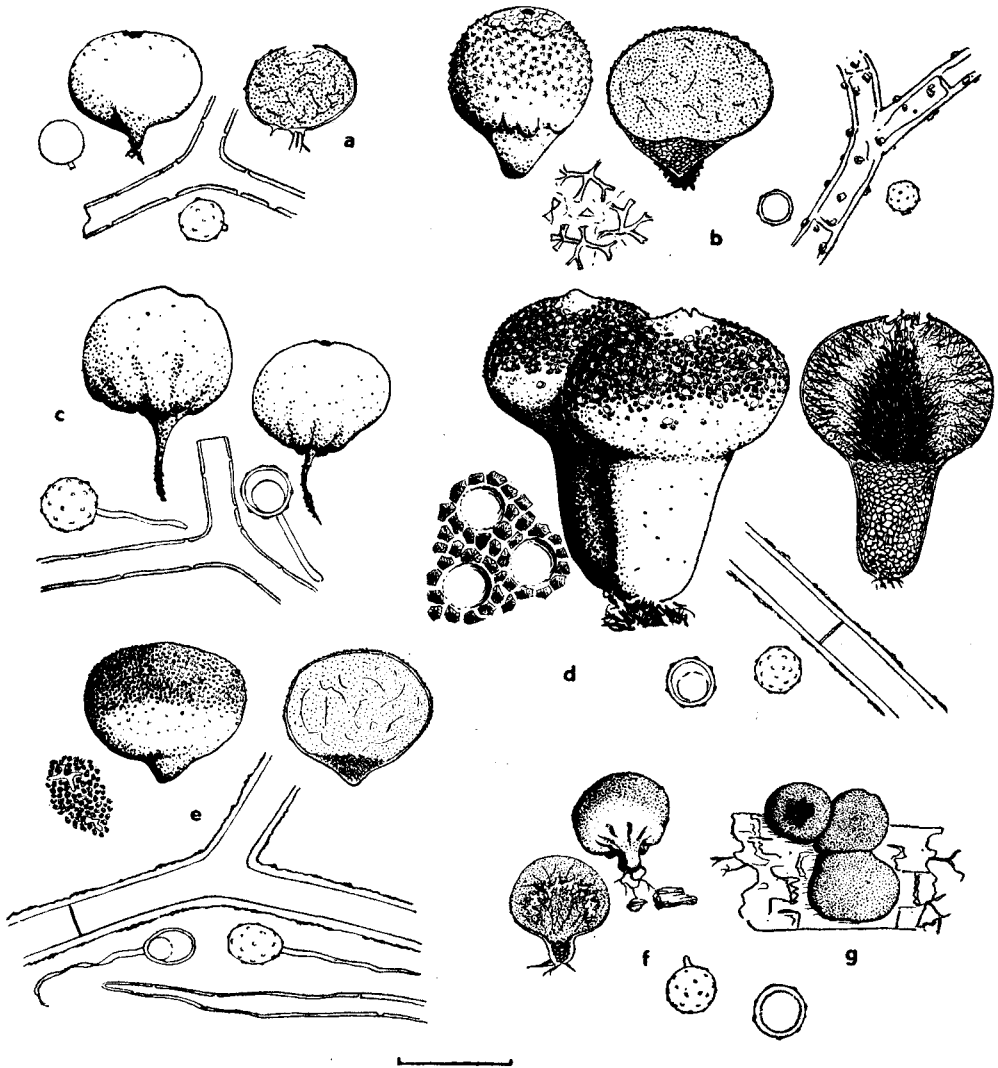


Fig. 4. *Lycoperdon*. a, *L. pusillum* habit and v.s.  $\times \frac{1}{2}$ , spores (on right as seen in air) and capillitium (BULLER); b, *L. pratense*, habit and v.s.  $\times \frac{1}{2}$ , details of exoperidium  $\times 5$ , spores and Para capillitium (VERDCOURT 395); c, *L. citrinum*, habit  $\times \frac{1}{2}$  (RAYNER 730, after watercolour by E. M. Rayner), spores and capillitium (MAITLAND 39); d, *L. perlatum*, habit and v.s.  $\times \frac{1}{2}$ , exoperidial details  $\times 5$ , spores and capillitium (IRWIN 591); e, *L. asperum* sensu Dissing & Lange, habit and v.s.  $\times \frac{1}{2}$ , exoperidial details  $\times 5$ , spores and capillitium (IRWIN 557); f-g, *L. fuliginium* sensu Dring, f, habit and v.s.  $\times \frac{1}{2}$ , spores (INGOLD), g, habit  $\times \frac{1}{2}$  (RAYNER 720).

large central wart falling away to leave a marked areolus. Endoperidium buff or umber, dehiscing by an apical, raised, torn mouth. Subgleba grey-brown, of large well-marked chambers. Gleba olivaceous, with large pseudocolumella; capillitium of long threads, smooth, aseptate, sparingly dichotomous, with a few large and small pits in the walls; spores globose, 3.5–4.5 $\mu$ , minutely warted.

HABITAT: On leaf litter, particularly in conifer plantations.

DISTRIBUTION: Widespread.

MATERIAL EXAMINED: KENYA: G. F. SCOTT ELLIOT, Ruwenzori Exp. 198, Yeria, Ruwenzori, 8–9,000 ft., May 1894 (BM); IRWIN 521, Endebess, Mt. Elgon (K); IRWIN 591 and 623, E. Mt. Elgon, cypress plantation, 1.6.1963 and 28.8.1963 (K).

NOTES: This is the common European species often called *L. gemmatum*. The material from Mt. Elgon is very close to *L. perlatum* var. *perlatum*, with spines near the top of the fruit-body distinctly divided into two sizes. In all the specimens the large spines have fallen, leaving a distinct areolus surrounded by small, simple, black spines. The spines on the lower part of the fruit-body, including the sterile base, are all small. The sterile base is well-developed and cylindrical in all the fruit-bodies, and the subgleba tan-coloured, large-chambered.

*L. pusillum* Batsch ex Schum. (? aggregate sp.) (Fig. 4a)

Sporocarp globose, up to about 2 cm. diam., sterile base absent, strong rooting strand or strands present. Exoperidium of fugaceous, mealy scales; endoperidium membranous, smooth, ochraceous, becoming brown with age, stoma plane, irregular. Gleba yellowish, becoming brown, pseudocolumella absent; capillitial threads honey-coloured to brown, aseptate or occasionally septate, freely branched, up to about 4 $\mu$  diam., irregularly shaped, fragmenting, pits of varying diameter frequent in the walls; spores globose 3.5–5 $\mu$ , very minutely verrucose, with the remains of a pedicel.

HABITAT: On the ground in exposed situations.

DISTRIBUTION: Cosmopolitan.

MATERIAL EXAMINED: UGANDA: MAITLAND 471, Entebbe, Bot. Garden, dunged flower bed, March 1919 (K). MALAWI: E. J. BULLER, Mlanje, Ruo Estate, under tea bushes, Feb.-March 1927 (K). RHODESIA: EYLES HERB. 7220, Salisbury, March 1932 (K).

NOTES: This widespread and common fungus needs little additional description. The spores of the E. African specimens appear smooth except when viewed in air-bubbles under oil-immersion.

There is a tendency for the spores to be sub-globose, slightly elongated along the axis of the pedicel. In MAITLAND 471 occasional spores have a longer pedicel than usual, up to twice as long as the spore.

*L. citrinum* Berk. & Br. (Fig. 4c)

Fruit-body globose to depressed globose, to 4 cm. diam., without sterile base or almost so, but with stout, branched, white rooting strand. Exoperidium of tiny warts, variable in colour but usually darker than the endoperidium, persistent. Endoperidium bright ochraceous, becoming umber with a metallic sheen. Gleba bright amber, becoming fulvous, without pseudocolumella; spores golden-yellow, globose, 3.5–5.5 $\mu$  diam., smooth to just perceptibly (mounted in water, under oil-immersion) punctate, pedicel up to 20 $\mu$  long; capillitium golden yellow, threads up to about 6 $\mu$  diam., undulating, fragile when young, becoming more elastic in age, walls with minute pits difficult to see even under oil-immersion and often practically disappearing with age. Subgleba absent.

HABITAT: On the ground, very common on Kikuyu-grass lawns in Kenya.

DISTRIBUTION: Ceylon, southern tropical Africa.

MATERIAL EXAMINED: KENYA: IRWIN 557, E. Mt. Elgon, 8,000 ft., in *Cupressus macrocarpa* plantation (K). UGANDA: MAITLAND 39, Victoria Nyanza region [1914] (K, as *L. asperum* (Lév.) Speg.). S. RHODESIA: EYLES HERB. 7219, 7221, Salisbury, Feb.-March 1932, Dec. 1931 (K).

NOTES: This species is recognizable by the distinctive colour, by the configuration of the peridium and by the pedicellate spores. The Kenya material (Fig. 4c) is placed here only tentatively. It consists of a single fruit-body which differs from all the others in lacking a persistent rooting strand, its solitary habit, larger size, almost black exoperidial scales, ovoid spores, brown capillitium and compact subgleba. It corresponds almost exactly with the description and illustration given by Dissing & Lange (1962) for Congolese material attributed to *L. asperum* (Lév.) de Toni except that the spores are more narrowly ellipsoid, 4–5  $\times$  3–3.5 $\mu$ . Kreisell (1964), however, says "*Lycoperdon citrinum* Berk & Br. 1873 = ? *L. asperum* sensu Dissing & Lange, 1962". We are not convinced that the Kenya material, at any rate, is either.

RAYNER 732, from Kenya (Shield's garden, Kiambu, on *Paspalum notatum* lawn, 5,600 ft., 3.12.1944) of which there is only a description, strongly suggests *L. capense* Cke. & Mass. The specimens must have resembled large (up to 8 cm. diam.) versions of *L. citrinum* in colour and habit. There is no type specimen of *L. capense* in Herb. K but it would seem from the description to be quite recognizable if found again. If it were rediscovered it would need renaming, Cooke and Masee's binominal being a later homonym of *L. capense* Fr.

An admirable, though brief, treatment of the puff-balls of the *pusillum* and *citrinum* group is given by Kreisel (1964). In this paper he places all those *Lycoperdon* in which the subgleba is absent or compact in the genus *Bovista*, reserving *Lycoperdon* for the more typical species with chambered subgleba. We have not, for the moment, accepted his line of demarkation between the two genera (see below).

*L. fuliginum* sensu Dring (1964) (Fig. 4f, g)

Sporocarp depressed globose to turbinate, occasionally umbonate, to 2.5 cm. diam., solitary to crowded, on rotten wood. Exoperidium fuscous above, usually lighter below, minutely granular, adherent to the endoperidium. Endoperidium pale chestnut, fragile, dehiscing by a torn apical stoma. Gleba amber; capillitium of hyaline, septate, often collapsed hyphae up to about 5 $\mu$  diam., often grouped into fascicles (paracapillitium of Kreisel), spores globose, moderately to strongly echinulate, 3–4 diam. Subgleba scanty to well developed, tan, minutely but definitely chambered, chambers to c. 0.25 mm. diam.

HABITAT: Rotten wood.

DISTRIBUTION: Ghana, São Tome, Kenya, Uganda.

MATERIAL EXAMINED: KENYA: B. F. SCOTT ELLIOT 145, Ruwenzori Exp. 1893–4, Ruwenzori 8,000 ft., May, in forest (BM); RAYNER 729, Karura Forest, nr. Ruraka River 5,700 ft.; 2.12.1945 (K). UGANDA: C. T. INGOLD, Upanda Forest, nr. Kampala, Spring 1963 (K).

NOTES: This is really a separate, probably undescribed, species in the *L. fuliginum* group. It differs from the type of that species in the presence of a chambered instead of a compact subgleba and in the more granular exoperidium.

