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# NOTES ON ENTOMOGENOUS FUNGI FROM GHANA
# I. THE GENERA GIBELLULA AND PSEUDOGIBELLULA

R. A. SAMSON and H. C. EVANS

Centraalbureau voor Schimmelcultures, Baarn (Netherlands) and Cocoa Research Institute, Tafo (Ghana)

SUMMARY

All species of the genus *Gibellula* were regularly collected on arthropod hosts in Ghana. *Gibellula alata* Petch, *G. leiopus* (Vuill.) Mains and *G. pulchra* (Sacc.) Cavara are briefly mentioned together with notes on their distribution. These species are considered to be specialized parasites. The new genus *Pseudogibellula* is proposed to accomodate *Gibellula formicarum* Mains, separated from the phialidic *Gibellula* by conidia produced singly and on sympodial conidiogenous cells. *P. formicarum* is common on a wide range of arthropod hosts and grows freely on agar media.

PETCH (1932) revised the genus *Gibellula* and recognized only two species, *G. aranearum* (Schw.) Sydow and *G. alata* Petch. Later MAINS (1950) considered *G. aranearum* as a synonym of *G. pulchra* (Sacc.) Cavara and separated it from *G. leiopus* (Vuill.) Mains. *G. alata* Petch has been only known from the type material on spiders from Ceylon. A further species on an ant from Liberia, *G. formicarum*, was described by MAINS (1949). All these four species were regularly collected on arthropods in various localities in Ghana.

1. **Gibellula pulchra** (Sacc.) Cavara – *Fig. 6f.*

The fungus occurs in Ghana on a wide variety of Araneida, particularly on free-living Salticidae species. Specimens have been collected from:

Eastern Region – Apedwa, Atewa, Begoro, Bunso, Kukurantumi, Oyoko, Nobi, Tafo.

Western Region – Enchi.

Very common in cocoa farms, usually on spiders attached to the underside of cocoa leaves, less frequently on cocoa tree bark. Equally common in High Forest and found particularly on the leaves of various herbs and shrubs. Consistently collected from forest litter on sampling quadrats (20 sq m), with a density of up to ten specimens/month/quadrat over a full year. A detailed analysis of ten mature cocoa trees yielded an average of eight diseased spiders/tree. PETCH (1932) and MAINS (1950) listed specimens from a number of countries throughout the world, and undoubtedly this is a ubiquitous pathogen of spiders which may well be an important mortality factor.

Colony colour is extremely variable on fresh specimens and ranges from white to grey, lilac to bright yellow or orange. Frequently associated with perithecia of *Torrubiella arachnophila* (Johnston) Mains var. *pulchra* Mains which develop from a yellow, curly mycelial mat.

2. **Gibellula leiopus** (Vuill.) Mains[1]
Less common than *G. pulchra* but with similar wide distribution and Araneida host range. Easily distinguished by its very short conidiophores which impart a compact appearance and a characteristically deep lilac colour to the synnemata. Mycelial mat predominantly light yellow and occasionally bearing perithecia of *Torrubiella arachnophila* (Johnston) Mains var. *leiopus* Mains[1].

3. **Gibellula alata** Petch – *Fig. 1*
Not common; on small spiders attached to the cocoa leaf surface. A species easily distinguished by its short slender tan-coloured synnemata terminating in a bulbous outgrowth from which project a number of conidiophores and a typical "wing". This wing consists of a delicate network of loose, hyaline, anastomosing hyphae. Conidia are more or less cylindrical to clavate, apiculate, 4–9 × 2–4 μm.


Fig. 1. *Gibellula alata*. Synnema, terminating in a bulbous outgrowth from which project a number of conidiophores and the typical "wing" (× c. 40).

*Gibellula formicarum* Mains
Until now this species has been known only from the type specimen (MICH), which was described and illustrated by MAINS (1949) on an ant collected in Liberia; the host is clearly identifiable as the Ponerine ant *Paltothyreus tarsatus*

[1] MAINS (1950) used also the epithet "*pleiopus*". The specific epithet is, however, based on *G. arachnophila* forma *leiopus* Vuill. (in MAUBLANC 1920).

(Fabr.). Dr. R. L. SHAFFER kindly compared the type material with a Ghanian specimen and found it to be identical, "even the two ants look like twins". Although there are several characters in common with species of the genus *Gibellula*, important differences in conidial ontogeny are recognizable. The conidia are produced singly and sympodially and not in chains from phialides. Furthermore the fungus can be grown on agar media contrary to the other 3 species. Therefore the new genus *Pseudogibellula* is proposed.

