

KEY TO THE SPECIES OF *ARACHNOCREA*

1. Part-ascospores mostly 3–4 μm wide, ends acute or subacute, slightly spinulose *A. scabrida*
2. Part-ascospores mostly 2–2.5 μm wide, ends acute, smooth-walled *A. stipata*

land, Waitemata City, Waitakere Ranges, Marguerite Track, on *Rhopalostylis sapida*, 21 Mar. 1977, G. J. Samuels 77-25 (NY ex PDD 35883).

ILLUSTRATIONS.— Doi (1972, Fig. 3).

DIALHYPOCREA Speg., Bol. Acad. Nac. Ci. 23: 475, 1919.

Type: *D. puiggariana* Speg.

Stromata discrete, tuberculate with protruding perithecial apices, pseudoparenchymatous, yellow-orange, KOH–. Ascumata immersed below a narrow layer of pseudoparenchymatous stromal tissue, few to several produced within each stroma, individual ascumata retaining their integrity at least over the upper half; wall KOH–. Apical paraphyses persisting among the nearly mature asci. Asci cylindrical, apex with a ring. Ascospores one-septate, disarticulating early in the development at the septum, hyaline, spinulose. Anamorph unknown. On decaying branches.

NOTES.— This unispecific genus was established for a species having *Nectria*-like ascumata and one-septate ascospores that separate into part-ascospores as in *Hypocrea*. Weese (1927) placed *Dialonectria puiggariana* in *Neoskofitzia* Schulzer, a genus for which no type specimen exists. *Dialhypocrea* was considered a synonym of *Hypocrea* by Clements & Shear (1931) and Müller & von Arx (1962). Based on an examination of the type specimen, *Dialhypocrea* is accepted in the *Hypocreaceae*, distinguished from *Hypocrea* on the basis of stromal anatomy and perithecia that are nearly free from each other over a large part of their length. Just as Müller and von Arx (1962) were dubious about placing the species in *Hypocrea*, we are doubtful in retaining *Dialhypocrea*. At the very least, the species would be unusual in *Hypocrea* and there is no doubt about the close affinity of *D. puiggariana* with *Hypocrea*. Characters of asci and ascospores of *D. puiggariana* are typical of *Hypocrea*, and the substratum, i.e. rotten, decorticated wood, is also a feature that sets *Hypocrea* apart in the *Hypocreaceae*. If the anamorph of *D. puiggariana* were a *Trichoderma*, then this species should be placed in *Hypocrea*. However, until the anamorph is discovered or DNA sequences of *D. puiggariana* are analyzed, *Dialhypocrea* is retained as a genus distinct from *Hypocrea*.

Dialhypocrea puiggariana Speg., Bol. Acad. Nac. Ci. 23: 475, 1919. — Plate 17, a–d.

≡ *Neoskofitzia puiggariana* (Speg.) Weese, Mitt. Bot. Lab. TH Wien 4: 86, 1927.

≡ *Hypocrea puiggariana* (Speg.) E. Müll., in Müller & von Arx, Beitr. Kryptogamenfl. Schweiz 11(2): 645, 1962.

Anamorph: None known.

Stromata densely gregarious, tuberculate, 1 mm diam \times 0.5 mm high, each with 3–20 ascumata. Stromal surface layer ca 30 μm thick, of angular cells 5–15 μm diam with walls to 4 μm thick; cells of the stroma below the ascumata pseudoparenchymatous, tending to *textura epidermoidea* with ca 4 μm thick walls, not sharply distinguished from the surface region; surface region separated from the ascumata by a narrow layer of small, non-pigmented cells. Ascumata globose to subglobose, 260–310 μm high \times 170–200 μm diam, non-papillate, smooth, easily separating from the surrounding stromal tissue at the apex. Asci narrowly cylindrical, 55–87 \times 3.5–6.5 μm , 8-spored, apex with a ring; ascospores uniseriate. Part-ascospores dimorphic: distal part conical to subglobose, (3–)3.5–4.5(–5.5) \times 2.5–3 μm ; proximal part wedge-shaped to oblong, (3.5–)4–5(–6) \times 2–2.5(–3) μm , hyaline, spinulose.