The group as a whole forms a natural segregate from *Lycoperdon* which will be dealt with in another paper (Kreisel & Dring, 1967). It is characterized by lignicolous habit, by the dark colour and small size of the fruit-bodies, and by lack of true capillitium.

**Bovista Dill. ex Pers.**

Resembling the sessile *Lycoperdons* in a general way but with capillitium divided into separate elements with an obvious main axis, dichotomous at the ends and laterally branched, not having permanent connexion with the endoperidium nor confluent into a pseudocolumella.

Only one E. African record of *Bovista* is known to us. *B. membranacea* H. Lowag was originally described from Kilimanjaro. The type seems to have been lost but from the description it is clear that *B. membranacea* is a later synonym of *B. fusca* Lév. Yet another synonym of *B. fusca* is *B. umbrina* Bottomley, described from Natal. We are indebted to Dr. H. Kreisel for the above information.

The type material of *B. umbrina* in K (REV. N. ROBERTS 5659, Woodbush, Jan. 1913) consists of a single fruit-body, subglobose, 2 cm. diam., with fulvous, granular, exoperidium worn away at the top to expose the greyish-sepia, metallic-looking endoperidium. Spores are dark brown, smooth, 5 $\times$ 4 $\mu$ , with a pedicel up to 15 $\mu$  long; capillitium hyphae dark brown, to 13 $\mu$  diam.

R. W. R. has observed a similar *Bovista* in the grounds of the French Mission, nr. Nairobi.

**Calvatia Fr.**

Sporocarp medium to large, with a strongly rooting sterile base. Exoperidium usually thin, occasionally of two layers, the outer one thick; endoperidium thin, the apical part breaking away in irregular patches to expose the gleba. Gleba copious; paracapillitium seemingly absent; subgleba ranging from small and dense to massive with very large chambers, often poorly differentiated from the gleba, even when the latter is mature at the top.

*C. longicauda* (Henn.) Lloyd (= *C. agaricoides* Dissing & Lange) (Fig. 5b)

Fruit-body extravagantly top-shaped to agaricoid, to about 8 $\times$ 8 cm., the flat- to concave-topped head abruptly differentiated from the stipe. Stipe sub-cylindrical, slightly tapering towards the base, 4–7 $\times$ 1½–2 cm. Exoperidium minutely velvety, the tomentum consisting of short columns of bladder-like cells, about 20 $\mu$  diam., amber, adherent to endoperidium. Endoperidium very thin on drying, fragmenting and falling away. Gleba cinnamon buff to hazel, occasionally with a slight purplish tinge; capillitium of pale yellowish, slightly sinuous, much branched (at angles from about 60° to 120°) threads, often swollen at the frequent septa, about 3–4 $\mu$  diam., pits absent; spores subglobose to ovoid or ellipsoid, 3.5–4.5 $\times$ 4–4.5 $\mu$ , minutely spiny, pale yellowish, with the persistent stump of a pedicel, often with a conspicuous oil-drop. Subgleba brown, chambers ½–1 mm. diam.

HABITAT: In forest.

DISTRIBUTION: Cameroons, Congo, Uganda, Madagascar.

**MATERIAL EXAMINED:** UGANDA: MAITLAND 259, Entebbe, Botanic Gardens, on dry soil, April 1918; MAITLAND 260A, Entebbe, Botanic Gardens, on clay soil, April 1918; 260B, Busi, on leaf-mould, March 1919; 260C, Entebbe, in forests [no date].

**NOTES:** This species usually recognizable by its habit; less markedly agaricoid specimens are distinguishable from *C. gardneri* by the obviously chambered subgleba, umber rather than ochraceous peridium and irregularly branched capillitial hyphae which lack the large holes so characteristic of the capillitium of *C. gardneri* and its relatives. The gleba is much more persistent in this species than in the *C. gardneri* group. This is associated with the fact that the hyphae do not fragment nearly so readily, as is quickly noticed when one attempts to tease out the capillitium of both species in the course of making microscopic preparations.

*C. subtomentosa* Dissing & Lange (Fig. 6c)

Fruit-body shortly pyriform, with prominent sterile base, rooting by means of white strands. Exoperidium velvety, with slight tendency to form tufts, isabelline, splitting (with the endoperidium) into large scales and falling away from the upper part of the fruit-body. Gleba amber to fulvous, spores globose, 3.5–4.5 $\mu$  diam., sparsely echinate, light yellow; capillitium hyphae 3–6 $\mu$  diam., much branched, septate, fragmenting, though not necessarily at the septa, pits frequent, ranging from minute (just visible under oil immersion) to 4 $\mu$  diam. Subgleba minutely and obscurely chambered, lighter in colour than the gleba.

**HABITAT:** On the ground in woodland.

**DISTRIBUTION:** The Congo, Kenya.

**MATERIAL EXAMINED:** KENYA: IRWIN 489, Endebess, Mt. Elgon, *Cupressus macrocarpa* plantation, Sept. 1962.

**NOTES:** The single fruit-body of this collection is placed here with slight hesitation because of its rather luxuriant exoperidium which cracks into large scales (c. 1 cm<sup>2</sup>). This may be partly a reflection of the conditions under which it grew. In all other respects it agrees with the type specimen.

*C. gardneri* (Berk.) Lloyd (= *Lycoperdon gautieroides* Berk. & Br.) (Fig. 5a)

Sporocarp turbinate, to 10 × 10 cm., half the height being occupied by the sterile base. Exoperidium chestnut, minutely velvety below, tufted above, sometimes breaking into small scales. Endoperidium ochraceous, becoming rust colour above, paler below, brittle. Gleba ochraceous, fragile; capillitium of branched, septate, fairly straight, honey-coloured threads, to 7 $\mu$  diam., usually c. 3 $\mu$ , with occasional large pits in the walls; spores globose to subglobose, 3.5–5 $\mu$  diam., slightly rough to minutely and sparsely spiny, concolorous with capillitium. Subgleba at first ochraceous, becoming brown, minutely and obscurely chambered.

**HABITAT:** On the ground.

**DISTRIBUTION:** Ceylon, Mauritius, E. Indies, tropical Africa.

**MATERIAL EXAMINED:** UGANDA: MAITLAND 259, Entebbe, Botanical Gardens, on clay soil, April 1918.

**NOTES:** This was originally a mixed collection, some of the fruit-bodies being referable to *C. longicauda* or they may have strayed into the packet from MAITLAND 260A.

In a previous paper (Dring, 1964) the spores of this species were described as being 5.5–7.5 $\mu$  diam. This was an error; they are in fact much smaller 3.5–4.5 $\mu$  in African material and 3.5–4.5 × 4–5 $\mu$  in the type specimen from Ceylon.

The structure of the tufts of hyphae of the exoperidium is interesting. Microscopically they have a central core of elongated cells up to 5 × 20 $\mu$  arranged in branched columns. This core is surrounded by rather shorter columns of much stouter cells about 15 × 20 $\mu$ . Unfortunately it was not possible to be completely satisfied about the microscopic structure of the exoperidium of the type material. Columns of both narrow and wide cells are present but whether they have the same arrangement in the tuft was not determined. However, in another specimen from Ceylon (PETCH 416, Peradeniya, May 1917 (K), the characteristic structure of the tuft was seen.

This species is very similar to *C. rubroflava* (Cragin) Lloyd. The differences are that the latter lacks the large sterile base, is perhaps generally more brightly coloured, stains yellow on bruising and has a shorter exoperidial tomentum. The spores are apparently always globose, whereas those of *C. gardneri* tend to be broadly ellipsoid, particularly in Asiatic specimens.

The capillitial hyphae of both species have the characteristic large holes in the walls, though in *C. rubroflava* they are much more variable in number and in size, resembling those of *C. subtomentosa*.

In all three species of this group (*C. subtomentosa*, *C. gardneri* and *C. rubroflava*) the capillitial hyphae tend to fragment at the weak places caused by these holes, rather than at the septa as occurs in the lilac-spored *Calvatias* (see below). The very persistent gleba of *C. longicauda* consists of hyphae without pits and which seldom break at the septa.

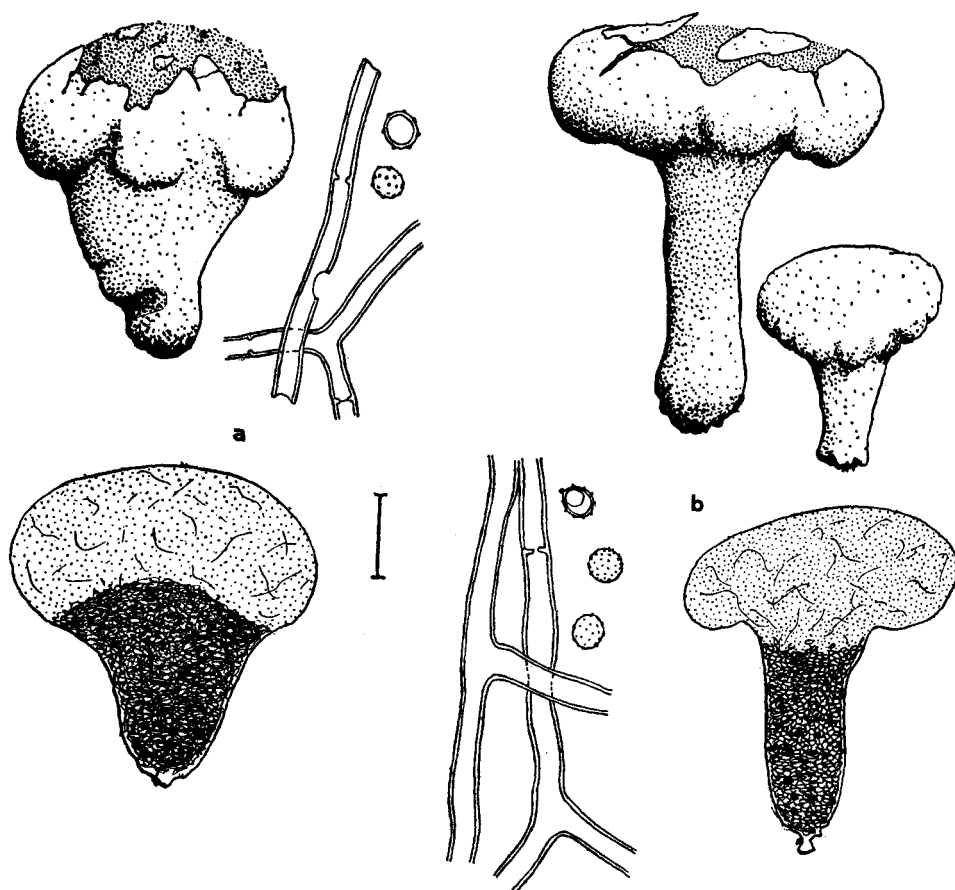


Fig. 5. *Calvatia*, p.p. a, *C. gardneri*, habit and v.s.  $\times \frac{1}{4}$ , spores and capillitium (MAITLAND 259); b, *C. longicauda*, habit and v.s.  $\times \frac{1}{4}$ , spores and capillitium (MAITLAND 260).