**Pseudogibellula** Samson & Evans, *gen. nov.*

Synnemata erecta, plus minusve cylindrica, e hyphis brunnescentibus, parallelis, septatis constant conidiophorisque lateraliter oriundis; conidiophora e mycelio diffuso formicam tegente vel e hyphis synnema laxe involventibus oriuntur, plerumque septata, vesicula terminata e qua ramuli inflati et cellulae conidiogenae exeunt; cellulae conidiogenae lageniformes vel cylindricae, sursum paulum constrictae, cicatricibus inconspicuis obductis; conidia continua, hyalina, levia. Species entomogena. Status perfectus ignotus.

Synnemata erect, more or less cylindrical, consisting of brownish, parallel, septate hyphae, bearing conidiophores laterally; conidiophores arising from the mycelium covering the host or from hyphae loosely attached to the synnematal surface, septate, terminating in a small vesicle bearing swollen branches and conidiogenous cells; conidiogenous cells flask-shaped to cylindrical, somewhat constricted in the upper part, showing inconspicuous scars; conidia one-celled, hyaline, smooth. Entomogenous.

Perfect state unknown.

Type species: *Gibellula formicarum* Mains.

**Pseudogibellula formicarum** (Mains) Samson & Evans, *comb. nov.* – *Fig. 2–6.*
= *Gibellula formicarum* Mains *in* Mycologia **41**: 309. 1949 (basionym).
? *Gibellula elegans* Hennings *in* Hedwigia **41**: 148. 1902.

Synnemata scattered, arising from natural body openings and intersegmental and appendage joints of the insect, usually yellow brown to brown, occasionally becoming creamish due to conidial blooms, more or less cylindrical, up to 5 mm in length and 20–40 μm in diameter, surrounded by a loose covering of pigmented, verrucose hyphae bearing the conidiophores, which also may arise from hyphae covering the insect; conidiophores verrucose, septate, averaging 3 μm in diameter and 50–80 μm in length, terminating in a small vesicle, 4–6 μm in diameter; conidial heads radiating, biseriate, 40–60 μm in diameter; conidiogenous branches swollen, more or less globose, 3–5 μm in diameter; conidiogenous cells 4–7.5 × 1.5–2 μm, flask-shaped to cylindrical, somewhat constricted in the upper part, bearing inconspicuous scars; conidia hyaline, smooth, cylindrical, apiculate, 3.5–4.5(-6) × 1.2–2 μm.

Ascigerous state unknown.

On malt-agar *P. formicarum* grows slowly at 25 °C, forming a densely matted felt with floccose overgrowth. After 3 weeks some conidiophores occur, but sporulation generally remains poor. Colonies on oatmeal-agar grow slowly, attaining a diameter of 3 cm within 4 weeks with less overgrowth of aerial mycelium than on malt agar. Conidiophores produced in localized areas, erect, up to 100 µm in length and 2–3 µm in diameter, verrucose, septate, hyaline, each bearing a whorl of conidiogenous branches and cells on a small vesicle. Usually the ramifications are restricted to the swollen apical part, but occasionally conidial structures extend over a greater lenght of the conidiophore (see *fig. 6 c–e*). Conidiogenous branches almost globose, bearing 4–6 conidiogenous cells. Conidiogenous cells and conidia as on the natural substrate. No chlamydospores; perfect state not observed.

