

Lycoperdaceae of New Zealand.

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A natural family of the Gasteromycetes is the Lycoperdaceae, containing eight genera, most of the species of which have a wide distribution. In the family are included those fungi popularly known as "puff-balls," some of which are among the largest fungi known.

The writer would limit the family to those genera possessing a non-stipitate, two or more layered peridium, copious capillitium, and long-sterigmate, 4 or 8 spored basidia.

In the past many more genera were included in the family, for the earlier workers arranged genera on external characters only; consequently when microscopic structure came to be studied, it was gradually realized that many genera were in an anomalous position, with the result that they were removed to other families and orders. It is considered unnecessary to give the different classifications which have been put forward, for all but the most recent are of interest only from an historical point of view.

The writer would divide the family into the two sub-families:—

Sub-family Lycoperdeae:

Peridium two-layered, dehiscing by an apical stoma or by the gradual falling away of the upper portions of the peridium; capillitium present, attached or free, simple or freely branched; basidia sterigmate, 4-spored.

Sub-family Geastreae:

Peridium three-layered, dehiscing by a definite apical stoma, or by several; capillitium present, simple, attached; basidia sterigmate, 4-8 spored.

STRUCTURE OF THE MATURE PLANT.

In species of the genera included in the sub-family Lycoperdeae, the mature plant consists of a two-layered peridium (exoperidium and endoperidium) either attached to the substratum by a rooting base (*Bovistella*, *Calvatia*, *Lycoperdon* and *Mycenastrum*) which holds plants to the place of origin even though they may be old and weathered; or the plant may be attached by a small rooting strand or mycelial cord, and at maturity break away and be carried by wind for some distance (*Abstoma*, *Bovista* and *Disciseda*). The outer layer of the peridium (the exoperidium) is usually pseudoparenchymatous, but may be membranous, and is often composed of warts and spines adherent at the base. This structure is usually quite thin, and in the majority of species flakes away in irregular patches.

In *Abstoma* and *Disciseda* the exoperidium is frequently in the nature of a thick (1-3 mm.) sand-case, consisting of loosely interwoven hyphae with which are immixed sand particles. The whole structure is firm but quite brittle, and falls away in irregular fragments.

The inner layer (the endoperidium) is in most genera thin and membranous or papyraceous, but in *Mycenastrum* is thick (2-5 mm.), corky, coriaceous and pseudoparenchymatous, and in young plants may appear almost cartilaginous.

The peridium encloses the gleba, which at maturity consists of capillitium threads and spores. The threads are discussed more fully below, and serve as most useful generic characters. In many species of the genera *Bovistella* and *Lycoperdon* is present the so-called columella, a cylindrical or elliptical structure of sterile tissue traversing the lower portion of the gleba and attached to the base of the plant. In certain species of the genera *Bovistella*, *Calvatia* and *Lycoperdon* a sterile base is present. This consists of a (usually) cellular tissue occupying the lower portion of the gleba, and is most frequent in those plants with a well-developed stem-like base. In certain species of *Calvatia* and *Lycoperdon* the sterile base is separated from the gleba by a definite diaphragm.

The spores are globose or shortly elliptical, and possess rough or smooth epispires. Their shape, size, colour and degree of roughness are useful specific characters. They are borne on long and slender sterigmata which in turn are borne apically on small basidia. Should the sterigmata with their attached spores break away from the basidia and remain attached to the spores, the latter are said to be pedicellate; should stumps only of the sterigmata remain attached to the spores the latter are said to be apiculate; or, should the spores become completely detached from the sterigmata, they are said to be apedicellate. The basidia in all members of this sub-family are regularly tetrasporous.

In the genus *Geaster*, placed in the sub-family Geastreae, the structure of the mature plant is complicated in that no less than three well-defined tissues form the exoperidium—an outer mycelial layer consisting of a palisade of short, stout fibres, a central fibrillose layer of interwoven hyphae with long axes predominantly radial, and an inner fleshy layer, definitely pseudoparenchymatous in structure. The basidia are long-sterigmate and commonly 8-spored.

Genera of the sub-family Lycoperdeae show a close family resemblance, so close in fact that difficulty is sometimes experienced in separating species—as for example species of *Calvatia* from *Lycoperdon*. Separation is best effected by means of the capillitium threads and method of dehiscence. In *Calvatia* and *Lycoperdon* these threads are very long, even throughout their length, sparingly septate or continuous, and seldom branched (save in certain species of the latter genus, as *Lycoperdon pusillum*, *L. glabrescens* which are freely branched). The threads are usually free at one end, and attached by the other to the inner wall of the peridium and (when present) a central columella.

Calvatia is separated from *Lycoperdon* by the method of dehiscence. In the former genus the upper portions of the peridium flake away in pieces, so that at maturity the whole may have disappeared, the gleba then being directly exposed. In *Lycoperdon* dehiscence is effected by a definite apical aperture or stoma. In two species, the dehiscence is first effected by means of an apical stoma, but as the plant ages, irregular flaking away of the whole of the apex of the

peridium occurs; consequently difficulty might be experienced in placing plants of these species according to whether they were collected when mature or immature.

In *Abstoma* and *Disciseda* the capillitium threads are very short, unbranched, and usually continuous, and are so characteristic as usually to place any species in these two genera. In immature plants, however, the capillitium threads approach those of *Lycoperdon*, and in such cases the nature of the exoperidium and the habit show them to be members of these genera. Dehiscence in *Disciseda* is effected by a stoma which is usually apical, but in one or two species is said to be basal. In *Abstoma* no stoma is present, the spores being freed by the irregular rupture of the endoperidium.

Bovista and *Bovistella* both possess capillitium threads which are peculiar and characteristic. Each thread is free, and has a distinct short, thick main stem with numerous short, dichotomous, acuminate branches. Dehiscence is effected by means of an apical stoma as in *Lycoperdon*. The two genera are separated from each other only upon habit, *Bovista* being a genus in which plants break away at maturity from the place of growth, *Bovistella* persisting by means of a strong rooting base, as does *Lycoperdon*. Herbarium specimens may usually be differentiated by the presence or absence of the rooting base; if present the plant is placed under *Bovistella*, if absent, under *Bovista*.

Mycenastrum is characterised both by the capillitium threads and method of dehiscence. The threads are short, free, short-branched, and covered with numerous spinous processes. Dehiscence is similar to that of *Calvatia*, the corky peridium either flaking away irregularly from the apex, or splitting in a stellate manner.

In *Geaster* dehiscence is effected by the exoperidium (of three layers) splitting at maturity from the apex downwards into several stellate lobes, exposing the endoperidium, which in turn dehisces by an apical stoma. The capillitium threads resemble those of the genus *Lycoperdon*, but are usually continuous, simple, and dark coloured.

KEY TO THE GENERA.

Sub-family Lycoperdeae: Peridium 2-layered, basidia 4-spored.

- | | |
|---|-----------------------|
| a. Capillitium threads attached to the endoperidium and central columella, when present. | |
| (a). Peridium dehiscing by irregular apical rupture | 1. <i>Calvatia</i> |
| (b). Peridium dehiscing by a definite apical stoma | 2. <i>Lycoperdon</i> |
| b. Capillitium threads free within the endoperidium. | |
| (a). Threads simple, or short-branched | |
| *Threads short, simple, smooth. | |
| †Stoma present, apical or basal | 5. <i>Disciseda</i> |
| ‡Stoma absent | 6. <i>Abstoma</i> |
| **Threads short, simple, spinose | 7. <i>Mycenastrum</i> |
| (b). Threads freely branched, of a central main stem, and short, dichotomous, acuminate branches. | |
| *Plants with a strong rooting base | 3. <i>Bovistella</i> |
| **Plants without a definite rooting base | 4. <i>Bovista</i> |

Sub-family Geastreae: Peridium 3-layered, basidia 4-8 spored.

*Peridium with a single apical stoma	8. <i>Geaster</i> .
**Peridium with several apical stomata	(<i>Myriostoma</i>)

(1) *Calvatia* Fries, *Summa Veg. Scand.*, p. 442, 1849.

Peridium globose, subglobose or pyriform, frequently with a well-developed rooting base; of two layers, an outer exoperidium which is warted, spinose, granular or smooth, and flakes away in irregular patches; and an inner endoperidium which is thin, papyraceous or membranous, and dehisces by the gradual flaking away of the apical portion; with or without a sterile base; distinct diaphragm present or absent.

Gleba of capillitium and spores; columella absent; capillitium threads long, sparingly branched or simple, equal, septate or continuous, attached to the inner wall of the endoperidium. Spores globose or elliptical, coloured, rough or smooth, continuous.

Habitat: Solitary or in small groups on the ground in pastures, sand-dunes or outskirts of the forest; epigaeal.

Distribution: Britain; Europe; Asia; North and South America; India; Africa; Australia; New Zealand.

The genus is separated from *Lycoperdon* solely by the method of dehiscence, which is effected by the irregular breaking away of the upper portion of the endoperidium. Its relationship was obscure until its position and limits were defined by Morgan (1890). In it are included most of the largest species of "puff-balls."

About eight species are known, three of which are present in New Zealand.

KEY TO THE SPECIES.

Diaphragm present:	
Spores smooth	1. <i>C. caelata</i>
Spores strongly verrucose	2. <i>C. ulacina</i>
Diaphragm absent	3. <i>C. gigantea</i>

1. *Calvatia caelata* (Bulliard) Morgan, *Jour. Cin. Soc. Nat. Hist.*, vol. 12, p. 169, 1890. (Fig. 1.)

Lycoperdon caelatum Bull., *Champ.*, vol. 1, p. 156, 1809.

L. Fontanesii Dur. et Mont., *Fl. Alger.*, vol. 1, p. 381, 1849.

L. favosum Bon., *Bot. Zeit.*, vol. 15, p. 595, 1857.

L. Sinclairii Berk., Mass., *Jour. Roy. Micr. Soc.*, p. 176, 1887.

Calvatia Fontanesii (D. et M.) Lloyd, *Lyc. Aus.*, p. 36, 1905.

C. favosa (Bon.) Lloyd, *l.c.*

C. Sinclairii (Berk.) Lloyd, *l.c.*, p. 37.

Peridium up to 10 cm. diam., depressed-globose or subpyriform, tapering abruptly into a well-developed, crenulate, stem-like rooting base; exoperidium at first white, becoming pallid olivaceous, areolate, floccose, areolae more conspicuous basally; endoperidium brown, fragile, breaking away in irregular flakes from the apical portion; sterile base well developed, persistent, forming the lower third of the peridium, distinctly cellular throughout, separated from the gleba by a well-defined diaphragm.

Gleba at first yellowish, becoming olivaceous, at first compact, becoming pulverulent; capillitium threads long and flexuous, sparsely branched, septate, olivaceous. Spores globose, 4-5 mmm. diam., frequently apiculate; epispore olivaceous, perfectly smooth.

Habitat: Solitary on the ground, frequent on sand-dunes near the sea coast.

Distribution: Britain; Europe; North America; Algeria; Australia; New Zealand.

Queenstown, Otago, May, 1920, *J. B. Cleland!*

Otaki, Wellington, Nov., 1924, *E. H. Atkinson!*

The plant is characterised by the areolate exoperidium, perfectly smooth spores, prominent diaphragm, and large, cellular base.

2. *Calvatia lilacina* (Berk. et Mont.) Lloyd, *Lyc. Aus.*, p. 35, 1905. (Fig. 3.)

Bovista lilacina Berk. et Mont., in Hook. *Jour. Bot.*, vol. 4, p. 62, 1845.

Lycoperdon novae-zelandiae Lev., *Ann. Sci. Nat.*, ser. 3, vol. 5, p. 164, 1846.

L. lilacinum (B. et M.) Masee, *Jour. Roy. Micr. Soc.*, p. 706, 1887.

Calvatia cyathiformis (Bosc.) Morgan, *Jour. Cin. Soc. Nat. Hist.*, vol. 12, p. 168, 1890.

Peridium up to 15 cm. diam., subglobose or pyriform, tapering abruptly into a large, well-developed, strongly crenulate rooting base; exoperidium smooth or more frequently floccose, often areolate, cream to bay brown, thin, fragile, fugacious; endoperidium brown, thin, fragile, breaking away irregularly from the apical portion; sterile base well developed, persistent, cellular at the periphery, hemi-compact within, separated from the gleba by a prominent diaphragm.

Gleba some shade of purple, sometimes with a greyish tinge, at first compact, soon pulverulent; capillitium threads long, branched, septate, equal, pallid olivaceous. Spores globose, 5.5-7.5 mmm. diam., occasionally apiculate; epispore strongly verrucose, violaceous.

Habitat: Solitary on the ground, usually in sandy areas.

Distribution: ? Southern Europe; North America; South Africa; Australia; New Zealand.

Weraroa, Wellington, Oct., 1922, *G. H. C.*; Mar., 1925, *J. C. Neill!*

Dunedin, Otago, Sept., 1922, *Miss H. K. Dalrymple!*

Otaki Beach, Wellington, Nov., 1924, *E. H. Atkinson!*

Characterized by the prominent sterile base, conspicuous diaphragm, and especially by the strongly verrucose, violaceous spores. The peridium and gleba are fragile, consequently the sterile base is often the only portion of the plant collected; nevertheless even this can be determined readily owing to its structure. It is liable to confusion only with that of *C. caelata*, but may be separated by its peculiar, partly compact, partly cellular structure.

The peridium is usually stated to be smooth externally, but this is by no means a constant feature; on the contrary, collections frequently show the exterior to be floccose and even areolate.

3. *Calvatia gigantea* (Persoon) n. comb. (Fig. 2.)

Lycoperdon giganteum Pers., *Syn. Meth. Fung.*, p. 140, 1801.

Bovista gigantea (Pers.) Nees, *Syst. Pilze*, p. 34, 1817.

Lycoperdon Bovista Fr., *Syst. Myc.*, vol. 3, p. 29, 1829.

Calvatia maxima (Schaeff.) Morg., *Journ. Cin. Soc. Nat. Hist.*, vol. 12, p. 166, 1890.

C. gigantea (Batsch) Lloyd, *Myc. Notes*, p. 166, 1904.

C. primitiva Lloyd, *Lyc. Aus.*, p. 36, 1905.

Peridium subglobose, up to 40 cm. diam., with a cord-like rooting base; exoperidium smooth, finely tomentose, closely resembling chamois leather, fragile, cream or yellowish, fugacious; endoperidium brown, thin, fragile, flaking away irregularly; sterile base scanty, compact, frequently wanting, diaphragm absent.

Gleba yellowish, becoming olivaceous, hemi-compact; capillitium threads long, sparingly branched, septate, olivaceous. Spores globose, 4-5.5 mm. diam., occasionally apiculate; epispore olivaceous, finely verruculose.

Habitat: Solitary on the ground in pastures.

Distribution: Britain; Europe; North America; Australia; New Zealand.

