

# REPRESENTATIVES OF THE MESOPHELLIA- CEAE IN NORTH AMERICA<sup>1</sup>

S. M. ZELLER

(WITH 6 FIGURES)

*Abstoma reticulatum* Cunningham was previously reported from California.<sup>2</sup> Recently Dr. W. H. Long has sent a specimen of a new *Abstoma* from New Mexico and there is also presented here a new genus, all of the three species of which are from far western states. This paper accordingly brings together descriptions of all of these representatives of the new family, *Mesophelliaceae*, as they occur in North America.

1. *ABSTOMA RETICULATUM* Cunningham, Linn. Soc. New So. Wales Proc. 52: 242-243. 1927.

Fructifications depressed-globose, up to 6 cm. broad; peridium of two layers, exoperidium very thin or up to 2 mm. thick, fragile, fugacious, whitish or brownish, composed of hyphae intermixed with particles of earth or sand, sometimes merely a meshy hyphal layer covering the endoperidium, which is smooth, dark-colored, mostly umber or sepia-brown, tough, membranous, dehiscing by irregular rupture; gleba at first yellowish, then olivaceous with purplish tints, powdery; capillitium tinted, thin-walled; spores globose, 8-12  $\mu$  in diam., dark brown, distinctly reticulate.

Under or on duff under cypress or fir, central and northern California. January to July.

Specimens examined: California; Monterey county, Point Lobos, near Pacific Grove, *Gertrude S. Burlingham*, 7, January 6, 21 and 22, March 26, 1937; Siskiyou county, near Horse Camp on Mt. Shasta, *Wm. B. Cooke*, 14642, July 8, 1940.

The specimens from Mt. Shasta are referred here with some hesitancy because they are quite young.

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<sup>2</sup> Zeller, S. M. Further notes on fungi. *Mycologia* 33: 196-214. 1941. (See p. 213.)

## 2. *Abstoma Longii* sp. nov.

Fructificationes depresso-globosae, obscure brunneae, 2 cm. crassae; exoperidium tenuo terroso, difficiliter separabilis; endoperidio membranaceo, sed duro et rigido; gleba primo molli dein obscure brunnea, floccoso-pulverulenta; capillitio tincto vel hyalino, flaccido; sporis globosis, obscure brunneis, echinulatis, 26.2–28.75  $\mu$  (cum aculeis); aculeis 3.7–5  $\mu$  longis, mollis, flexuosis, confertis.

Fructifications depressed globose, dark brown, up to 2 cm. in diam.; exoperidium thin with sand inclusions, mostly persisting; endoperidium papery thin, but hard and shell-like; gleba at first soft, then dark-sepia and flocculent, powdery; capillitium tinted or almost hyaline, threads short, fragmentary, flexuous; spores spherical, dark-brown, echinulate, 26.2–28.75  $\mu$  including echinulae, which are 3.7–5  $\mu$  long, close together, softish or flexuous.

In open sandy mesquite dunes, Jornada Range Experiment Station, about 23 miles from Las Cruces, Dona Ana county, New Mexico, *W. H. Long*, 8310, Nov. 11, 1918, **type**.

## *Radiigera* gen. nov.

Fructificationes hypogaeae vel epigaeae, subglobosae; peridio duvel triplici; basis sterilis pulvinatis; capillitium fasciatans ad columellam basalam spongiosam percursum radians; gleba primo albida, molli, succoso-subcarnosa, postremo obscure brunnea vel atra, pulverulenta; basidiis subglobosis. Vel pyriformis, fasciatis, pendere ex radiant hyphae, quadri- vel multisporis; sporis obscure brunneis, sphaericis, verrucosis vel echinulatis.

Fructifications hypogeous or epigeous, subglobose; peridium of 2–3 layers; thickened sterile base supporting a spongy pulvinate to subspherical columella or core from which the capillitium fibrils radiate to the endoperidium; gleba at first white, soft, succulent to subfleshy, becoming black or dark-brown and powdery at maturity; basidia pyriform to subglobose borne in groups along radiating hyphae, 4–many-spored; spores colored, spherical, verrucose to echinulate.

The type species is *Radiigera fuscogleba* Zeller.

The genus *Radiigera* (*to bear or exhibit radii*) in the Gasteromycetes is essentially the counterpart of some of the higher Plectascales, such as *Elaphomyces*. *R. atrogloba* especially reminds one of *Elaphomyces* both externally and internally; externally because of the matrix-like or mycelial-spawn-like coating, and internally because of the black, powdery gleba with cottony

or evanescent core or columella. The spores are also similar to those of species of *Elaphomyces*.

