The genus *Mitrula* in North America

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The genus *Mitrula* is monographed for North America. Endemic to North America are *M. elegans*, ***M. lunulatospora*** sp. nov., and ***M. borealis*** sp. nov. The last-named species also occurs in Europe, as does *M. paludosa*. Each species has a distinctive geographic range, sporulating period, and ascospore morphology.

A neotype is chosen for *Mitrula paludosa* and both *M. norvegica* and *M. omphalostoma* are placed in synonymy with that species. *Mitrula morchelloides* is transferred to the genus *Verpatinia*. *Mitrula gracilis* is transferred to the genus ***Bryoglossum*** gen. nov.

Each of the accepted species of *Mitrula* is illustrated and described, and a key to the species is given.

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L'auteur présente une monographie du genre *Mitrula* pour l'Amérique du Nord. Trois espèces sont endémiques en Amérique du Nord soit le *M. elegans*, le ***M. lunulatospora*** sp. nov. et le ***M. borealis*** sp. nov. Cette dernière espèce existe aussi en Europe, tout comme le *M. paludosa*. Chaque espèce a une distribution géographique, une période de sporulation et une forme d'ascospore distinctes.

Un nouveau type est choisi pour le *Mitrula paludosa* et le *M. norvegica* ainsi que le *M. omphalostoma* sont placés en synonymie avec la première espèce. Le *Mitrula morchelloïdes* est transféré au genre *Verpatinia*. Le *Mitrula gracilis* est transféré au genre ***Bryoglossum*** gen. nov.

L'auteur présente et illustre chacune des espèces acceptées et propose une clé pour leur identification.

[Traduit par le journal]

The Geoglossaceae is one of the most thoroughly studied families of fungi to date (Benedix 1962; Bille-Hansen 1954; Cooke 1875*a*, 1875*b*; Durand 1908; Eckblad 1963; Favre 1949; Grund and Harrison 1967; Imai 1940, 1941; Knudsen 1975; Lloyd 1916; Mains 1954, 1955; Massee 1897; Nannfeldt 1942; Seaver 1951; Velenovský 1934). In spite of these studies the species and generic concepts of common taxa are still fluctuating (Kankainen 1969; Maas Geesteranus 1964, 1965, 1972; Ohenoja 1975).

From Fries (1821) to the present the genus *Mitrula* Fr., Geoglossaceae, has been variously defined to include a large number of unrelated species. Recently Imai (1941) and later Maas Geesteranus (1964) restricted the genus to the type species *M. paludosa* Fr. based on microscopic morphology. This species has never had a type specimen designated. Characteristics commonly attributed to *M. paludosa* are as follows: (1) an orange clavate fleshy hymenophore; (2) a white stipe; (3) inflated stipe hyphae; (4) hyaline ascospores; (5) an amyloid apical ascal apparatus; and (6) a habitat on decaying vegetation in shallow water. Mains (1955) noted three basic ascospore forms in the North American collections that he referred to as *M. paludosa*. Seemingly in contradiction with Main's observations, Kankainen (1969) using European materials of *M. paludosa* reported ascospores of variable sizes and forms in some ascocarps and attached no importance to the variations. Only Boudier (1905–1910) used differences in spore sizes in combination with hymenophore shape and colour variations to segregate taxa from *M. paludosa*.

Observations on two adjacent colonies of *Mitrula* were made in August 1974 near Black Sturgeon Lake, Thunder Bay District, Ontario. Troops of ascocarps from both colonies were occupying the same forest pool and overlapped slightly. The major differences between the ascocarps from the two colonies were their hymenophore colours, *flesh* for one and *pale luteous* for the other (Rayner 1970). The pale luteous ascocarps were mostly narrow and cylindrical (Fig. 4). The flesh-coloured ascocarps were mostly irregularly pyriform (Fig. 5). The former had broadly elliptical ascospores (Fig. 9A) and the

latter had lunate to cymbiform ascospores (Fig. 16A). Both collections keyed down to '*M. paludosa*.'