New Plymouth, Taranaki, Dec, 1923, *W. W. Smith!*

Weraroa, Wellington, Mar., 1925, *J. C. Neill!*

Ashburton, Canterbury, Jan., 1926, *J. C. Neill!*

The (usually) very large size, leathery peridium and absence of a well developed sterile base characterizes this species. No diaphragm is present, consequently the scanty sterile base merges imperceptibly with the tissues of the gleba. The spores are usually stated to be smooth, but are seen to be distinctly verruculose under the oil immersion.

This is the commonest species in New Zealand, and may regularly be found during the spring and autumn months in certain pastures in the lowland areas. All three species are edible, if collected and eaten while the gleba is white.

(2) *Lycoperdon* Tournefort ex Persoon, *Syn. Meth. Fung.*, p. 138, 1801.

Utraria Quel., *Bull. Soc. Myc. Fr.*, vol., 24, p. 366, 1876.

Globaria Quel., *l.c.*, p. 370.

Peridium variously shaped, with a strong rooting base or basal mycelial strand; of two layers, a fugacious exoperidium which is pseudoparenchymatous, warted, spinose or granular; and a persistent endoperidium which is membranous or papyraceous, thin, tough, and dehisces by a solitary apical stoma; sterile base present or absent, cellular or compact, diaphragm present or absent.

Gleba of capillitium and spores; columella present or absent; capillitium threads long, simple or branched, continuous or septate, hyaline or coloured, attached by one end to the endoperidium or columella, when present. Spores continuous, globose or shortly elliptical, rough or smooth, coloured.



FIG. 1.—*Calvatia caelata*, natural size.

FIG. 2.—*Calvatia gigantea*, $\times \frac{1}{2}$. Small form.

Photos, H. Drake.

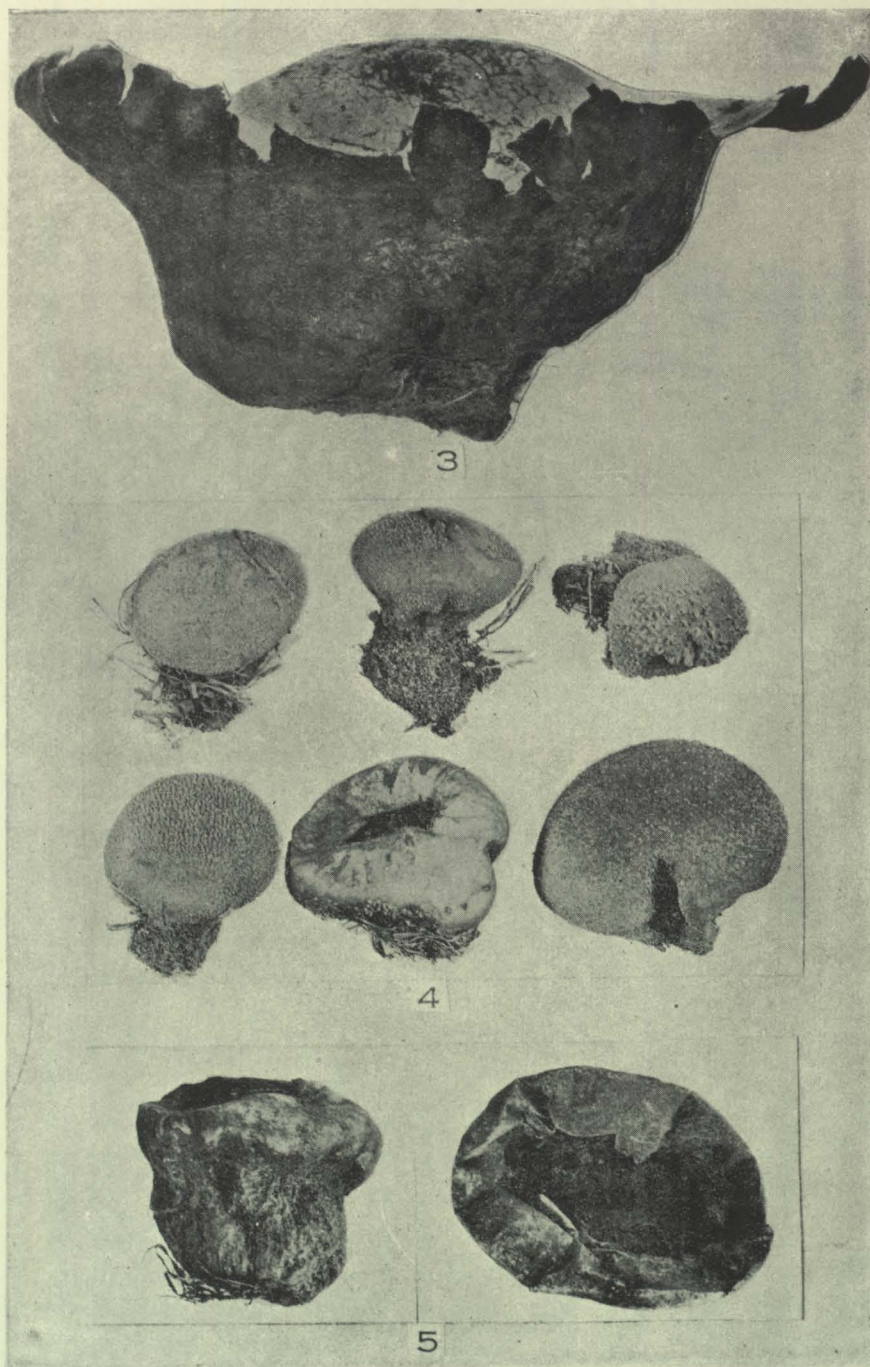


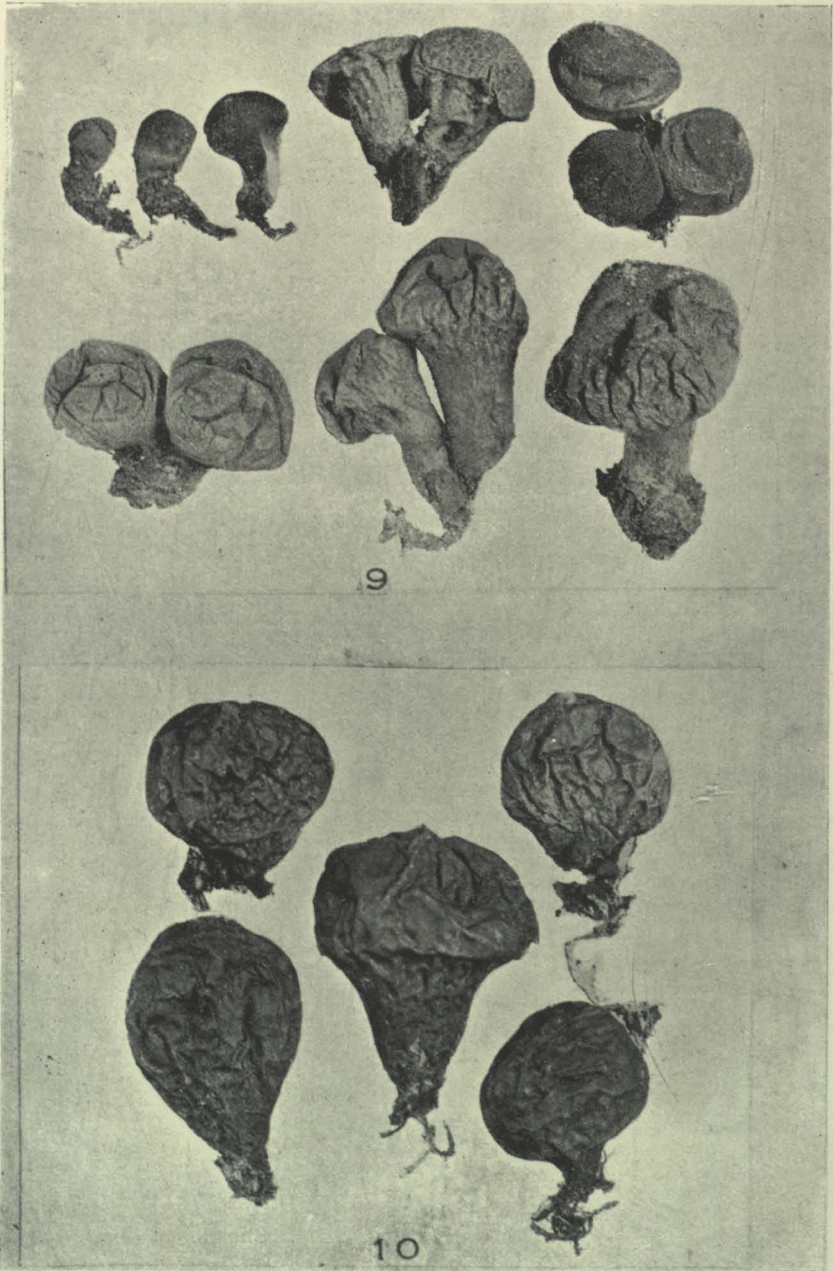
FIG. 3.—*Calvatia lilacina*, natural size. Sterile base; note the conspicuous diaphragm.
 FIG. 4.—*Lycoperdon depressum* $\times \frac{1}{2}$. Showing variations in the nature of the exoperidium.
 FIG. 5.—*Lycoperdon depressum*, natural size. Showing the prominent sterile base and the manner in which the endoperidium breaks away from the apex of old specimens.

Photos, H. Drake.



Photos, G. H. Cunningham.

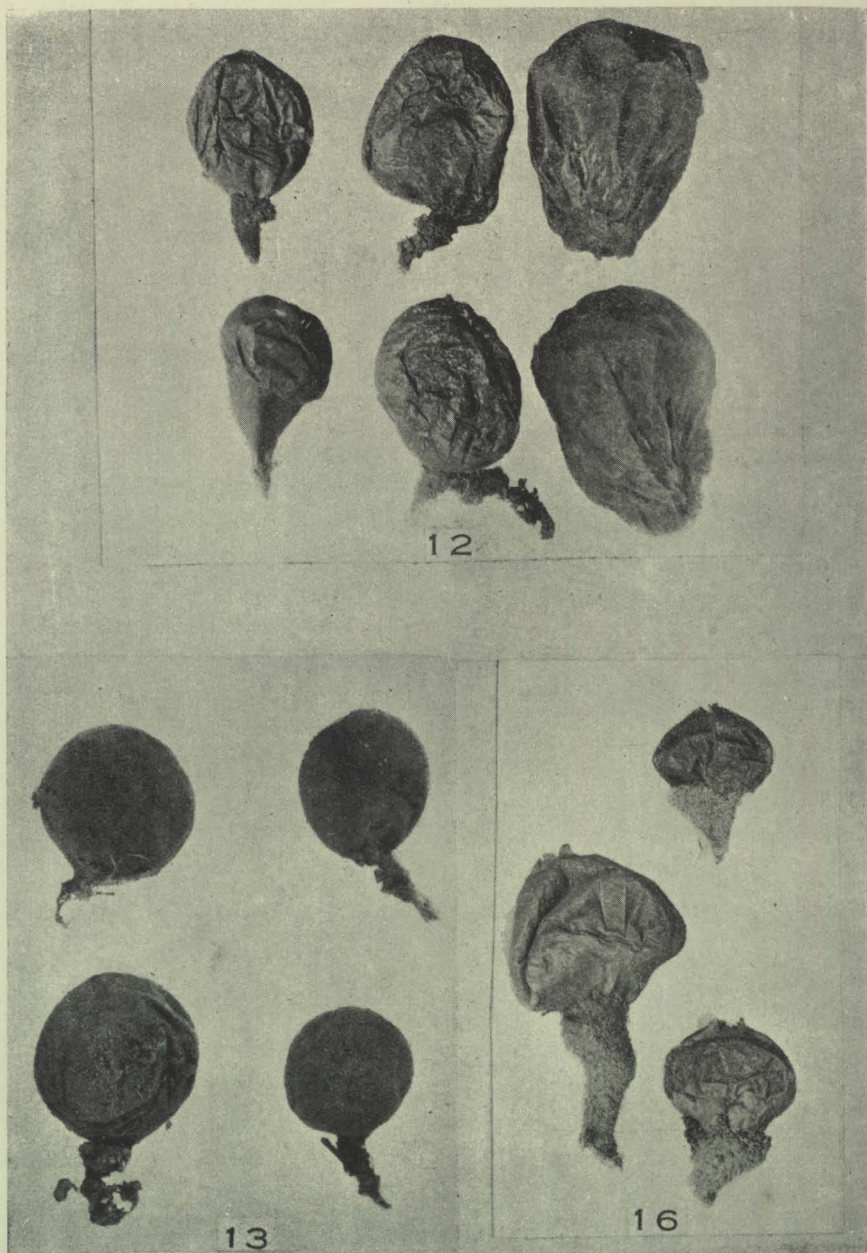
- FIG. 6.—*Lycopodium depressum*, natural size. Showing the prominent diaphragm separating the gleba from the sterile base.
- FIG. 7.—*Lycopodium compactum*, natural size. Showing the caespitose habit, and ligneous habitat.
- FIG. 8.—*Lycopodium compactum*, $\times 2$. Showing the spines of the exoperidium and, where these have fallen away, the reticulations on the endoperidium.
- FIG. 11.—*Lycopodium piriforme*, natural size. Note the minute granules of the exoperidium.



Photos, G. H. Cunningham.

FIG. 9.—*Lycopodium perlatum*, $\times \frac{1}{3}$. Showing the range and shape. Scars left by fallen verrucae are shown on several. Note also the caespitose habit.

FIG. 10.—*Lycopodium pyriforme*, $\times \frac{1}{2}$.