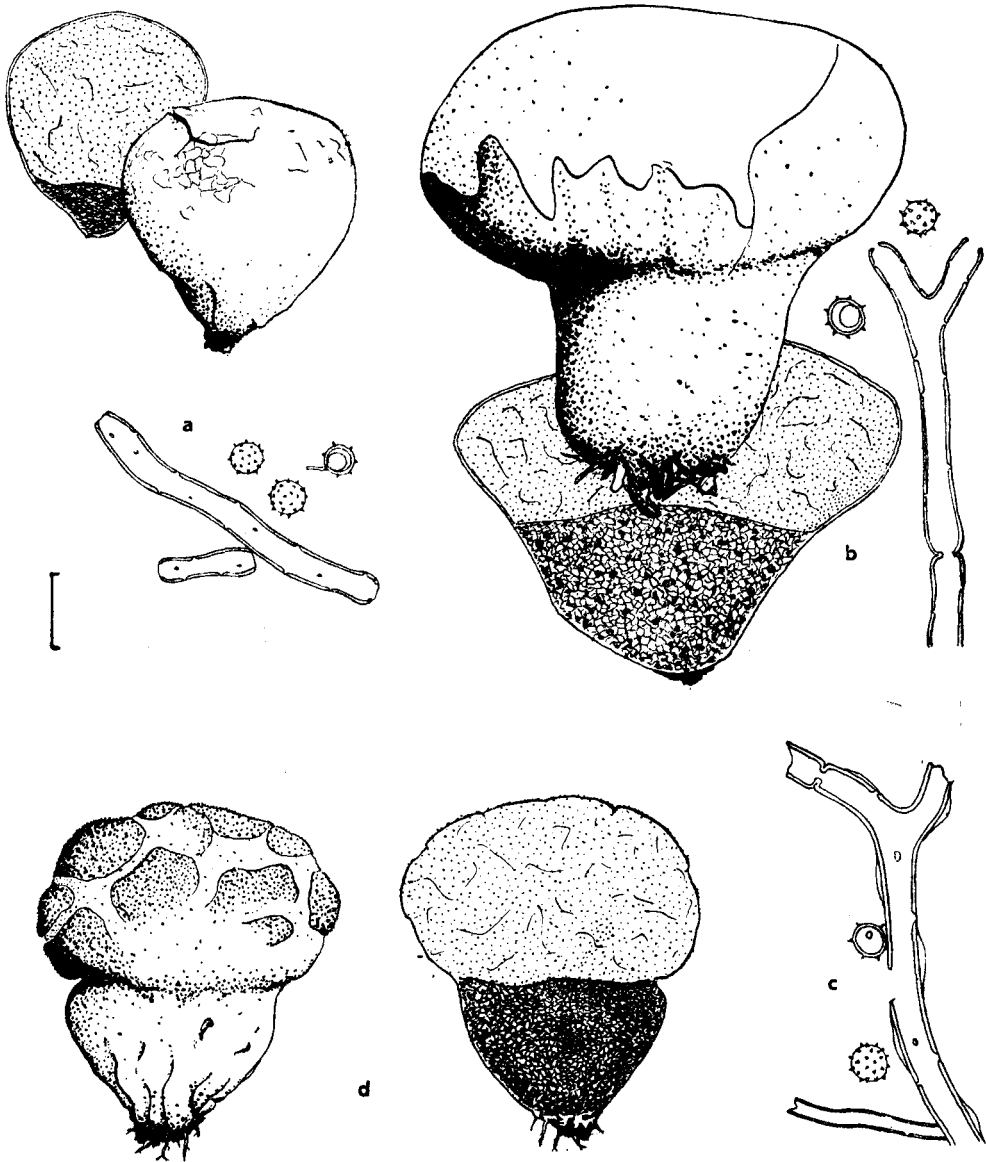


Fig. 6. *Calvatia* p.p. a, *C. cyathiformis* ssp. *fragilis*, habit and v.s.  $\times \frac{1}{2}$ , spores and capillitium (Maitland 48); b, *C. c.* ssp. *cyathiformis*, habit and v.s.  $\times \frac{1}{2}$  (Rayner 728, from watercolour by E. M. Rayner) spores and capillitium; c, *C. subtomentosa*, habit and v.s.  $\times \frac{1}{2}$ , spores and capillitium (Irwin 489).

*L. gautieroides* Berk. & Br. is a synonym of *C. gardneri*. The type, from Ceylon, and many other collections in Herb. K, consists of small examples of *C. gardneri*. The type and PERCH 3241, Peradeniya, Oct. 1910 (K) appear to have been growing on or associated with rotten wood, notwithstanding that the original description specifies burnt earth as the substrate. It is evident from variant spellings in Berkely's manuscripts and the faint preposterousness of "gautieroides" that this is an error. The probable intention was "guatterioides" after the genus *Guatteria* (Annonaceae). Unfortunately the fungus does not resemble the fruit of *Guatteria* in the least though it might easily be taken for the fruit of an *Annona*.

*C. cyathiformis* (Bosc) Morgan

Sporocarp subglobose to pyriform, to 15 cm. diam., tapering abruptly to a crenulate sterile base. Exoperidium thin, continuous, smooth or floccose, whitish at first, later vinaceous buff, young specimens blackening on bruising. Endoperidium brown at maturity, thin, fragile, often becoming areolate, dehiscing by irregular cracking, often following the areolar margins. Gleba greyish purple; capillitium threads branched, septate, fragmenting, about the same diameter as the spores, with very frequent, minute pits in the walls; spores globose, 4–6 $\mu$  diam., violaceous-brown, shortly pedicellate, moderately to strongly echinulate.

*C. cyathiformis* ssp. *cyathiformis* (= *C. lilacina* auctt.) (Fig. 6b)

Sporocarp large, sterile base large, usually marked-off from the fertile part by a constriction. Subgleba of moderately large chambers c. 0.5–1 mm. diam., rather ill-defined, spores usually strongly echinulate.

HABITAT: In grassy places where rainfall is high.

DISTRIBUTION: Widespread in the tropics and subtropics, N. America to Alberta, Ontario and Manitoba.

MATERIAL EXAMINED: UGANDA: C. B. USSHER, Mabira forest, June 1908; MAITLAND 261, Entebbe, Botanic Garden, on lawn, April 1918; and in front of Land Office, in pasture, Feb. 1919.

KENYA: RAYNER 782, Kikuyu-grass, Vet. Labs., Kabete, 7,000 ft., 4.11.1946.

NOTES: This is recognizable by its large size, large sterile base with chambered subgleba and by the ornamentation of the spores.

For a discussion of the choice of the epithet "*cyathiformis*" see Dring, 1964.

*C. cyathiformis* ssp. *fragilis* (Vitt.) Dring (= *C. fragilis* Vitt. = *C. lilacina* (Mont. & Berk.) Henn.) (Fig. 6a)

Sporocarp medium sized to about 6 mm. diam., sterile base small, subgleba compact to minutely and obscurely chambered, occasionally with a few larger chambers near the base. Spores usually with small warts.

HABITAT: On the ground in open spaces.

DISTRIBUTION: Widespread in tropics and subtropics, N. America to Ontario, Central Europe.

MATERIAL EXAMINED: UGANDA: MAITLAND 48, Victoria Nyanza Region (K); MAITLAND 38, Mabira Forest, 1915 (K).

NOTES: Most of the African material (Dring, 1964), including MAITLAND 48, corresponds well with Vittadini's specimens of *Lycoperdon fragile* in K, except that the sterile bases tend to be larger in African collections. MAITLAND 38, however, has the long-spined spores more characteristic of ssp. *cyathiformis*.

**Mycenastrum Desv.**

Peridium woody, hygroscopic, typically dehiscing in an irregularly stellate manner. Capillitium of branched and spiny hyphae which are not attached to the peridium nor converging into a centra pseudocolumella.

The genus contains but one accepted species.

*M. corium* (Guersent) Desv. (Fig. 7b, c)

Fruit-body subglobose, medium-sized. Exoperidium single layered, thin and evanescent. Spores globose, 9–13 $\mu$ , with irregularly reticulate ornament.

HABITAT: On the ground in dry places.

DISTRIBUTION: Widespread.

MATERIAL EXAMINED: KENYA: RAYNER, Limuru, c. 7,000 ft., bare ground in *Acacia* plantation; MRS. JOY BALLY, Isiolo. TANGANYIKA: H. E. DINGLE, Lake Manyara National Park, very dry ground under *Acacia*, Sept. 1962. UGANDA: WILSON 1333, Moroto, old kraal site.

**Langermannia Rostk. (=Lanopila Fr.)**

Sporocarps medium to large, globose or depressed globose, sterile base absent or vestigial, weakly rooting, usually becoming detached at maturity. Exoperidium thin, smooth to floccose, made up of a single layer. Endoperidium thin, fragile, falling away completely at maturity. Gleba copious; capillitium persisting as a free, more or less naked spongy mass after abscission of the peridium, consisting of branched, interwoven threads, spores globose, smooth to verrucose.

The genus has the same characters as *Calvatia* except for the lack of a significant sterile base, the habit of becoming detached from the ground, and the completely deciduous peridium. The capillitial hyphae do not fragment, unlike those of most *Calvatia* spp.

For a discussion of the synonymy used here see Dring (1964). A single species is recorded for E. Africa.

***L. wahlbergii* (Fr.) Dring (=Lanopila wahlbergii Fr.) (Fig. 7a)**

Sporocarps to 15 cm. diam., globose to depressed globose, sterile base absent, weakly rooting. Peridium dirty white at first, becoming pinkish rust colour to hazel. Capillitium of septate hyphae, without pits, 2–5 $\mu$  diam., pale brown, spores globose 5–7.5 $\mu$  diam., brown, closely and strongly warted.

**HABITAT:** On the ground, free at maturity.

**DISTRIBUTION:** Africa south of the Sahara, tropical Asia.

**MATERIAL EXAMINED:** KENYA: J. McDONALD, Rangai Forest, 6,000 ft., on ground in forest nursery, 22.11.1922 (K); MRS. H. E. BROWN, Rakrup Forest, on ground, common near elephant dung, which it resembles, 26.4.1964 (K); without data, via C.M.I. (K). UGANDA: WILSON 1332, Kadam Mt., 7,000 ft. (K, EA). TANGANYIKA: BRAUN 1949, Dodwe River, Amani, 16.2.1908 (EA, as *Lanopila bicolor*).

***Gastrum Micheli* ex Pers.**

In this genus and its allies the exoperidium is well developed and dehisces radially from the apex, the resulting lobes bending back to give a stellate appearance to the mature fruit-body. The exoperidium consists of three layers, the outer mycelial, the middle fibrous and the inner fleshy. Tissue-tension between the two inner layers results in the rays being held at an angle more or less characteristic of the species. Some species are strongly hygroscopic, the rays being folded over the endoperidium when dry, spreading when wet, again due to tension between the two layers. The endoperidium, which is absent in a few species, dehisces by an apical pore. The characters of the peristome are important in distinguishing species.

***G. velutinum* (aggregate sp.) (Fig. 8a, b)**

Unexpanded sporocarp globose or ovoid, top rounded or slightly umbonate, epigeal, attached to the substrate by a central, basal, radicate projection or occasionally a single, well-developed hyphal strand. Exoperidium saccate, split to about the middle into 5–8 expanded, broad, thick, subequal rays; fleshy layer flesh-coloured, becoming umber to dark umber when dry, moderately thick, adnate, usually cracking across the base of the rays to reveal the buff fibrous layer; mycelial layer thick, pliable, typically very finely felted-tomentose, buff-ochraceous, like very fine sand-paper to the touch, or sometimes more coarsely felted-tomentose, umber, but in any case almost free from debris, adnate or sometimes tending to bend away from the fibrous layer, especially at the points of the rays. Endoperidium smooth, sessile, globose to depressed globose, to 2 cm. diam., enclosed by the saccate base of the endoperidium; peristome broadly conical, fibrillose, depressed round the edge; concolorous or paler. Gleba umber, pseudocolumella cylindrical to spindle-shaped; spores globose 2.5–4 $\mu$  diam., fuscous, minutely to finely, occasionally moderately, verrucose.

