Torrubiella dimorpha, a new species of spider parasite from Taiwan

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Torrubiella dimorpha sp. nov. on an infected spider from Taiwan is described and illustrated. It is characterized by producing perithecia on an orange white, pulvinate, lanose mycelial mat covering the host. The anamorph, *Gibellula dimorpha* sp. nov., produces gibelluloid and granulomoid synanamorphs on aspergillate, distinctly roughened or warty conidiophores, or sometimes produces both synanamorphs on the same aspergillate vesicle. The differences between *T. dimorpha* and the closely related *T. globosa*, *T. globoso-stipitata*, *T. arachnophila*, *T. ratticaudata* and *T. clavata* are briefly discussed.

Torrubiella was established in France (Boudier, 1885) to accommodate a single species *Torrubiella arachnida* Boud. on a spider. Since then many new taxa of *Torrubiella* parasites on spiders, coccids, leaf hoppers, ants, moths, psyllids, and on *Cordyceps* species have been described (Petch, 1923, 1932, 1944; Mains, 1950; Samson & Evans, 1973, 1977, 1992; Kobayasi & Shimizu, 1976, 1982; O'Donnell, Common & Imshaug, 1977; Humber & Rombach, 1987; Samson, Reenen-Hoekstra van & Evans, 1989; Hywel-Jones, 1993, 1995). Kobayasi (1982) provided keys to *Cordyceps* and *Torrubiella*. Kobayasi & Shimizu (1982) also monographed the 56 valid species of *Torrubiella*. Thirty-four species were described from spiders and only four of these produced *Gibellula* anamorphs, including *T. globosa* Kobayasi & Shimizu, *T. globoso-stipitata* Kobayasi & Shimizu, *T. arachnophila* (J. R. Johnst.) Mains, and *T. gibellulae* Petch (Petch, 1932; Mains, 1950; Kobayasi & Shimizu, 1982). More recently, *T. ratticaudata* Humber & Rombach was described from salticid spiders from the Solomon Islands; its anamorph, *Gibellula clavulifera* (Petch) Samson & H. C. Evans var. *alba* Humber & Rombach, was characterized by ovoid conidia on phialidic conidiogenous cells borne on penicillate conidiophores, and bacilliform conidia initiated from polyblastic conidiogenous cells arising directly from the mycelium (Humber & Rombach, 1987). *Torrubiella clavata* Samson & H. C. Evans was described from Araneida on cacao (*Theobroma cacao* L.) from western Ecuador; its anamorph *G. clavata* Samson & H. C. Evans, produced unique broadly clavate, solitary, occasionally paired synnemata, and the gibelluloid morph having short, distinctly roughened conidiophores and the granulomanoid morph having one-celled oval-cylindrical conidiogenous cells arising from irregular branched hyphae or on short branches (Samson & Evans, 1992). Nonetheless, the taxonomy of *Torrubiella* was problematic because many specimens collected have been immature or at different developmental stages, and also because the distinguishing characters were few. It has been stressed that the presence or absence of anamorph is crucial for distinction of the species of the genus (Mains, 1950; Samson, Reenen-Hoekstra van & Evans, 1989).

During a survey of the entomopathogenic fungi from Taiwan, which has been in progress since 1989, a total of 117 spider cadavers infected by fungal pathogens was collected. Of these, 11 specimens were infected by *Torrubiella* spp., two *T. flava* Petch, one *T. gonylepticida* (F. H. Møller) Petch, two *T. minutissima* Kobayasi & Shimizu, two *T. tenuis* Petch, and three *T. luteorostrata* Zimm. (Petch, 1923; Kobayasi & Shimizu, 1982). One was infected by a *Torrubiella* species with gibelluloid and granulomanoid synanamorphs which was different from the known *Torrubiella* species from spiders with *Gibellula* anamorphs (Kobayasi & Shimizu, 1981, 1982; Humber & Rombach, 1987; Samson & Evans, 1992), and is described here as a new species. Colour nomenclature follows Kornerup & Wanscher (1978).

Torrubiella dimorpha Tzean, L. S. Hsieh & W. J. Wu sp. nov. (Figs 1–17)

Anamorph: **Gibellula dimorpha** Tzean, L. S. Hsieh & W. J. Wu sp. nov.