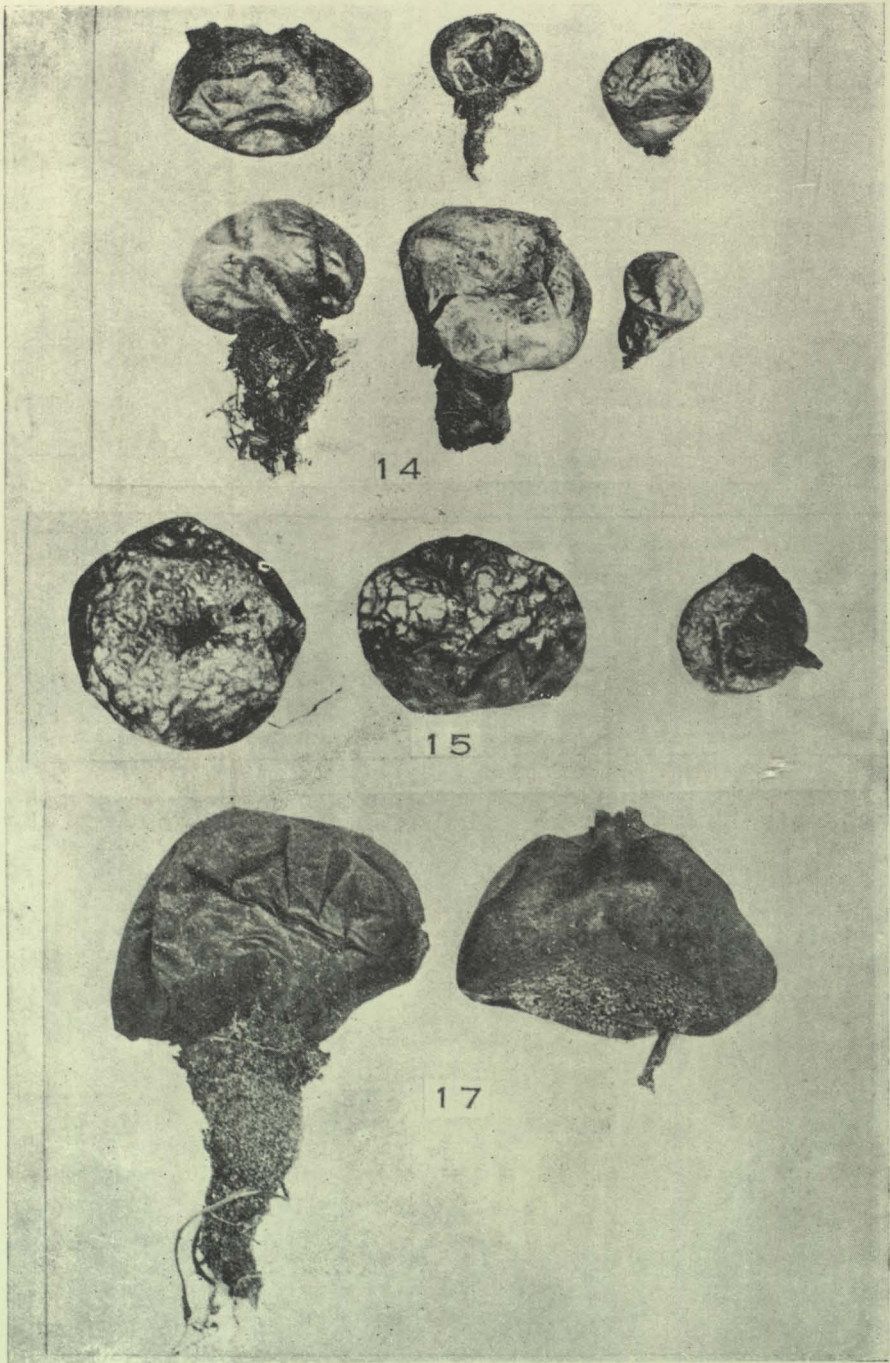


Photos, 12 and 16 by G. H. Cunningham, 13 by H. Drake.

FIG. 12.—*Lycoperdon polymorphum*, $\times \frac{1}{2}$. Note the almost glabrous exterior.

FIG. 13.—*Lycoperdon pusillum*, $\times 2$. Note the furfuraceous exoperidium and prominent rooting strand.

FIG. 16.—*Lycoperdon scabrum*, natural size. Showing the nature of the exoperidium.

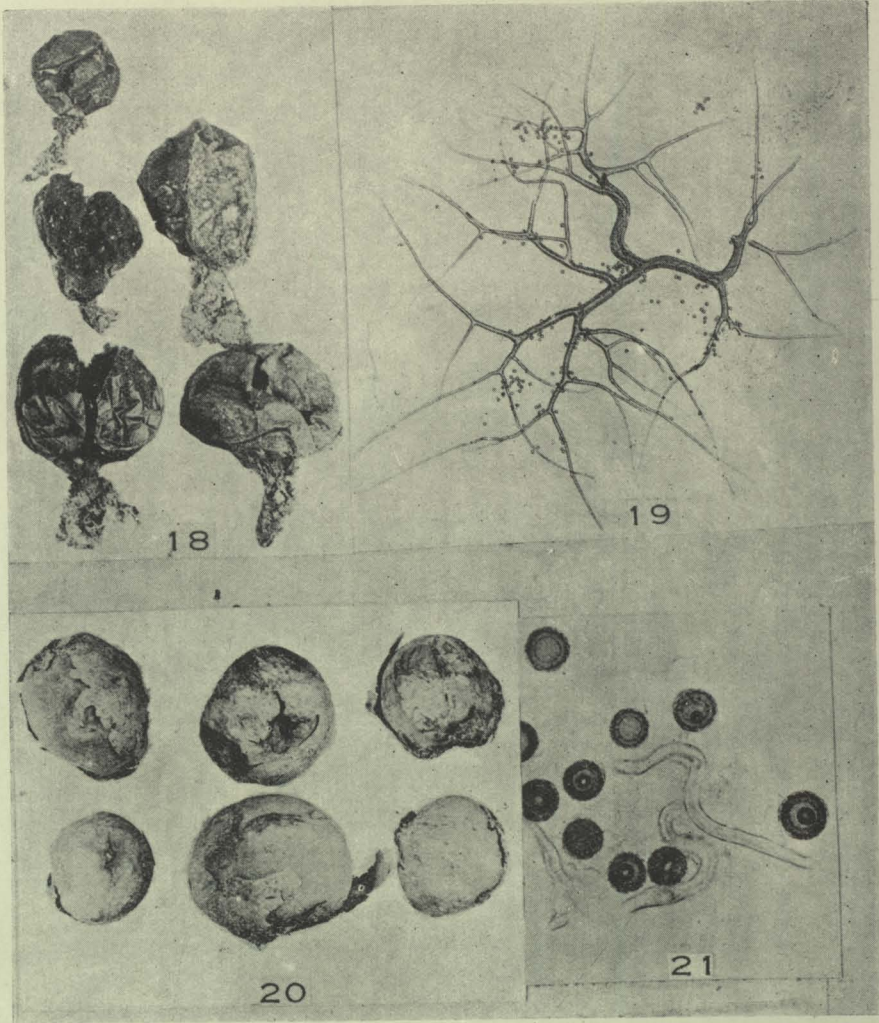


Photos, 14 by G. H. Cunningham, 15 and 17 by H. Drake.

FIG. 14.—*Lycoperdon glabrescens*, $\times \frac{1}{2}$. Note the glabrous endoperidium.

FIG. 15.—*Bovista brunnea*, natural size. Note the areolate nature of the peridium of this collection.

FIG. 17.—*Lycoperdon scabrum*, $\times 2$. Showing the sterile base and prominent rooting base.



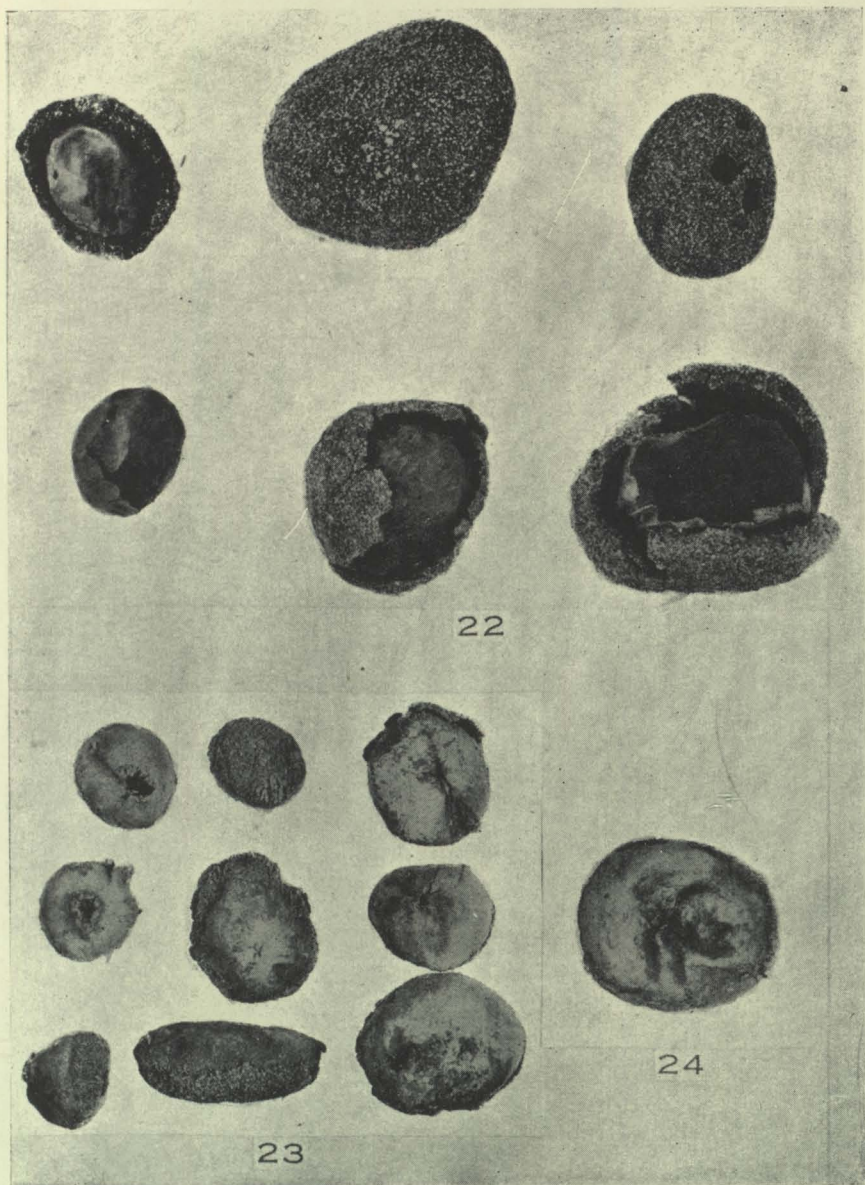
Photos, G. H. Cunningham.

FIG. 18.—*Lycoperdon spadiceum*, natural size. Section showing the cellular sterile base in left centre; this collection is more furfuraceous than usual. White objects in gleba are insect larvae.

FIG. 19.—*Bovista purpurea*, capillitium $\times 110$.

FIG. 20.—*Bovista purpurea*, $\times \frac{3}{2}$. Note the partially persistent exoperidium.

FIG. 21.—*Abstoma purpureum*, capillitium and spores, $\times 540$.

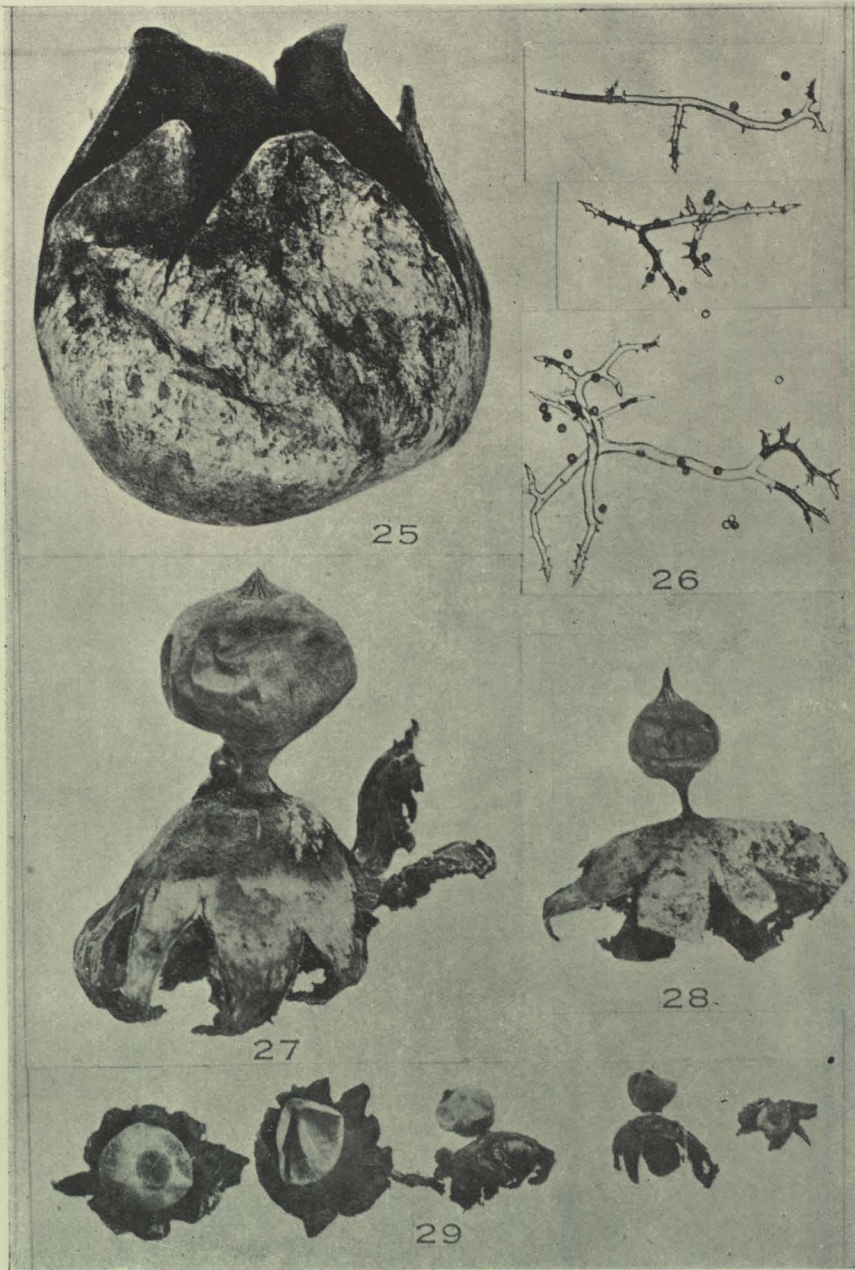


Photos, 22 by H. Drake, 23 and 24 by G. H. Cunningham.

FIG. 22.—*Abstoma purpureum*, natural size. Note the thick, sand-case exoperidium (lower right), thin nature of the endoperidium, and the manner in which the exoperidium is worn through by sand erosion (top right).

FIG. 23.—*Disciseda candida*, $\times \frac{3}{4}$. Note the persistent exoperidium, reticulate, gelatinous layer and fimbriate, mammosedentary stoma.

FIG. 24.—*Disciseda verrucosa*, natural size.



Photos, 26 by G. H. Cunningham, others by H. Drake.