Collections labelled *Mitrula paludosa* or its synonym *M. phalloides* (Bull.) Chev., deposited in major North American herbaria, were examined to determine how common and how distinct the two forms of '*M. paludosa*' were. This survey revealed the existence of a third North American form which was more common than the two forms collected at Black Sturgeon Lake. It was distinguished by its narrow cylindrical to clavate ascospores (Fig. 14). The few European collections examined at that time seemed to belong to this last form although their ascospores were slightly broader and more variable. However after more European collections were compared with their North American counterparts it became apparent that they consistently produced larger ascospores (Fig. 20). In a blind test of 12 collections with cylindrical to clavate ascospores from Europe and North America in which the collections data were hidden, all were correctly assigned to the continent of origin. I conclude there were four forms of '*M. paludosa*' based on ascospore morphology, three as noted by Mains (1955) and the fourth by Kankainen (1969). Some herbarium packets contained mixtures of ascocarps representing more than one of the four forms but no single ascocarp was found that was an intermediate of hybrid form. It was concluded that more than one colony had been sampled in these cases as might have happened at Black Sturgeon Lake.

The geographic distribution of each of the three North American forms was distinctive (Figs. 1–3) as was the sporulating period. These differences indicated that the four forms represented four independently evolving populations with no interbreeding even where their ranges overlapped. They are therefore considered as distinct species.

The type collections of *Leotia elegans* Berk., *Mitrula morchelloides* Mains, *M. norvegica* Rostr., *M. omphalostoma* Benedix, and an original Fries collection of *M. paludosa* were examined. Other species once placed in the genus *Mitrula* either lack type collections or have been placed in other genera. The two common species of *Mitrula* discovered in my survey were identified as *M. paludosa* Fr. for Europe and *M. elegans* (Berk.) Fr. for North America. The two uncommon species originally discovered at Black Sturgeon Lake were undescribed. All four species are described in detail below followed by a discussion on some excluded species.

Mitrula E. Fries, Syst. Mycol. 1: 491. 1821.

Ascocarps solitary, gregarious or caespitose, erect, clavulate, stipitate, fleshy to slightly tremullose, translucent moist. Clavula inflated, globose to clavate, pyriform, cylindrical or lobed, glabrous, occasionally furrowed, hollow, water-filled, totally fertile, yellow, orange or flesh-coloured, lacking a sterile margin. Stipes unbranched, water-soaked, fistulose, whitish, glabrous, slightly lubricous. Basal hairs and mycelium matted, submerged, whitish.

Asci elongate-clavate, eight-spored, attenuated above, with croziers, and with amyloid apical pores. Ascospores cylindrical, elliptical or lunate, one- or two-celled, with or without a thin gelatinous sheath, hyaline, thin-walled, smooth, inamyloid, partially or wholly obliquely biseriate, confined to the upper portion of the asci. Paraphyses abundant, filiform to narrowly clavate, thin-walled, smooth, septate, branched, surpassing the asci. Subhymenial hyphae loosely packed, much branched, hyaline, thin-walled septate, rarely inflated, smooth, radiating outwards. Clavula medulla hyphae branched, thin-walled, inflated or not, hyaline, distantly spaced. Stipe medulla hyphae widely spaced, loosely interwoven, septate, branched, hyaline, thin-walled, noninflated. Stipe inner cortical hyphae parallel, inflated, separating easily, thin to moderately thick-walled, interspersed with occasional oleiferous hyphae. Stipe outer cortical hyphae noninflated, septate, branched, embedded in a gelatinous matrix, giving rise to nongelatinized basal mycelial hairs. Basal mycelial hairs septate, noninflated, branched, smooth, thin-walled, rounded at the apices.

On submerged or water-soaked decaying leaves, needles, stems, or fruits of vascular plants, gametophytes of bryophytes, or rich soils in ponds, streams, ditches, forest pools, *Sphagnum* bogs, swamps, and seepage sites.

Early spring to late summer. Coniferous or deciduous forests in the Northern Hemisphere.

Type species (sel.): *Mitrula paludosa* Fr. (fide Imai (1941) and Maas Geesteranus (1964)).