Hospes aranea infecta tegete densa, myceliali, alba, eburnea vel aurantialba (4-5A2), pulvinata, tomentosa vel lanosa, margine praedito patenti, subiculum byssoideum formanti, obtectus. *Hyphae* ramosae, septatae, hyalinae, distincte verrucosae, interdum laevi-tunicatae, 2·4–5·6 µm latae. *Perithecia* in tegete myceliali producta, superficialia vel subinclusa, aspersa, ovoidea, 490–600 × 250–320 µm, eburnea (1-2A2), tomentosa, parietibus 12–18 µm crassis praedita. *Asci* octospori, cylindrici, 6·4–8·2 µm lati, pileo incrassato 4·8–6·4 µm crasso 6·8–8·7 µm lato praedita. *Ascosporae* filiformes, multiseptatae, in seriebus parallele dispositae, 1·6–2·4 µm latae, in partisporas abrumpentes. *Partisporae* cylindricae, truncatae, laeves, hyalinae, 3–8·7 × 2–2·3 µm. *Synnemata* solitaria, e tegete myceliali exorientia,

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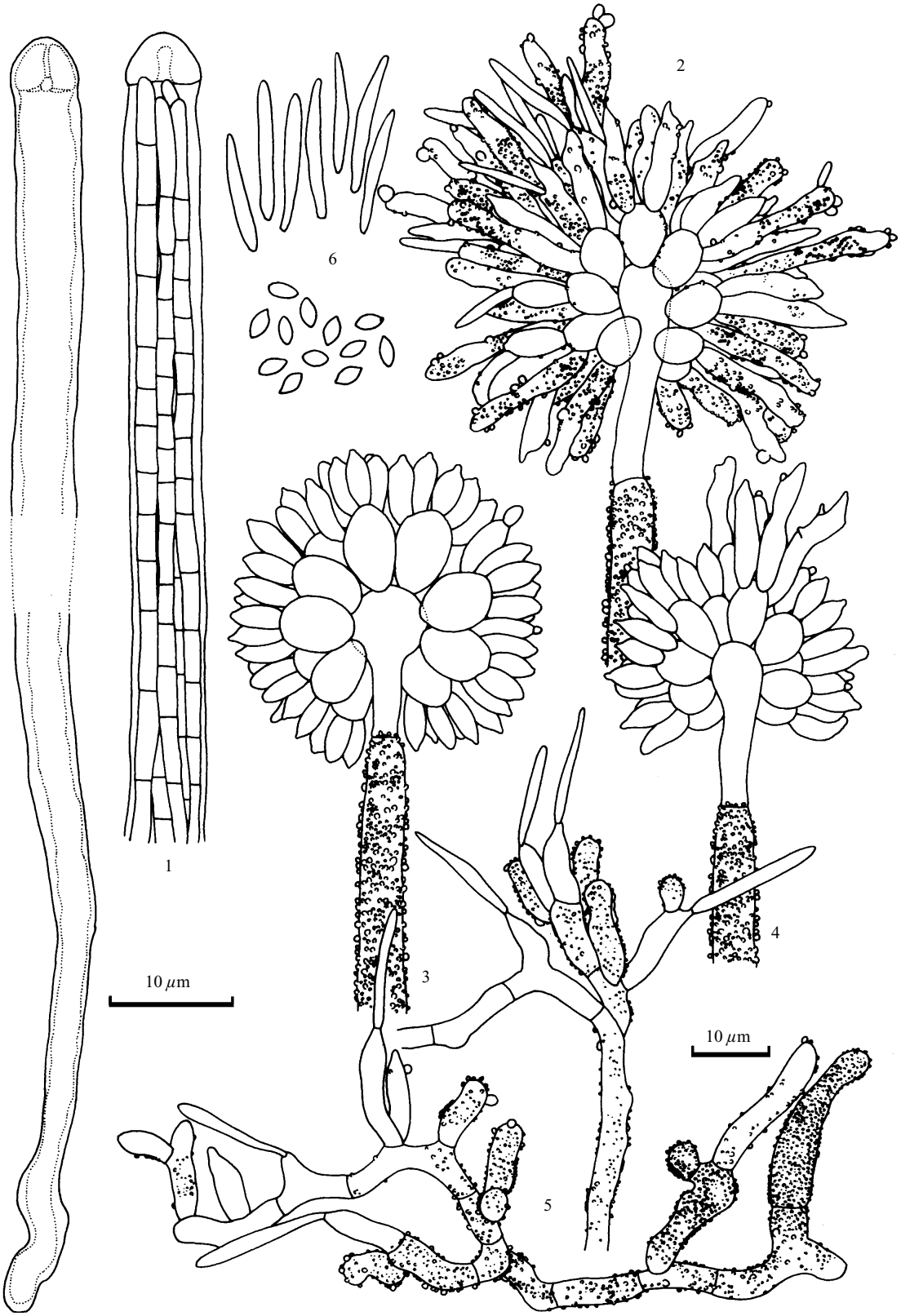
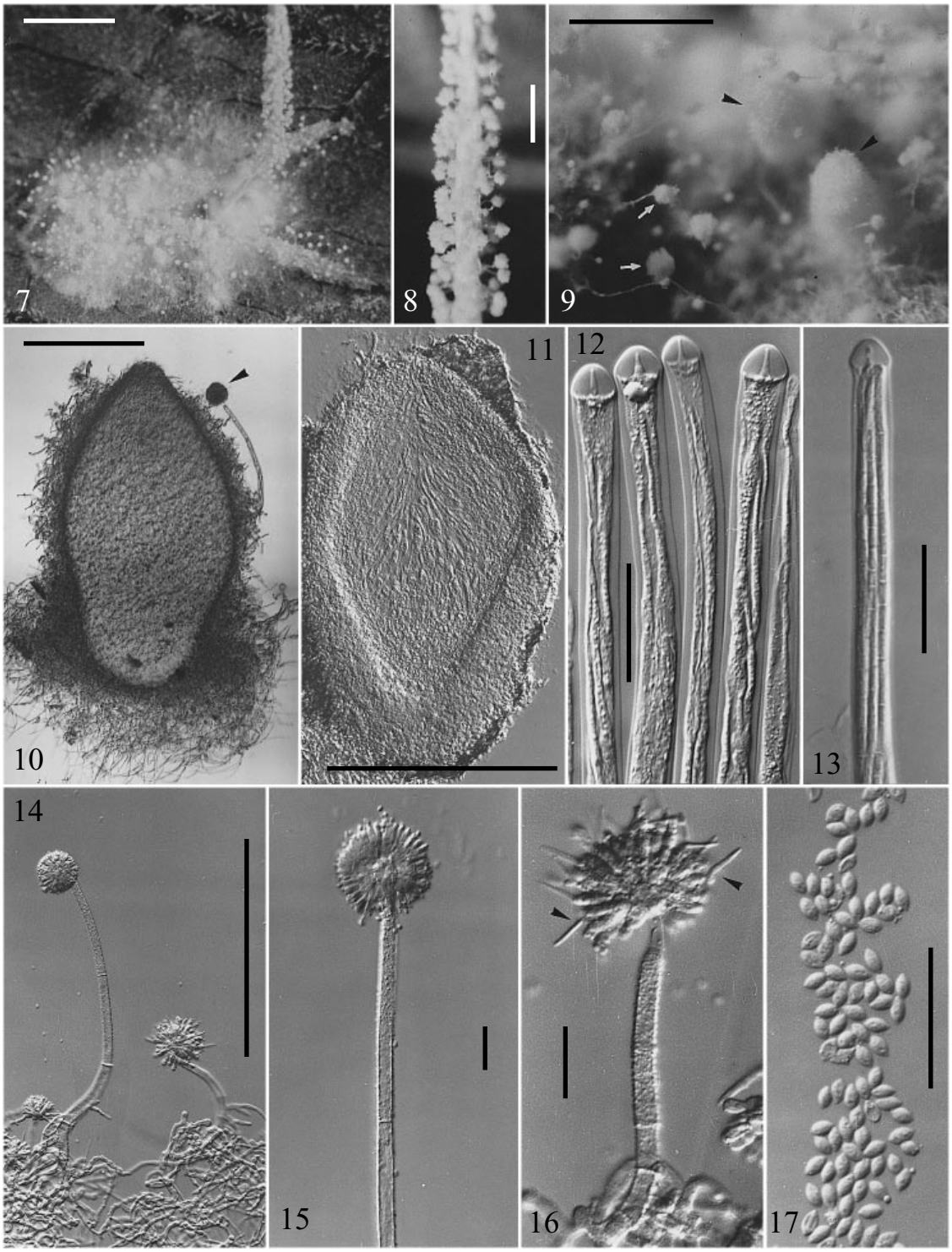