**HABITAT:** On the ground or rotting plant debris, in forest.

**DISTRIBUTION:** Widespread outside Europe.

**MATERIAL EXAMINED:** KENYA: P. J. GREENWAY, Muguga, in *Acacia* plantation (K). UGANDA: T. D. MAITLAND 81, Victoria Nyanza Reg. (K); DUEMMER 1419, Kipango, 4,000 ft., on leaf-mould in forest (K); C. G. HANSFORD 2017, Masaka rd., mile 7, in forest (K); G. N. CALDER 10, Mpangu, 4,300 ft., forest litter, 23.3.1964 (K); CALDER 44, Mpangu, forest litter in light shade 13.4.1964 (K).

**NOTES:** This group is distinguished from *G. saccatum* by its usually larger size, harshly felted, usually paler, thicker, more pliable and continuous mycelial layer which often separates from the fibrous layer especially at the tips of the rays, and by its smaller, more finely verrucose, darker spores. HANSFORD 2017, CALDER 44 and DUEMMER 1419 have shortly tomentose, markedly "sand-papery", greyish ochre, separable mycelial layers. The remainder have a mycelial layer which is more orangy-ochre in colour, and the tangled hyphae of which tend to be woven together into loose bunches,

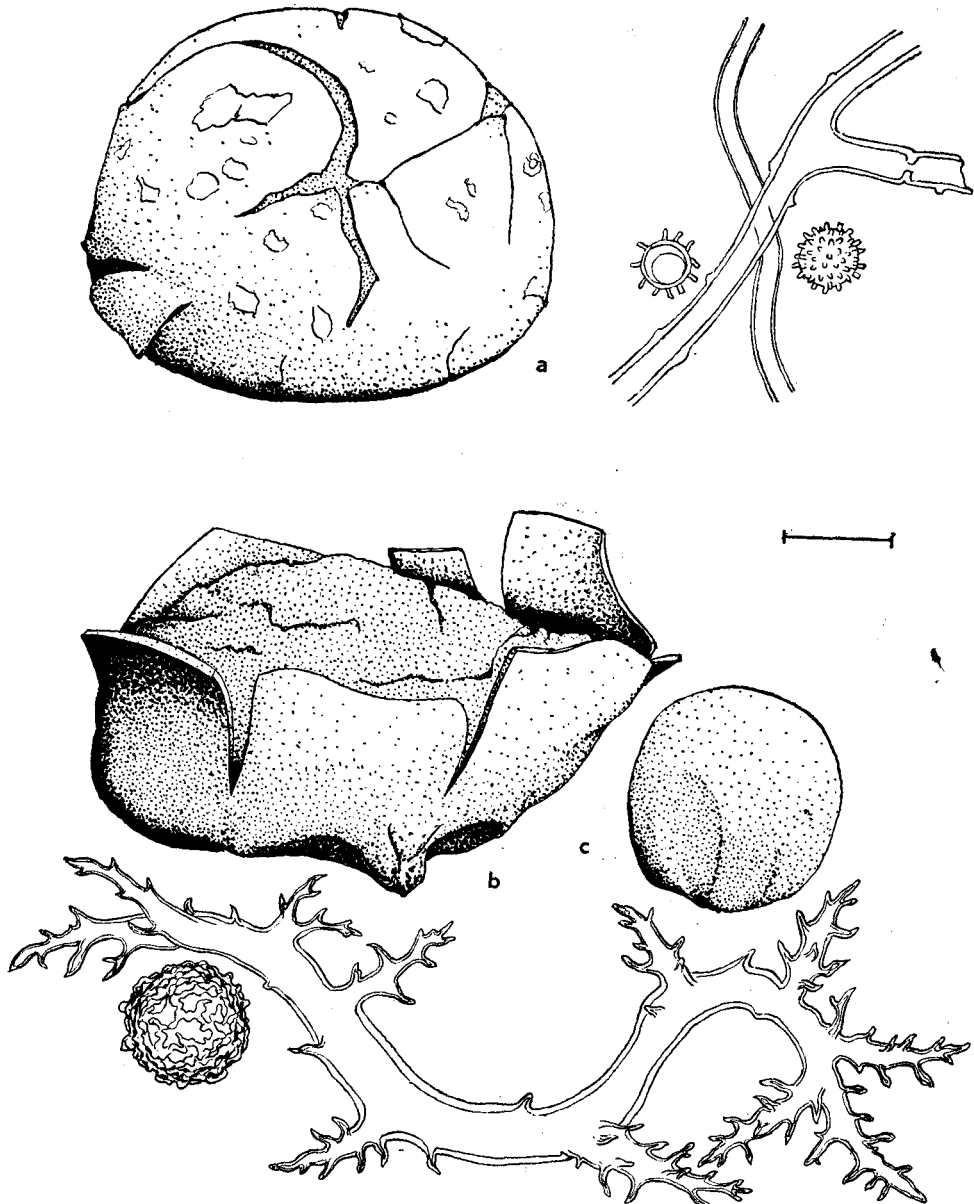


Fig. 7. Lycopodiaceae p.p. a, *Langermannia wahlbergii*, habit  $\times \frac{1}{2}$ , spores and capillitium (WILSON 1332); b-c, *Mycenastrum corium*: b, habit  $\times \frac{1}{2}$ , spore and capillitial element (WILSON 1333); c, habit, unexpanded,  $\times \frac{1}{2}$  (BALLY 337).

often holding a little debris. There is less tendency for the mycelial layer to split away from the fibrous layer, and the fruit-bodies tend to be smaller, with more numerous and pointed rays.

There are other fairly well-marked forms of "velutinous" geasters, some of which have been given specific recognition, e.g. *G. scleroderma* Mont., and it is obvious that a thorough revision of the whole group is desirable.

*G. schweinitzii* (Berk. & Curt.) Zeller (= *G. mirabile* Mont.) (Fig. 8c)

Unexpanded sporocarps small, caespitose, obovoid, attached to a thick buff-coloured subiculum. Exoperidium deeply saccate, split into 5–7 unequal, short rays; fleshy layer flesh-coloured, drying brown, continuous or cracking across the base of the rays, adnate; mycelial layer buff, glabrous but in dried specimens minutely wrinkled. Endoperidium sessile 3–10 mm. diam., subglobose, dark brown, almost hidden in the saccate base of the exoperidium; peristome broadly conical, silky, concolorous or darker, marginally depressed. Gleba dark brown, spores 3–4 $\mu$  diam., fuscous, minutely to finely verrucose.

HABITAT: On decaying wood, occasionally other plant debris, in forest.

DISTRIBUTION: Africa, America, Australia, Ceylon, Japan, Pacific Is.

MATERIAL EXAMINED: UGANDA: DUEMMER 1462, Kipayo, on log in forest (K); MATTLAND 291, Entebbe, in forest (K), HANSFORD 2017, Musaka rd., mile 7 (K). MAURITIUS: TELFAIR, ex Herb. W. Bojer (K, as *Lycoperdon pusillum*).

NOTES: This and a small group of similar species, is distinguished by the small size, crowded habit and growth from a subiculum on dead wood.

The type specimen of *Coilomyces schweinitzii* (K), though immature, is unmistakably conspecific with that of *G. mirabile* (P), and the earlier, though less familiar, epithet must be used.

HANSFORD 2017 was a mixed collection, mainly this species but with other fruit-bodies distributed in *G. saccatum* and *G. velutinum*.

*G. saccatum* Fr. (Fig. 8d, e)

Unexpanded sporocarp ovoid, umbonate, half-buried, attached by a bunch of hyphal strands which leave a prominent umbilical scar at the base of the sporocarp. Exoperidium splitting to about the middle into 5–7, occasionally up to 10, pliable, thin, subequal, acute rays which may become strongly revolute, or expanded, or remain at an angle of 45° to the vertical; fleshy layer pale rust colour to umber, adnate, frequently rimose; mycelial layer straw colour to ochraceous or rust colour, smooth, thin, radially and irregularly wrinkled at the base of the sporocarp, with adherent debris, flaking off in weathered specimens. Endoperidium sessile, 10–15 mm. diam., subglobose, glabrous, greyish-brown, usually partly enclosed by the saccate base of the exoperidium; peristome fibrillose; almost plane, concolorous with the rest of the endoperidium or paler, depressed at the periphery. Gleba umber; pseudocolumella indistinct, spores globose, 4–6 $\mu$ , usually 4–5, moderately to strongly (occasionally finely) verrucose.

HABITAT: On soil or vegetable debris in damp places.

DISTRIBUTION: Widespread, frequent in warmer areas.

MATERIAL EXAMINED: KENYA: C. A. THOROLD 38, Elburgon, 8,000 ft., on soil in forest, July 1932 (K); VERDCOURT, Muguga, 1954 (K); A. FRENCH 8, Mpanya Forest, on ground in shelter of log, 30.3.1957 (K, with picture); IRWIN 592, E. Mt. Elgon, 30.5.1960 (K); BALLY B12250, Nairobi, 5.5.1960 (K). UGANDA: DUEMMER 1424, Kipango, 4,000 ft., leaf mould in forest, April 1915 (K); HANSFORD 2017, Masaka rd., mile 7 (K).

NOTES: This species is often confused with *G. velutinum* to which it is not related. Fruit-bodies of *G. saccatum* tend to be smaller and the spores larger and lighter coloured. The mycelial layer is absolutely different, being thinner, rather dirty and smooth; in dried specimens it is thrown into characteristic wrinkles.

It is more difficult to distinguish between *G. saccatum* and *G. lageniforme* to which it is closely related and with which it is connected by a few intermediate forms. *G. saccatum*, however, has shorter wedge-shaped rays and a lighter, thicker often more fragile mycelial layer.

The East African sporocarps examined are all smaller and paler than is usual for the species. The mycelial layer is parchment coloured and lacks the characteristic cracks along the rays.

*G. lageniforme* Vitt. (Fig. 8h)

Unopened sporocarp ovoid with a strongly pointed apex, dehiscing when about 1.5 cm. broad. Exoperidium splitting to two-thirds or more of the way down into 5–8 (occasionally 10) subequal segments with long acuminate points; mycelial layer very thin, pale fulvous, entire; fleshy layer umber, adnate. Endoperidium sessile, 1–1.5 cm. diam., the base usually enclosed in the saccate