HOLOTYPE.— BRAZIL, São Paulo, in the forest near Apiaty, on fragments of decaying branches, April, 1890, J. Puiggari 186 (LPS).

HYPOCREA Fr., Syst. Orb. Veg. 1: 104, 1825.

Type: *H. rufa* (Pers.: Fr.) Fr. (≡ *Sphaeria rufa* Pers.: Fr.).

≡ *Creopus* Link, Handbuch Erk. Gewächse 3: 349, 1833. — Type: *C. gelatinosus* (Tode: Fr.) Link (≡ *Sphaeria gelatinosa* Tode: Fr.), recognized as *Hypocrea gelatinosa* (Tode: Fr.) Fr.

≡ *Chromocrea* Seaver, Mycologia 2: 63, 1910. — Type: *C. gelatinosa* (Tode: Fr.) Seaver (≡ *Sphaeria gelatinosa* Tode: Fr.), recognized as *Hypocrea gelatinosa* (Tode: Fr.) Fr.

Stromata discrete to effused, pseudoparenchyma or highly compacted hyphae, with ascumatal elevations evident or not, stromatal surface variously wrinkled, creased or tuberculate, margins of stromata free from or adherent to the substratum, nearly hyaline, white, yellow, rufous, dark brown to nearly black; ascumata immersed in the stroma, ascumatal wall and stromal tissues KOH+ or KOH–. Asci cylindrical. Ascospores