Figs 1–6. *Torrubiella dimorpha*. **Fig. 1.** Ascus with thickened ascal apex and part of ascospores. **Fig. 2.** Granulomanoid vesicle. **Fig. 3.** Gibelluloid conidiophore. **Fig. 4.** *Gibellula* vesicle bearing gibelluloid and granulomanoid conidiogenous cells. **Fig. 5.** Granulomanoid conidiophores irregular, branched, bearing conidiogenous cells and conidia. **Fig. 6.** Granulomanoid and gibelluloid conidia.

cylindrica, attenuata, curva, 5 mm × 200 μm, e hyphis compactis longitudinaliter septatis composita, hyalina, laevia, raro exasperata, 2·2–4 μm. *Conidiophora* status Gibellulae mono-vel synnematica, chloroleuca vel pallide viridia (30A2-3), 140–422 × 7·1–10·3 μm, septis incrassatis, conspicuis, saepe atro-pigmentosis praedita, base distincte exasperata, verrucata, in apicem gracilem, laevi-tunicatum 3·2–4·5 μm latum abrupte astricta, in vesiculam tumidam terminantia. *Caput conidiale* sphaericum, diametro 36–54 μm. *Vesicula* globosa vel



Figs 7–17. *Torrubiella dimorpha*. **Fig. 7.** Habit of spider infected by *Torrubiella dimorpha*. **Fig. 8.** Synnema and conidiogenous head. **Fig. 9.** Production of conidial heads (arrows) and perithecia (arrow heads) from the mycelium or weft of interwoven hyphae. **Fig. 10.** Perithecium with an anamorphic conidiophore, bearing conidial head (arrow head). **Fig. 11.** Perithecium and asci. **Fig. 12.** Thickened ascal apex. **Fig. 13.** Part of mature ascus and ascospores. **Fig. 14.** Coexistence of gibelluloid and granulomanoid conidiophores and conidiogenous structures. **Fig. 15.** Gibelluloid conidiophore and conidiogenous structures. **Fig. 16.** Granulomanoid conidiophore and conidiogenous structures, and filiform conidia (arrow heads). **Fig. 17.** Gibelluloid conidia. Scale bars: Fig. 7 = 2 mm; Figs 8, 9 = 500 μm; Figs 10, 11, 14 = 200 μm; Figs 12, 13, 15–17 = 20 μm.

subglobosa, diametro 7·9–11·1 μm. Phialides cylindricae vel anguste clavatae, collo brevi saepe in apice incrassato praeditae, laeves, hyalinae, 5·6–8·7 × 2·5–4 μm, usque ad 21. *Metulae* late obovoidea, basem versus angustatae, hyalinae, 7·1–11·9 × 6·4–8·7 μm, usque ad 27. *Conidia* plerumque ellipsoidea vel limoniformia, hyalina, laevitunicata, unica vel catenata, 3·2–4·1 × 2–2·4 μm. *Conidiophora* morphae status Granulomani praesentia, capite conidiali metulas dense verticillatas (usque ad 20) et cellulas polyblasticas conidiogenas ferenti praedita, exasperata vel distincte verrucosa, 68–140 × 5·2–7·1 μm, interdum hyphis ramosis cellulas solitarias, polyblasticas,

conidiogenas ferentibus praedita. *Metulae* late obovoideae, 5·6–8·7 × 4·4–6·4 μm, laeves, interdum minute verruculatae. Cellulae conidiogenae cylindricae, ellipsoideae, anguste clavatae, conoideae vel irregulariter formatae, 7·9–20·6 × 3·2–4 μm, laeves, interdum exasperatae, denticulos 1–3 conspicuos ferentes. Conidia filiformia, laevi-tunicata, hyalina, 9·1–23·8 × 0·8–2·4 μm. Aliquando, granulomanoid conidiogenesia evenit in eadem conidiophora morphae status gibelluloid.