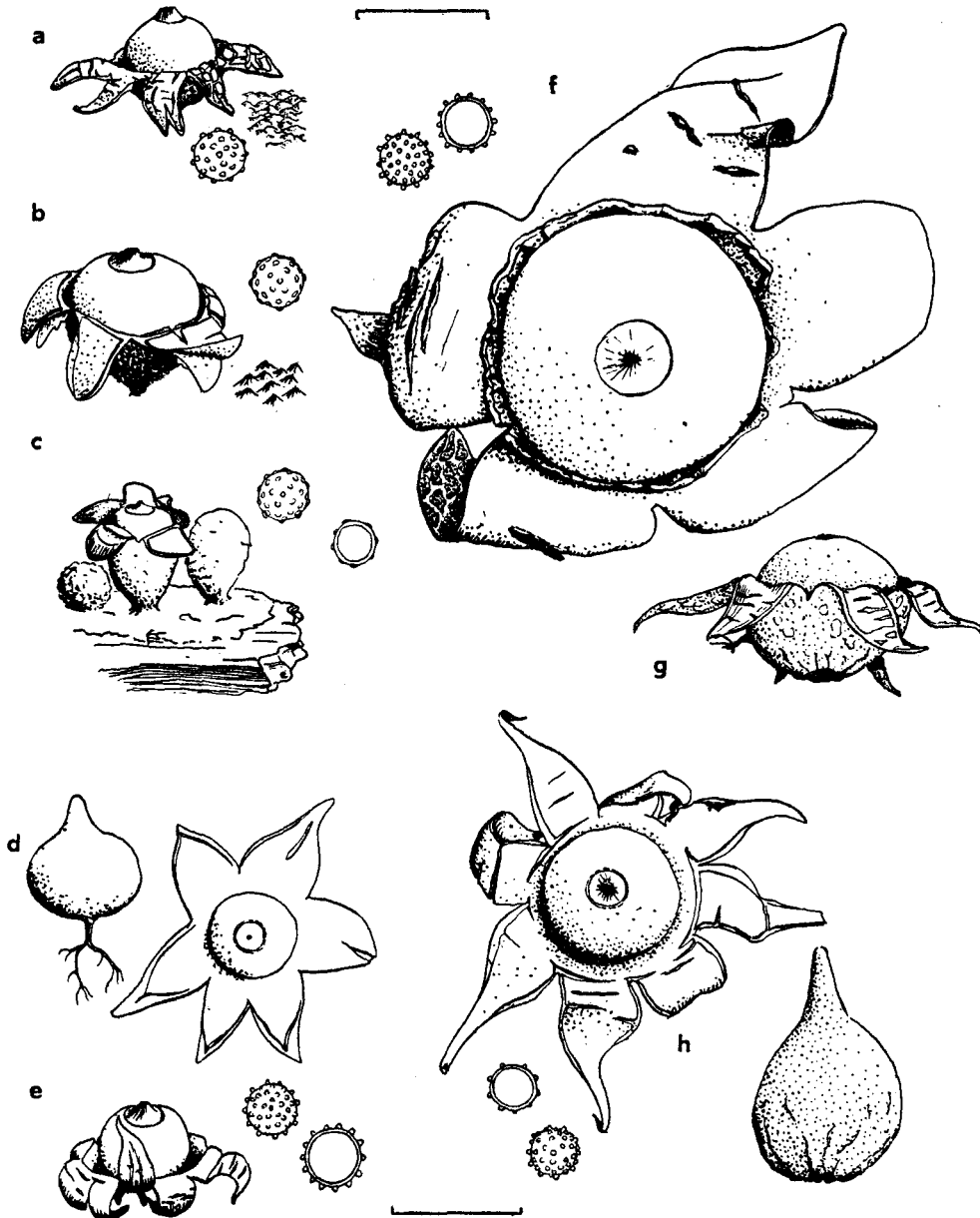


Fig. 8. *Geastrum* p.p. a, *G. velutinum*, felted form, habit  $\times \frac{1}{2}$ , mycelial layer  $\times 5$ , spore (HANSFORD 2017); b, *G. velutinum*, velutinous form, habit  $\times \frac{1}{2}$ , mycelial layer  $\times 5$ , spore (CALDER 4417); c, *G. schweinitzii*, habit  $\times 2$ , spores (MAITLAND 291); d, *G. saccatum* habit, egg and expanded specimen,  $\times \frac{1}{2}$  (from drawing by A. French); e, *G. saccatum* habit  $\times \frac{1}{2}$ , spores (VERDCOURT); f, *G. triplex*, habit  $\times \frac{1}{2}$ , spores (IRWIN 590); g, *G. triplex*, habit  $\times \frac{1}{2}$  (RAYNER); h, *G. lageniforme*, habit, expanded specimen and egg,  $\times \frac{1}{2}$ , spores (BALLY 7404).

base of the exoperidium, umber; peristome fibrillose, often lighter than the surrounding endoperidium, conical, marginally depressed. Gleba umber, pseudocolumella clavate; capillitium up to 10 $\mu$  diam., thick-walled, straw-coloured, often encrusted; spores globose, 3.5–4.5 $\mu$ , pale to dark brown with regular or irregular, close, short, often flat-topped warts.

HABITAT: On soil or vegetable debris in damp places.

DISTRIBUTION: Cosmopolitan.

MATERIAL EXAMINED: KENYA: BALLY B7404, Lumbwa, Thiele-Winkler Estate, 7,300 ft., on forest floor, 12.9.1949 (K, EA).

*G. triplex* Junghuhn (Fig. 8f, g)

Unopened fruit-body 2 cm. diam., umbonate to pointed, with prominent basal mycelial tuft which falls away on drying to leave a marked scar. Exoperidium splitting to two-thirds of the way down into 5–8 broad, recurved or spreading rays; mycelial layer papery to leathery, pale umber, smooth to squamulose, peeling off in flakes in old specimens, debris-encrusted in patches; fibrous layer leathery, thin, persistent, buff to straw colour on the outside, darker inside; fleshy layer thick, buff to pale rust colour, drying sepia, cracking, particularly across the bases of the rays, the cracked edges tending to curve away from the fibrous layer. Endoperidium sessile, to about 1.5 cm. diam., globose to depressed globose, smooth, pale vinaceous grey to vinaceous buff; peristome broad, often barely defined, silky, usually darker than endoperidium; mouth usually broad with fimbriate margin. Gleba umber, pseudocolumella ovoid; capillitium about equal in diameter to the spores, pale to medium brown, tapering at the ends, often encrusted; spores globose, 4.5–6 $\mu$  diam., regularly, closely and moderately to strongly warted, pale to dark brown.

HABITAT: On plant debris, etc., on the forest floor.

DISTRIBUTION: Cosmopolitan.

MATERIAL EXAMINED: KENYA: RAYNER, 5,500–6,000 ft., in *Acacia* forest; RAYNER 740, Limuru Distr., Rift Highlands, 7,000 ft. (K); IRWIN 590, E. Mt. Elgon, 8,000 ft., 26.5.1963 (K).

TANGANYIKA: K. PIROZYNSKI M593, Kakombe, Kigoma, damp soil, 24.2.1964 (K).

NOTES: This species is distinguishable by the characteristic mode of cracking of the fleshy layer around the base of the rays to leave a "cup" enclosing the base of the endoperidium. This feature is not always present but is better seen in fresh than in dried specimens.

*G. fornicatum* (Huds. ex Pers.) Hook. (Fig. 9e)

Immature sporocarp subglobose, hypogaeal. Exoperidium splitting to two-thirds of the way down into 4–5 rays, which bend backwards causing the mycelial layer to split away except at the tips of the rays and remain in the ground as a cup, whilst the other two layers become completely inverted, carrying the endoperidium upwards. Mycelial layer thickly coated with debris; fleshy layer often falling away in large patches. Endoperidium pedicellate, depressed globose, with an apophysis, hard, fuscous, minutely granular under the hand-lens; peristome silky, at first mammosse and sub-definite, soon becoming indefinite and ragged, gleba brown vinaceous; capillitium threads brown, up to 15 $\mu$  diam.; spores globose, finely verrucose, dark brown 3.5–5 $\mu$ .

HABITAT: On humus under trees or shrubs.

DISTRIBUTION: S. Africa, Mauritius, Europe, Mediterranean region, N. and central America, Australia.

MATERIAL EXAMINED: MAURITIUS: H. BOLUS, without data, ex Herb. Berkeley (K, photograph only).

NOTES: The record consists of only a photograph but is certainly referable to this species. The description of the microscopic and colour details is drawn from other material at Kew.

*G. dissimile* Bottomley (Fig. 9f)

Resembling *G. fornicatum* except for the mouth characters. Peristome conical, sub-definite, not tearing readily but becoming radially folded though not truly sulcate.

MATERIAL EXAMINED: KENYA: E. A. HERB. 1167, Naivasha, Rongoni Forest, at roots of *Acacia* (K); RAYNER 739, Limuru, E. Rift Highlands, 1942–3 (K).

NOTES: This is accepted only provisionally as being specifically different from *G. fornicatum*. Rayner's specimens have had most of the peristome eaten by insects, but the little which remains seems to be of the *dissimile* type.

Contrary to Talbot's claim (in Bottomley, 1948, p. 604) we do not accept that there is any material difference between type material of *G. dissimile* and the collection in Herb K, labelled by Lloyd "*G. fornicatus* Huds. forma *macowani* Kalch" and presumably the same as the specimens described by him as *G. macowanii*. The real identity of *G. macowanii* is unknown. It resembled the European

form of *G. fornicatus* but was three times the size: it would have been a very large earth-star indeed. *G. dissimile*, however, is only about half the size of the European form. The peristome was, unhappily, missing from the type material of *G. macowanii* at the time when it was described.

*G. drummondii* Berk. (Fig. 9b)

Unexpanded fruit-body globose, epigeal, dehiscing when 1–2 cm. diam. Exoperidium splitting to the middle into 8–12 acute, subequal, strongly hygroscopic rays; fleshy layer sepia, adnate, continuous; mycelial layer thin, whitish, covered with debris, often becoming detached. Endoperidium sessile or (in dried specimens) occasionally shortly pedicellate, globose to depressed globose, up to 15 mm. diam., dirty white or, less frequently, umber, finely asperulate often becoming smooth with age; peristome boldly and regularly sulcate, often darker than the surrounding parts of the endoperidium. Gleba rust colour; spores globose, 4–6 $\mu$  diam., moderately and irregularly verrucose, often briefly pedicellate.

HABITAT: On the ground in dry places.

MATERIAL EXAMINED: KENYA: VERDCOURT 638, Muguga on bare soil after rain, 16.4.1952 (K).

NOTES: The truly sulcate peristome distinguishes this species from those noted above and the hygroscopic nature of its rays separates it from the two following species.

Southern African specimens of *G. drummondii* differ from the type in a number of ways, notably in having a thinner fleshy layer and being less hygroscopic. They tend, in fact, towards the European and N. American *G. campestre*.

*G. lloydianum* Rick (Fig. 9c, d)

Expanded sporocarps to c. 5 cm. diam. Exoperidium splitting to about the middle into 9–13 narrow unequal acute rays, somewhat hygroscopic; mycelial layer externally encrusted with soil particles, floccose, white to buff, peeling off in sheets, particularly from the tips of the rays; fibrous layer straw colour to buff, thin; fleshy layer reddish brown, to about 1 mm. thick, drying fairly thin, continuous to rimose, often completely lacking in old specimens. Endoperidium globose to depressed globose, sessile, finely felted, mid- to pale umber; peristome concolourous or darker, sulcate. Gleba sepia, capillitial hyphae pale straw coloured, completely occluded, to 6 $\mu$  diam.; spores dark brown, globose to irregular moderately and often irregularly warted, 3–5 $\mu$  diam.

DISTRIBUTION: South and central America. Tropical Africa.

MATERIAL EXAMINED: ZAMBIA: ANGUS M313, Chilanga, nr. Mt. Makulu, 8.1.1957, on soil in woodland (K). MADAGASCAR: REV. R. BARON 5318, ?N.-W. Madagascar, 1887 (K).

NOTES: This species is distinguishable from *G. drummondii* by the much less strikingly and less regularly sulcate peristome, the almost smooth endoperidium, and the less hygroscopic rays with less persistent fleshy layer and flocculent mycelial layer.

*G. nanum* Pers. (= *G. schmidelii* Vitt.) (Fig. 9a)

Unopened fruit-body hypogaeal to exposed. Exoperidium splitting to about the middle into about 5–8 unequal rays which become recurved; mycelial layer umber to sepia in the dried specimen, persistent, covered with a layer of debris; middle layer pale buff; fleshy layer adnate, entire or occasionally cracked. Endoperidium c.  $\frac{1}{2}$ –1 cm. diam., ovoid to urn-shaped, often with a slight basal apophysis, shortly pedicellate in the dried specimen, light brown to greyish, the latter colour being due to a farina which covers the endoperidium of unweathered specimens, peristome sulcate, conical, concolourous with or darker than the rest of the endoperidium, surrounded by a groove. Gleba very dark brown, spores globose to subglobose, strongly and somewhat irregularly warted, 3–5.5 $\mu$  diam., usually rather fuscous.

HABITAT: Woodland or open places.