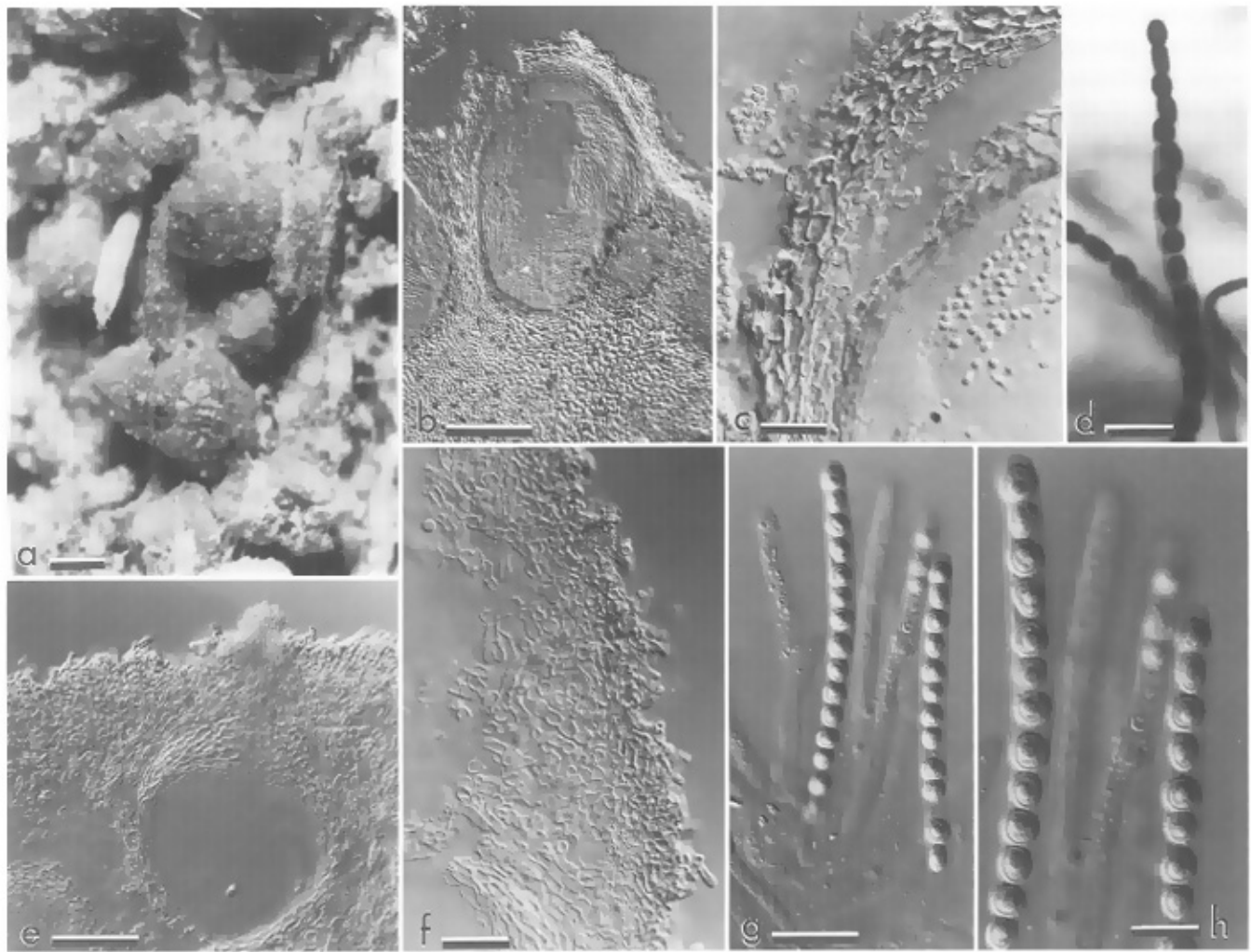


Plate 17. a–d. *Dialhyopocrea puiggariana*. a. Stromata with immersed ascocmata. b. Median section of ascocma. c. Ascocmatal wall. d. Ascus with disarticulating ascospores. **e–h.** *Hypocrea rufa*. e. Median section of stroma with immersed ascocma. f. Close-up of section of stromal surface. g, h. Immature and mature asci with disarticulating ascospores. a–d. Holotype – LPS. e–h. BPI 744478. Scale bars: a = 250 μ m; b = 100 μ m; c, f = 25 μ m; d, h = 10 μ m; e = 50 μ m; g = 20 μ m.

1-septate, disarticulating early in the development into two equal or unequal, globose, subglobose, ovoidal, oblong or wedge-shaped part-ascospores, hyaline or green, typically spinulose or warty, rarely smooth. Anamorphs: *Acremonium*-like, *Gliocladium*-like, *Trichoderma*, *Stilbella*, and *Verticillium*-like. On decaying woody substrata, also other fungi.

NOTES.— The genus *Hypocrea* is characterized by ascocmata that are completely immersed in a stroma and ascospores that are one-septate and disarticulate at the septum so that the ascus appears to contain sixteen ascospores rather than eight. There is considerable variation in color and form of the stroma in *Hypocrea*. The stroma is typically discrete, as in *H. rufa*, but it may be pulvinate with the margins attached to the substratum, or it may be constricted at the base and even appear to be stalked, as in *H. poronioidea* (Samuels & Lodge, 1996a). In some species the stroma is effused over the

substratum to a greater or lesser extent. Colors of stromata in *Hypocrea* are typically in shades of rufous to brown or black, also commonly yellow. Ascospores in *Hypocrea* are usually hyaline, but also green. Rifai (1969b) and Samuels & Rossman (1992) segregated species of *Hypocrea* with non-septate ascospores into *Sarawakus* Boedijn.

The genera *Chromocrea* and *Creopus* were segregated from *Hypocrea* on the basis of their green ascospores, but are not recognized here. Three species were included in *Chromocrea*, with *C. gelatinosa* designated as type. This species, currently accepted in the genus *Hypocrea* as *H. gelatinosa*, is also the type of the earlier generic name, *Creopus* Link 1833. Thus *Creopus* and the obligate synonym *Chromocrea* are synonyms of *Hypocrea*.