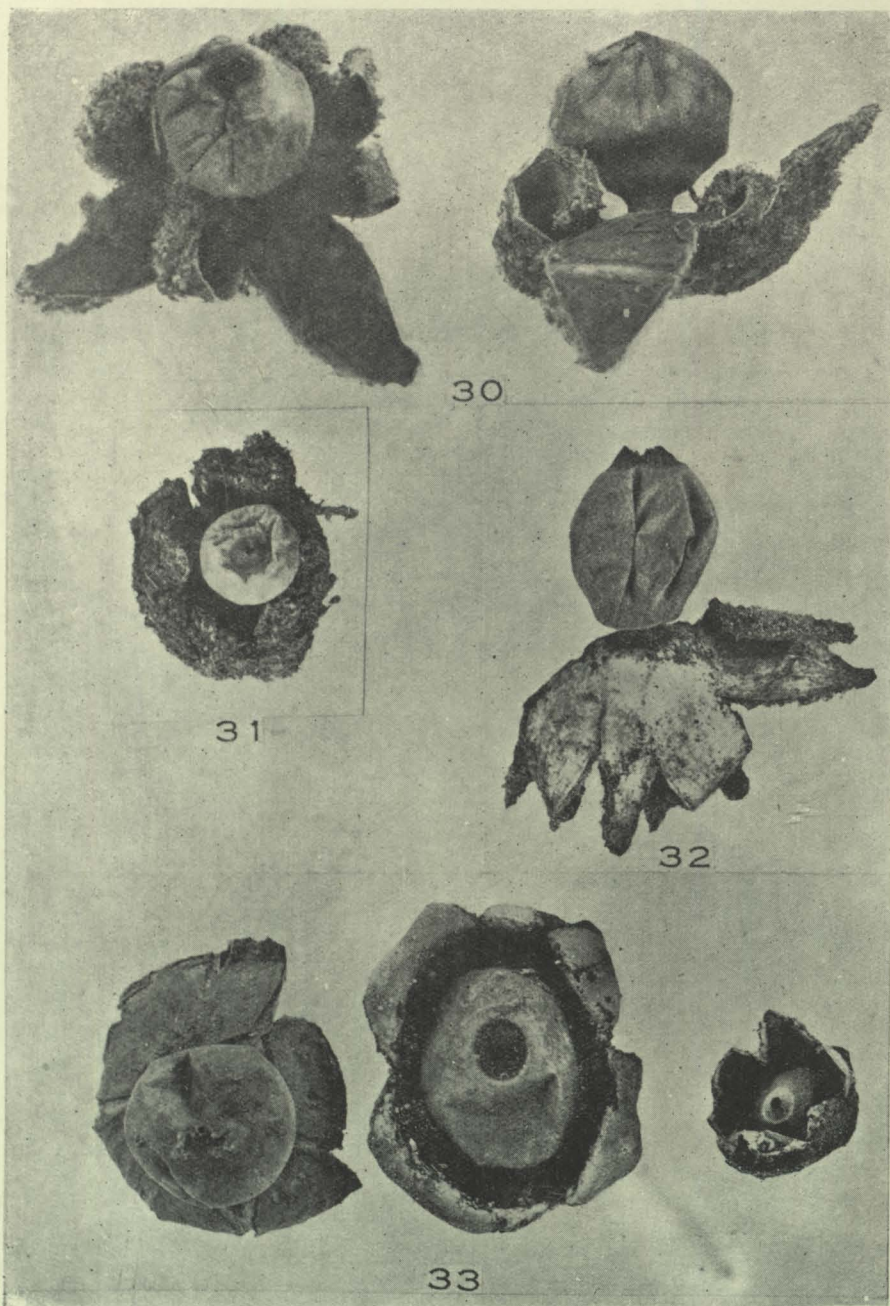
FIG. 25.—*Mycenastrum corium*, $\times \frac{3}{4}$. Showing the thick endoperidium and stellate method of dehiscence.

FIG. 26.—*Mycenastrum corium*, capillitium $\times 125$. Showing the spinose nature of the threads; air bubbles in the lumen of the threads show dark in the photo.

FIG. 27.—*Geaster pectinatus*, natural size. Showing the sulcate peristome.

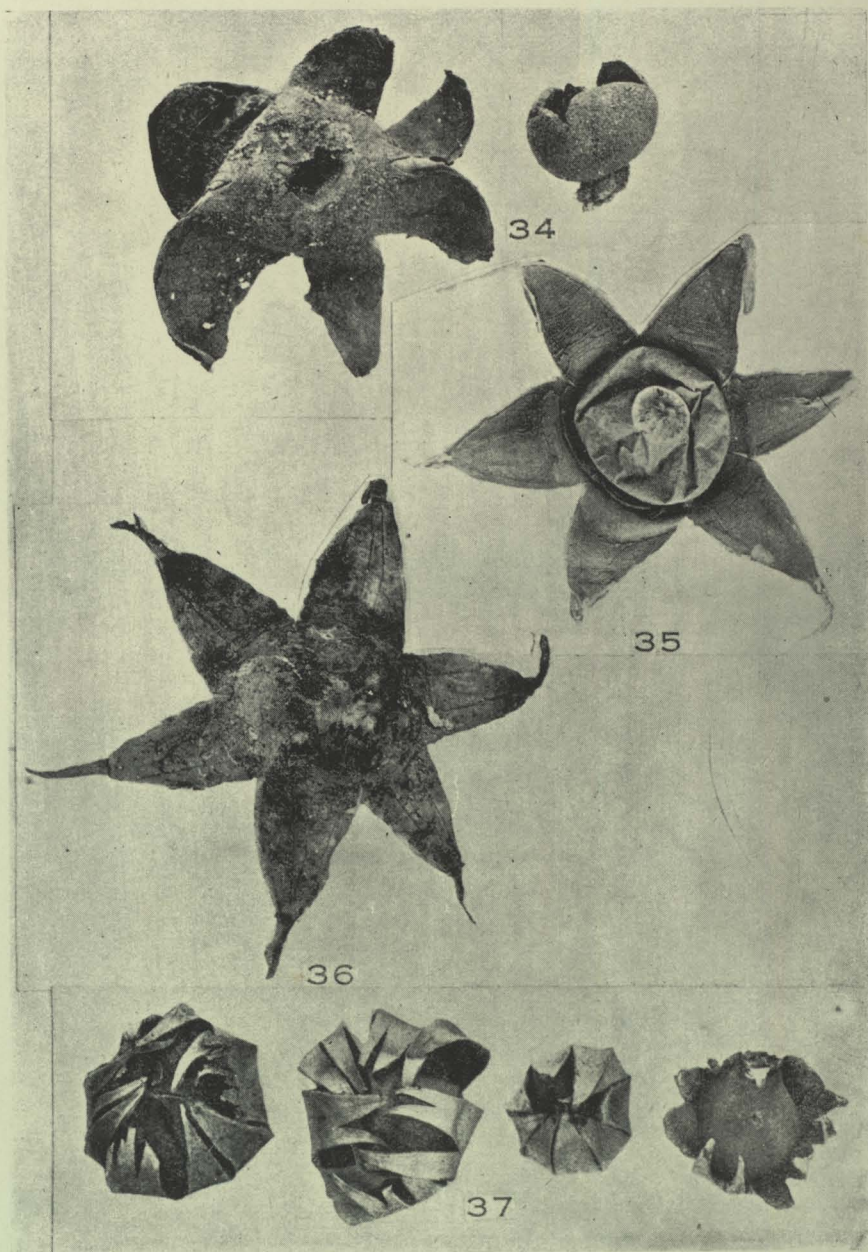
FIG. 28.—*Geaster plicatus*, natural size.

FIG. 29.—*Geaster minus*, natural size.



Photos, H. Drake.

- FIG. 30.—*Geaster limbatus*, typical form. Natural size.
 FIG. 31.—*Geaster limbatus*, natural size. Farinose, sub-hygroscopic form.
 FIG. 32.—*Geaster limbatus*, natural size. This Lloyd has named *G. rufescens*.
 FIG. 33.—*Geaster velutinatus*, natural size. Typical form in the centre; freshly expanded plant on the right.



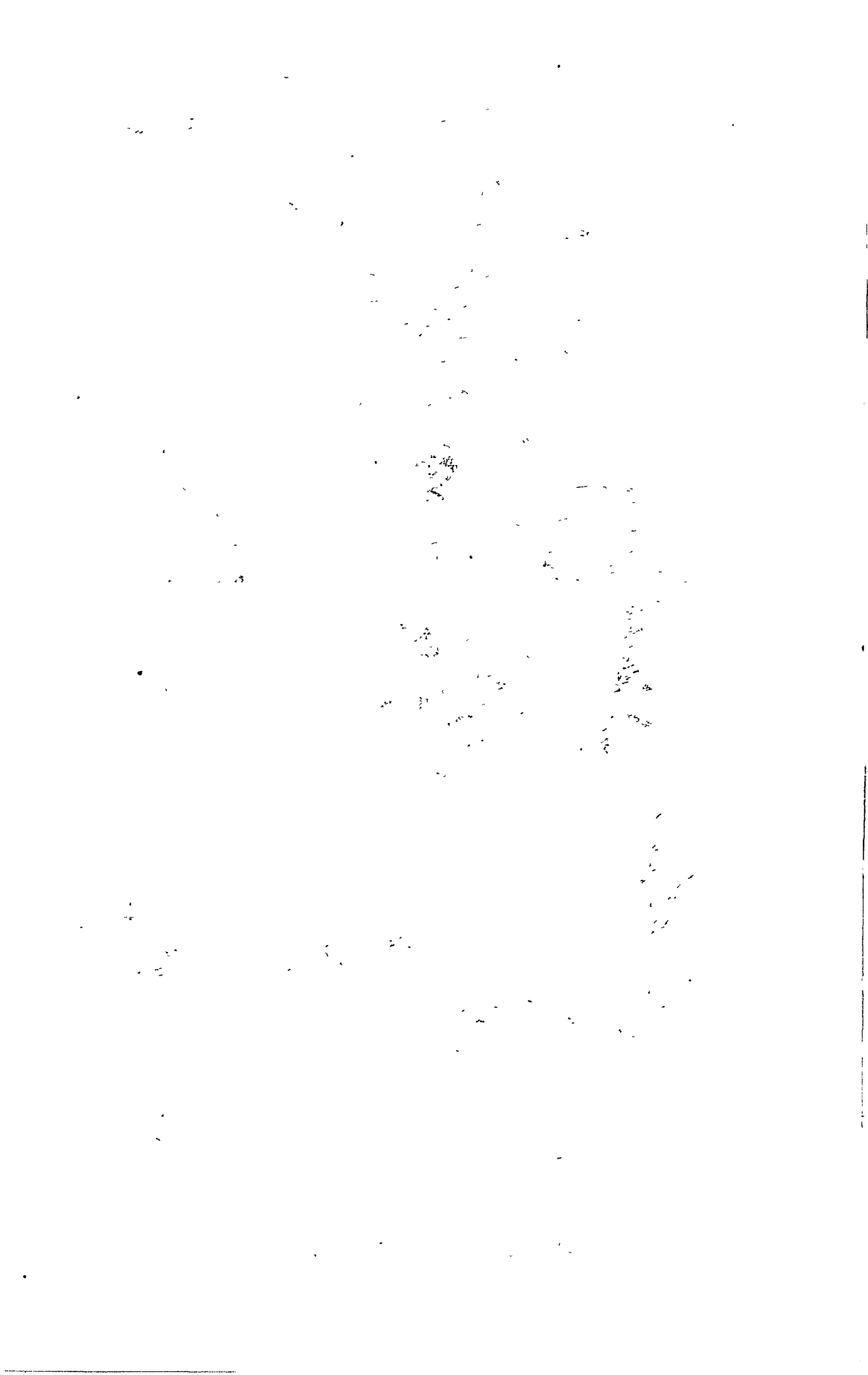
Photos, 35 by G. H. Cunningham, others by H. Drake.

FIG. 34.—*Geaster velutinus*, natural size. Exterior of exoperidium showing its tomentose nature and prominent umbilical scar.

FIG. 35.—*Geaster triplex*, $\times \frac{1}{2}$.

FIG. 36.—*Geaster triplex*, $\times \frac{1}{2}$. Showing the glabrous exterior of the exoperidium.

FIG. 37.—*Geaster floriformis*, natural size. Note the strongly hygroscopic exoperidium.



Habitat: Solitary, in groups, or caespitose on the ground or upon rotting wood in pastures or in the forest; epigeaeal.

Distribution: World-wide.

A cosmopolitan genus found in practically every country in the world. It is a difficult one for the systematist, as different plants in the same collection may vary to such an extent as to make specific delimitation often a matter of difficulty.

In the past most species were erected upon such variable characters as the colour of the gleba, size and shape of the peridium, nature of the exoperidium, and presence or absence of a sterile base. To-day these are not considered of specific import unless well characterized, for the colour of the gleba would appear to depend upon the age of the plants at the time they were collected; if gathered when immature, the gleba may be yellow, the olivaceous or purple colour appearing only in the mature plant. The size and shape of the peridium are also of little value as specific characters, for in *Lycoperdon polymorphum* plants range in size from minute forms the size of a pea to large forms 6 cm. or more in diameter; the shape may range from globose, through pyriform to turbinate. The sterile base is also a variable character, for in the same collection may be plants in which this structure is strongly developed or almost wanting. Finally the exoperidium may in the same collection be spinous, verrucose, or almost granular (*L. depressum*), yet upon the degree of roughness of the exoperidium most species have been erected.

Various attempts have been made to subdivide the genus. For example Quelet erected the genus *Globaria* to contain those species without a sterile base—a character which was previously used by Persoon to separate *Bovista* from *Lycoperdon*. This character cannot be considered of generic value, however, for as has been pointed out, the sterile base may be present or absent in different plants of the same collection, being in fact one of the most variable features of the genus.

More recently Lloyd (1905, a) has separated from *Lycoperdon* and placed under *Bovistella* all plants possessing a rooting base together with pedicellate spores or capillitium of the *Bovista* type, or both. The result has been to take away species with typical *Lycoperdon* capillitium, and place them under *Bovistella*, solely because the spores were pedicellate. In the Lycoperdeae the capillitium is the most satisfactory character by which most of the genera may be separated, consequently such treatment does not aid the systematist.

Owing to the different opinions held by systematists regarding the specific value of many of the characters discussed, it is difficult to obtain any idea as to the number of species extant, for this number varies considerably with different workers; for example Masee (1887) discusses no less than 129 species! Probably the number is in the vicinity of 30, for the modern tendency is to reduce rather than to increase the number, the many others that have been proposed being now considered as variable forms of these.

In New Zealand there are nine well-marked species, recognisable in that they can be "keyed," for the writer believes this to be the final test of a species.

KEY TO THE SPECIES.

- A. Spores without definite pedicels
- a. Diaphragm present, separating the gleba from the prominent sterile base 1. *L. depressum*
- b. Diaphragm absent
- (a): Sterile base cellular, usually well developed
- *Capillitium hyaline 2. *L. compactum*
- **Capillitium deeply coloured
- †Capillitium sparingly branched, or simple
1. Exoperidium of minute con-
nivent spines 3. *L. piriforme*
2. Exoperidium of conspicuous
pointed verrucae 4. *L. perlatum*
- ‡Capillitium freely branched 5. *L. spadiceum*
- (b). Sterile base compact, not cellular 6. *L. polymorphum*
- (c). Sterile base absent 7. *L. pusillum*
- B. Spores long-pedicellate
- a. Exoperidium furfuraceous 8. *L. glabrescens*
- b. Exoperidium of long, cruciate spines 9. *L. scabrum*

1. *Lycoperdon depressum* Bonorden, *Bot. Zeit.*, vol. 15, p. 611, 1857.
(Figs. 4, 5, 6.)