DISTRIBUTION: Southern Africa, N. and S. America, Australia, India, Pakistan.

MATERIAL EXAMINED: KENYA: L. D. VERDCOURT, Muguga, Jan. 1956, abundant after rains on soil in woods, etc. (EA).

NOTES: Hennings (1902) records this species for the Usambaras as *G. schmidelii*.

**Myriostoma Desv.**

This genus resembles *Gastrum* but the spore sac dehisces by several pores and is supported on a number of pedicels. The gleba contains a number of pseudocolumellae. There is a single species.



*M. coliforme* (Dickson ex Pers.) Corda (Fig. 9i)

Unopened sporocarp to about 6 cm. diam. Exoperidium splitting to about halfway into 5–10 sub-equal triangular spreading or reflexed segments. Fleshy layer soon peeling off to expose the dirty white middle layer; mycelial layer thin, smooth, flaking off in a manner like that of *Geastrum triplex*. Endoperidium to 4 cm. diam., depressed globose, umber, becoming shining grey, coarsely roughened, with several pedicels and several naked stomata. Gleba with pseudocolumellae corresponding to the pedicels. Spores globose, 3–4 $\mu$  diam., excluding the incompletely reticulate ornament which may be up to 2 $\mu$  high; capillitium hyphae mostly about 4 $\mu$  diam., coloured, branched, spirally twisted, thick-walled, with large crescentic pits in the walls, fragmenting at these pits, occasionally with large, spore-like swellings.

HABITAT: On the ground.

DISTRIBUTION: Cosmopolitan.

MATERIAL EXAMINED: KENYA: R.W.R.'s notes.

NOTES: The gleba is strikingly different from that of any other earth-star. The capillitial hyphae exhibit hygroscopic movements when first mounted on the slide, the rope-like strands uncoiling.

Microscopic data have been taken from S. African specimens in K, leg. MACOWAN.

**Astraeus Morgan**

This genus differs from *Geastrum* principally in lacking a true hymenium at any stage of its development. This has been taken by many authors to imply that there is no close relationship between these genera and that any similarity is due to parallel evolution. *Astraeus* has thus been placed in a separate family. Partly for convenience, however, we have here included it in the Lycoperdaceae.

The single species resembles *Geastrum* macroscopically to a remarkable degree. There is, however, no pseudocolumella. Microscopically, the spores are much larger than those of most *Geastrum* species and the capillitium is unlike that of any *Geastrum*, being hyaline or nearly so, with swollen septa and modified clamp connexions, and strangely reminiscent of the capillitium of *Tulostoma*.

*Astraeus hygrometricus* (Pers.) Morg. (= *Geastrum hygrometricum* Pers.) (Fig. 9g,h)

Unopened fruit-body 4–6 cm. diam., subglobose. Exoperidium splitting to  $\frac{3}{4}$  of the way down into 5–10 (occasionally more) acute, thick segments, strongly hygroscopic. Mycelial layer thin, scabrous, not persistent; middle layer hard, smooth brown; fleshy layer light umber or greyish becoming almost black with age, rimose. Endoperidium depressed globose, sessile, membranous, somewhat tomentose and marked with a network corresponding to the rimose cracking of the fleshy layer; mouth torn, indefinite; peristome indefinite. Gleba umber, capillitium threads to 8 $\mu$  diam., branched, thick-walled, often collapsed, almost hyaline, swollen at the septa; spores globose, 6–10 $\mu$  diam., strongly and very closely verrucose, brown, with the stump of a pedicel.

HABITAT: On the ground in woodland.

DISTRIBUTION: Worldwide.

MATERIAL EXAMINED: ZAMBIA: ANGUS M2615, nr. Chiwefwe Mine, nr. Mkushi Boma, soil in *Brachystegia* woodland, 8.4.1964 (K).

**Broomeia Berk.**

Sporocarps crowded together in groups of a few to about a thousand, each occupying a depression in the top of a common stroma, the whole said to be covered when young by a common exoperidium, opening to expose the individual endoperidia each of which dehisces by a single apical stoma.

This genus shares with the related, monotypic *Diplocystis* from Cuba the distinction amongst gasteromycetes of being stromatic. The affinities of *Broomeia* and *Diplocystis* are unknown; though they seem close to the Lycoperdaceae, and are here included in that family. Zeller (1949) has placed them, together with *Lycogalopsis*, which they scarcely resemble, in the Broomeaceae. A number of differences between *Broomeia* and more typical Lycoperdaceae are indicated below, but whether *Broomeia* is indeed a member of that family will remain uncertain until much more detailed studies have been carried out. This lack of knowledge extends particularly to the development of the fruit-bodies, but immature material, fresh or preserved in liquid preservative, would be necessary for such a study, and is not available.

The character of the exoperidium is usually given as the basis of generic distinction between *Broomeia* and *Diplocystis*. In *Diplocystis* each fruit-body is said to have its own exoperidium while in *Broomeia* a common exoperidium enshrouds the whole cluster of fruit-bodies although passing between them and being continuous with the walls of the alveoli. Such a generic distinction cannot, however, be logically justified at the moment for a variety of reasons.

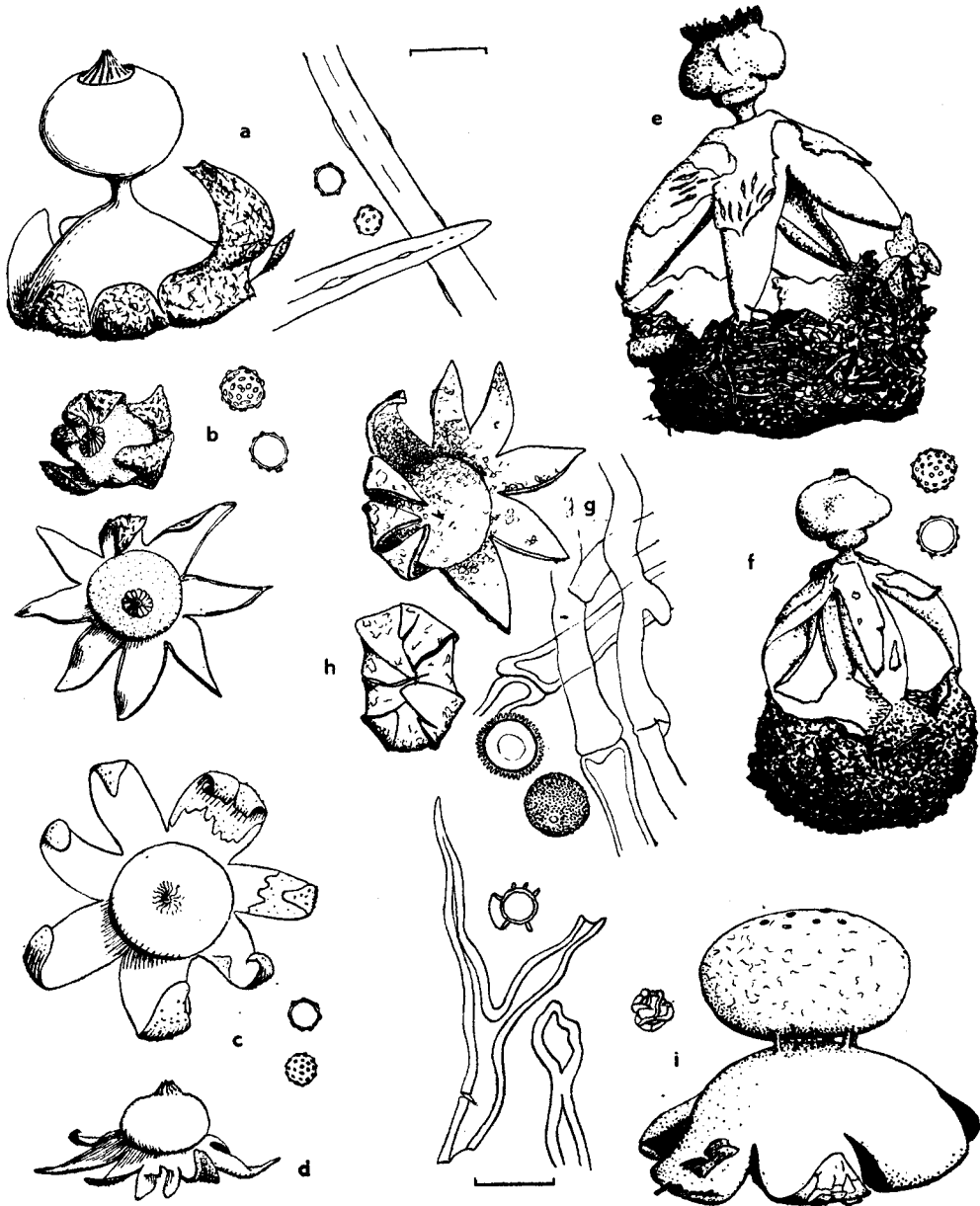


Fig. 9. Geastreae p.p. a, *Geastrum nanum*, habit  $\times 2$ , spores and capillitium (VERDCOURT); b, *G. drummondii*, habit, dry and wet specimens  $\times 1$ , spores (VERDCOURT); c, *G. lloydianum* habit  $\times 1$  and spores (ANGUS); d, *G. lloydianum*, habit  $\times 1$  (BARON); e, *G. fornicatum* habit  $\times 1$  (Mauritius, from photo); f, *G. dissimile* habit  $\times 1$ , spores (E.A. HERB. 1167); g, *Astraeus hygrometricus* habit, wet specimen  $\times 1$ , spores and capillitium (ANGUS); h, *A. hygrometricus* habit, dry specimen  $\times 1$  (Israeli material); i, *Myriostoma coliforme*, habit  $\times \frac{1}{2}$ , spores and capillitium (S. African material).

Dissing & Lange (1962) rightly refuse to assume that in *B. ellipospora* the exoperidium does in fact cover the fruit-bodies before maturity as it does in *B. congregata*. The exoperidium has never been seen in *B. ellipospora* or *D. wrightii*, and mature specimens betray not the slightest trace of ever having possessed such a membrane. In any case it is perhaps unjustifiable to call such a membrane an exoperidium; it is an extension of the stroma and its homology must be an object of doubt and study.

Finally, an exoperidium which covers each fruit-body separately cannot really be distinguished from one which is common to all, yet passes between each fruit-body and the next, and there becomes confluent with the rim of the alveolus in which each fruit-body is seated.

The real difference between the two genera lies in the alveolae themselves. In *Broomeia* the alveolae are purely depressions in the stromatic surface; in *Diplocystis* they are not truly alveolae at all but cups, each of which is separate and does not have a wall in common with its neighbours.

The two species of *Broomeia* are distinguished by the thickness of their stromata and the form of the spores.

#### *B. congregata* Berk. (Fig. 10d-f)

Sporocarps in clusters of up to a thousand, borne on a massive corky stroma, which is convex at the top. Spores subglobose to ovoid, 6–8.5 $\mu$  in major diam., finely reticulate.

HABITAT: In dry areas, usually at the base of trees, often *Acacia*, on which it is probably parasitic.

DISTRIBUTION: S. Africa, S.W. Africa, Mozambique, Kenya, Nigeria.

MATERIAL EXAMINED: KENYA: RAYNER, Crater Lake, Naivasha, sandy soil nr. *Acacia xanthophloea* (K).

NOTES: This species has been recently described elsewhere (Bottomley, 1948; Dring, 1964) so only points of special interest, which are many, will be discussed here.

The spores are reticulate in the type (K), in Rayner's specimen and all the other collections to which we have had access. Reticulate spores are unknown in the Lycoperdaceae except in this species and a few species of *Disciseda* and *Abstoma*.

The gleba of *B. congregata*, though powdery at maturity, is very compact. Capillitial hyphae often pass directly through the groups of spores, becoming characteristically tortuous, presumably by pressure of the spores against them. Sections of slightly immature gleba show spores nestling in the bends of the capillitium threads.