Most species of *Hypocrea* occur on bark, decorticated wood, or *Aphylliphorales*, although there is no apparent host specialization. A few exceptions include

Hypocrea pulvinata Fuckel, commonly found on the polypore genera, *Tyromyces*, *Fomitopsis* and *Piptoporus* (*Coriolaceae*), and *Hypocrea spinulosa* Fuckel on grasses in alpine and boreal regions.

To characterize species in *Hypocrea*, it is essential to know the anamorph. Apart from the work of a few authors (Doi, 1969, 1972, 1975 a, b; Rifai & Webster, 1966 a, b; Samuels & Lodge, 1996a; Samuels *et al.*, 1998b), anamorphs have not been documented for most of the approximately two-hundred described species of *Hypocrea*. Most proven anamorphs of *Hypocrea* are species of *Trichoderma* and have either green or, less commonly, white (hyaline) conidia. Other anamorphs are *Acremonium*-like, *Gliocladium*-like, *Verticillium*-like or transitional between these genera and *Trichoderma*. Species that have effused stromata, e.g. *H. citrina*, tend to have *Acremonium*-like anamorphs, which were also classified as *Trichoderma* sect. *Hypocreanum* (Bissett, 1991a). Seifert & Samuels (1997) reported a synnematosus (*Stilbella*) anamorph for *H. cinereoflava* Samuels & Seifert.

No comprehensive monograph of *Hypocrea* in the modern sense exists for any geographical area. The most complete treatment of the genus is Doi (1972) for Japan. Several common European species have been well illustrated in Breitenbach & Kränzlin (1981) and Schmid & Schmid (1991). Seaver (1910a) included 23 species of *Hypocrea* and related genera in his account of the *Hypocreales* of North America. In defining species, Seaver and other early workers considered only gross characters of stromal shape and color along with ascospore characteristics. In his study of species of *Hypocrea* in Japan, Doi (1972) used stromal anatomy as well as anamorphs to divide *Hypocrea* into the two subgenera *Heterocrea* and *Hypocrea*, and further subdivided subgenus *Hypocrea* into two sections, each with subsections, series, and groups. Doi (1972, 1975b) documented the anamorphs for a number of Japanese and extralimital species of *Hypocrea*. These treatments represent a baseline for monographic accounts of *Hypocrea* but are limited in their regional focus and do not provide keys to either *Hypocrea* or their *Trichoderma* anamorphs. Whether the subdivisions of *Hypocrea* proposed by Doi are applicable to a larger, more diverse group of species has yet to be tested.

The *H. schweinitzii* complex and its anamorphs are the subject of a monographic treatment by Samuels *et al.* (1998b). See Plate 4, g.

Hypocrea rufa (Pers. : Fr.) Fr., *Summa Veg.* p. 383, 1849. — Plate 17, e–h.

= *Sphaeria rufa* Pers. : Fr., *Persoon, Observ. Mycol.* 1: 20, 1796; Fries, *Syst. Mycol.* 3: 335, 1822.

Anamorph: *Trichoderma viride* Pers. : Fr.

Stromata discrete, pulvinate, at most slightly constricted at the base, 1–4 × 1–1.5 mm, sides of stroma nearly perpendicular to the substratum, surface plane, sometimes appearing velvety when young, ostiolar openings not evident or, when moist, appearing as numerous, small viscid dots covering the stromal surface, at first, pale tan with white margin, becoming dark brown or reddish brown. Stromatal surface of several layers of darkly pigmented cells, 4–6 µm wide, some of which extend as cylindrical, septate hairs up to 30 µm long × 3–5 µm wide. Tissue below the stroma surface of loosely packed, ca 6 µm wide hyphae. Ascomata ca 200 µm high × 140–160 µm diam. Asci cylindrical, 100–124 × 6–7 µm, apex thickened, with a pore, ascospores uniseriate. Ascospores one-septate, disarticulating into two part-ascospores in the asci; part-ascospores dimorphic, with distal part (to the ascus base) subglobose to conical, proximal part oblong to wedge-shaped, hyaline, spinulose. Description modified from Webster (1964).