The gelatinous nature of the endoperidium in fresh specimens sets the genus off from other related genera except *Mesophellia* of which Cunningham<sup>3</sup> says "The endoperidium is . . . composed of a pseudoparenchyma of closely woven, partly gelatinized hyphae."

In *Mesophellia* the central core of the gleba is compact and cheesy in consistency and is held in a central position by strands of the same tissue which extend to and are firmly attached to the inner wall of the endoperidium. In *Radiigera*, the core is essentially a subspherical columella which usually crowns the apex of the sterile base. In *R. atrogleba*, although attached at first, this core may become free or entirely collapsed or evanescent. In all three species the columella (core) is very delicate, either cottony or a soft pithy parenchyma.

*Radiigera* is similar to *Abstoma* in several respects. There is no apical mouth in the endoperidium, dehiscence occurring through the gradual weathering or breaking up of these membranes. The capillitium is unbranched and the spores are spherical.

The structure of the gleba in *Radiigera* is very similar to that of *Geastrum*. The gleba outside of the conspicuous columella or basal core is composed essentially of radiating fascicles of hyphae and capillitium arranged to simulate tubes which reach from the columella to the endoperidium. These fascicles are attached at both ends but in *R. fuscogleba* they separate readily from the endoperidium while in *R. atrogleba* they may separate from both, the columella and the endoperidium. Sections of young dried fructifications, cut tangentially across the fascicles in tube-like arrangement, reveal nothing which could be construed as true tramal tissues. The origin and development of the radial fascicles must be learned through the study of histological preparations of very young fructifications, however, before exact interpretations may be made.

Basidia are borne in groups along the hyphae which are included in the radiating glebal fascicles. Each group of basidia may originate more or less directly from the radial hyphae or are

<sup>3</sup> Loc. cit. p. 313-314.

borne on short hyphal branches. This arrangement of basidia is very similar to that illustrated by Fischer<sup>4</sup> for the basidia of *Podaxis*. The basidia of *Radiigera* are broadly pyriform with several spores as found in some other genera like *Calostoma*, *Sphaerobolus*, or *Lycogalopsis*. The spores are sterigmate.

The capillitium is long and mostly unbranched. In *R. fusco-gleba* the filaments are variable, dark, flexuous, walls uneven, sometimes almost moniliform. In *R. atrogleba* the capillitial filaments are smooth and almost glistening, somewhat wavy, dark. In *R. Taylorii* there are two sizes of capillitial hyphae, which are only slightly colored.

To place a genus like *Radiigera* in its correct taxonomic position presents a perplexing problem because of its diversified affinities, and the lack of knowledge concerning the developmental morphology and the manner in which basidia are borne in some of the apparently affiliated genera. The simple course of basing the classification entirely upon the characters that may be seen in mature fructifications is misleading, but undoubtedly our present incomplete knowledge of the origin and morphology of the glebal tissues of many described Gasteromycetes will probably lead to imperfections in any systematic plan which may be chosen for these fungi.

In 1933 Fischer<sup>5</sup> devised a plan for the Gasteromycetes based on morphological development and the manner in which the basidia are borne. In this plan the genera which have apparent affinities with *Radiigera*, namely, *Abstoma*, *Castoreum*, *Geastrum*, and *Mesophellia*, have been referred to four distinct families, although *Castoreum* and *Mesophellia* were placed under "genera doubtfully included or imperfectly known."

Working independently at the same time and without Fischer's knowledge Cunningham<sup>6</sup> devised a plan which we believe more nearly satisfies this particular group of genera, especially *Abstoma*, *Castoreum*, *Mesophellia*, and *Radiigera*. His plan included

<sup>4</sup> Fischer, Ed. Gastromyceteeae. E. & P. Nat.-Pfl. 7a: p. 118. fig. 91A and B. 1933.

<sup>5</sup> Loc. cit.

<sup>6</sup> Cunningham, G. H. The Gasteromycetes of Australasia XV. The genera *Mesophellia* and *Castoreum*. Linn. Soc. New So. Wales Proc. 57: 313-322. illus. 1932.

the tribe *Mesophelliaceae*, with tribes *Lycoperdeae* and *Geastrae* in the family *Lycoperdaceae*. It would seem, however, that Fischer's scheme for suborders and families is more feasible from the morphological viewpoint. It is proposed to combine the two ideas therefore and to include the *Mesophelliaceae* in the suborder *Lycoperdineae* (sensu Fischer). The *Mesophelliaceae* would therefore contain the genera *Abstoma*, *Castoreum*, *Mesophellia*, and *Radiigera*.