The surface of the endoperidium is inconspicuously verrucose, as mentioned by Berkeley but overlooked subsequently. The curious microscopic structure of the warts is shown in Fig. 10e. They are usually subspherical to ovoid and most of them are only loosely attached to the endoperidium. In the next species, *B. elliposporus*, they are even better developed, whereas in *Diplocystis wrightii* the endoperidium is smooth. The endoperidial warts of *Geastrum drummondii* and related species are very different. They are cylindrical, firmly attached and consist of rather distorted, plate-like, hyaline cells.

The stroma consists of interwoven hyaline hyphae apparently of uniform structure throughout. However, the part immediately beneath the sporocarps is more compact, whereas the centre consists of looser tissue, eventually becoming hollow. (See Pole Evans & Bottomley, 1919, pl. xxi, for a photo of a fresh, hollow stroma.) Dried herbarium material therefore often consists only of the sporocarps plus the upper parts of the stroma, the basal attachment having broken off through the hollow centre. The structure of the mature stroma of *B. congregata* therefore approaches that of *B. ellipospora*.

Fresh specimens are said to smell of aniseed, and the flesh of the fresh stroma is said to be red, resembling that of *Fistulina hepatica*. In herbarium material the red colour is limited to the compact upper layer of the stroma and is considerably less marked than in dried *F. hepatica*. Both the smell and the pigment are unique in the Lycoperdaceae.

#### *B. ellipospora* v. Höhn. (= *Diplocystis junodii* Pole Evans & Bottomley) (Fig. 10a-c)

Sporocarps in clusters of up to 80 on a thin, saucer-shaped stroma. Spores ovoid, 6–8  $\times$  3.5–4.5 $\mu$ , smooth or minutely roughened, sterigmatic scar visible at the broader end.

HABITAT: On sandy soil.

DISTRIBUTION: S. Africa, Mozambique, Angola, S.W. Africa.

MATERIAL EXAMINED: MOZAMBIQUE: REV. H. JUNOD, Rikatli, Lourenço Marques, 22.5.1919 (Cotype of *D. junodii*, K).

NOTES: The species has been well described by Bottomley (1948) and Dissing & Lange (1962), though the characteristically warted surface of the endoperidium is not mentioned in either paper nor in von Höhnel's original description. Macroscopically the warts are brownish and rather prominent but partly hidden by the floccose outer covering of the endoperidium. Both warts and flocci tend to wear off. In the case of the warts it is noticeable that their connexion with the underlying layer is tenuous, in fact their whole structure suggests that of sclerotia (Fig. 10b).

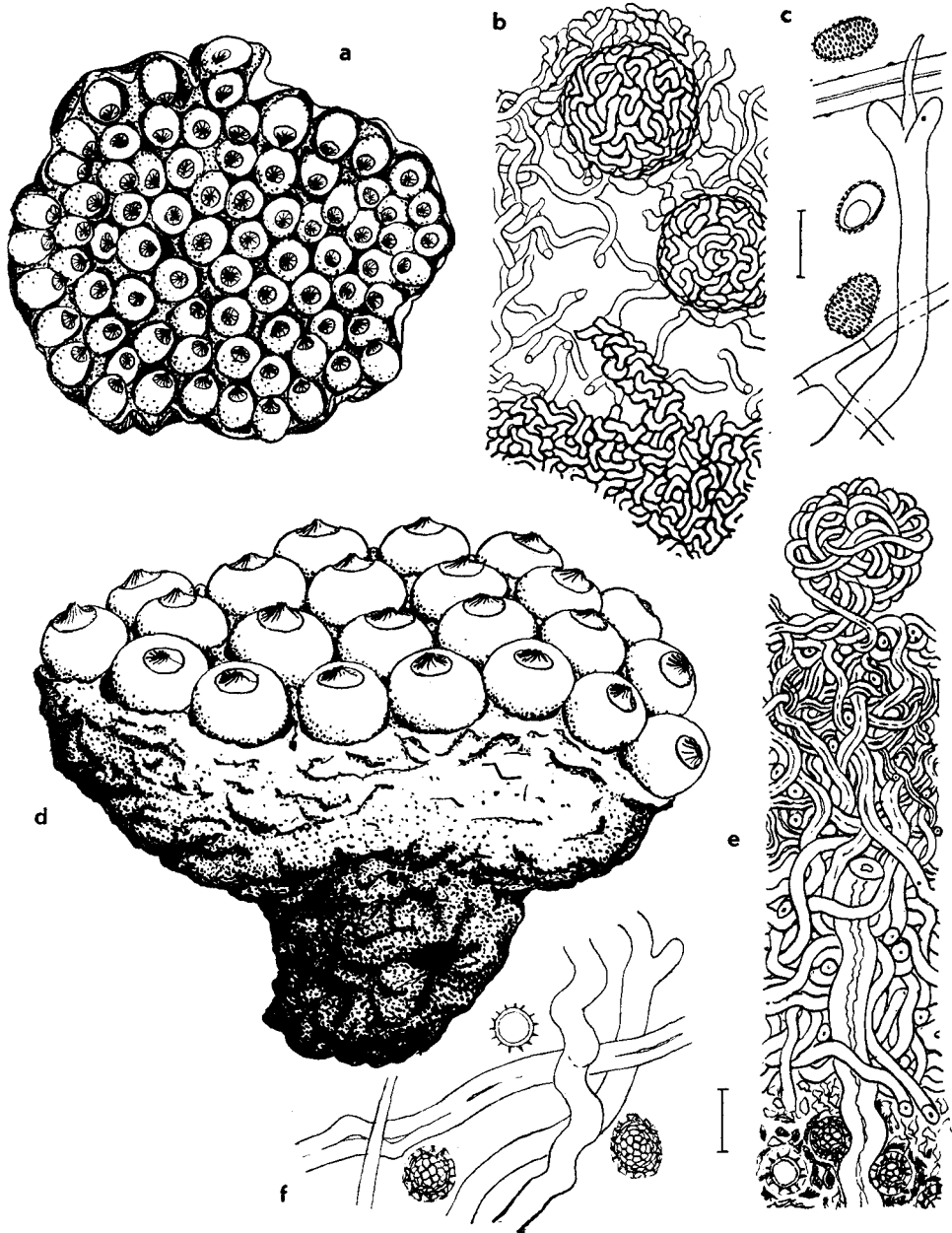


Fig. 10. *Broomeia*. a-c, *B. ellipospora*: a, habit  $\times 1$ ; b, v.s. peridium; c, spores and capillitium (type of "*Diplocystis junodii*"); d-f, *B. congregata*: d, habit  $\times 1$ ; e, v.s. peridium passing through a wart; f, spores and capillitium (RAYNER).

According to the descriptions the spores of the type collection and Dissing & Lange's (1962) collection from Angola are smooth. Bottomley describes the spores as smooth to rough. Those of the Lourenço Marques collection are minutely verrucose. The arrangement of the warts is rather difficult to see except when the spores are viewed in Melzer's iodine solution which shows up the ornament, though whether it reacts with it is difficult to establish.

The morphology of the stroma is described by Dissing & Lange (1962). As they state, there seems to be a "spurious" mycelial layer under the stroma and separate from it except, perhaps, at points directly under each fruit-body where the stroma protrudes downwards. The specimens at Kew give the impression that the space between the "mycelial layer" and the stroma is created by shrinkage of the tissues similar to that which occurs in *B. congregata*. Young stages have never been recorded, however, and one must in a genus so aberrant as *Broomeia*, accept such extrapolations only with extreme caution.

#### TULOSTOMATACEAE

This family, though very natural, is difficult to define in few words. Its members have a true stipe and a two-layered peridium, the outer layer of which encloses the immature fruit-body as a universal veil, splitting when the stipe elongates and then often remaining as a volva at the base of the stipe. The stipe is cleanly separable from the inner peridium of the head in one tribe, the Tulostomateae, confluent with it in the other, the Phellorineae.

The mature gleba is always powdery and lacks any suggestion of columella or pseudocolumella. Nevertheless, the constitution of the gleba differs in the two tribes. In the Phellorineae, the mature gleba is characterized by the persistence of the tramal plates and of fascicles of basidia. True capillitium is lacking, though the remains of the tramal plates may be mistaken for capillitial hyphae. In the Tulostomateae the gleba contains true capillitium and the tramal plates and basidial fascicles do not persist at maturity except in the transitional genera *Battarraea* and *Schizostoma*.

The mode of dehiscence of the inner peridium is very variable and is used as a criterion for distinguishing between genera.

#### Phellorinia Berk.

Sporocarp consisting of a subglobose head supported on a thick, solid woody stipe. Outer peridium covering both head and stipe, warted or scaly, tending to fall away. Inner peridium continuous with the stipe tissue, dehiscing by irregular rupture and erosion of the apical part. For an explanation of the nomenclature applied to the genus and its one accepted species, see Dring (1964).

#### *P. herculeana* (Pallas ex Pers.) Kreisel

Sporocarp to 10 cm. tall; head 3-5 × 2-4 cm.; stem 3-5 × 1-2 cm. Peridium cream coloured. Gleba rust colour, powdery, spores globose, 4.5-7 μ diam., finely and closely warted, brown; capillitium absent but replaced by hyaline collapsed threads, aggregated into bundles, the remains of the tramal plates.

#### *P. herculeana* ssp. *herculeana* (= *P. iniquans* auctt. non Berk.) (Fig. 11e)

The outer peridium consists of large intricate scales and the head is usually ellipsoid rather than subglobose.

HABITAT: On the ground in dry, open places.

DISTRIBUTION: Africa, S. W. United States, Mediterranean region, central Europe, Australia.

MATERIAL EXAMINED: SOMALIA: BALLY B9591, E. of Ghelinsor, 1,000 ft., open grassland, 5.4.1954 (K).

NOTES: In the young, fresh state there is no possibility of confounding this subspecies with the next, though in herbaria much confusion has occurred. The feathery, overlapping scales make this one of the most beautiful of gasteromycetes, but unfortunately they are slightly sticky and tear away or become compacted when the specimen is handled. A good photograph or drawing, made *in situ*, of a young specimen is much to be desired.

#### *P. herculeana* ssp. *strobilina* (Kalch.) Dring (= *P. iniquans* Berk.) (Fig. 11d)

This differs from ssp. *herculeana* in that the outer peridium is very thick and splits into large zonate warts as maturity approaches. The habit is usually more squat than that of ssp. *herculeana*, the stipe being shorter and the head more rounded.

DISTRIBUTION: Africa, Asia, Australia.

MATERIAL EXAMINED: KENYA: JOY ADAMSON, nr. Lake Rudolph, Spring 1944 (K); RAYNER 741, N. Frontier Distr., nr. Lake Rudolph, c. 1944 (probably part of the same coll., K).

**Battarraea Pers.**

Head concave below, convex above, firmly fixed to the stipe, dehiscing around the intersection of the two faces. Stipe long, scaly, hollow, with a well developed volva at the base.

*B. stevenii* (Liboschitz) Fr. (= *Sphaericeps lignipes* Welw. & Curr.) (Fig. 11h)

Immature sporocarp hypogaeal, obovoid to obconical, enclosed in a universal veil. Head thrust above ground at maturity by elongation of the stipe. Stipe 10–50 cm. long, covered with coarse, imbricate scales, volva thick, woody, remaining below ground if stipe be pulled up. Gleba rust colour to sepia; capillitium of two types of hyphae, spirally or annularly thickened, elongated-fusoid threads, usually called “elaters” but constituting the capillitium proper, and collapsed, simple, hyaline threads bound together in fascicles, and really the remains of the trama (cf. paracapillitium); spores brown, subglobose, 4.5–6(–7) $\mu$  diam., seemingly finely truncate-verrucose.