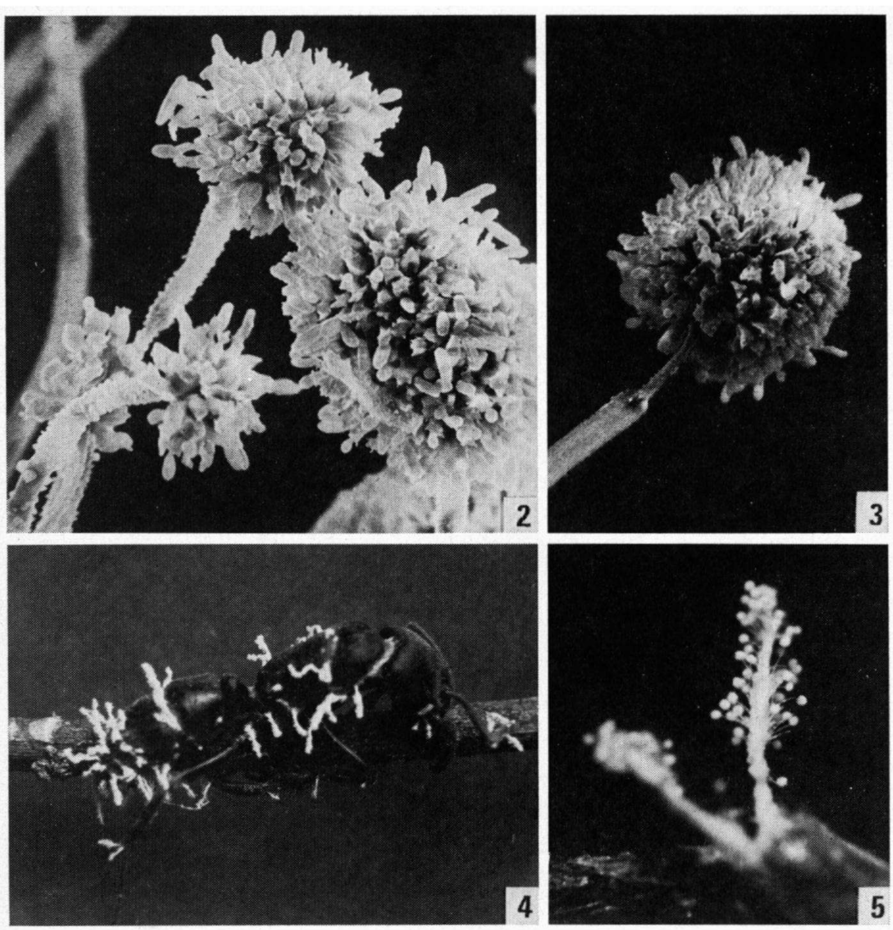


Fig. 2–5. *Pseudogibellula formicarum*. 2–3. Scanning electron micrographs of conidiophores (× 1450). 4. Synnemata arising from the body of *Paltothyreus tarsatus* (× 5). 5. Detail of synnema (× c. 50).

Material examined:
Living cultures
CBS 871.72, isolated from *Ricania mediana* Walk. on cocoa leaf, Tafo.
CBS 432.73, isolated from *Paltothyreus tarsatus* (Fabr.), collected in Atewa.
CBS 433.73, isolated from Cercopidae species on cocoa leaf, Tafo.
Herbarium specimens
on *Paltothyreus tarsatus* (Fabr.), collected in Tafo, Mt. Atewa, Begoro, Atewa (in herb. CBS with accession numbers RAS 0010, 0011, 0073 and 0161).
on *Ricania mediana* Walk., collected in Tafo on cocoa leaf (RAS 0043, 0162).
on *Crematogaster* spp., collected in Mt. Atewa (RAS 0019).
on Cercopidae (froghoppers) collected in Tafo on Theobroma cacao L. (RAS 0044, RAS 0163).
on *Macromischoides aculeatus* (Mayr), collected in Begoro and Mt. Atewa (RAS 0160).

Host Range in Ghana
Hymenoptera
- Formicidae
  - Myrmicinae:
    - *Crematogaster bequarti* (Forel)
    - *C. clariventris* Mayr
    - *C. striatula* Emery
    - *Macromischoides aculeatus* (Mayr)
    - *M. inermis* Bernard
  - Ponerinae:
    - *Paltothyreus tarsatus* (Fabr.)

Homoptera
- Ricaniidae; *Ricania* spp.
- Cercopidae (froghoppers)

Coleoptera
- Lagriidae: *Derolaria* species

Arachnida
- Araneida (spiders)

Fairly common on various Homoptera in cocoa farms; invariably the diseased insects are found attached to the ventral midrib of cocoa leaves. Also responsible for local epizootics on several ant species in moist primary forest. *Paltothyreus* can easily be collected in large numbers and is freely exposed, clinging with its mandibles and legs to plant stems. Myrmicine ants are usually hidden and more difficult to find and occur chiefly on the leaves of herbs on the forest floor.

## Discussion

The clusters of conidiogenous cells in *Pseudogibellula formicarum* are somewhat reminiscent of the conidial structures produced in species of the genus *Beauveria*. However, in *Pseudogibellula* the conidiogenous cells occur terminally on distinct conidiophores, which are lacking in *Beauveria*. In this genus the conidiogenous cells have a typical geniculate, denticulate rachis and the conidial structures are not aggregated into true synnemata.

