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SARAWAKUS LLOYD, A GENUS OF THE PYRENOMYCETE
FAMILY HYPOCREACEAE

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SUMMARY

The scope of the monotypic genus *Sarawakus* is enlarged to enable it to accommodate the newly described species *Sarawakus succius* Rifai. A complete taxonomic revision of the genus is presented, in which it is shown that *Sarawakus* belongs to the Hypocreaceae and not to the Xylariaceae as some authors have suggested. *Hypocrea gelcutinosa* (Tode ex Fr.) Fr. subsp. *oligotheca* Penz. & Sacc. is accorded specific status as *Hypocrea oligotheca* (Penz. & Sacc.) Rifai and *Phaeocreopsis pezizaeformis* Boedijn is transferred to *Hypocreopsis*.

INTRODUCTION

The discovery of an undescribed species of *Sarawakus* Lloyd has made it necessary to propose an emendation to the scope of this so far monotypic genus. This is mainly due to the fact that the characters of the new species deviate in such a way from the type species that the need for a new generic delimitation is inevitable: it is reflected by the fact that it has been found justifiable to classify each species in a subgenus of its own.

The discovery of this new species has also induced me to restudy the taxonomic position of *Sarawakus*. As is well known the type species of this genus, *Sarawakus lycogaloides* (Berk. & Br.) Lloyd, was twice described as new and had been referred to five genera — i.e. *Hypoxylom*, Bull. ex Fr., *Hypocrea* Fr., *Sarcoxylon* Cooke, *Penzigia* Sacc. apud Sacc. & Paolet and *Clintoniella* (Sacc.) Rehm — which in turn are usually distributed among two families (the Xylariaceae and the Hypocreaceae), which some mycologists placed in one order (the Sphaeriales) while others would classify them in two orders (the Sphaeriales and the Hypocreales). Much of our understanding of *Sarawakus* comes from the extensive study of Boedijn (1934), who tentatively considered this genus as a transitional form between the xylariaceous and the hypocreaceous fungi. In contrast

* Herbarium Bogoriense, Bogor, Indonesia.

von Arx & Müller (1954) definitely included the genus in the Xylariaceae, whereas Petch & Bisby (1950) and Ainsworth (1961) listed it as a member of the Hypocreales. More recently Boedijn (1964) stated that *Sarawakus* ". . . . is most probably related to Xylariaceae" It will be shown below that the place of *Sarawakus* should be amongst the hypocreaceous alliance.

THE TAXONOMY OF SARAWAKUS

SARAWAKUS Lloyd *emend.* Rifai

Sarawakus Lloyd, Mycol. Writ. 7(71): 1258. 1924; Boedijn in Bull. Jard. bot. Buitenz. III, 13: 263. 1934; von Arx & Müller in Beitr. Kryptogamenfl. Schweiz 11 (1) : 340. 1954; Ainsworth in Ainsworth & Bisby's Diet. Fung. : 359. 1961.

Stromata superficial, gregariously seated on an extensive and compact tissue-like subiculum or the latter very poorly developed to almost absent, subglobose, globose-depressed or sometimes pulvinate, sessile or contracted below into a short and broad stalk-like base, smooth surfaced, yellow or brown coloured but at maturity dotted with darker and ultimately greenish ostioles, with fleshy to firm fleshy or fleshy corky consistency. *Stromal tissue* indistinctly prosenchymatous but often almost simulating a pseudo-parenchymatous tissue and consisting of hyaline or subhyaline to yellowish, subglobose, angular, polygonal elongated or lobed celled hyphae interspaced by more distinct filamentous hyphal elements, surrounded on the outside by a distinct, darker-coloured cortex layer made up of smaller, sometimes more isodiametric and much thicker-walled cells. *Perithecia* one-layered, completely immersed and confined to the upper part of the stroma, ovoidal or subglobose, their yellowish walls quite distinct and composed of a few layers of slightly flattened angular cells, provided with slightly prominent ostioles lined with a dense layer of periphyses. *Asci* eight-spored, cylindrical, thin-walled, unitunicate and having a simple apical apparatus with pores not turning blue in Melzer's reagent. *Asco'spores* uniseriate, one-celled, ellipsoidal to rarely ovoidal, at first hyaline but soon turning dark green or olive-green, becoming brown in preserved material, without germ-slit or germ-pore, but with surface studded with numerous large tubercles. *Pseudoparaphyses* present at young stage, partly or wholly deliquescent at maturity.

HABITAT: on bark of living trees and culm sheaths of bamboo shoots.

TYPE SPECIES: *Hypoxylon lycogaloides* Berk. & Br.

SCOPE AND DISTRIBUTION: two species from Ceylon, Borneo and Java.

The generic name *Sarawakus* was derived from the geographical name Sarawak (Malaysian Borneo). The latter is the type locality of *Hypocrea rhytidospora* Ces., which is a later synonym of *Hypoxylon lycogaloides*; the latter species was originally described from Ceylon. For the purpose of euphony and to comply with the Recommendation 75A of the Inter-

national Rules of Botanical Nomenclature I take this opportunity to designate the gender of *Sarawakus* as masculine.

In proposing this genus Lloyd (1924) did not give a formal generic diagnosis or description, so that for about ten years its existence was ignored (Clements & Shear, 1931). It was left to Boedijn (1934) to formulate the concept of the genus, in spite of Lloyd's (1924) expressed reluctance for the need of creating this genus.