Holotypus in araneo, Arachnida, Liukui, Shanping, Comitatus Kaohsiung, Taiwan, 22 Oct, 1994, PPH Ar. 80.

Infected spider host covered with dense mycelial mat, white, yellowish white to orange white (4-5A2), pulvinate, tomentose, lanose, margin spreading, forming byssoid subiculum. *Hyphae* branched, septate, hyaline, distinctly verrucose, sometimes smooth-walled, 2·4–5·6 μm wide. *Perithecia* produced on mycelial mat, superficial or partly embedded, scattered, ovoid, 490–600 × 250–320 μm, yellowish white (1-2A2), tomentose, perithecial wall 12–18 μm thick. *Asci* eight-spored, cylindrical, 220–310 × 6·4–8·2 μm, with a thickened perforated apex, 4·8–6·4 μm high, 6·8–8·7 μm wide. *Ascospores* filiform, multiseptate, arranged in parallel rows, 1·6–2·4 μm wide, breaking into part-spores. *Part-spores* cylindrical, truncate, smooth, hyaline, 3–8·7 × 2–2·3 μm. *Synnemata* solitary, arising from mycelial mat, cylindrical, attenuated, curved, 5 mm × 200 μm, consisting of compacted septate longitudinal hyphae, hyaline, smooth, rarely roughened, 2·2–4 μm wide. *Conidiophores* for the gibelluloid state, arising from the mycelium or synnemata, greenish white to pale green (30A2-3), 140–422 × 7·1–10·3 μm, septa thickened, conspicuous, often darkly pigmented, base distinctly roughened, warty, narrowing abruptly to a slender, smooth-walled apex, 3·2–4·5 μm wide, terminating in a swollen vesicle. *Conidial head* spherical, 36–54 μm diam. *Vesicle* globose to subglobose, 7·9–11·1 μm diam. *Phialides* cylindrical to narrowly clavate, with a short neck, often apically thickened, smooth, hyaline, 5·6–8·7 × 2·5–4 μm, numerous, borne on metulae, up to 21. *Metulae* broadly obovoid, narrowing towards base, hyaline, 7·1–11·9 × 6·4–8·7 μm, numerous, borne on vesicle, up to 27. *Conidia* fusoid, ellipsoidal or lemon-shaped, hyaline, smooth-walled, single or catenate, 3·2–4·1 × 2–2·4 μm. Granulomanoid morph conidiophores present, spherical conidial head bearing densely whorled metulae (up to 20) and polyblastic conidiogenous cells, roughened to distinctly verrucose, 68–140 × 5·2–7·1 μm, sometimes with branched hyphae bearing solitary, polyblastic conidiogenous cells. *Metulae* broadly obovoid, 5·6–8·7 × 4·4–6·4 μm, smooth, occasionally minutely warted. *Conidiogenous cells* cylindrical, ellipsoidal, narrowly clavate, conoid, or irregularly shaped, 7·9–20·6 × 3·2–4 μm, smooth, sometimes roughened, bearing 1–3 conspicuous denticles. *Conidia* filiform, smooth-walled, hyaline, 9·1–23·8 × 0·8–2·4 μm. Sometimes, the granulomanoid conidiogenesis occurring on the same conidiophore with the gibelluloid state.

Specimen examined: on spider (Arachnida), Liukui, Shanping, Kaohsiung County, Taiwan, R.O.C., 22 Oct., 1994, holotype PPH Ar. 80 (dried specimen) deposited in the Department of Plant Pathology and Entomology, National Taiwan University, Taipei, Taiwan, R.O.C.