Peridium yellow, becoming pallid brown, up to 5 cm. diam., elliptical, obconic or subturbinate, frequently constricted towards the base and plicate; exoperidium of white spines united at their apices, immixed with numerous simple spines and granules, larger and more numerous basally, partially disappearing with age; endoperidium yellow-brown, dehiscing by a definite apical stoma, later the whole of the apical portion falling away; sterile base occupying the lower third of the peridium, bay brown or umber, of large cells, separated from the gleba by a well-defined diaphragm.

Gleba yellowish, becoming pallid olivaceous; columella absent; capillitium threads hyaline, simple or sparingly branched, septate, not pitted. Spores globose, 3-5.5 mmm. diam., apedicellate; epispore pallid olivaceous, finely and closely verrucose.

Habitat: Solitary or in small groups on the ground, often forming rings in pastures.

Distribution: Britain; Europe; South Africa; Australia; New Zealand.

Queenstown, Otago, May, 1922, *J. B. Cleland!*

Rotorua, Auckland, June, 1919, *J. Barr!*

Tasman, Nelson, Feb., 1922, *G.H.C.*

Mapua, Nelson, May, 1922, *G.H.C.*

Tapanui, Otago, Mar. 1923, *G.H.C.*

Dun Mt., Nelson, June, 1923, *J. C. Neill!*

Whakatikei, Wellington, June, 1923, *J. C. Neill!*

Weraroa, Wellington, May, 1924; Mar., 1925, *J. C. Neill!*

Ashburton, Canterbury, Jan., Feb., Mar., Aug., 1925, *J.*

C. Neill!

The species is characterised by the prominent diaphragm, large, cellular base, and hyaline, freely septate, simple or sparingly branched, capillitium. It is the most abundant species in New Zealand and Australia, is apparently common in Europe, but strangely

absent from North America, where it appears to be replaced by a form Lloyd has named *L. sub-pratense*, separated by its coloured capillitium.

Lloyd (1905, c) states he believes this species is probably *L. hiemale* Vitt., and possibly *L. pratense* Pers., but has produced no evidence in support of this statement; nevertheless the species is regularly discussed in his works under the latter name.

2. *Lycoperdon compactum* n. sp. (Figs. 7, 8.)

Peridium up to 4 cm. diam., subglobose or pyriform, depressed above, compressed below into a short, stem-like base; exoperidium of strong brown spines, 3-4 mm. long, separate at the base, frequently connivent at the apices, surrounded by a ring of minute brown warts or granules, the spines partially disappearing with age, when the endoperidium appears reticulate from the presence of the persistent rings of granules; endoperidium membranous, ochraceous, becoming brown, dehiscing by an apical, plane, torn, small stoma; sterile base occupying the stem-like base, often rudimentary, minutely cellular, ochraceous; diaphragm absent.

Gleba olivaceous, pulverulent; columella small, elliptical; capillitium threads hyaline, sparsely branched or simple, septate, diameter of the spores, not pitted. Spores globose, 3.5-4.5 mmm. diam., with caducous pedicels up to 5 mmm. long; epispore olivaceous, closely and finely verrucose.

Habitat: In small groups or caespitose on rotting wood on the forest floor.

Distribution: New Zealand.

Lake Papaetonga, Wellington, Aug., 1919, G.H.C.

York Bay, Wellington, Feb., 1923, E. H. Atkinson! Type collection.

The species is characterized by the strongly spinous exoperidium, minutely cellular sterile base, hyaline, septate capillitium, and finely verrucose spores. It is peculiar in that it possesses certain characters of several species, for it has the exoperidium of *L. echinatum* Pers.; a sterile base resembling that of *L. Hoylei* Berk., spores of *L. perlatum* Pers., and capillitium of *L. depressum* Bon.

The exoperidium is clothed with long (3-4 mm.) dark brown, almost black spines, which are free at their bases, but frequently connivent at their apices; at the base each is surrounded with a ring of numerous coloured granules. When the spines fall away, the endoperidium appears reticulate, owing to the presence of these rings of granules, which persist and form a net-like series of fine lines.

The habit of growing upon wood is also a feature of the plant, being peculiar to only one other New Zealand species, *L. piriforme*.

3. *Lycoperdon piriforme* Schaeffer ex Persoon, *Syn. Meth. Fung.*, p. 149, 1801 (Figs. 10, 11.)

Peridium up to 10 cm. diam., grey to bay brown, pyriform, sub-turbinate or subglobose, with a compressed, slender, stem-like base; exoperidium of fine, scattered, brown or black, persistent, pointed verrucae and granules; endoperidium brown, membranous, dehiscing

by an apical, small, plane, torn stoma; sterile base prominent, forming the stem-like base, cellular, pallid tan or yellowish; diaphragm absent.

Gleba greenish-yellow, becoming ferruginous or olivaceous; columella prominent, subglobose; capillitium threads olivaceous, sparingly branched or simple, continuous, about the diameter of the spores, not pitted. Spores globose, 3.5-4.5 mmm. diam., apedicellate; epispore pallid olivaceous, delicately verruculose.

Habitat: Solitary, in groups, or caespitose on rotting wood on the forest floor, or on standing stumps.

Distribution: Britain; Europe; North and South America; India; Japan; Australia; New Zealand.

Lake Papaetonga, Wellington, Aug., 1919, *G.H.C.*

Pokaka, Waimarino County, Feb., 1922, *D. Miller!*

Weraroa, Wellington, Aug., 1919, May, 1923, *G.H.C.*

Whakatikei, Wellington, June, 1923, *J. C. Neill!*

Day's Bay, Wellington, Apl., 1926, *D. W. McKenzie!*

Characterised by the minute verrucae of the exoperidium, the (usually) pyriform shape, almost smooth spores, and habit of growing upon rotting wood. It is liable to confusion only with *L. perlatum*, from which it may be separated by these characters.

4. *Lycoperdon perlatum* Persoon, *Syn. Meth. Fung.*, p. 148, 1801. (Fig. 9.)

L. gemmatum Batsch ex Auett.

L. excipuliforme (Scop.) Vitt., *Mon Lyc.*, p. 49, 1842.

L. montanum Quel., *Champ. Dura*, p. 444, 1876.

L. Cölensoi Cke. et Mass., *Jour. Roy. Micr. Soc.*, p. 711, 1887.

L. tasmanicum Mass., *Kew. Bull.*, p. 158, 1901.

L. macrogemmatum Lloyd, *Myc. Notes*, p. 265, 1906.

Peridium up to 6 cm. diam., yellowish, becoming bay-brown, subglobose, pyriform or turbinate, often tapering into a cylindrical stem-like base; exoperidium of white verrucae, surrounded by a ring of smaller warts and granules, which give a reticulated appearance to weathered specimens; endoperidium bay-brown, membranous, dehiscing by a small stoma situated at the apex of a definite umbo (which is frequently wanting); sterile base occupying the stem-like base, prominent, cells large, ferruginous, often tinged with purple; diaphragm absent.

Gleba yellowish, becoming olivaceous; columella prominent, elliptical; capillitium threads deep chestnut brown, sparsely branched or simple, continuous, not pitted. Spores globose, 3.5-4 mmm. diam., apedicellate; epispore pallid olivaceous, finely and closely verrucose.

Habitat: Solitary, in groups or caespitose on the ground, usually in vegetable debris on the forest floor.

Distribution: Britain; Europe; North and South America; India; East and South Africa; Algeria; Australia; New Zealand.

Weraroa, Wellington, Jan., 1920, *G.H.C.*

Raurimu, Jan., 1920, *E. H. Atkinson!*

Whakatikei, Wellington, June, 1923, *J. C. Neill!*

Orepuki, Southland, Nov., 1924, *J. C. Neill!*

The peculiar pointed verrucae of the exoperidium, which fall away and leave the endoperidium reticulate on account of the persistent smaller warts and granules, is the chief character of this species. It closely resembles *L. piriforme*, but is separated by this character, and by the more strongly warted spores; the sterile base, too, is usually more deeply coloured than that of *L. piriforme*.

5. *Lycoperdon spadicum* Persoon, *Jour. Bot.*, vol. 2, p. 20, 1809 (Fig. 18.)

L. Cookei Mass., *Jour. Roy. Micr. Soc.*, p. 714, 1887.

Peridium up to 25 mm. diam., subglobose or more commonly shortly pyriform, with a long and slender rooting base, which may sometimes be branched; exoperidium furfuraceous, often in the form of mealy squamules; endoperidium umber brown, papyraceous, smooth, dull, flaccid, sometimes covered with lime granules, dehiscing by an apical, torn, plane stoma; sterile base scanty, occupying the lower third of the peridium, of minute cells, umber brown; diaphragm absent.

Gleba olivaceous, becoming umber; columella absent; capillitium threads olivaceous, freely branched, continuous, about the diameter of the spores, not pitted. Spores globose, apiculate, 4-4.5 mm. diam.; epispore olivaceous, minutely but distinctly verruculose.

Habitat: Solitary or in small groups on the ground.

Distribution: Britain; Europe; Australia; New Zealand.

Ashburton, Canterbury, Aug., 1925, *J. C. Neill!*

Kelburn, Wellington, July, 1925, *G.H.C.*

The plant may be recognised by the small size, pyriform shape, long rooting base and small-celled sterile base. The capillitium is freely branched, the plant differing in this respect from the European form; but in all other particulars it appears to be similar, even to the incrustation of lime granules on the peridium of occasional plants.

The cellular base separates it from *L. pusillum*, which it resembles in size, colour and nature of the gleba; and from small forms of *L. polymorphum*, that of the latter plant being compact.

6. *Lycoperdon polymorphum* Vittadini, *Mon. Lyc.*, p. 39, 1842. (Fig. 12.)

L. furfuraceum, Schaeff. ex de Toni, in *Sacc. Syll. Fung.*, vol. 7, p. 110, 1888.

L. cepaeforme (Bull.) Mass., *Jour. Roy. Micr. Soc.*, p. 722, 1887.

L. hungaricum Hollos, *Mathem. Term.*, vol. 19, p. 1, 1901.

L. nigrum Lloyd, *Lyc. Aus.*, p. 30, 1905.

Peridium up to 6 cm. diam., yellow, becoming brown, depressed-globose, or more frequently pyriform, with or without a stem-like base; exoperidium of minute spines or verrucae, often furfuraceous, fugacious, endoperidium membranous, often smooth and polished, dehiscing by a small, torn, plane apical stoma; sterile base compact, of the same nature as the gleba, concolorous, frequently scanty; diaphragm absent.

Gleba yellowish, becoming olivaceous; columella absent; capillitium threads pallid olive, thin walled, freely branched, continuous, about the diameter of the spores, pitted. Spores globose, 4.5-5.5 mm. diam., apiculate; epispore tinted, closely and finely verruculose.

Habitat: Solitary or in small groups on the ground.

Distribution: Britain; Europe; North America; Algeria; South Africa; Australia; New Zealand.

Weraroa, Wellington, Oct., 1919, *E. H. Atkinson!*

The species is characterized by the nature of the sterile base, which is compact and composed of intricately interwoven hyphae of a similar type to that of the tissues of the gleba. Frequently the sterile base is scantily developed, when plants approach *L. pusillum*; to this form the name *L. cepaeforme* has been applied, but it is not possible to maintain this as a species, for in the same collection may be present plants with either scanty or well-developed sterile bases.

7. *Lycoperdon pusillum* Persoon, *Jour. Bot.*, vol. 2, p. 17, 1809. (Fig. 13.)

Bovista pusilla Pers., *Syn. Meth. Fung.*, p. 138, 1801.

Lycoperdon pusillum (Batsch) Fries, *Syst. Myc.*, vol. 3, p. 33, 1829.

L. dermoxanthum Vitt., *Mon. Lyc.*, p. 34, 1842.

L. microspermum Berk., in Hook. *Jour. Bot.*, vol. 6, p. 172, 1854.

L. mundulum Kalkbr., *Grev.*, vol. 9, p. 3, 1880.

Bovista pusilla (Fr.) de Toni; Mass., *Jour. Roy. Micr. Soc.*, p. 722, 1887.

B. dermoxanthum (Vitt.) de Toni, in Sacc. *Syll. Fung.*, vol. 7, p. 100, 1888.

B. mundula (Kalkbr.) de Toni, *l.c.*, p. 98.

Lycoperdon pseudopusillum Hollos, *Noev. Koezl.*, vol. 2, p. 75, 1903.

L. semi-immersum Lloyd, *Myc. Notes*, p. 1306, 1924.

Peridium up to 20 mm. diam., globose or sub-globose, yellowish, becoming brown, with a prominent basal rooting strand; exoperidium covered with minute fugacious mealy squamules or flattened verrucae; endoperidium membranous, smooth, shining, flaccid, dehiscing by a small, irregular, plane, apical stoma; sterile base absent.

Gleba yellowish, becoming brown; columella absent; capillitium threads olive, continuous, freely branched, pitted. Spores globose, 3.5-5 mm. diam., apiculate; epispore olive, finely and distinctly verruculose.

Habitat: Solitary or in small groups on the ground, often in cultivated fields.

Distribution: Britain; Europe; North America; China; East and South Africa; Ceylon; Australia; New Zealand.

Ashburton, Canterbury, Jan., May, 1925, *J. C. Neill!*

Roxburgh, Otago, May, 1925, *J. C. Neill!*

This is a small plant with a sub-globose peridium, and small but strongly developed rooting base. It is characterized by the absence of a sterile base, the freely branched, pitted capillitium, and flaccid, shining peridium.

8. *Lycoperdon glabrescens* Berkeley, *Fl. Tas.*, vol. 2, p. 226, 1860.
(Fig. 14.)

Bovistella glabrescens (Berk.) Lloyd, *Lyc. Aus.*, p. 28, 1905.

B. australiana Lloyd, *l.c.*

B. rosea Lloyd, *Myc. Notes*, p. 248, 1906.

Peridium up to 5 cm. diam., depressed globose or sub-globose, often pyriform, tapering into a small but well-developed stem-like base; exoperidium of small warts, larger towards the apex; fugacious; endoperidium bay brown, smooth, membranous, dehiscing by a small, erumpent, torn, apical stoma; sterile base well developed, cells small, often tinged with purple; diaphragm absent.

Gleba dark olivaceous, often with a purple cast; columella wanting; capillitium threads freely branched, deeply coloured, about the diameter of the spores, continuous, pitted. Spores globose, 4-5 mm. diam., pedicels tinted, acuminate, up to 15 mm. long; episporium olivaceous, minutely verruculose.

Habitat: In groups on the ground, usually in pastures.

Distribution: Australia; New Zealand.