The characters stressed by Boedijn (1934, 1964) in delimiting *Sarawakus*, and later in distinguishing this genus from *Thuemenella* Penz. & Sacc. *emend.* Boedijn, are the more or less corky stromata which "..... originate in large numbers from extensive subiculum. The stromal tissue consists of cells with thickened cell-walls. The cortical layer is distinct and is made up of very thick-walled cells of which the lumina are nearly obliterated. The dark spores are ellipsoidal." (Boedijn, 1964: 2). The poorly developed subiculum of the new species is markedly different from the extensive and tissue-like subiculum of *Sarawakus lycogaloides*, and if compared with the latter species its stromal tissue and cortex layer have thinner-walled cells so that on the whole its stromata have also a softer consistency. The stromata of *Thuemenella britannica* Rifai & Webster (1965) have even a much softer consistency than those of the new species because their tissue is also made up of more delicate cells. Although in this respect the new species would appear to occupy an intermediate position between *Sarawakus* and *Thuemenella*, the idea to merge the two genera is unwarranted because of the closer relationship between the new species and *Sarawakus lycogaloides*. Nevertheless it is obvious that the inclusion of the new species in *Sarawakus* will bring the latter to a position close to *Thuemenella*, and invalidates much of the taxonomic evidence enumerated by Boedijn (1964) to distinguish the two genera. The separation of *Sarawakus* and *Thuemenella* based on the last character mentioned by Boedijn — that of the ascospore shape — is fully justified, because the genera of the hypocreoid fungi such as *Hypocrea*, *Hypocreopsis* Karst., *Thuemenella*, *Thyronectria* Sacc, *Calonectria* de Not., *Nectria* Fr., *Pseudonectria* Seaver and others are often distinguished from each other solely by their ascospore characters. The ellipsoidal and tuberculate ascospores of the new species make it a stranger amongst species of *Thuemenella*. The ascospore shapes of the two genera indicate further that *Thuemenella* is closer to *Hypocrea* than *Sarawakus* is: the globose, subglobose or elongated ellipsoidal, smooth-walled or minutely echinulate or warted ascospores of the former two genera have broadly rounded to almost truncated

ends so that in optical section they often appear subcuboidal, subangular to almost oblong (compare the descriptions and illustrations of ascospores of various species of *Thuemenella* and *Hypocrea* given by Seaver, 1910; Boedijn, 1964; Webster, 1964; Rifai & Webster, 1965, 1966, 1966a).

The creation of another genus based on this new species and distinguished from *Sarawakus* by the absence of a distinct subiculum and by the softer consistency would seem to be unwarranted, because by themselves these two characters do not appear to be of diagnostic value at the generic level. In other genera of Hypocreaceae one finds that *Podostroma* Karst., for example, contains species with stromata having a fleshy to horny consistency (Boedijn, 1934a, 1938), whereas species of *Hypocrea* may vary from the soft fleshed *Hypocrea gelatinosa* (Tode ex Fr.) Fr. to the firm fleshed *Hypocrea aureo-viridis* Plowr. & Cooke apud Phill. & Plowr. (Webster, 1964; Rifai & Webster, 1966). In the latter genus the subiculum may be completely absent or variously developed but it must be admitted that as far as I am aware none of its species has developed a subiculum as extensive and distinctive as in *Sarawakus lycogaloides*.

The foregoing considerations indicate that the new generic delimitation proposed above is the best course to accommodate satisfactorily this somewhat aberrant new species. On the other hand, to draw attention to the "remoteness" of its relationship to *Sarawakus lycogaloides*, and because of its outstanding morphological deviation from the latter, it is better to divide the genus *Sarawakus* into two subgenera, *Sarawakus* and *Thuemenelladelphus*.

KEY TO SPECIES OF SARAWAKUS

- 1a. Ascospores small to medium sized, subglobose, elongate or short subcylindrical, often subangular, their ends broadly rounded to almost truncats; epispore smooth, minutely echinulate to warted. *Thuemenella* Penz. & Sacc. *emend.* Boedijn
- b. Ascospores medium to large sized, ellipsoidal, their ends neither broadly rounded nor truncate; epispore tuberculate. 2
- 2a. Subiculum large and extensive, tissue-like; stromata yellowish, with a fleshy corky consistency, 3—10 mm diameter; perithecia 370—450 x 270—350 μ .; on bark of living trees (sufagem. *Sarawakus*). *Sarawakus lycogaloides* (Berk. & Br.) Lloyd
- b. Subiculum scanty to almost absent; stromata brownish, fleshy to firm fleshy, less than 5 mm diameter; perithecia 190—250 x 120—180 μ ; on culm sheaths of bamboo shoots (subgen. *Thuemenelladelphus*) *Sarawakus suocisns* Rifai

Subgen. *Sarawakus*

Stromata suberosa, gregaria e subicula magna et compacta oriunda.
— Typus: *Sarawakus lycogaloides* (Berk. & Br.) Lloyd.

Stromata fleshy corky in consistency and gregariously seated on an extensive, compact and tissue-like subiculum.

SARAWAKUS LYCOGALOIDES (Berk. & Br.) Lloyd. — Fig. 1 — 2a

Hypoxyton lycogaloides Berk. & Br. in *J. Linn. Soc.*, Bot. 14: 120. 1873; Sacc, *Syll. Fung.* 1: 355. 1882. — *Sarcoxyton lycogaloides* (Berk. & Br.) Cooke in *Grevillea* 12: 50. 1883; Patch in *Ann. roy. Bot. Gard.*, Peradeniya 8: 143. 1924. — *Penzigia lycogaloides* (Berk. & Br.) Sacc, *Syll. Fung.* 9: 569. 1891; Lindau in *Engler & Prantl*, *Nat. Pflanzenfam.* I, 1: 491. 1897. — *Sarawakus lycogaloides* (Berk. & Br.) Lloyd, *Mycol. Writ.* 7(71): 1258. 1924; Boedijn in *Bull. Jard. bot. Buitenz.* III, 13: 264. 1934; Petch & Bisby, *Fung. Ceylon*: 31. 1950; von Arx & Muller in *Beitr. Kryptogamenfl. Schweiz* 11 (1): 340. 1954.