The systematic key will be as follows:

Suborder: LYCOPERDINEAE

- I. Ectoperidium not opening stellately at maturity.
  - A. Peridium 2-layered, dehiscent by an apical stoma (irregular or wanting in *Calbovista*, *Calvatia*, and *Mycenastrum*); capillitium attached or free, simple or freely branched. . . . . 1. LYCOPERDACEAE.
  - B. Peridium 2-3-layered, indehiscent, or rupturing irregularly at apex; capillitium unbranched. . . . . 2. MESOPHELLIACEAE.
- II. Ectoperidium opening stellately at maturity; peridium usually 4-layered, endoperidium dehiscent by an apical stoma; capillitium attached, unbranched. . . . . 3. GEASTRACEAE.

The genera in *Lycoperdaceae* and *Geastraceae* may be classified as in Fischer except the genera as included in the *Mesophelliaceae* below.

**Mesophelliaceae** fam. nov.

Peridium usually 3-layered, indehiscent or rupturing irregularly at the apex; capillitium unbranched; spores globose or ellipsoid, variously roughened or with a gelatinous sheath; basidia inflated, sterigmate.

KEY TO GENERA

- Spores spherical, echinulate, reticulated or verrucose.
  - Gleba without a sterile base. . . . . 1. *Abstoma*.
  - Gleba with a sterile base. . . . . 2. *Radiigera*.
- Spores ellipsoid, smooth or irregularly roughened.
  - Gleba with a central core. . . . . 3. *Mesophellia*.
  - Gleba without a central core. . . . . 4. *Castoreum*.

So far as known *Castoreum* and *Mesophellia* do not occur in North America.