Queenstown, Otago, May, 1922, *J. B. Cleland!*

Ashburton, Canterbury, Aug., 1925, *J. C. Neill!*

This and the following species possess long, persistent pedicels attached to the spores; these structures are usually 12-15 mm. in length, tinted and acuminate. Species with this character are readily segregated into a pedicellate section. As has been shown, Lloyd places these two species in *Bovistella*, but as both possess the capillitium of the *Lycoperdon* type, the writer believes they should be retained in the latter genus.

Lloyd has named this species *Bovistella australiana*, but as the species is well covered by the description of *L. glabrescens*, his specific name *australiana* is considered superfluous.

The species is separated from the following solely by the nature of the exoperidium, which consists of fine fugacious warts and granules, not of cruciate spines; they are closely related, however, so much so that it would not be possible to separate forms of either species from which the exoperidium had disappeared.

9. *Lycoperdon scabrum* (Lloyd) n. comb. (Figs. 16, 17.)

Bovistella scabra Lloyd, *Myc. Notes*, p. 282, 1906.

B. nigrica Lloyd, *Myc. Notes*, p. 1115, 1922.

Peridium up to 3 cm. diam., depressed globose or pyriform, umber, with a well-developed rooting base; exoperidium of long black or brown spines, 1-3 mm. long, free at base, frequently connivent at apices, fugacious; endoperidium umber, at length smooth, shining, membranous, dehiscing by an apical, erumpent, torn, toothed stoma; sterile base occupying the lower third of the peridium, of small cells, colorous; diaphragm absent.

Gleba olivaceous, becoming umber; columella absent; capillitium threads olivaceous, freely branched, pitted, continuous. Spores globose, 4-5 mm. diam., pedicels up to 15 mm. long, tinted, acuminate; episporium olive, finely and evenly verruculose.

Habitat: Solitary or in small groups on sandy ground.

Distribution: Australia; New Zealand.

Werarora, Wellington, Oct., 1919, *E. H. Atkinson!*

Levin, Wellington, Nov., 1919, *G.H.C.* Type collection of
Bovistella nigrica Lloyd.

Characterized by the long connivent spines of the exoperidium. *Bovistella nigrica* is identical in all particulars save that of colour, but the colour is not constant, for in one collection are both bay brown and umber brown specimens.

DOUBTFUL AND EXCLUDED SPECIES.

The following have been recorded in literature as having been collected in New Zealand. Most of the records are in Masee's Monograph (1887), in which he appears to have described as new every specimen in the Kew herbarium which was not placed in the cover of some well-known European species. His so-called species have been compiled in Cooke's Handbook (1892), but apparently no attempt has been made to ascertain their validity.

- a. *L. Colensoi* Cke. et Mass. = *L. perlatum* Pers.
- b. *L. Fontanesii* Dur. et Mont = *Calvatia caelata* (Bull.) Morg.
- c. *L. microspermum* Berk. = *L. pusillum* Pers.
- d. *L. novae-zelandiae* Lev. = *Calvatia lilacina* (B. et M.)
Lloyd.
- e. *L. reticulatum* Berk. in Herb.; Mass. This is probably a synonym of *L. pusillum* Pers. or *L. perlatum* Pers., but the description is too poor to allow of its being placed with any degree of certainty.
- f. *L. Sinclairii* Berk. = *Calvatia lilacina* (B. et M.)
Lloyd.

(3) *Bovistella* Morgan, *Jour. Cin. Soc. Nat. Hist.*, vol. 14, p. 145, 1892.

Peridium globose or pyriform, with a well-developed rooting base; of two layers, an external, thin, usually fugacious exoperidium; and an inner, flaccid, membranous endoperidium which dehisces by an apical, definite stoma; sterile base present or absent; diaphragm absent.

Gleba of capillitium and spores; columella absent; capillitium threads free, each consisting of a thick main stem and numerous dichotomous tapering, acuminate branches. Spores coloured, continuous, rough or smooth, globose or elliptical, pedicellate or not.

Habitat: Solitary or in small groups on the ground; remaining attached at maturity to the place of origin; epigaeal.

Distribution: Britain; Europe; North America; India; Australia; New Zealand.

Morgan's conception of the genus, based on a single species, was a *Bovista* with a sterile base. In his earlier paper Lloyd (1905, a) claimed the presence of a sterile base was not a good character on which to separate *Bovistella* from *Bovista* (basing his argument on

the fact that its absence has not been considered of sufficient importance to separate the proposed genus *Globalaria* Quel. from *Lycoperdon*), and proposed to separate the two upon habit, *Bovista* being a genus in which plants break away at maturity from the point of attachment, *Bovistella* persisting as does *Lycoperdon*. And it will be seen that this is the only character upon which separation of the two genera is possible. In a later paper Lloyd (1906) further emended the genus to include all plants possessing a rooting base together with either pedicellate spores or capillitium of the *Bovista* type, or both. This would necessitate the removal of many species from *Lycoperdon*, possessing the *Lycoperdon* type of capillitium but differing in the possession of pedicellate spores.

The writer cannot agree with Lloyd in this treatment of the genus, as several genera of the Lycoperdeae are separated upon the structure and nature of the capillitium, and to thus arbitrarily destroy this method of differentiation does not aid the systematist. Had he erected a separate genus, or a separate section, for those species of *Lycoperdon* possessing pedicellate spores and *Lycoperdon* capillitium, no complaint could be lodged, but his present stand is untenable.

Many species of *Lycoperdon* possess a freely branched capillitium, which superficially resembles that of *Bovistella* (as for example, *L. pusillum*, *L. spadiceum*, *L. polymorphum*); but as the threads of *Bovistella* may be readily removed intact, mounted and photographed (Fig. 19) it is evident the resemblance is merely superficial, and should not lead to confusion.

The genus contains about six species, only one of which is known to occur in New Zealand.

1. ***Bovistella bovistoides*** (Cke. et Mass.) Lloyd, *Myc. Notes*, p. 247, 1906.

Mycenastrum bovistoides Cke. et Mass., *Grev.*, vol. 16, p. 26, 1888.

Scleroderma bovistoides (C. et M.) de Toni, in *Sacc. Syll. Fung.*, vol. 7, p. 489, 1888.

Peridium globose, depressed globose or shortly pyriform, up to 2 cm. diam., with a strong rooting base; exoperidium thin, white, sometimes persisting as small areolate areas, but usually falling away completely; endoperidium flaccid, dull, bay brown, darker basally, stoma apical, slightly erumpent and toothed, or plane; sterile base absent.

Gleba olivaceous, becoming umber; capillitium threads scantily branched, thin walled, pitted, pallid chestnut brown. Spores globose, seldom obovate, 4-6 mmm. diam., pedicels tinted, attenuate, up to 15 mmm. long; epispore chestnut brown, closely and finely verruculose.

Habitat: Solitary or in small groups on the ground.

Distribution: Australia; New Zealand.

Lake Te Anau, Otago, Jan., 1920, *E. H. Atkinson!*

The rooting base separates the species from *Bovista brunnea*, which otherwise it resembles closely. As this structure may be absent from old and weathered specimens it then becomes difficult to place old specimens. In such cases the capillitium serves as the only character by which separation can be made, being more scantily branched and lighter in colour than that of *Bovista brunnea*.

EXCLUDED SPECIES.

a. *Bovistella australiana* Lloyd = *Lycoperdon glabrescens* Berk.

b. *Bovistella cuprica* Lloyd, Letter No. 60, p. 9, 1915.

This the writer believes to be a *Lycoperdon*, but the description is so poor as to make the placing in any genus uncertain.

c. *Bovistella nigrica* Lloyd = *Lycoperdon scabrum* (Lloyd)
G. H. Cunn.

d. *Bovistella scabra* Lloyd = *Lycoperdon scabrum* (Lloyd)
G. H. Cunn.

(4) **Bovista** Dillenius ex Persoon, *Syn. Meth. Fung.*, p. 136, 1801.

Peridium globose, subglobose or shortly pyriform; of an outer fugacious, thin and fragile exoperidium; and an inner membranous, tough, firm endoperidium; dehiscing by a single apical stoma; sterile base absent.

Gleba of capillitium and spores; columella absent; capillitium threads free, each consisting of a thick stem and numerous dichotomous, tapering, acuminate branches. Spores coloured, continuous, rough or smooth, globose, obovate or elliptical, pedicellate.

Habitat: Solitary or in small groups on the ground; breaking away from the point of attachment at maturity; epigaeal.

Distribution: Europe; North and South America; Australia; New Zealand.

The name *Bovista* was used by Persoon as a generic name for all plants of the genera *Bovista*, *Bovistella*, *Calvatia*, *Disciseda* and *Lycoperdon* devoid of a sterile base. This classification was followed by all workers until Morgan (1892) published an emended description of the genus, limiting it to plants with the characteristic capillitium described above, and devoid of a sterile base. As has been shown, the absence of a sterile base is not of generic value, so the writer would follow Lloyd (1905, a) in limiting the genus to plants with the *Bovista* capillitium and habit of breaking away from the point of attachment at maturity.

The walls of the capillitium threads are generally perforated with conic pits (absent from *B. purpurea*); but the pits are also present in certain species of *Bovistella* and *Lycoperdon*, so cannot be considered of generic import.

About 8 species are known, but only two are known to occur in New Zealand, one being endemic.

1. **Bovista brunnea** Berkeley, *Fl. N.Z.*, vol. 2, p. 119, 1855. (Fig. 15.)

Peridium depressed globose, up to 3 cm. diam., with a minute rooting base which usually breaks away at maturity; exoperidium white, furfuraceous, evanescent, often areolate; endoperidium chestnut-brown or pallid umber, firm, smooth, shining, often marked with fine areolate lines, stoma irregular, indefinite, slightly erumpent, toothed or entire, frequently plane.

Gleba pallid ferruginous or olivaceous; capillitium freely branched, walls thick, pitted, dark chestnut brown. Spores globose or obovate, 3.5-5 mmm. diam., pedicels tinted or hyaline, acuminate,

up to 14 mmm. long; epispore pallid ferruginous, closely and finely verruculose.

Habitat: Solitary on the ground.

Distribution: Australia; New Zealand.

Lake Te Anau, Otago, Jan., 1920, *E. H. Atkinson!*

Tapanui, Otago, Mar., 1922, *G. H. C.*

Peninsula, Otago, July, 1922, *Miss H. K. Dalrymple!*

Methven, Canterbury, Feb., 1925, *J. C. Neill!*

Lewis River, Caterbury, Feb., 1926, *G. H. C.*

Maruia River, Westland, Feb., 1926, *G.H.C.*

Characterized by the firm, brown, smooth and shining endoperidium, and freely branched, dark coloured, thick-walled capillitium threads. It closely resembles *Bovistella bovistoides* (see the note under this species), so much so that until he collected abundant specimens in the valleys of the Lewis and Maruia rivers, the writer was in doubt as to which species certain collections previously made should be referred, and in a previous paper (1925) placed several collections under *Bovistella bovistoides*.

2. *Bovista purpurea* Lloyd, *Myc. Notes*, p. 1201, 1923. (Figs. 19, 20.)

Peridium globose or depressed globose, up to 2.5 cm. diam.; with a small, pulvinate rooting base; exoperidium thin, dingy white or bay brown, falling away in irregular flakes, but partly persisting towards the base; endoperidium usually lead coloured, often purple, smooth, firm, shining, dehiscing by an irregularly torn, circular or elliptical, erumpent, toothed stoma.

Gleba purple brown; capillitium threads stout, freely branched, not pitted. Spores obovate or globose, 5-6 mmm. diam., pedicels hyaline, acuminate, up to 12 mmm. long; epispore chestnut brown, verruculose.

Habitat: Solitary on the ground.

Distribution: New Zealand.

Mapua, Nelson, May, 1922, *G.H.C.* Type collection.

Ashburton, Canterbury, Jan., 1925, *J. C. Neill!*

Blenheim, Marlborough, May, 1925, *J. C. Neill!*

The species is characterized by the dark colour, flaking, partly persistent exoperidium, and stout, freely branched, non-pitted capillitium threads.

DOUBTFUL SPECIES.

Bovista ovalispora Cke. et Mass., *Grev.*, vol. 16, p. 33, 1887.

This species, described from New Zealand material forwarded to Kew, is said to possess oval spores, 6x 4.5 mmm. Whether it is a valid species the writer is unable to judge from the description; but it is significant that the spores of *Bovista brunnea* and *B. purpurea* are frequently obovate.

(5) *Disciseda Czernaiaiev*, *Act Mosc.*, vol. 2, p. 153, 1845.

Catastoma Morgan, *Jour. Cin. Soc. Nat. Hist.*, vol. 14, p. 142, 1892.

Peridium depressed globose; of an outer exoperidium which may be thick or thin, membranous, or compact and formed of hyphae im-

mixed with sand or vegetable debris, fragile; breaking away irregularly save a small discoid basal portion; endoperidium papyraceous or membranous, tough, variously coloured, smooth or furfuraceous, dehiscing by a definite apical or basal stoma; sterile base absent.

Gleba of spores and capillitium, pulverulent at maturity; capillitium threads short, simple, occasionally short-branched, smooth, usually continuous, hyaline or coloured. Spores pedicellate or not, globose or elliptical, continuous, rough or smooth, coloured.

Habitat: Solitary, in small groups or caespitose on or in the ground; epigaeal or hypogaeal.

Distribution: Europe; Asia; Africa; North and South America; Australia; New Zealand.

Species of this genus were included under *Bovista* until Morgan (1892) showed the genus was separated by the nature of the capillitium, this consisting of simple fragments of hyphae, differing in this particular from *Bovista* (which has capillitium threads of a complex nature) and *Lycoperdon*, in which the threads are of a similar type but not fragmented.

In the species on which he based the genus *Catastoma*, Morgan stated that the stoma was at the base of the plant, and made this one of the chief characters of the genus. But since this period many species have been found with the stoma apical, so that this cannot be considered of generic import. It has been suggested that a separate genus should be erected to contain those species with the latter character, but this is impracticable, for with most species now placed in the genus it is not known whether the stoma is apical or basal.

On the appearance of Morgan's paper, Hollos (1903) was able to recognize the fact that the genus *Catastoma* was the same as the one erected 45 years previously by Czernaiaiev, so the name *Disciseda* must replace *Catastoma*. Lloyd has taken exception to this and throughout his publications uses the generic name *Catastoma*, a name which is untenable according to the rules of priority.

In most species the exoperidium is in the nature of a membrane composed partly of hyphae, partly of attached debris; in some it is distinctly membranous, yet even with species possessing this latter condition the former may be present.

About eight species are known, only two of which are found in New Zealand.

KEY TO THE SPECIES.

- | | |
|--|--------------------------|
| Spores 3-5 mmm. almost smooth | 1. <i>D. candida</i> |
| Spores 8-10 mmm., strongly verrucose | 2. <i>D. verrucosa</i> . |

1. *Disciseda candida* (Schw.) Lloyd, *Myc. Notes*, p. 100, 1902. (Fig. 23.)