Hypocrea rhytidospora Ces. in *Atti Accad. Sci. fis. mat. Napoli* 8: 14. 1878; Sacc, *Syll. Fung.* 2: 532. 1883; van Overeem & van. Overeem — de Haas in *Bull. Jard. bot. Buitenz.* III, 4: 27. 1922. — *Clintoniella rhytidospora*. (Ces.) Sacc. & Syd. apud Sacc, *Syll. Fung.* 16: 588. 1902.

Subicula conspicuous, large and extensive, each one harbouring numerous stromata; they are pale dirty yellow coloured and are composed of septate, branched, thin-walled, hyaline to subhyaline, 3—7 μ . diameter hyphae which are interwoven with each other to form a somewhat compact tissue-like structure, up to 0.5 mm thick near the stromata, thinning towards the somewhat byssoid, effused, uneven margin. *Stromata* gregariously seated on a common subiculum, at first appearing as small nipple-like or globose protrusions on the latter, ultimately mostly becoming subglobose depressed with a flattened smooth surface, 3—10 mm diameter and up to 4 mm high in the middle, almost sessile or often provided with a short stalk-like base less than 1 mm high by 2—4 mm wide; the stromata at first have a pale yellow coloration, turning dark yellow with age, but soon their upper surfaces are dotted with darker ostioles which later on exude green ascospores so that at complete maturity the surface of the stromata become greenish ("asphodel green" of Ridgway according to Boedijn, 1934). *Stromal tissue* indistinctly prosenchymatous which often appears like a pseudoparenchymatous tissue, made up of polygonal, lobed or angular elongated thick-walled cells 6—27 μ . diameter with cell-walls up to 2 μ . thick, interspaced irregularly with more distinct thread-like hyphal elements; towards the periphery these cells become smaller sized, thicker-walled (up to 5 μ thick) and often with their lumina almost obliterated, more distinctly prosenchymatous, darker-coloured and forming a distinct cortex layer 50—70 μ . thick; on the whole the stromata have a fleshy corky consistency. *Perithecia* completely immersed immediately under the cortex

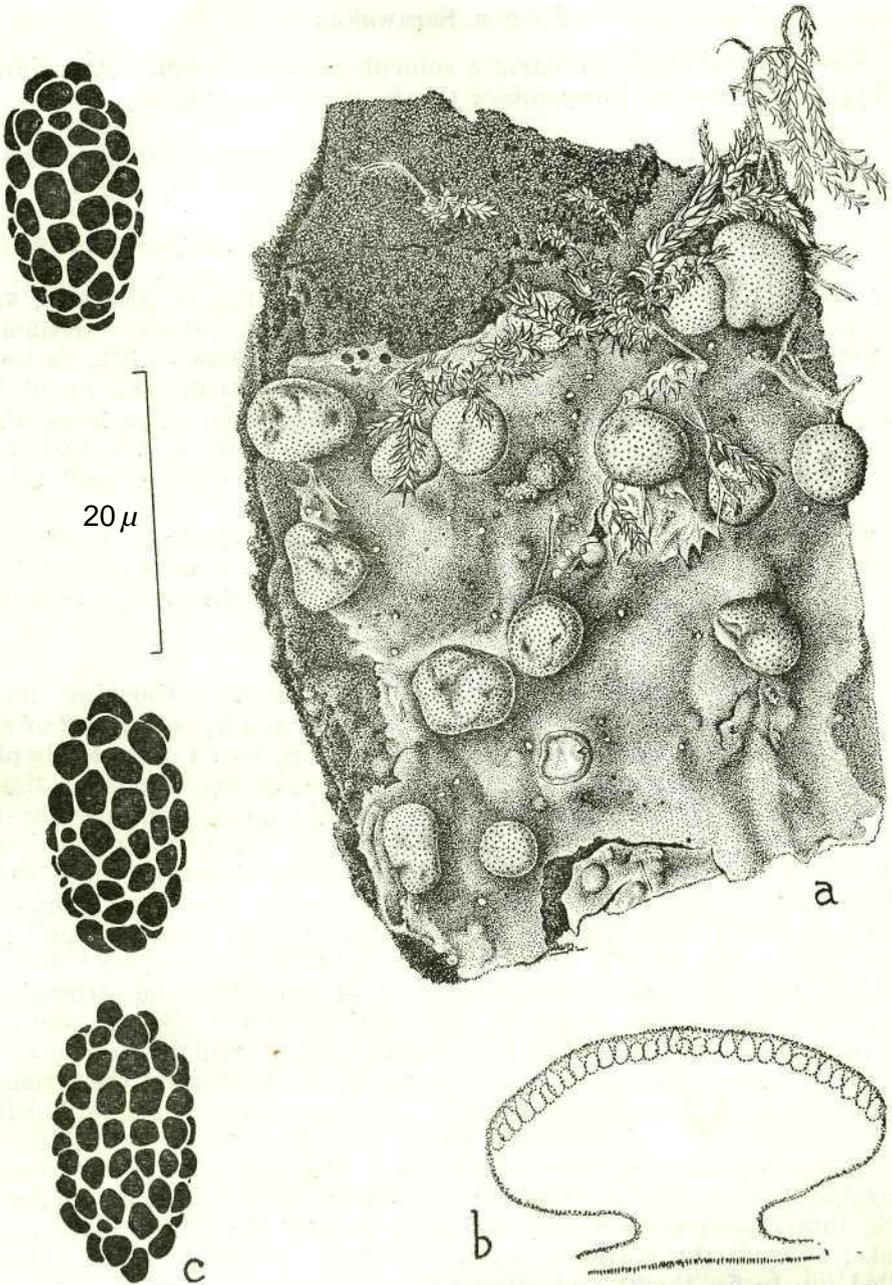


Fig. 1. *Sarawakus lycogaloides*: a, habit sketch (2.5 x); b, median section through a stroma (7.5 x); c, ascospores (from Boedijn 617).