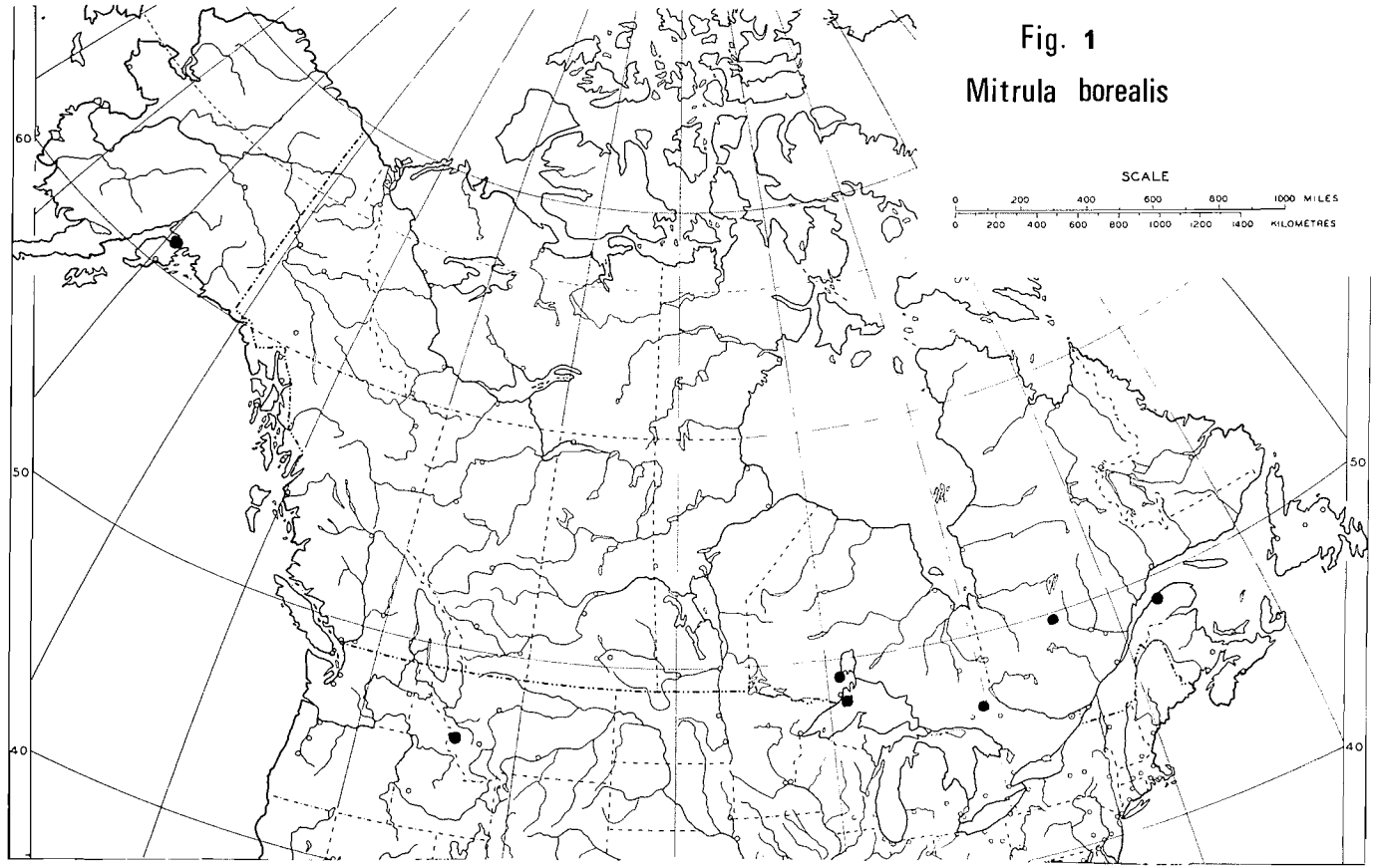


FIG. 1. *Mitrula borealis*, known North American distribution.