HABITAT: Dry, sandy soil.

DISTRIBUTION: Mediterranean area, Hungary, U.S.S.R., Mongolia, Pakistan, the Americas, Africa, Australia.

MATERIAL EXAMINED: KENYA: RAYNER, nr. Lake Naivasha, sandy ground in *Acacia* woodland, May 1945 (K); BALLY B10537, Maji ya Chumvi, Coast Prov., 2,700 ft., in *Euphorbia* thicket on sandy soil, 13.5.1956 (K). SOCOTRA: PROF. BAYLEY BALFOUR 1300, 1345, and another collection without no., all collected Feb.-March, 1880 (all K).

NOTES: In addition to the above, this species has been recorded for Mozambique (Bottomley, 1948).

There is some doubt that *B. stevenii* is really separable from the European *B. phalloides*. The latter tends to be smaller, with a less scaly stipe, less persistent gleba (i.e. thinner tramal plates), more heavily and irregularly ornamented spores, and has a volva consisting of two membranous layers said to be separated by a gelatinous layer when fresh. Individuals from the same collection sometimes show a remarkable variation in the first three of these characters. In fact, whatever their geographical provenance, the larger individuals tend to have a more scaly stipe and more persistent gleba.

Spores of almost all the extra-European material of *Battarraea* in K are minutely and regularly ornamented, while the European material in K (almost all of which is English) has spores with just discernibly less regular and slightly stronger ornament.

**Schizostoma Ehrenberg ex Léveillé**

Mature sporocarp consisting of a relatively slender stipe fitting into a wide, shallow socket at the base of the head. Stipe hollow, woody, clearly differentiated from head but not cleanly separable from it as in *Tulostoma* and *Queletia*. Endoperidium dehiscing in a stellate manner. Universal veil forming a more or less well marked volva at the base of the stipe. Gleba consisting of true capillitium and subglobose, smooth spores.

*S. laceratum* Ehrenb. ex Lév. (Fig. 11f, g)

Sporocarps to about 6 cm. tall, stipe to 0.5 cm. diam., usually not markedly scaly; head pulvinate, to about 3 cm. diam., 2 cm. high, splitting into about 4–6 blunt major lobes. Volva usually reduced to a sand-encrusted swelling at the base of the stipe. Gleba ochraceous, becoming a dark, rich, reddish-brown (near vinaceous of Dade); capillitium of dark, thick-walled, and paler, thin-walled, collapsed hyphae, irregularly shaped, branched, fragmenting into short lengths at the septa, to 10 $\mu$  diam., spores dark, irregularly globose, 3.5–6 $\mu$  diam., absolutely smooth under oil-immersion, apiculate.

HABITAT: In semi-arid, sandy places.

DISTRIBUTION: Somalia, Sudan, Mali, Persia, W. Pakistan, Khazakstan, N. and S. America, Australia.

MATERIAL EXAMINED: SOMALIA: BALLY 3034, Burao, 26.1.1944, in sandy soil.

NOTES: The above specimen, and the description, refer to *S. laceratum* in the restricted sense. A number of authors consider *S. laceratum* to be the only valid species.

**Tulostoma Pers.**

Fruit-bodies stipitate, the subglobose head having a well-marked socket below, into which fits the slender, hollow, woody stipe and from which it may be broken away fairly readily and cleanly.

Outer peridium taking the form of a universal veil in the immature fruit-body, remaining in the adult as a more or less well marked basal volva and a collar round the socket, and sometimes continuing over the entire head, in which case it is warted. Endoperidium membranous, dehiscing by an apical stroma which may be indefinite or definite, and in the latter case tubular or more or less plane and with a definite peristome or without (in which case it is often called naked). Capillitium of branched and septate hyphae; spores globose to subglobose, smooth or variously ornamented.

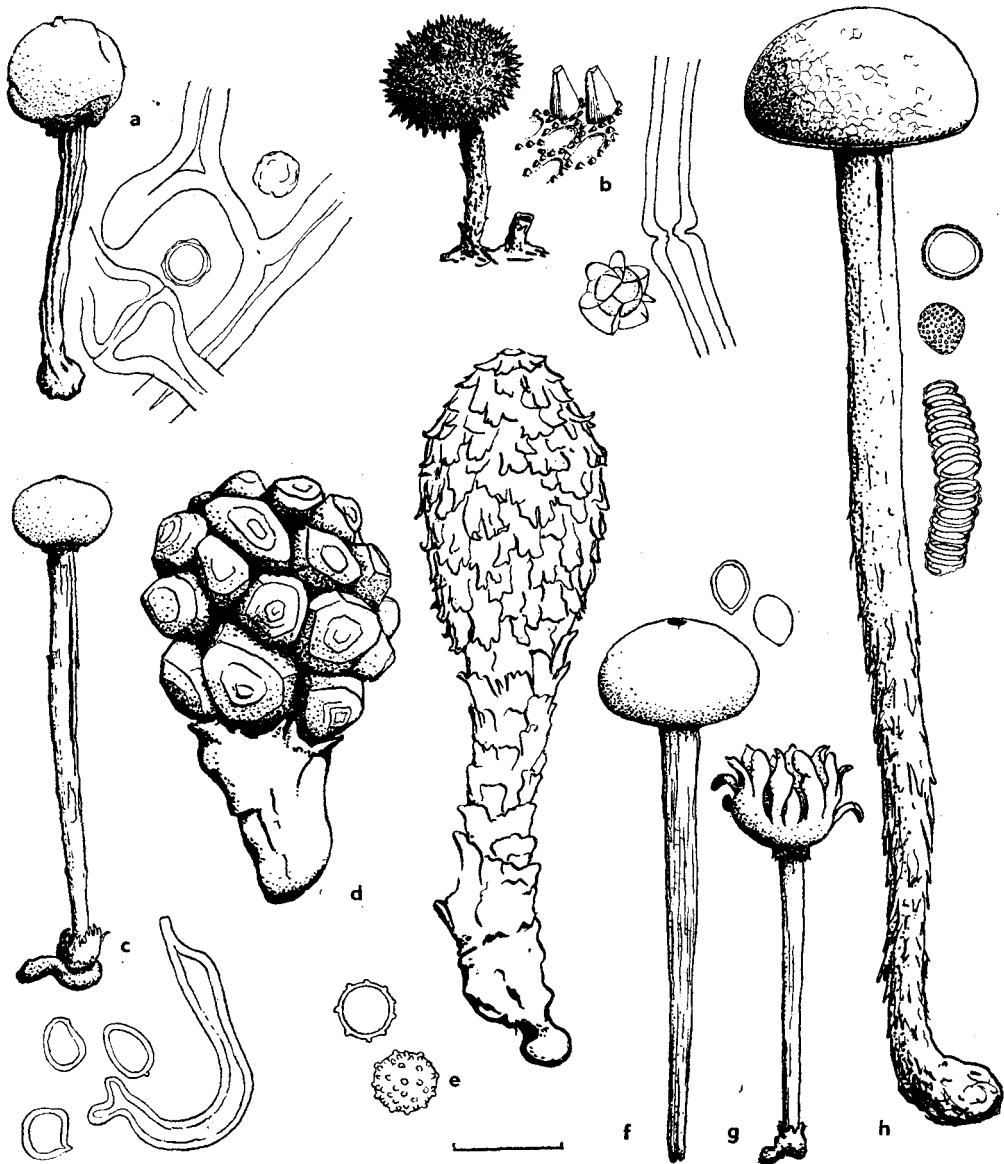


Fig. 11. Tulostomataceae. a, *Tulostoma album*, habit  $\times 1$ , spores and capillitium (BALLY); b, *T. exasperatum*, habit  $\times 1$ , peridial details  $\times 5$ , spore and capillitium (GREENWAY); c, *T. volvulatum*, habit  $\times 1$ , spores and capillitium; d, *Phellorinia herculeana* ssp. *strobilina*, habit  $\times \frac{1}{2}$  (W. African material); e, *P. h.* ssp. *herculeana*, habit  $\times \frac{1}{2}$ , spores (W. African material); f, *Schizostoma laceratum*, young specimen without volva, habit  $\times \frac{1}{2}$ , spores (BALLY); g, *S. laceratum*, old specimen, habit  $\times \frac{1}{2}$  (N. American material); h, *Battarraea stevenii*, habit, without volva and upper part of peridium,  $\times \frac{1}{2}$ , spores and elater (RAYNER).

*T. volvulatum* Borshchov (Fig. 11c)

Fruit-body usually 7–10 cm. tall, straw-colour throughout. Head depressed globose with plane, naked, circular to elliptical stroma and wide socket. Stipe scaly and longitudinally furrowed, with well marked volva at base. Gleba rust colour; spores subglobose to irregular, 4.5–5.5 $\mu$  diam., smooth and apiculate; capillitium of irregular, short, branched hyphae.

HABITAT: Semi-arid ground.

DISTRIBUTION: Africa north of the Equator, Central Europe, Asia.

MATERIAL EXAMINED: BRITISH SOMALILAND: BALLY 7379, on rocky ground, 2.6.1949 (K). SOMALIA: BALLY 10401, Berbera-Behendulla road, on rocky ground 17.11.1954.

*T. album* Masee (Fig. 11a)

Head globose or depressed-globose, to about 2 cm. diam. Exoperidium impregnated with earth, cracking away late leaving a thick cup at the base. Endoperidium rosy-buff, minutely felted under the lens; mouth shortly tubular, elliptic; collar moderately wide. Stipe to 4 cm.  $\times$  3 mm., equal, or more usually attenuate downwards, with a well developed basal bulb, markedly striate, not scaly, concolorous with endoperidium to pale reddish brown. Gleba fulvous; capillitium hyaline, thick-walled to occluded, to c. 6 $\mu$  diam., swollen and lightly pigmented at the septa; spores irregularly globose, 3.5–5 $\mu$  diam., honey coloured, very irregularly and more or less prominently verrucose, the verrucae being hyaline.

HABITAT: On the ground.

DISTRIBUTION: Australia, Southern Africa.

MATERIAL EXAMINED: KENYA: BALLY 2627 [without data] (K).

NOTES: The material consists of a single sporocarp and is in some ways intermediate between *T. album* and *T. albicans* White. It is closely similar to J. P. H. Alcock's collection 403, from Kimberley (K), which Bottomley (1948) doubtfully ascribed to *T. albicans*. Both differ from the type specimen in having less prominently verrucose spores but these are certainly not smooth as in *T. albicans*.

*T. exasperatum* Montagne (Fig. 11b)

Sporocarps in groups on rotten wood. Head depressed globose, to about 1.5 cm. diam.; outer peridium very dark umber, of long and short spines, covering the head, wearing off late to leave an areolate surface reminiscent of that of *Lycoperdon perlatum*; inner peridium vinaceous; ostiole fimbriate, peristome definite, conical. Stipe to 5 cm. long, almost concolorous with peridial warts, with short, persistent, suberect scales. Gleba cinnamon buff, spores globose, very pale yellow, with deep hyaline ridges, 6.5–8.5 $\mu$  diam., including ornament. Capillitium hyaline, branched, thick-walled, slightly swollen and not coloured at the frequent, perforated septa.

HABITAT: On rotten wood in forest.

DISTRIBUTION: Tropical Asia, tropical S. America, tropical Africa.

MATERIAL EXAMINED: TANGANYIKA: GREENWAY 5979, Msalai-Zaria, E. Usambara, 4,500 ft., 4.8.1940 (K, EA).

NOTES: This species is easily recognizable by the long (to 2 mm.) peridial spines. The ornamentation of the spores is also distinctive, and the habit of growing on wood in forest remarkable in the genus.

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