layer, in one layer and confined to the upper side of the stromata, mostly ovoid or sometimes subglobose, $370-450 \times 270-350 \mu$., their densely periphysate ostioles normally slightly protruding above the surface of the stroma; perithecial wall thin, consisting of a few layers of flattened angular cells, slightly darker coloured than the rest of the stromal tissue. *Asci* thin-walled, nearly cylindrical, slightly attenuate below into a short stipe, $165-190 \times 10-12 \mu$, 8-spored, apical apparatus simple, not turning blue in Melzer's reagent. *Ascospores* unicellular, uniseriate, sometimes obliquely uniseriate, ellipsoidal or often obovoid-ellipsoidal, especially the lower ones, and rarely unequal sided; they measure $17.5-20.5 \times 8-10 \mu$., at first colourless soon turning pale green, then becoming beautiful green, at last dark olive-green, appearing greenish black in mass, whereas in preserved specimens these ascospores have sepia-brown coloration; at maturity the surface of these ascospores are studded with large, rounded and irregular tubercles. *Pseudoparaphyses* thread-like, colourless, partly deliquescent at maturity.

HABITAT: on bark of living trees.

DISTRIBUTION: Ceylon (type locality), Sarawak (Borneo) and Java.

ILLUSTRATIONS: Berkely & Broome in J. Linn. Soc., Bot. 14: pi. 6, fig. 33. 1873; Cesati in Atti Accad. Sci. fis., mat. Napoli 8: pi. 3, fig. 1. 1878; Lloyd, Mycol. Writ. 7(71): fig. 2739. 1924; Boedijn in Bull. Jard. bot. Buitenz. III, 13: 265, fig. 1. 1934; von Arx & Müller in Beitr. Kryptogamenfl. Schweiz 11(1): 326, fig. 99 f. 1954.

CEYLON. On bark, Central Province, December 1868 (K; type specimen of *Hypoxylon lycogaloides* Berk. & Br.)

BORNEO. On bark, Sarawak, 1865, *O. Beecari* (K; isotype specimen of *Hypocrea rhytidospora* Ces.).

JAVA. On bark, Tjibodas, trail to Mt. Gedeh, 27 November 1921, *Docters van Leeuwen, Dakus & Bruggeman* (BO 4508); on the bark at the base of a living tree, Tjibodas, ca. 1500 m alt., April 1930, *Boedijn* 272 (BO 11513); *ibid.*, *Boedijn* 617 (BO 11570); on the bark of a living tree, Puntjak Pass, near Telaga Warna, 29 May 1939, *van Steenis* 11241 (BO 17017); on the bark of a living tree, Telaga Warna, June 1939, *van Steenis* (BO 17059).

Subgen. *Thuemenelladelphus* Rifai, *subgen. nov.*

A *Sarawakus* subgen. *Sarawakus subiculo* inconspicuo, stromatibus carnosus recedit. — Typus: *Sarawakus succisus* Rifai.

Stromata have a fleshy to firm fleshy consistency, typically gregariously seated on poorly developed or inconspicuous subicula, otherwise similar to *Sarawakus* subgen. *Sarawakus*.

Sarawakus succisus Rifai, *spec. nov.* — Fig. 2b — 3

Subiculum effusum, minutum, inconspicuum vel nullum, candidum ex hyphis septatis, ramosis, hyalinis, $3-7 \mu$ crassis compositum. *Stromata*