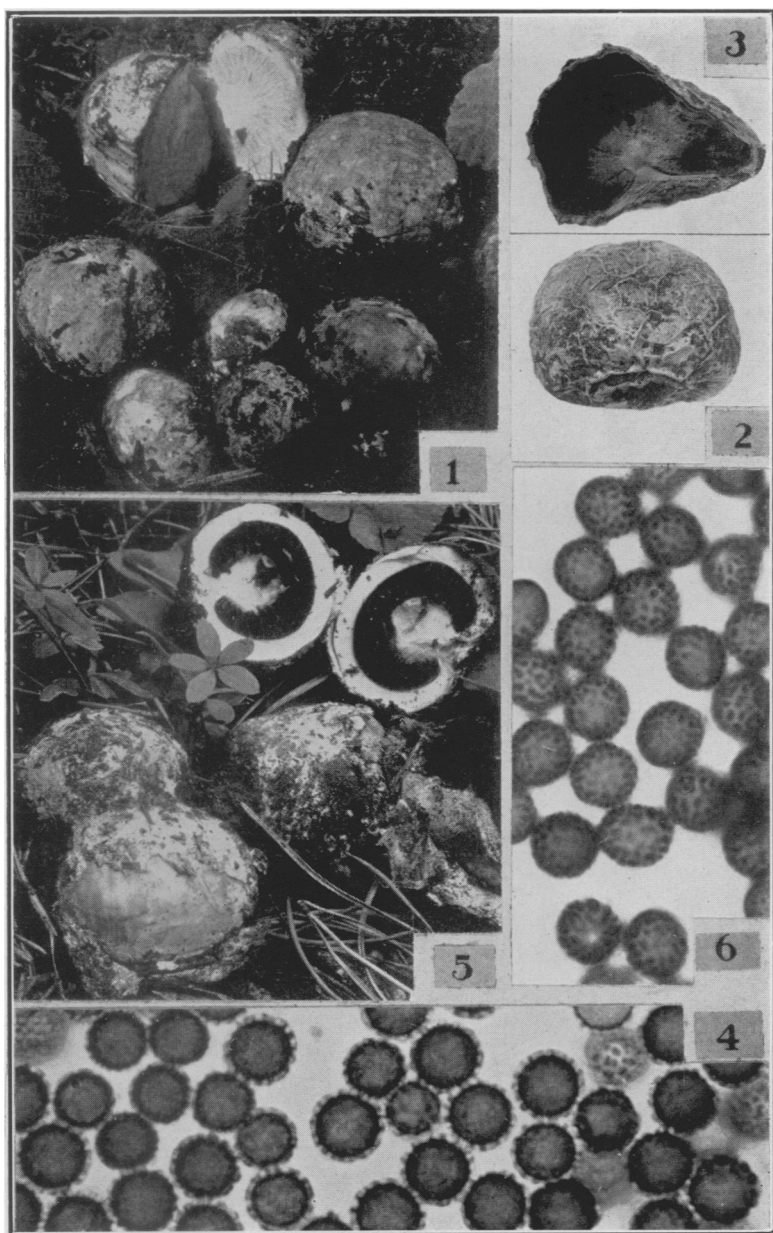


FIG. 1. Several fructification of *Radiigera fuscogleba* in natural habitat. Slightly reduced from kodachrome by Wm. B. Gruber. FIG. 2. Dried specimen from the type collection of *R. fuscogleba*. Note reticulate wrinkling of

1. *Radiigera fuscogleba* sp. nov.

Fructificationes subglobosae, 4–8 cm. crassae, basi saepe radicanti; superficie alba vel isabellina, saepe leniter purpurans, ligno-brunnea vel pallidior siccata, laevi, saepe innato-reticulato-fibrillosa; basis sterilis crasso-conica; columella subglobosa, mollo-spongiosa vel byssoidea, 5–8 mm. crassa; peridio tristratoso, facile a glebo separabili siccato; ectoperidio duplici, strato externo tenui, filamentoso, strato interno (primo) subhyalino, parenchymato, 1 mm. crasso, tenuissimo siccato; endoperidio 2 mm. crasso, subgelatinoso, parenchymato, duro siccato; gleba alba, dein olivaceo-brunnea, funiculi hypham capillitiam que composita, ad columellam percursum radians; capillitium obscure, simplicis, flexuosum, inaequalum, 2.7–3.2  $\mu$  crassum; hyphis radium subhyalinis, ramis brevis, basidiophoris; basidiis crasso-pyriformibus, 4–multisporis, brevi-sterigmatibus; sporis brunneis, globosis, alveolato-echinulatis, 4.7–5.2  $\mu$ , echinulae subtruncatae.

Sub foliis putridis in pinetis. Oregon, Amer. bor.

Fructifications subglobose 4–8 cm. in diam., with a distinct slightly projecting basal attachment; surface white to old gold or isabella color, sometimes with purplish tints, drying wood brown or lighter, smooth but sometimes with innate reticulate fibrils; sterile base broadly conic in vertical section, crowned by a sub-spherical columella which is soft, pithy toward the center and more cottony farther out, 5–8 mm. in diam.; peridium of 3 layers, not readily separating from each other but separating from gleba on drying; outer very thin layer (or surface pelt) filamentous, main ectoperidial layer of light-colored, large-celled parenchyma, about 1 mm. thick, drying to papery thinness; endoperidium of dark, large-celled and thin-walled parenchyma, somewhat gelatinous, 2 mm. thick, drying to thin, flinty hardness, inner surface a very thin filamentous layer of hyphae very similar to capillitium; gleba white throughout at first, drying olive brown, com-

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surface resulting from drying. These wrinkles follow more or less the reticulate fibrils over the surface. About natural size. FIG. 3. Vertical section of a fructification of *R. fuscogleba* in the type collection. Note sterile base crowned by a globular columella of two textures and tones, the central lighter colored and pithy, the outer zone slightly darker and more cottony. Note also the radiating fascicles from the columella to the endoperidium. About natural size. FIG. 4. Spores of *R. fuscogleba*. Note the alveolate-echinulate epispore.  $\times 2000$ . Photograph by F. P. McWhorter. FIG. 5. Several fructifications of *R. atrogleba* in natural habitat. This shows three fructifications enveloped in a more or less common ectoperidium as described in the text. There is also a vertical section of a sporophore showing spherical columella, black gleba with radiating fascicles, and thick peridium, with more or less easily separable ectoperidium. Slightly reduced from kodachrome by Wm. B. Gruber. FIG. 6. Spores of *R. atrogleba*.  $\times 2000$ . Photograph by F. P. McWhorter.

posed of radiating fascicles of hyphae and capillitium arranged to simulate tubes, fascicles attached to the columella and inner wall of endoperidium, readily separating from latter on drying; capillitium dark, unbranched, flexuous, 2.7–3.2  $\mu$  in diam., walls uneven, sometimes almost moniliform; fascicular hyphae small, almost hyaline, with short branches, all basidia-bearing; basidia broadly pyriform, 4–many-spored, with short sterigmata; spores dark, spherical, 4.7–5.2  $\mu$ , alveolate-echinulate, echinulae somewhat truncate, often connivent at their apices.