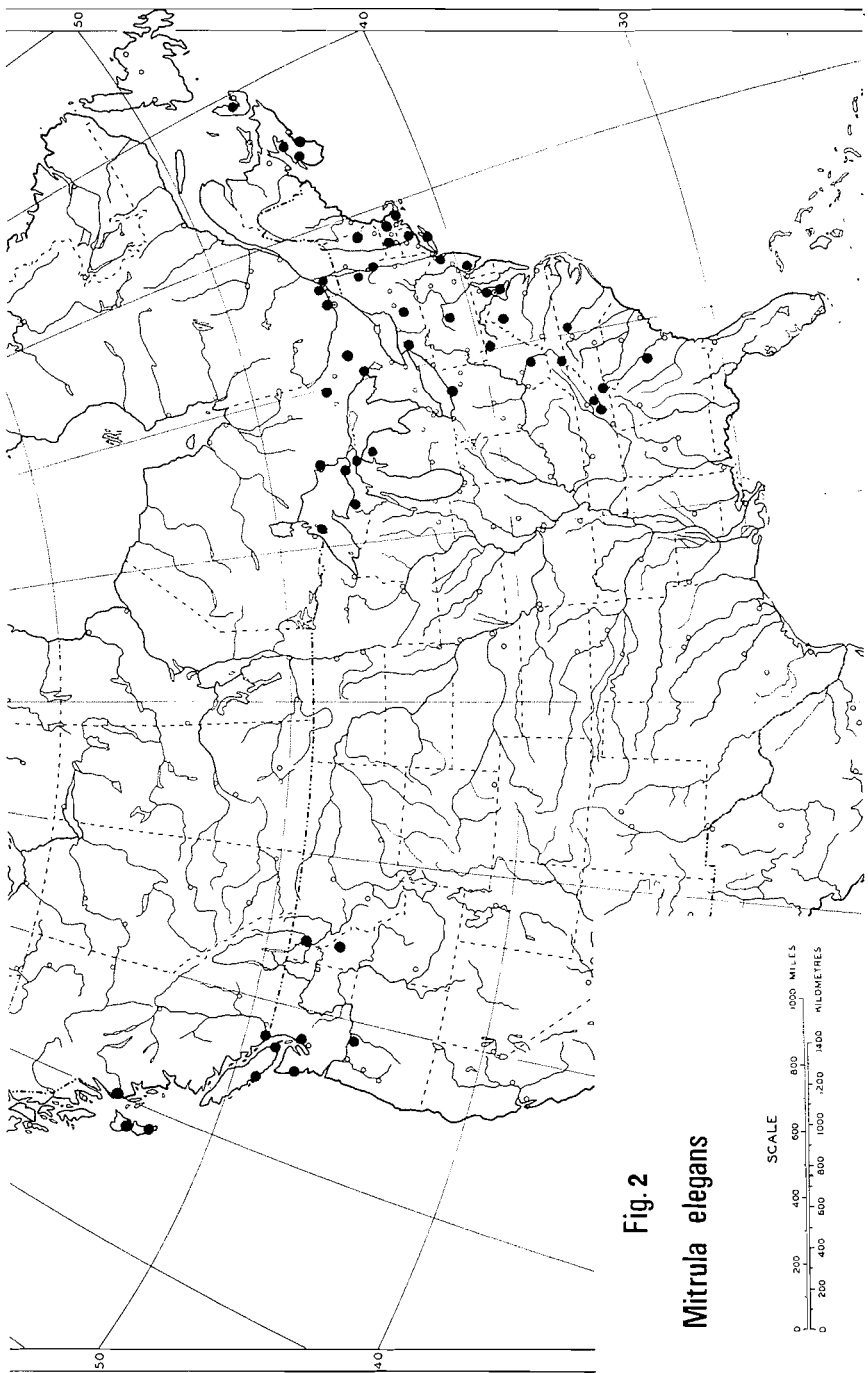


FIG. 2. *Mitrula elegans*, known world distribution.

A KEY TO THE SPECIES OF *Mitrula*

A. Ascospores cylindrical to narrowly clavate in deposits, flexible, mostly lacking a gelatinous sheath.....B
A. Ascospores lunate or elliptical to ovate in deposits, inflexible, usually with a gelatinous sheath.....C

B. Ascospores 11–17.5 × (1.5–)2–2.5(–3) μm; North America.....*M. elegans*
B. Ascospores 11–19(–24) × (2–)2.5–3.5(–4) μm; Europe (?Asia).....*M. paludosa*

C. Ascospores 10.5–18 × (2.5–)3–4(–5) μm, elliptical to ovate; hymenium normally luteous at maturity; Europe, North America.....*M. borealis*
C. Ascospores 11–19 × (2–)2.5–3.5(–4) μm, lunate to cymbiform; hymenium normally saffron to flesh at maturity; North America.....*M. lunulatospora*

NOTE: The latin descriptions of the two new species of *Mitrula* are based on data obtained from the type collections only. The English descriptions contain additional data.