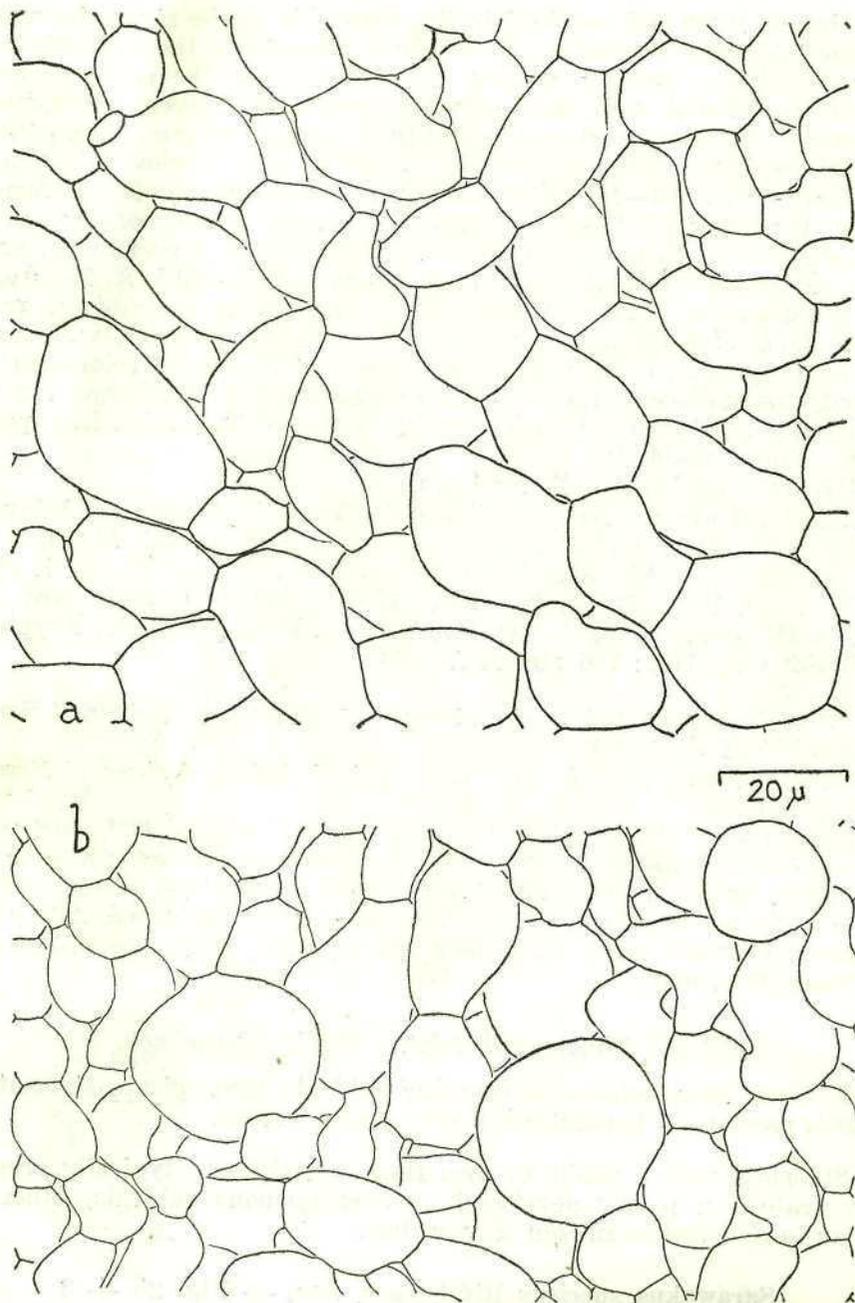


Fig. 2. Stromal tissue of: a, *Sarawakus lycogaloides* (from Boedijn 617);
b, *Sarawakus succisus* (from Rifai 254).

solitaria vel caespitosa, subglobosa, flavo-brunnea, carnosa, 0.3—3 mm crassa. *Perithecia* immersa, in area superiore limitata, subglobosa, bstitolata, 190—250 X 120—180 μ ., *Asci* cylindranei, breve stipitati, octospori, 115—158 x 8.5—11 μ , pseudoparaphysati. *Ascospori* uniseriati, non septati, ellipsoidei vel obovato-ellipsoidei, tuberculati, virides vel olivaeo-virides, sicci brunnei, 15.5—22.5 X 8.5—10 μ .

Hab. in vaginis culmorum *Dendrocalami gigantei*, Hortus Botanicus Bogoriensis, Java, 12 Februari 1962, Rifai 254 (BO) typus est.

This species is found on sheaths of young and growing bamboo shoots; it grows mostly on the lower (the first three) sheaths, but sometimes also on the higher sheaths; as is the case with *Sarawakus lycogaloides*, there is no indication that the present species caused any harmful effect to the living host plant. The *subicula* of *Sarawakus succisus* are mostly scanty and very poorly developed, forming small watery white to white patches around the stromata and are made up of thin-walled, colourless, septate, 3—7 μ . diameter hyphae; at maturity these subicula may be inconspicuous or entirely disappear. *Stromata* scattered to caespitose, subglobose, globose-depressed or rarely globose, sometimes lobed, mostly sessile at the contracted base, their surface convex or flattened but in the larger stromata they may be slightly irregularly depressed in the middle which makes them appear bumpy, whereas on the underside of detached stromata an inward depression can mostly be found; when, young the stromata at first white, soon becoming pale or dirty-yellow, but upon nearing maturity the surface turning yellowish or pale brown to brown and dotted with brown and almost prominent ostioles which at complete maturity appear greenish from the extruding asospores, while the rest of the stromata remains yellowish brown. *Stromal tissue* indistinctly prosenchymatous to pseudo-parenchymatous, consisting of compactly arranged subglobose, subangular, polygonal or lobed cells 6—30 μ . diameter, interspersed with elongated and thread-like hyphal elements; a distinct cortex layer about 35 μ , thick, composed of smaller sized and slightly thicker-walled cells covers the stromal tissue; in contrast with the latter, which is whitish to pale yellow, this cortex layer is usually dark-yellow or pale brownish yellow; the stroma has a fleshy to firm fleshy consistency. *Perithecia*, in one layer, confined to the upperside of the stroma and completely immersed, ovoidal, globose or globose-depressed and measure 190—250 x 120—180 μ or 190 μ . high by 250 μ . wide, provided with narrowly conical or subcylindrical and almost prominent ostioles lined by a dense layer of periphyses; perithecial wall thin, composed of a few layers of flattened cells up to 10 μ thick, with pale brownish yellow coloration. *Asci* subcylindrical, attenuate below into a very short stipe, thin-walled, 8-spored, 115—158 x 8.5—11 μ ; apical apparatus simple and reacting negatively with Melzer's reagent. *Ascospores* uniseriate, usually obliquely uniseriate, unicellular, ellipsoidal to ovoidal, sometimes unequal sided, ornamented with irregularly rounded tubercles of various size, 15.5—22.5 x 8.5—10 μ , hyaline when young but soon