Bovista candida Schw., *Fung. Carol.*, no 333, 1822.

B. circumscissa Berk. et Curt., *Grev.*, vol. 2, p. 50, 1874.

Catastoma circumscissa (B. et C.) Morgan, *Jour. Cin. Soc. Nat. Hist.*, vol. 14, p. 143, 1892.

Disciseda circumscissa (B. et C.) Hollos, *Term. Fuez.*, vol. 25, p. 102, 1902.

Peridium up to 3 cm. diam., depressed globose; exoperidium thick, firm, of hyphae and vegetable debris immixed, breaking away irregularly, save the cupulate basal portion; endoperidium ferruginous or umber, membranous, tough, covered in part by a gelatinous, reticulate layer (which may be wanting), dehiscing by a fimbriate, mam-mose stoma.

Gleba olivaceous, umber, or tinged with purple, pulverulent; threads of the usual type. Spores globose, 3.5-5 mmm. diam., apicu-late; episore pallid chestnut brown, very finely verruculose.

Habitat: Solitary or in small groups in grassy areas; hypogaeen.
Distribution: North America; Europe; South America; Aus-tralia; New Zealand.

Roxburgh, Otago, Aug., 1925, *J. C. Neill, D. W. McKenzie!*
Waikare, Canterbury, Jan., 1926, *G.H.C.*

Characterized by the small, almost smooth spores, fimbriate stoma, and gelatinous layer lying between the exoperidium and endoperidium. According to Morgan the stoma is situated at the base of the plant.

The gleba is olivaceous when young, deep umber when mature; frequently in Australian and New Zealand specimens, identical in all other respects, it is tinted purple. It might be suggested that the latter plants belong to a different species, but to separate a species on such a flimsy character seems to the writer to be absurd, especially as the colour is known to vary in other species. For example in the Australian *D. hyalotrix*, the colour may be purple or olivaceous.

2. *Disciseda verrucosa* n. sp. (Fig. 24.)

Peridium up to 3cm. diam., depressed globose; exoperidium brown, tough, consisting of hyphae and debris immixed, flaking away irregularly save a small persistent basal portion; endoperidium thick, tough, membranous, bay brown or purplish, dehiscing by an irregu-larly torn, toothed apical stoma.

Gleba purplish, pulverulent; capillitium threads tinted, usual type. Spores globose, 9-10.5 mmm. diam., apedicellate; episore chestnut brown, covered with coarse, round-topped pallid verrucae.

Habitat: Solitary on the ground; hypogaeen.

Distribution: Australia; New Zealand.

Milford Track, Otago, Jan., 1920, *E. H. Atkinson!* Type col-lection.

Characterized by the large, coarsely verrucose spores, indefinite toothed stoma and purplish gleba. The species would appear to be not uncommon in Australia, for four collections are in the possession of Dr. J. B. Cleland, Adelaide.

DOUBTFUL SPECIES.

Lloyd records *D. hypogaea* as being collected in Canterbury. The writer has seen no specimens from New Zealand.

Lloyd (1917) also describes a species under the name of *Catastoma magnum*, stated to have been collected in Canterbury. He considers

it differs from *D. anomala* in the larger size, thick, leathery exoperidium, and in the apedicellate, strongly roughened spores, but claims it is but a form of *D. anomala*. From his description it is impossible to say to what species it should be referred. The same "species" is recorded from South Africa by Verwoerd (1925).

(6) **Abstoma** n. gen.

Peridium subglobose, of two layers; a thick, fragile, exoperidium composed of hyphae immixed with sand particles, breaking away irregularly; and a papyraceous, fragile, coloured endoperidium which dehisces by irregular rupture, a stoma being absent.

Gleba of spores and capillitium, firm at maturity; capillitium threads short, occasionally branched, smooth, continuous, coloured. Spores apedicellate, globose, rough, coloured.

Habitat: Solitary or in small groups on the ground; hypogaeal.

Distribution: New Zealand.

Abstoma is separated from *Disciseda* because of the absence of a stoma, dehiscence being effected by the irregular breaking away of both exoperidium and endoperidium. The genus is known from the following endemic species.

1. **Abstoma purpureum** (Lloyd) n. comb. (Figs. 21, 22.)

Catastoma purpurea Lloyd, *Myc. Notes*, p. 1120, 1922.

Peridium up to 4 cm. diam., subglobose or depressed globose; exoperidium a sand case, up to 3 mm. thick, firm, brittle, dull purple, breaking away irregularly and completely; endoperidium thin, papyraceous, fragile, dark purple, almost black, free from the endoperidium save at the base, where attached, but not organically, dehiscing by irregular rupture.

Gleba purple, firm; capillitium threads deep chestnut brown, short, thick-walled. Spores globose or shortly elliptical, 10-14.5 mmm. diam., apedicellate; epispore deep chestnut brown, closely and finely reticulate.

Habitat: In sand among sand-dunes; hypogaeal.

Distribution: New Zealand.

Weraroa, Wellington, Nov., 1919, *E. H. Atkinson*, *S. A. Cunningham*, *G.H.C.* Type collections.

The species is characterized by the purple colour of the whole plant, the thick sand-case exoperidium, fragile, non-stomate endoperidium and deeply coloured, reticulate spores.

The habit is peculiar. The plant grows buried to a depth of several centimetres, 7-10 or more, in sand at Weraroa beach. When wind erosion occurs, as is frequent in this area of shifting dunes, the sand is blown for some distance, large amphitheatres being formed, and the globose plants are carried by the wind often to one kilometre or more from their place of origin. They are rolled along the ground and finally arrested by debris of the nature of branches of trees and stumps half buried at the tops of the long dune slopes. Here they come to rest, and the peridium is gradually removed by friction of sand-particles.

- (7) *Mycenastrum* Desvaux, *Ann. Sci. Nat.*, ser. 2, vol. 17, p. 143, 1842.

Peridium globose or subglobose, of two layers; a thin, floccose, fugacious exoperidium; and a thick, indurated, persistent endoperidium, dehiscing in a stellate manner, or by the irregular rupture of the apical portion; sterile base absent.

Gleba olivaceous, becoming umber, pulverulent; capillitium threads very abundant, of numerous short hyphæ, continuous, short-branched, branches beset with stout, spinous processes. Spores subglobose, coloured, coarsely echinulate.

Habitat: Solitary, in small groups or caespitose on the ground; epigeal.

Distribution: Europe; North America; Asia; India; Africa; Australia; New Zealand.

The genus contains a single species, and is characterized by the nature of the capillitium, the hard and coriaceous endoperidium and the method of dehiscence.

1. *Mycenastrum corium* (Guersent) Desvaux, *l.c.*, p. 147. (Figs. 25, 26.)

Lycoperdon corium Guersent, in DC., *Fl. Fr.*, suppl. 2, p. 598, 1815.

Scleroderma corium Grav., in Duby, *Bot. Gall.*, vol. 2, p. 892, 1830.

Mycenastrum phaeotrichum Berk., in Hook. *Jour. Bot.*, vol. 2, p. 418, 1843.

M. spinulosum Peck, *Thirty-third Rept.*, for 1879, p. 15, 1883.

M. olivaceum Cke. et Mass., *Grev.*, vol. 16, p. 33, 1887.

Scleroderma olivaceum (C. et M.) de Toni, in Sacc. *Syll. Fung.*, vol. 7, p. 139, 1888. *S. phaeotrichum* (Berk.) de Toni, *l.c.*

Peridium globose, subglobose or pyriform, up to 20 cm. or more in diam.; exoperidium tomentose, fugacious, greyish; endoperidium thick, 2-5 mm., smooth, polished, at first greyish, becoming bay brown, dehiscing in a stellate manner, or by the irregular falling away of the upper portion.

Gleba olivaceous, becoming umber; capillitium threads of the usual type. Spores subglobose, 11-13 mmm. diam., apedicellate; epispore chestnut brown, densely echinulate; wall 2 mmm. thick.

Habitat: Solitary, in groups or caespitose on the ground.

Distribution: Same as that of the genus.

Castlepoint, Wairarapa, Jan., 1923, *Miss Edwin!*

Spring Creek, Blenheim, Jan., 1925, *W. D. Reid!*

The species varies greatly in the size of the peridium, degree of spininess and branching of the capillitium, roughness of the spores; and colour of the gleba. If plants are collected and dried when young the gleba appears olivaceous; if dried when mature it is umber or even purple. On the former condition was based *M. olivaceum*;

on the latter *M. phaeotrichum*. Caespitose plants are frequent, at least in Australia and New Zealand.

(8) *Geaster Micheli* ex Fries, *Syst. Myc.*, vol. 3, p. 9, 1829.

Geastrum Pers., p.p., *Syn. Meth. Fung.*, p. 130, 1801.

Cycloderma Klotzsch, *Linnaea*, vol. 7, p. 203, 1832.

Peridium globose or acuminate; exoperidium of three layers, an external mycelial layer, a middle fibrillose layer, and an internal fleshy layer; at first closely investing the endoperidium, but distinct, splitting at maturity from the apex downwards into several stellate rays which may be revolute or involute; endoperidium pedicellate or sessile, membranous or papyraceous, thin, glabrous or roughened; dehiscing by a single apical stoma which may be peristomate or naked.

Gleba of capillitium and spores; columella present or absent; capillitium threads simple, long, apically acuminate, arising from the columella or inner wall of the endoperidium, coloured. Spores globose or subglobose, continuous, coloured, rough or smooth.

Habitat: Solitary, in groups, or caespitose on the ground or vegetable debris in open pastures, under hedgerows or on the forest floor; epigaeal or hypogaeal.

Distribution: World-wide.

In this genus are included about 30 species, of which 23 are found in Australasia, and 7 in New Zealand. No endemic species are known.

The mature plant consists of two well-defined groups of tissues—the exoperidium and the endoperidium.

EXOPERIDIUM.

In the mature plant this splits from the apex downwards into 5-14 or more variable rays. These may be expanded, revolute or involute; those plants with rays which are involute when dry (or during dry weather) are said to be hygroscopic; those with rays which remain expanded (or revolute) are said to be non-hygroscopic.

The exoperidium consists of three well-defined tissues:—

The mycelial or outer layer;

The fibrillose or middle layer; and

The fleshy or inner layer.

Mycelial layer. This is well seen in unexpanded plants. If these are epigaeal the exterior is either felted-tomentose (*G. velutinum*) or comparatively smooth (*G. triplex*). In the former case the layer is composed of stout, persistent hyphae arranged in a palisade 1-2 mm. thick; in the latter the layer is thin, more or less evanescent and composed of thin-walled hyphae.

If plants are hypogaeal the mycelial layer consists of long hyphae arising from all parts of the plant and ramifying for some distance into the substratum; consequently when such plants expand, this layer either holds the exoperidium permanently to the substratum, or, as more frequently happens, is torn away from the substratum, the mycelial layer then holding firmly to the exterior of the exoperidium quantities of vegetable debris. Thus the habit of freshly

gathered plants may be told at a glance, those which are epigaeal possessing an exterior free or almost free from debris, those which are hypogaeal having the exterior wholly or partially covered with debris. Even in herbarium specimens the habit as a rule may be determined by the presence or absence of debris.

Fibrillose layer. This tissue consists of intricately woven hyphae of two kinds, arranged with their long axes predominantly radial. The portion next the fleshy layer is strengthened by numerous thick-walled hyphae similar to those of the capillitium. At the base this layer is attached to the endoperidium and the columella and pedicel if present. The whole tissue is tough and membranous, and in old and weathered plants may be the only remaining tissue of the exoperidium.

Fleshy layer. This in freshly expanded plants is soft, thick and flesh coloured; after exposure it shrinks considerably, changes to some shade of brown, and frequently becomes rimose. It occasionally flakes away in irregular patches, and sometimes may peel from the fibrillose layer and assume a cupulate appearance around the base of the exoperidium. This tissue is definitely pseudoparenchymatous.

ENDOPERIDIUM.

This structure encloses the gleba, consisting of capillitium and spores. It is attached basally to the base of the exoperidium, and is perforated apically by a solitary stoma, through which at maturity the spores escape. In texture it is membranous or papyraceous, consisting of partly gelatinized hyphae. The exterior is usually glabrous, but may be farinose (*G. pectinatus*, *G. limbatus*), tomentose (*G. triplex*), or covered with roughened particles (*G. minus*). The colour ranges from dingy white to dark umber.

The endoperidium may be pedicellate, being attached by its base to the exoperidium by a pedicel of varying length and thickness, or sessile (the common condition with saccate plants) when it is attached by a broad base and partly enclosed within the saccate base of the exoperidium.

The apical stoma may be a poorly defined aperture scarcely discernible from the endoperidium—when the species is said to possess a naked, indefinite mouth; or the stoma may be enclosed within a definite peristome, when the species is said to possess a definite, peristomate mouth. Should the peristome be regularly pleated or fluted it is said to be plicate; if silky and made up of innumerable parallel fibrils arranged radially around the stoma it is said to be fibrillose.

Gleba. This embraces all tissues enclosed within the endoperidium. The capillitium threads consist of innumerable fusiform or cylindrical, coloured, continuous, sparsely branched hyphae. They arise from the columella and less abundantly from the inner surface of the endoperidium.

The spores are globose or sub-globose, usually some shade of brown, and possess verrucose or verrucose-echinulate epispores. Their size and epispore markings are useful diagnostic characters.

The columella arises from the base of the exoperidium (fibrillose layer) and is a continuation of the pedicel, when present. It is

usually cylindrical, but may be clavate or globose. It is often wanting in the mature plant (being used in the production of the threads of the capillitium) but may be readily seen when unexpanded plants are sectioned.

All the New Zealand species, with two exceptions (*G. triplex* and *G. velutinus*) are hypogaeal, developing underground and appearing on the surface only at dehiscence.

KEY TO SPECIES.

Mouth peristomate.	
Peristome sulcate:	
Base of the endoperidium smooth or striate	1. <i>G. pectinatus</i>
Base of the endoperidium plicate	2. <i>G. plicatus</i>
Peristome fibrillose.	
Endoperidium pedicellate.	
Plants minute, 1-3 cm.	3. <i>G. minus</i>
Plants large, 4-8 cm.	4. <i>G. umbatus</i>
Endoperidium sessile.	
Exoperidium externally tomentose	5. <i>G. velutinus</i>
Exoperidium externally smooth	6. <i>G. triplex</i>
Mouth naked and indefinite	7. <i>G. floriformis</i>

1. *Geaster pectinatus* (Persoon) Lloyd, *Geastreae*, p. 15, 1902. (Fig. 27.)

Geastrum pectinatum Pers., *Syn. Meth. Fung.*, p. 132, 1801.

Geaster striatus Fr., p.p., *Syst. Myc.*, vol. 3, p. 13, 1829.