HABITAT.— On rotting wood.

DISTRIBUTION.— Cosmopolitan, especially in temperate regions.

TYPE.— No specimen of *Hypocrea rufa* examined by Persoon exists and a neotype has never been designated for this taxon. Thus, the specimen at UPS of Fries: Scleromyceti Sueciae 303 issued as *Sphaeria rufa* is herein designated the **neotype**.

ADDITIONAL SPECIMEN EXAMINED.— UNITED STATES. North Carolina: Wayah Bald, on decorticated log, G. J. Samuels 89-142 (BPI 744478).

ILLUSTRATIONS.— Breitenbach & Kränzlin (1981, Fig. 319); Dennis (1978, Pl. 30N); Doi (1975a, Fig. 19); Ellis & Ellis (1985, Fig. 110); Tulasne & Tulasne (1865, Tab. III, Figs. 1–10).

NOTES.— The connection between *Hypocrea rufa* and *Trichoderma viride*, type of *Trichoderma*, has been known since the outstanding description of Tulasne & Tulasne (1865). Meyer & Plaskowitz (1989) recognized two entities within the *T. viride*-complex that can be separated based on conidial morphology. Using morphological and molecular techniques, Samuels *et al.* (1999) examined single part-ascospore isolates of *H. rufa* and determined that the segregate of *T. viride* having coarsely warted conidia conformed to the anamorph of *H. rufa* as described by Webster (1964) and agreed with the type specimen of *T. viride*.

Hypocrea spinulosa Fuckel, is related to *H. gelatinosa* (Tode : Fr.) Fr. Mathieson (1952) published an account of the genetics of *H. spinulosa* as *Creopus spinulosus*.

SPECIMEN EXAMINED.— FINLAND. Mustiala, Tammela, Tavastia australis, 6 Oct 1867, leg. & det. P.A. Karsten (H 4474, holotype of *H. spinulosa*).

SPECIMENS ILLUSTRATED:

Hypocrea aureoviridis f. *macrospora* Y. Doi: UNITED STATES. Indiana: Porter Co., Indiana Dunes National Lake shore, in hardwood area, on *Phellinus ferruginosus*, 19 Aug 1996, Jack Murphy 2201, comm. S. Huhndorf, det. G.J. Samuels G.J.S. 96-189 = CBS 101603 (BPI 744524). Plate 4, f (page 25).

Hypocrea pseudokoningii Samuels & O. Petrini: NEW ZEALAND. Westland, Harihari, Lower Pucora Valley, on *Dacrydium cupressinum*, 5 Apr 1963, J. Dingley, det. G. Samuels (PDD 23871). Plate 4, g (page 25).

HYPOCREOPSIS P. Karst., Symb. Mycol. Fenn. 2: 251. 1873.

Type: *H. riccioidea* (Bolton) P. Karst. (= *Sphaeria riccioidea* Bolton), a synonym of *Hypocreopsis lichenoides* (Tode) Seaver.

[= *Dozya* P. Karst. 1873, non *Dozya* Lacoste 1866].

Ascomata immersed in a well-developed, radiately spreading, indefinite, often lobate, pseudoparenchymatous stroma; stromal surface reddish brown to grey, generally smooth in young lobes, becoming rugose, with minute, black ostioles of perithecia evident, occasionally covered with conidiophores of the anamorph; stromal context soft, light-colored. Ascomata globose, white to pale yellow, KOH-, thin-walled. Asci cylindrical, 8-spored. Ascospores ellipsoid to fusiform, 1-septate, rarely 3-septate, hyaline, minutely to coarsely warted. Anamorph, where known, *Stromatocrea*. On decaying woody substrata, often on *Hymenochaete* spp. and other resupinate basidiomycetes.