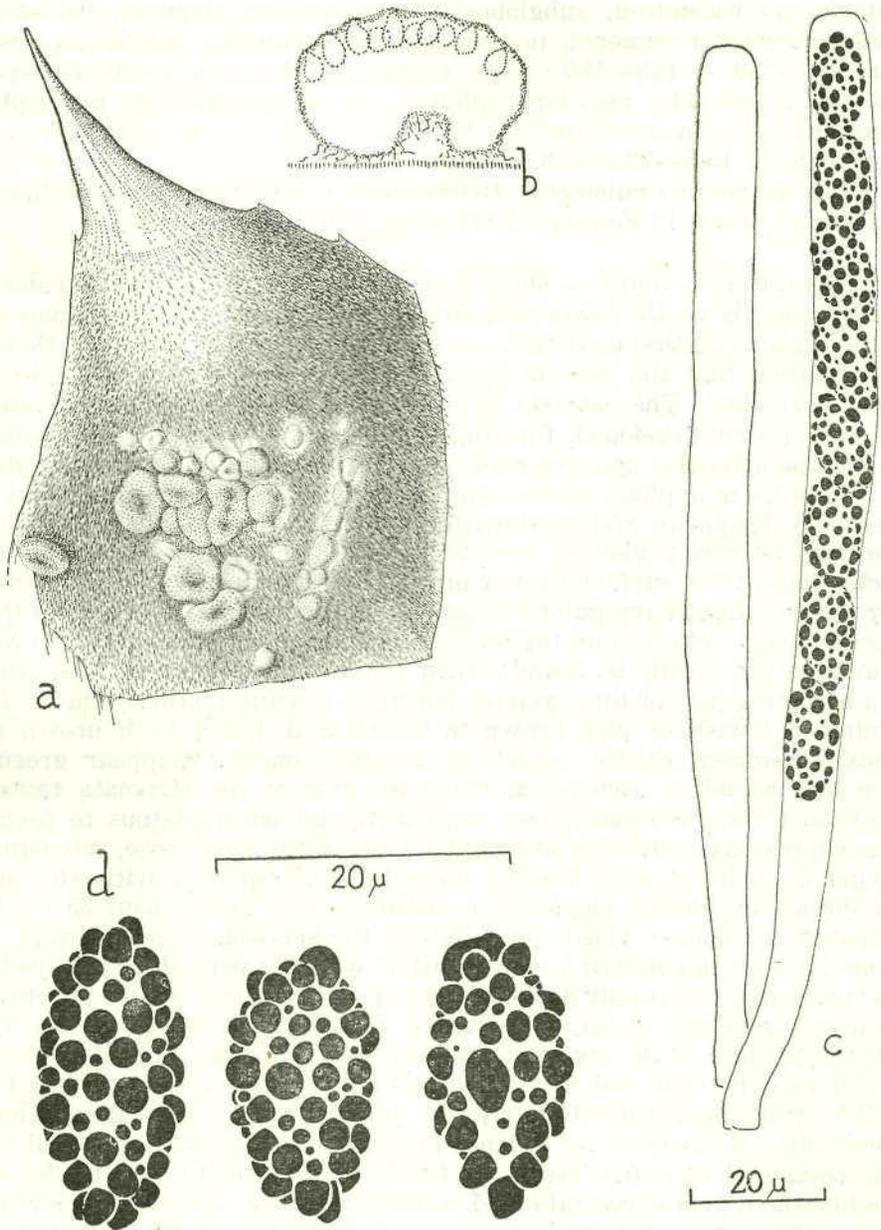


Fig. 3. *Sarawakus suceisus*: a, habit sketch (2.5 x); b, median section through a stroma (15 x); c, asci; d, ascospores (from Rifai 254).

becoming pale green and gradually turning to beautiful green, ultimately dark olive-green at maturity and appear greenish black in mass; in preserved (dried) specimens these ascospores are brown. *Pseudoparaphyses* present in young stage only, thread-like, colourless, completely deliquescing at maturity.

HABITAT: on living shoot sheaths of bamboos.

DISTRIBUTION: West Java (known only from the type locality).

JAVA. On the shoot sheath of bamboo, Bogor Botanic Garden, February 1924, *Nongnong s. n.* (BO 5534); on *Dendrocalamus giganteus*, Bogor Botanic Garden, 12 February 1962, Rifai 254 (BO; type specimen of *Sarawakus succisus* Rifai); *ibid.*, 7 — 20 February 1962, Rifai 250, 251, 256, 261; on *Gigantochloa*, sp., Bogor Botanic Garden, 1 March 1962, Rifai 267 (all in BO).

THE AFFINITY OF SARAWAKUS

The true taxonomic affinity of *Sarawakus* with either the Xylariaceae or the Hypocreaceae can be determined best by closely comparing the anatomy and morphology of its species with members of the two respective families. For this purpose it is necessary first to review the delimitations of the two families according to ideas currently prevailing in taxonomic mycology.

From the very beginning it has been realized that the traditional characters — consistency and coloration — employed in distinguishing the Hypocreales and the Sphaeriales (to which the Xylariaceae belongs) are unsatisfactory, especially because of the presence of paradoxical genera, such as *Sarawakus*, *Thuemenella*, *Sarcoxyton* and others, which at first sight would appear to represent intermediate forms between the two orders. Therefore, the Hypocreales have often been merged with the Sphaeriales (Nannfeldt, 1932; von Arx & Müller, 1954; Dennis, 1960; Müller & von Arx, 1962). In recent years, however, it has been demonstrated that the soft consistency and the bright coloration of the stromata or perithecia of the hypocreaceous fungi are correlated with other characters of more significant diagnostic value such as types of conidial stages (mostly phialo-sporous), types of ascospores, the simple structure of the apical apparatuses of their asci, the downward growing pseudoparaphyses and others. Consequently in many modern treatises the Hypocreales have also been maintained as a distinct order (Miller, 1949; Luttrell, 1951; Chadefaud, 1960; Martin, 1961; Alexopoulos, 1962; Hawker, 1966). Although further critical developmental studies of more species are desirable, this order is upheld here to include the Hypomycetaceae and those genera accepted by Boedijn (1964) in the Hypocreaceae and Nectriaceae, with a note that in

this group of fungi I prefer to adopt a wider generic delimitation than that conceived by Boedijn. It follows that the Melanosporaceae, the Polystigmataceae and those genera classified — correctly, in my opinion — in the Clavicipitales, which in the past have been included in the Hypocreales, should be excluded from the latter.