G. Schmidellii Vitt., *Mon. Lyc.*, p. 12, 1842.

Plants at first globose, submerged, becoming superficial and expanded when 3-5 cm. across. Exoperidium split to about the middle into 5-12 subequal, acute rays which are expanded or subrevolute; fleshy layer brown, usually flaking away in irregular patches, leaving exposed the ochraceous, fibrillose layer; exterior covered with debris held by the adnate mycelial layer, which is persistent but tends to flake away; base concave.

Endoperidium pedicellate, subglobose, depressed-globose or urceolate, 1-2 cm. diam., brown or lead coloured, often farinose, base tapering into pedicel, striate or not, apophysis present or absent; pedicel slender, 3-6 mm. long. Peristome sulcate, prominent, narrowly conical, concolorous.

Gleba ferruginous; columella inevident; capillitium threads tinted, fusiform, simple. Spores globose, 5.4-6.2 μ m.; epispore dark amber, moderately and coarsely verrucose, reticulate.

Habitat: Solitary or in groups on vegetable debris on the ground; hypogaeal.

Distribution: Britain; Europe; North America; South Africa; Australia; New Zealand.

Dunedin, Otago, Aug., 1921, *Miss H. K. Dalrymple!*

Otaki Forks, Wellington, May, 1922, *E. H. Atkinson!*

Two other species, *G. plicatus* and *G. Bryantii* (latter not present in New Zealand) closely resemble *G. pectinatus* save in one or two minor characters. *G. plicatus* is separated solely by the plicate base of the endoperidium, *G. Bryantii* by the presence of a well-defined

collar around the base of the endoperidium immediately above the pedicel.

The endoperidium is often quite covered with a farinose substance which may be readily rubbed away. This covering is present also on other species, as for example *G. limbatus* and *G. minus*.

2. *Geaster plicatus* Berkeley, *Ann. Nat. Hist.*, vol. 3, p. 399, 1839. (Fig. 28.)

G. tenuipes Berk. *Fl. Tas.*, vol. 2, p. 264, 1860.

G. biplicatus Berk. et Curt., *Proc. Am. Acad. Arts & Sci.*, vol. 4, p. 124, 1860.

This subspecies is separated from the preceding solely on account of the plicate base of the endoperidium, for in all other respects it is practically the same.

Distribution: India; Bonin Is.; Ceylon; New Caledonia; South Africa; Australia; Tasmania; New Zealand.

Lake Papaetonga, Wellington, Aug., 1919, *G.H.C.*

Sandhills, Weraroa, Wellington, Nov., 1919 *E. H. Atkinson!*

Both collections determined as above by Lloyd.

3. *Geaster minus* (Persoon) n. comb. (Fig. 29.)

Geastrum quadrifidum var. *minus* Pers., *Syn. Meth. Fung.*, p. 133, 1801.

G. minimus Schw., *Syn. Fung. Carol.*, no. 327, 1822.

Geaster fornicatus Fr. p.p., *Syst. Myc.*, vol. 3, p. 12, 1829.

G. marginatus Vitt., *Mon. Lyc.*, p. 19, 1842.

G. granulatus Fcl. *Enumerat.*, p. 41, 1860.

G. coronatus (Schaeff.) Schroet., p.p., *Krypt. Fl. Schw.*, vol. 3, 1889; Lloyd, *Geastreae*, p. 31, 1902.

G. calceus Lloyd, *Myc. Notes*, p. 311, 1907.

G. juniperinus McBr., *Mycologia*, vol. 4, p. 85, 1912.

Plants at first globose, small, submerged, becoming erumpent and expanded when up to 3 cm. across. Exoperidium split to about the middle into 4-8 unequal, acuminate rays, which are commonly recurved or expanded, or may become fornicate by the mycelial layer splitting free from the fibrillose layer, which together with the fleshy layer becomes arched (fornicate) but remains attached by the apices of the rays to the mycelial layer, the latter remaining attached to the substratum; fleshy layer brown, rimose, frequently flaking away in patches.

Endoperidium pedicellate, 3-12 mm. diam., obovate, elliptical or depressed-globose, variable in size and shape, pallid white, tan, or bay brown, sometimes umber, glabrous, farinose or coated with closely adnate particles, giving to the whole a glistening appearance; pedicel up to 3 mm. long, frequently with an apical apophysis. Peristome variable, typically conical and fibrillose-fimbriate, frequently silky-fibrillose, sometimes almost plane and indefinite, seated on a definite silky area outlined by a depressed groove, or both silky area and groove may be wanting.

Gleba ferruginous; columella inevident. Spores globose, 4.5-5.8 mm.; epispore fuscous or umber, finely, sparsely and irregularly verrucose.

Habitat: Solitary, in groups or caespitose on the ground.

Distribution: Europe; North America; South Africa; Jamaica; Ecuador; Australia; New Zealand.

Sandhills, Weraroa, Wellington, Nov., 1919, *S. A. Cunningham!*

Dunedin, Otago, May, 1922, *Miss H. K. Dalrymple!*

Ashburton, Canterbury, Aug., 1925, *J. C. Neill; D. W. McKenzie!*

This is a most variable species; specimens range in size from minute plants 5 mm. across to forms over 4 cm. across. The exoperidium may be revolute, fornicate (a form not yet collected in New Zealand), subhygroscopic or saccate. The endoperidium may be pedicellate (the usual condition) or almost sessile, and may be smooth, covered with numerous glistening particles, or with a thick white crustation. The peristome may be plane, conical or obscure, and may be seated on a flattened silky zone outlined by a depressed groove, or this zone may be inevident and the groove wanting. The stoma may be fibrillose-silky, fimbriate-lacerate or almost indefinite. The spores, too, vary in the size and degree of roughness, and two types may be recognised, one averaging 5-5.8 mm., the other 3.5-4.2 mm.

Many names have been given these various forms, but it is not practicable to separate one from another owing to the difficulty of defining the limits of each.

The revolute and fornicate forms have been in the past considered as distinct species, the former being known as *G. minimus*, the latter as *G. coronatus*, but Coker (1924, p. 206) has shown that the fornicate form is but a condition of the other, for he found all connecting stages growing together.

4. *Geaster limbatum* Fries, *Syst. Myc.*, vol. 3, p. 15, 1829. (Figs. 30, 31, 32.)

Gastrum coronatum Pers., p.p., *Syn. Meth. Fung.*, p. 132, 1801.

Plants at first globose, submerged, becoming superficial and expanded when 4-8 cm. across. Exoperidium split to about the middle into 7-10 unequal, acute rays, which are expanded and revolute, or sometimes partially involute; fleshy layer brown or ferruginous, continuous or rimose, frequently farinose; exterior covered with debris held by the persistent, adnate mycelial layer, in old specimens partially flaking away; base concave or plane.

Endoperidium pedicellate; depressed-globose, obovate or subpyriform, globose when old, farinose when young, grey to umber, up to 1.5 cm. diam. Peristome depressed, acute, fibrillose, surrounded by a pallid or concolorous fibrillose or silky zone.

Gleba chocolate; columella almost obsolete. Spores globose, 4.9-5.4 mm.; epispore fuscous, acutely, densely and coarsely warted.

Habitat: On the ground, usually in shade of trees or hedges.
 Distribution: Britain; Europe, North America; East Africa; Australia; New Zealand.

Sandhills, Levin, Wellington, Oct., 1919, *E. H. Atkinson!*
 Wadestown, Wellington, Apl., 1923, *J. C. Neill!*
 Ashburton, Canterbury, Aug., 1925, *J. C. Neill; D. W. McKenzie!*
 Kelburn, Wellington, Nov., 1925, *G.H.C.*

This species is separated from the preceding by the large size, well developed, stout pedicel and definitely fibrillose peristome. It is not uncommon throughout, growing in the shade of hedges or trees. One form has the endoperidium covered with numerous glistening particles, and on this account may be separated from the typical form. But this is of little specific value for this covering may be well developed or absent on different plants in the same collection.

5. *Geaster velutinus* Morgan, *Journ. Cin. Soc. Nat. Hist.*, vol. 18, p. 38, 1895. (Figs. 33, 34.)

? *G. javanicus* Lev., *Ann Sci. Nat.* ser. 3. vol. 5, p. 161, 1846.
 ? *G. dubius* Berk., *Jour. Linn. Soc.*, vol. 14, no. 130, 1875.
Cycloderma ohioensis Cke., *Grev.*, vol. 11, p. 95, 1883.
G. Lloydii Bres. et Pat., *Myc. Notes*, p. 50, 1901.

Plants ovate, bluntly pointed, superficial, attached to the substratum by a central basal cord, becoming expanded when 3-6 cm. or more across. Exoperidium saccate, split to about the middle into 5-8 expanded or revolute, broad, thick, subequal rays which when dry frequently split into two thin fibrous and persistent layers; fleshy layer flesh coloured, umber and rimose when dry; exterior free from debris, covered with close brown felted tomentum; base convex, marked with a prominent umbilical scar.

Endoperidium sessile, globose or depressed-globose, up to 2 cm. diam., brown or pallid tan, minutely furfuraceous or tomentose, lower portion enclosed by the saccate base of the exoperidium. Peristome small, broadly conical, fibrillose, seated on a depressed silky zone which may be wanting, concolorous or pallid.

Gleba umber; columella cylindrical; capillitium threads occasionally branched near their apices. Spores globose, 4-4.5 mmm.; epispore fuscous, finely and sparsely echinulate, reticulate.

Habitat: Crowded or in small groups on vegetable debris, frequently on decaying wood on the forest floor; epigaeal.

Distribution: North America; Cuba; Porto Rico; Brazil; Gold Coast Colony; Africa; Australia; New Zealand.

Weraroa, Wellington, Aug., 1919, *G.H.C.*; May, 1923, *J. C. Neill!*

Botanical Gardens, Wellington, May, 1922, *J. B. Cleland!*
 July, 1925, *G.H.C.*

This is the most abundant species in New Zealand. It is separated from the following by the nature of the exterior of the exoperidium,

which is covered with a layer of close, felted tomentum; the latter possessing an almost smooth exterior. The epigaeal habit is also characteristic of both species.

6. *Geaster triplex* Junghuhn, *Tijdschr.*, vol. 7, p. 287, 1840. (Figs. 35, 36.)

G. lageniformis Vitt., *Mon. Lyc.*, p. 16, 1842.

G. Archeri Berk., *Fl. Tas.*, vol. 2, p. 264, 1860.

G. Michelianus W. G. Sm., *Gard. Chron.*, p. 608, 1873.

G. vittatus Kalchbr., *Ung. Akad., d.d. Wiss.*, vol. 17, p. 10, 1884.

G. coriaceus Col., *Trans. N.Z. Inst.*, vol. 22, p. 451, 1890.

G. Englerianus P. Henn., in *Engl. Bot. Jahrb.*, vol. 14, p. 361, 1891.

G. Morganii Lloyd, *Myc. Notes*, p. 80, 1901.

G. violaceus Lloyd, *l.c.*, p. 310, 1907.

Plants superficial, ovate, pointed, becoming expanded, when 2-13 cm. across. Exoperidium split to about the middle into 5-8 equal, narrowly acuminate rays, which are expanded or revolute; fleshy layer umber, rimose, frequently partially flaking away, sometimes a small portion persisting as a small collar around the base of the endoperidium; exterior free from debris, bay brown or tan coloured, glabrous, usually marked with several longitudinal striae; base plane, with a prominent umbilical scar.

Endoperidium sessile; depressed-globose or almost pulvinate, bay brown or umber, tomentose, finely pitted or smooth, membranous, 0.5-2.5 cm. diam. Peristome fibrillose, mammose, seated on a broad, depressed, silky, pallid zone which is usually outlined by an upraised margin.

Gleba ferruginous to umber; columella clavate or indistinct. Spores globose, 4.1-4.9 mmm. diam.; epispore almost black, finely and closely verrucose, reticulate.

Habitat: In groups on decaying vegetable debris; epigaeal.

Distribution: Britain; Europe; North and South America; Java; Australia; Tasmania; New Zealand.

Weraroa, Wellington, Aug., 1919, *G.H.C.* (2 coll.: det. by

Lloyd as *G. Englerianus*); May, 1923, *J. C. Neill!*

Dunedin, Otago, May, 1922, *Miss H. K. Dalrymple!*

Whakatikei, Wellington, June, 1923, *J. C. Neill!*

Characterized by the glabrous exterior of the exoperidium, the base of which is marked with a prominent umbilical scar, the prominent peristome and the epigaeal habit.

7. *Geaster floriformis* Vittadini, *Mon. Lyc.*, p. 23, 1842. (Fig. 37.)

G. delicatus Morgan, *Am. Nat.*, vol. 21, p. 1028, 1887.

G. hungaricus Hollos, *Gast. Hung.*, p. 64, 1904.

Plants at first globose, submerged, becoming superficial and expanded when 2-6 cm. across. Exoperidium split to about the middle into 7-12 subequal, narrow, acute rays which are expanded when wet, strongly involute when dry, then folding completely over (rarely

under) the endoperidium; fleshy layer adnate, smooth, umber, rimose when old; exterior at first covered with debris held by the closely adnate mycelial layer, soon flaking away and leaving exposed the glabrous, ochraceous or brown fibrillose layer; base strongly umbilicate.

Endoperidium up to 1.5 cm. diam., sessile, depressed-globose, minutely furfuraceous, glabrous when old. Mouth naked, indefinite, conical or more frequently plane, irregularly torn and apically fibrillose when old.

Gleba umber; columella small, cylindrical. Spores globose, or subglobose, 5.4-7.4 mmm.; epispore dark brown, closely and coarsely warted.

Habitat: In small groups on the ground in grassy areas; hypogaeal.

Distribution: Europe; North America; South Africa; Australia; New Zealand.

Masterton, Wairarapa, May, 1923, *Unknown collector!*
Dunedin, Otago, May, 1923, *Miss H. K. Dalrymple! !*
Ashburton, Canterbury, Aug., 1925, *J. C. Neill; D. W. McKenzie!*

The hygroscopic exoperidium, sessile endoperidium and naked, indefinite mouth, characterize the species. The large spores also are a marked feature.

DOUBTFUL AND EXCLUDED SPECIES.

G. affinis Colenso, *Trans. N.Z. Inst.*, vol. 16, p. 362, 1883. This is probably a synonym of *G. triplex* or *G. velutinus*, but impossible to place owing to the faulty description. No specimens are known.

G. coronatus Col., *l.c.* Probably a synonym of *G. triplex*, but as no specimens are known the matter cannot be settled. In any case the name is preoccupied.

G. fimbriatus Fr. Recorded from New Zealand by De Toni in Saccardo's *Sylloge Fungorum*, vol. 7, p. 83, 1888. The writer has not seen specimens of this species from New Zealand, although he has examined many Australian collections. The record is probably based on a small form of *G. triplex*.

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INDEX TO SPECIES AND GENERA.

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