NOTES.— The original citation of *Hypocreopsis* is in a list of corrections to Karsten's 1873 publication, in which the name *Dozya* P. Karst. is replaced by *Hypocreopsis*, because *Dozya* P. Karst. 1873 was a later homonym of *Dozya* Lacoste 1866; Karsten apparently realized this before the book was published. *Hypocreopsis* is typified by *H. riccioidea*, a species previously placed in *Hypocrea*. With changes in the International Code of Botanical Nomenclature that since 1981 allow priority for pre-Friesian names, the oldest epithet for this species is *H. lichenoides*, neither of the competing names being sanctioned by Fries. Niemelä & Nordin (1985) present a review of the entire genus.

Hypocreopsis lichenoides (Tode) Seaver, Mycologia 2: 82. 1910. — Plate 4, h-i (see page 25).

= *Acrospermum lichenoides* Tode, Fungi Mecklenb. sel. 1: 9. 1790.

= *Sphaeria riccioidea* Bolton, Fungi Halifax 4: 182. 1791.

= *Hypocrea riccioidea* (Bolton) Berk., Outl. Brit. Fungol. p. 383. 1860.

[= *Dozya riccioidea* (Bolton) P. Karst., Symb. Mycol. Fenn. 2: 221. 1873, gen. illeg., Art. 53.]

= *Hypocreopsis riccioidea* (Bolton) P. Karst., Symb. Mycol. Fenn. 2: 251. 1873.

= *Sphaeria parmelioides* Mont., Ann. Sci. Nat. Bot., Sér. 2, 6: 333. 1836.

= *Hypocrea parmelioides* (Mont.) Mont., Syll. Gen. Sp. Crypt. 210. 1856.

= *Hypocrea digitata* Ellis & Everh., J. Mycol. 1: 42. 1885.

Anamorph: *Stromatocrea cerebriformis* W.B. Cooke, Mycologia 44: 249. 1952.

Stromata developing as radiating ridges, up to 10 cm diam, 1–5 mm thick, divided in marginal areas into separate lobes, forming 2–4 mm wide finger-like projections; on small twigs, minute stromata of only a few separate lobes encircling the wood. Stromata brown, center greyish, margins paler, context pale tan, soft to corky. Surface smooth on young lobes, becoming rugose in central areas, covered by a palisade of fusiform conidiophores budding conidia from their apices, ascumatal ostioles visible as minute black dots. Stroma a uniform reticulum of intermixed hyphae forming a *textura intricata*, hyphae thin-walled, branched, 3–5 µm wide, near the surface with vesicular, intercalary, swollen cells, 10–15 µm diam. Ascomata globose, 180–250 µm diam. Ascumatal wall pseudoparenchymatous. Asci cylindrical, 80–110 × 7–11 µm, 8-spored. Ascospores ellipsoid to short-fusiform, (16–)22–30 × (5–)6–9.5 µm, 1-septate, hyaline, minutely warted.

ANAMORPH: Conidiophores developing on the surface of the stroma or associated directly with *Hymenochaete tabacina*. Conidia globose, (8–)9–11.5 µm diam, with warted, yellowish, 0.5 µm thick walls. Description modified from Niemelä & Nordin (1985).

HABITAT.— On dead wood of dicotyledonous trees and vines and herbaceous stems, often on *Hymenochaete* spp., usually above ground level.

DISTRIBUTION.— Canada (Labrador, Ontario, Quebec) (Cauchon & Ouellette, 1964; Niemelä & Nordin, 1985). Denmark (Strid, 1967). England, Finland (Niemelä & Nordin, 1985). France (Strid, 1967). Germany, Greenland (Læssøe, 1989). Luxembourg (Marsson, 1987). Norway (Eckblad & Torkelsen, 1974). Russia (Niemelä & Nordin, 1985). Spain (Candoussau, 1990). Sweden (Niemelä & Nordin, 1985; Strid, 1967). United States (Idaho – anamorph only, New Hampshire) (Cauchon & Ouellette, 1964).

TYPE.— The Tode specimen of *A. lichenoides* was destroyed; however, the illustration in Tode (1790) is an unequivocal iconotype. According to Dennis (1975), a portion of the type