The family Xylariaceae originally covered only the distinctly stromatic and dark-coloured (carbonaceous) genera of Sphaeriales such as *Hypoxylon* Bull. ex Fr., *Poronia* Willd. ex Fr., *Daldinia* Ces. & de Not., *Ustulina* Tul., *Xylarla*- Hill, ex Grev. (= *Xylosphaera* Dum.), *Nummularia* Tul. and others, but later workers have correctly assigned to it non-stromatic or indistinctly stromatic genera, such as *Rosellinia* Ces. & de Not. (which appears to represent an unnatural genus) and *Anthostomella* Sacc. as well. Other authors such as Munk (1957) would expand this family to include the allantosporous fungi, while von Arx & Miiller (1954) have transferred into it some unrelated genera now commonly placed in the Sordariaceae. Since these latter treatments will only make the Xylariaceae a heterogeneous assemblage, this family is interpreted here to embrace only those genera characterized by perithecia embedded in a stroma, developed in host tissue beneath a clypeus or on a variously developed subiculum, usually with a relatively tough consistency and having — at least in part — a carbonaceous pigmentation, with asci growing among persistent paraphyses and having intricately constructed apical apparatuses with amyloid pore-plugs, and with ascospores unicellular, smooth-walled, typically asymmetrical and provided with germ-slits and always dark coloured. This circumscription has been widely adopted by many recent authors (Dennis, 1980; Alexopoulos., 1962; Eriksson, 1968; Martin, 1967).

With some reservations the Hypomycetaceae are considered here to constitute one family of the Hypocreales, chiefly on the basis of evidence of Hanlin's (1963) developmental study of *Hypornyces lactifluorum* (Schwein.) Tul. Furthermore, the Hypocreaceae and the Nectriaceae, namely the two families distinguished and circumscribed by Boedijn (1964), should also be included in this order and maintained as two distinct taxa; Munk (1957), Dennis (1960) and Alexopoulos (1962) have also kept the two families apart.

Some well known genera that can be assigned to the Hypocreaceae in Boedijn's (1964) restricted sense are *Hypocrea* Fr. (inclusive of *Creopus* Link and *Chromocrea* Seaver), *Podostroma* Karst., *Hypocreopsis* Karst. (inclusive of *Phaeocreopsis* Sacc. & Syd. apud Lindau), *Thuemenella* Penz,

& Sacc. *emend.* Boedijn, and, as will be shown below, *Sarawakus* Lloyd as emended in the preceding pages.

Now we can compare the morphological and anatomical features of *Sarawakus* with those of the Hypocreaceae and the Xylariaceae. Except for the consistency, the overall field characters of *Sarawakus* such as the habit or general appearance and coloration, are more hypocreaceous than xylariaceous. As has been pointed out above, however, in the classification of these groups of fungi the consistency of the stromata has only a minor or unimportant diagnostic value. This is largely due to the fact that many types of consistency may be found in the same genus, especially in the larger or stromatic ones such as *Sarcoxydon*, *Xylaria*, *Hypocrea*, *Podostroma* and others. The absence of a sharp distinction between the consistency of the Xylariaceae and the Hypocreaceae has made all attempts to classify *Sarcoxydon* and *Sarawakus* on the basis of this character alone a very difficult undertaking. It seems to me that in determining the taxonomic affinity of the genus *Sarawakus* an undue emphasis has been placed on this character by Boedijn (1934, 1964).

Generally speaking members of the Xylariaceae can be characterized by their carbonaceous pigmentation; in most cases this coloration can be readily observed on the surface of the stromata but in some species such as *Xylaria tabadna* (Kickx) Berk, and *Sarcoxydon punctum*. (Jung.) Cooke it is necessary to section the stromata before this becomes visible. In contrast carbonaceous pigmentation never occurs in members of the Hypocreaceae. Berkeley & Broome's (1873) unaccountable statement that *Sarawakus lycogaloides* has black perithecia and reference to its resemblance to a small-scale *Sarcoxydon punctum* have led Cooke (1883), Saccardo (1882, 1891) and Lindau (1897) to classify this species in the xylariaceous genera *Sarcoxydon*, *Hypoxydon* and *Penzigia* respectively. As Lloyd (1924) has correctly pointed out, however, there is nothing carbonaceous about *Sarawakus lycogaloides*. Similarly *Sarawakus succisus* has no carbonaceous pigmentation, so that in this respect the genus *Sarawakus* appears to have a closer affinity with members of the Hypocreaceae than with those of the Xylariaceae.