Torrubiella dimorpha is characterized by scattered, yellowish-white, tomentose, ovoid, perithecia arising from an orange white, pulvinate, lanose mycelium mat. The anamorph, *Gibellula dimorpha*, produced gibelluloid and granulomanoid synanamorphs on aspergillate, distinctly roughened or warty conidiophores. Occasionally, the aspergillate conidial head bore phialidic and polyblastic conidiogenous cells on the same vesicle. Humber & Rombach (1987), while describing *G. clavulifera* var. *alba*, synonymized the form genus *Granulomanus* with *Gibellula*, because both typical gibelluloid conidiophores and sessile polyphialides bearing bacilliform conidia, which is characteristic of granulomanoid morph, can occur on the same hyphae covering the infected spider host. Also, the *Granulomanus* form almost never occurs in the absence of *Gibellula* and/or its teleomorphic, *Torrubiella* (Humber & Rombach, 1987). In *G. dimorpha*, the granulomanoid conidia being produced on a same conidiophore that is otherwise mainly gibelluloid. The same event also occurs in a recent described *Gibellula unica* Tzean, L. S. Hsieh & W. J. Wu, in which the phialidic or polyblastic conidiogenous cells of, respectively, *Gibellula* and *Granulomanus*, are concurrently or independently produced on the same well differentiated distinctly verrucose conidiophores (Tzean, Hsieh & Wu, 1997). The evidence presumably supports the concept of Humber & Rombach (1987) in synonymization of these two synanamorphic genera. The synopsis of the synanamorphs differed from the six known species of *Torrubiella* that parasitize spiders and produced only the gibelluloid morph (Petch, 1932; Mains, 1950; Kobayasi & Shimizu, 1982) or together with a granulomanoid morph (Humber & Rombach, 1987; Samson & Evans, 1992). *Torrubiella dimorpha* can be readily separated from *T. globosa*, *T. globoso-stipitata*, *T. gibellulae* and *T. arachnophila* by the morphological characteristics of the gibelluloid anamorph. No granulomanoid morph has been described for the latter four species. In addition, the part-spores of these four species are about 3–5 × 1–1·5 μm; and narrower and usually shorter than part-spores of *T. dimorpha*, 3–8·7 × 2–2·3 μm. The single synnemata of *T. ratticaudata* are long and slender (15 × 0·5 mm), whiplash-like, and whilst the sterile, granulomanoid morph is mostly penicillate. In contrast, in *T. clavata* the synnemata are broadly clavate, with a sterile basal stipe and fertile terminal region, produced singly or in pairs, and the conidiophores of the gibelluloid morphs were considerably shorter, 30–50 μm in length. The conidiophores of the granulomanoid morph of *T. clavata* consisted of irregular branched hyphae, bearing solitary, polyblastic conidiogenous cells. The microscopic conidial apparatus of *T. ratticaudata* and *T. clavata* sharply contrasts with that of *T. dimorpha*, which possess cylindrical, subulate synnemata, fertile along the whole length, and the gibelluloid and granulomanoid morphs were usually axpergillate. Also the conidiogenous cells of the granulomanoid morph were distinctly roughened and warty. The anamorph of *T. dimorpha*, *G. dimorpha*, somewhat resembles *G. unica* Tzean, L. S. Hsieh & W. J. Wu, described from a spider specimen collected from Taiwan (Tzean, Hsieh & Wu, 1997). Rarely *G. unica* also produced gibelluloid and granulomanoid morphs on the same sporulating apparatus. In *G. unica*, however, no teleomorph has been found and the conidia of its gibelluloid morph were fusiform (4–6·8 × 1·6–2·2 μm) in contrast to the predominantly ellipsoidal conidia (3·2–

4·1 × 2–2·4 μm) of *G. dimorpha*. The synnemata of *G. brunnea* Samson & H. C. Evans have a short, stout, yellow-tan stipe (0·2–0·8 × 0·2–0·4 cm), which widens into a lateral, globose to pyriform (0·5–0·8 × 0·8–1·4 cm) fertile head, and narrows into a pale brown, compact accuminate stipe tip. These features readily distinguish from the cylindrical, attenuated, curved, apparently shorter and narrower synnemata (5 mm × 200 μm) of *G. dimorpha*, although both species show some similarity in having distinctly roughened or warty conidiophores.

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