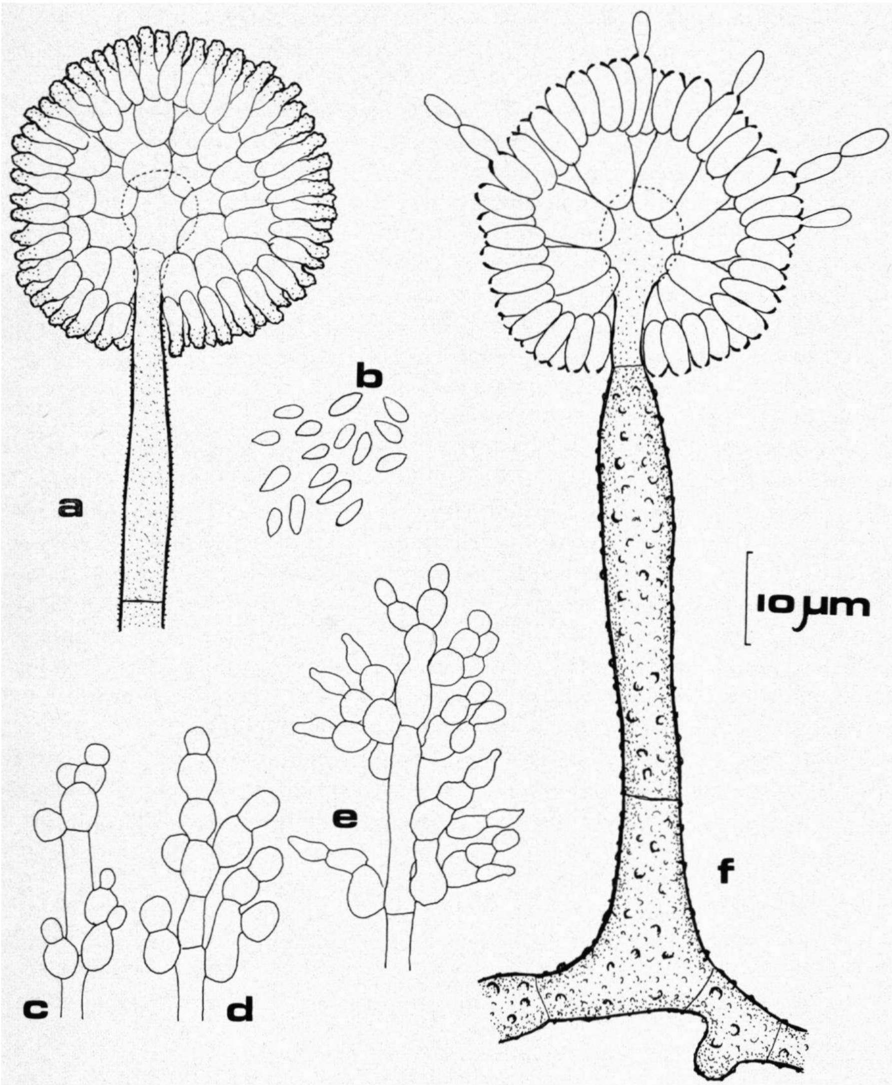


Fig. 6, a–e. *Pseudogibellula formicarum*. a. conidiophore, b. conidia, c–e. stages of development of irregular conidiophores on agar media. f. *Gibellula pulchra*, young conidiophore, showing cylindrical phialides with thickened apices and catenate conidia.

*Gibellula elegans* was described by HENNINGS (1902) from a grasshopper collected in Java; he compared it with the stamina of some *Aralia* species. The conidia of *G. elegans* were described as fusoidal, measuring 2.5–3 × 1 µm. MAINS (1950) doubted whether it was the same species as on spiders (*G. aranearum*) with which it had earlier been synonymized. The type specimen of *G. elegans* (B) contains the original drawings of HENNINGS, but no fungus material. The dimensions of the conidia and the drawings suggest identity with *P. formicarum*. However, since no type material is present, the species can only be regarded as a possible synonym of *P. formicarum*.

The three species of *Gibellula*, *G. alata*, *G. leiopus* and *G. pulchra* show close affinities with the genus *Aspergillus*. Species of both genera produce conidia in chains from phialides typically arranged on a vesicle. Their separation seems debatable, but there are important differences. Conidiophores of *Gibellula* are characteristically septate and verrucose with a rather reduced vesicle. Phialides lack a distinct neck or collarette and their apices are usually markedly thickened. Furthermore the conidial structures are usually aggregated into synnemata. All species of the genus *Gibellula* are araneogenous and so far have only been recorded on spiders. Despite numerous attempts, *G. leiopus* and *G. pulchra* have not been cultured on agar and it appears that these fungi have stringent nutrient requirements.

*Pseudogibellula formicarum* is a strongly competitive fungus on insect substrates and frequently exploits ant cadavers killed by other fungal pathogens. It was particularly found associated with *Cordyceps australis* (Speg.) Sacc. and often grows directly on the stroma. Hence it is impossible to link asexual and sexual stages from herbarium specimens without cultural confirmation. *P. formicarum* is apparently not very restrictive in its nutrient requirements and it may survive saprophytically in the soil on insect remains. This may also explain its ability to attack several orders of insects, in addition to spiders. On the other hand, infection by the more highly specialized *Gibellula* species may be prevented by insect cuticle defense mechanisms and substrate differences.

From evidence collected in Ghana (EVANS, in preparation) it seems probable that *Gibellula* and *Pseudogibellula* exert a measurable and constant natural control of spider and ant populations respectively in moist tropical forests.

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