It has been noted above that the carbonaceous coloration can further be found in the ascospores of all members of the Xylariaceae, so that here the pigmentation has a significant diagnostic value at the family level. In delimiting the family Hypocreaceae it was stated by Boedijn (1964) that its ascospores are "... colourless or green when fresh, brown or sepia in preserved material ...". As can be seen from the generic description given above, the ascospore colour of *Sarawakus* is very similar to

that of the Hypocreaceae. It should be pointed out here that Seaver (1910), Clements & Shear (1931), Petch (1938), Dennis (1960) and Boedijn (1964) held the view that the ascospore coloration of the Hypocreaceae (namely, whether they are colourless or pigmented) was an important generic character. Formerly it was shown, however, that in *Hypocrea* the segregation of genera based on this character alone was unnatural (Rifai & Webster, 1966) ; this view has already been adopted by Dingley (1952) and Müller & von Arx (1962). Penzig & Saecardo (1898, 1904) went a step further in believing that even at the specific level the diagnostic value of ascospore pigmentation was questionable and they included in the same species forms which had colourless and pigmented ascospores; in my opinion this is unjustifiable because there are ample morphological differences to show that *Hypocrea oligotheca* (Penz. & Sacc.) Rifai, *stab. & comb. nov.* [basionym: *Hypocrea gelatinosa* (Tode ex Fr.) Fr. subsp. *oligotheca* Penz. & Sacc. in *Malpighia* 11: 519. 1898; Penz. & Sacc, *Icon. Fung. Jav.*: 51, pi. 35, fig. 1. 1904. — Typus: in, culmis putridis, Tjibodas, Java, 4 Martii 1897, *Penzig* 128, BO 3429] deserves a specific status.

Boedijn (1959, 1962) excluded *Xylaria nigripes* (Klotzsch) Sacc. and *Xylaria spathulata* Berk. & Br. from the Xylariaceae because, among other things, their ascospores have no germ-slit, a character generally found in the ascospores of members of this family. In agreement with ascospore characters of the Hypocreaceae, neither germ-slit nor germ-pore can be detected in the ascospores of the two species of *Sarawakus* described in the present paper.

The ascospores of the Xylariaceae are invariably smooth-walled, whereas those of *Sarawakus* are ornamented with characteristic large tubercles. A similar type of epispore can be found in the bicellular ascospores of *Hypocreopsis pezizaeformis* (Boedijn) Rifai, *comb. nov.* (basionym: *Phaeocreopsis pezizaeformis* Boedijn in *Bull. Jard. bot. Buitenz.* III, 16: 371, fig. 4. 1940 — Typus: in ligno, Krakatau, Sumatra, 11 Julii 1929, *Docters van Leeuwen* 12658, BO 10470). In other members of the Hypocreaceae the ascospore walls may vary from coarsely warty to minutely echinulated or perfectly smooth.

Like those found in all other hypocreaceous fungi the asci of *Sarawakus* are non-reactive to Melzer's reagent and have simple apical apparatuses, whereas those of the Xylariaceae are mostly iodine-positive and have complicated apical apparatuses. Furthermore, in agreement with the other species of the Hypocreaceae the pseudoparaphyses of *Sarawakus* appear to undergo partial or complete deliquescence at maturity.

In describing Danish species of *Xylaria* it was stated by Munk (1957) that their stromal tissue is prosenchymatous, i.e. made up of textura intricata hyphae. During the course of this study I have examined many common north temperate and tropical species of *Xylaria* and I am able to corroborate Munk's observation; in many cases their long-cylindrical celled hyphae are so regularly orientated as to simulate even a textura porrecta tissue. I have further observed that this distinctly prosenchymatous tissue arrangement occurs in other species of xylariaceous fungi e.g. in species of *Daldinia*, *Sarcoxydon*, *Penzigia*, *Ustulina*, *Camarops* Karst. and in some members of *Hypoxylon*. Although many species of *Hypocrea* have prosenchymatous stromal tissue, it is slightly differently constructed as compared with that of the Xylariaceae in that their hyphae are often made up of barrel-shaped, lobed to almost subglobose cells, strongly constricted at the septa and irregular in width [cf. Dingley, 1952, 1955; Webster, 1964; Rifai & Webster, 1966, 1966a; the schematic illustration of tissue structure of *Hypocrea rufa* (Pers. ex Fr.) Fr. given by Müller & von Arx in Beitr. Kryptogamenfl. Schweiz 11(2) : 642 fig. 252. 1962 is erroneous]. In some other species of *Hypocrea* such as *Hypocrea gelatinosa* (Webster, 1964), as well as in other hypocreaceous genera, such as *Thuemenella* (Boedijn, 1964; Rifai & Webster, 1965), the stromal tissue would appear to be more correctly designated as being of a type intermediate between prosenchymatous and pseudoparenchymatous. Boedijn (1934) has indicated that the stromal tissue of *Sarawakus lycogaloides* is of this type, an interpretation which I find to be correct and applicable to *Sarawakus suceisus* as well. It is evident that in their tissue structure species of *Sarawakus* show a closer similarity to the Hypocreaceae than to the Xylariaceae.

It is hoped that ample fresh material will become available in the future so that a detailed study of the centrum development of *Sarawakus* can be undertaken. It is worth recording here, however, that in sections obtained by cutting preserved young material of *Sarawakus suceisus* on a freezing microtome the presence of the subhymenial pseudoparenchyma* has been observed. This structure was first reported by Doguet (1957) for *Hypocrea spinulosa* Fuckel and its existence apparently is limited to the hypocreaceous fungi.

I have not been able to culture either of the two species of *Sarawakus* described above, so it is impossible to state whether their cultural beha-

* Doguet (1957) termed this "plectenchym sous-hymenial", which, is translated here as subhymenial pseudoparenchyma; following Ainsworth (1961) and Alexopoulos (1962) I prefer to reserve the term plectenchyma for all organized tissue of fungi.

viour will provide additional evidence for determining the taxonomic position of this genus. As is well known the Hypocreales mostly have phialosporous conidial states (Tubaki, 1958), whereas the Xylariaceae typically are connected with radulasporous hyphomycetes (Martin, 1967; Greenhalgh & Chesters, 1968).

Despite the existence of two or three unresolved questions, all evidence discussed above indicates that the taxonomic affinity of *Sarawakus* is with the genera of the Hypocreaceae rather than with those of the Xylariaceae.

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