Hypogeous or epigeous in duff of coniferous forest, Mt. Scott, Portland, Multnomah county, Oregon, collected by *Wm. B. Gruber* (No. 8), July 1943, **type**, and embedded in a thoroughly decayed log (ash?), Jefferson, Marion county, Oregon, *H. C. Gilbert*, Sept. 1929 (both in Zeller Herb.).

## 2. *Radiigera atrogleba* sp. nov.

Fructificationes depresso-globosae, infra umbilicatae, 3.5–5 cm. crassae, 2.5–3.8 cm. altae, exoperidium completum, confluenso stromatiforme individuum complurium commune, crassum, compactum, coactile, ab endoperidio subfacile separum; superficie hebeti, inaequali, albi, canescenti, siccitate "tilleul-buff" vel "light vinaceous fawn" vel "buckthorn brown"; endoperidium 4–5 mm. crassum, albidum vel pallido-viridum, duplex, strato externo circa 1 mm. crasso, compacto prosenchymatibus, strato interno circa 3–4 mm. crasso subspongioso parenchymatibus; columella subglobosa, 10–15 mm. crassa, alba, canescenti, siccitate obscuriore, byssiodo-parenchymatam composita, saepe collabente, basi sterili pulvinati insedente; gleba atra, pulverascens; capillitio hyphisque basidiophoris columellae superficiae internae endoperidioque adnato, simplicio, laxo, obscuro, 2.5–3  $\mu$  crasso; hyphis basidiophoris hyalinis, ramis brevis, parvis; basidiis latopyriformibus, 4–multi-sporis; sporis obscure, subglobosis, verrucosis, 5.6–6.2  $\mu$ .

In terram arenosam subimmersum, prope McCall, Idaho, Amer. bor.

Fructifications depressed-globose, umbilicate under the slight sterile base, 3.5–5 cm. broad and about  $\frac{3}{4}$  as high, several fructifications together may be embedded in a very conspicuous spawn-like mycelial mat, as well as a heavy felty, compact layer immediately surrounding the sporophores which also constitutes the exterior layer of the peridium (ectoperidium); ectoperidium surface felty, dull, rough, white to grayish at first, drying tilleul-buff to light vinaceous-fawn or even buckthorn brown, of fine somewhat nodose hyphae, more or less readily separating from the endoperidium which has an even, dull, felty surface with whitish or rosy tints when fresh (or changes to olivaceous tints, such as chamois or isabella color when bruised), drying pale pinkish buff;



endoperidium 4–5 mm. thick, pure white or with pale greenish tints, of two layers, outer about 1 mm. thick, of very compact, small-celled prosenchyma, the inner 3–4 mm. thick of large-celled parenchyma; columella subspherical, 10–15 mm. in diameter, arising from a slightly elevated sterile base, white to grayish, drying darker, of very pithy parenchyma, sometimes evanescent or almost totally collapsed; gleba black, composed of radiating plate-like fascicles of hyphae and capillitium arranged to simulate flattish tubes, fascicles attached to the columella and inner wall of the endoperidium, readily separating from both on drying; capillitium unbranched, smooth, almost glistening, somewhat wavy, dark, 2.5–3  $\mu$  in diam.; fascicular hyphae small, hyaline, with short branches, all basidia-bearing; basidia broadly pyriform, 4–many-spored; spores dark, subspherical, verrucose, often with a prominent sterigmatal scar, 5.6–6.2  $\mu$  in diam.

Hypogeous or epigeous in sandy soil of a creek bed among tamarack and white pine, near McCall, Valley county, Idaho. Collected by *Wm. B. Gruber* (No. *P-20*), Aug. 20, 1943, **type** (in Zeller Herb.).

Mr. Gruber has furnished the following field notes on *Radiigera atrogleba*: "The outer crust tough and hard like wood when dry. The black core (*gleba*) radiates from the center and from below. The black material consists of an ink-like substance, staining everything but it washes off easily with water. Odor metallic, resembling that of actual ink. The puff balls appear in closely connected, almost ingrown, clusters of from 15 to 30. They are deep in the soil and only a few of the balls are visible. When 'unearthed' the cluster of puffballs is found to be protected by a fragile, thin, mycelial mat which envelopes the whole cluster except the top part of those exposed to the surface of the ground. I saw the plant only in mature stages of development, however, and it appeared as though the mycelial spawn might have completely enveloped the balls in younger stages. Later stages of development show that the black juice changes to a dry spore powder."

The illustration of the spores (FIG. 6) shows the verrucose nature of the epispore as well as the sterigmatic scar in a few cases. At the base of the spore the verrucae radiate from the sterigmatic scar.

3. *Radiigera Taylorii* (Lloyd) Zeller, comb. nov.

*Mesophellia Taylorii* Lloyd, Myc. Notes 73: 1305. fig. 2914.  
1924.

Fructifications subglobose, 2–3 cm. in diam., with a distinct rooting basal scar; surface drying dull drab or lighter, even, smooth or slightly velutinate; sterile base white, pulvinate in vertical section, crowned by a subspherical, white, cottony-soft columella, sometimes detached from the base as a free core, sometimes almost evanescent; peridium of two closely adnate layers which become easily separable when dry; exoperidium egg-shell thin when dry, cartilaginous; endoperidium white, gelatinous, about 3–4 mm. thick when fresh, drying very thin and light buff; gleba buffy-brown; capillitium in fascicles of long, parallel, non-branched filaments, fascicles extending radially from columella to endoperidium, composed of capillitial filaments and basidiophorous hyphae; capillitial filaments hyaline to slightly straw-colored, some large, up to 4  $\mu$  in diam., usual ones smaller, 2–2.5  $\mu$  in diam., apparently not branched; basidia borne in groups along the radiating hyphae, pyriform, up to 11- or 12-spored; spores sphaerical, slightly straw-colored to very light brown in mass, slightly verrucose, 2.5–3.75  $\mu$ .

Hypogeous under loose leaf mould of redwood near Eureka, Humboldt Co., California. Summer. The type was collected by *C. Wilder Taylor* (In Lloyd Collections, Smithsonian Inst., and in Zeller Herb.).

Under date of Sept. 30, 1924, the writer received the following note from Mr. C. G. Lloyd: "I enclose specimen that should be of interest to you. It will be published in the next issue of my notes, now in the printer's hands." He referred to a part of the type of *Mesophellia Taylorii* Lloyd. Mr. Lloyd was never satisfied with his reference of this species to the genus *Mesophellia*, according to his personal statement to the writer as well as to his comment on a later collection,<sup>7</sup> as follows: "Our American plant will no doubt be called a new genus in time," on the grounds of the soft, "cottony core, globose spores, and gelatinous endoperidium" . . . which are not to be found in other species of *Mesophellia*.

<sup>7</sup> Stevenson, J. A., and Edith K. Cash. The new fungus names proposed by C. G. Lloyd. Lloyd Library & Museum Bull. 35 (Mycological Ser. No. 8): 189. 1936.

Dodge,<sup>8</sup> who erroneously included *Mesophellia* in the Plectascales, excluded *M. Taylorii* from that genus on the same grounds as Lloyd had mentioned and further suggested its similarity to "juvenile, unexpanded stages of some puff-ball." Cunningham<sup>9</sup> believed "*M. Taylorii* was erected upon an unexpanded *Geaster*."

It differs, however, in several characters from *Geaster* and *Astraeus*, although it has some other characters in common with the former, and Mr. Lloyd, we believe, was too keen a student of *Geaster* to have made that mistake. There were several fructifications in each of the two collections received by Lloyd from California. None of them have an apical pore in the endoperidium, nor does the exoperidium divide regularly into astral rays. Both peridial layers break up irregularly. The fructifications accordingly remind one of *Abstoma*.

As soon as the writer received the specimens of *Radiigera fuscogleba* and *R. atrogleba* he was immediately reminded of their similarity to *Mesophellia Taylorii* Lloyd, and the three species have proved to possess likenesses enough to constitute a generic concept.

KEY TO SPECIES OF RADIIGERA

- Spores echinulate, gleba brown.....1. *R. fuscogleba*.
- Spores verrucose.
  - Spores 5.6–6.2  $\mu$ , exoperidium a heavy felt-like layer, gleba black at maturity.....2. *R. atrogleba*.
  - Spores 2.5–3.7  $\mu$ , exoperidium thin, cartilaginous when dry, gleba light brown or creamy.....3. *R. Taylorii*.

OREGON STATE COLLEGE,  
CORVALLIS, OREGON

<sup>8</sup> Dodge, C. W. The higher Plectascales. Ann. Myc. 27: 156. 1929.

<sup>9</sup> Cunningham, G. H. Gasteromycetes of Australasia. XV. The genera *Mesophellia* and *Castoreum*. Linn. Soc. New So. Wales 57: 313–322. illus. 1932.