Mitrula borealis S.A. Redhead sp. nov.

Figs. 1, 4, 9–11

Ascoma gregaria, solitaria vel subcaespitosa, mollia, 1.9–3.7 cm altum. Clavula forma varia, ovoidea vel pyriformis, inflata, obtusa, laevis, lutea vel luteola, 2–8 mm latum. Stipes subaequalis, cavus, albus vel raro latericius, 1–3 mm crassus.

Asci cylindraceo-clavati, apice attenuati, jodo obturaculo minutissimo caerulescentes, 105–140 × 7.5–9.5 μm. Paraphyses filiformes, 147–157 × 2–3 μm. Sporae 8: distichae vel oblique monostichae, ellipticae vel ovoideae, 7–17.5 × 2–5 μm.

Ad folia putrida in paludosis.

HOLOTYPUS: On dead foliage of *Thuja occidentalis* and *Alnus rugosa*. Black Sturgeon Lake, Thunder Bay District, Ontario, Canada, Aug. 16, 1974; leg. S. A. Redhead no. 1330 (TRTC 47282).

ISOTYPUS: CUP, DAOM, K, UBC.

ADDITIONAL ILLUSTRATIONS: Rehm (1896, p. 1143, Fig. 4).

MACROSCOPIC CHARACTERISTICS: Ascocarps gregarious, solitary to subcaespitose, fleshy, 1.5–4.5 cm high. Clavula ovoid to irregularly pyriform, cylindrical or clavate, smooth to rugose, slightly tremullose, tasteless, luteous to yellow-luteous, 2–12 mm wide. Stipes unbranched, glabrous and slightly lubricous above, 1–3 mm wide above, hyaline to white; basal portion occasionally enlarged, moderately covered with matted hyphal hairs below; occasionally developing reddish-brown stains.

MICROSCOPIC CHARACTERISTICS: Asci eight-spored, elongate-clavate, 105–140 × 7.5–9.5 μm. Apical pores amyloid. Croziers present. Paraphyses filiform, slightly enlarged above, 147–157 × 2–3 μm. Ascospores 10.5–18 × (2.5–)3–4(–5) μm in deposits, inflexible, elliptical to ovoid or broadly cylindrical, one- or two-celled, usually with a gelatinous sheath. Subhymenial hyphae 1.5–8.5 μm wide. Clavula medulla hyphae 4–21 μm wide. Stipe medulla hyphae 2–7 μm wide. Stipe inner cortical hyphae 8.5–33.5 μm wide, inflated, moderately thickened. Stipe outer cortical hyphae 3.5–6.5 μm wide. Basal mycelial hairs 3.5–7.5 μm wide.

HABITAT: Gregarious in shallow water, on decaying needles, twigs, cones, or leaves of *Abies excelsa* Poir., *Alnus rugosa* (Du Roi) Spreng., *Picea* sp., *Thuja occidentalis* L., and *Tsuga* sp., or decaying vegetation of other unidentified plants and musci including *Sphagnum*.

SPORULATING PERIOD: July–September.

DISTRIBUTION: Canada: Ontario, Quebec. U.S.A.: Alaska, Michigan, Montana. Estonia. Germany.

SPECIMENS EXAMINED: CANADA: ONTARIO: Lake Timagami, Metagama Point, Wintertote Road, Aug. 21, 1930, H. S. Jackson (TRTC 1753 *pro parte*); Thunder Bay District, Black Sturgeon Lake, Aug. 16, 1974, S. A. Redhead no. 1330 (TRTC 47282; Type). QUEBEC: Lac Cascapedia, Mt. Albert, Aug. 21, 1957, H. E. & M. E. Bigelow (DAOM 62946); 18 km N of Bochart on Highway 167, Sept. 1, 1976, S. A. Redhead no. 2147 (TRTC). U.S.A.: ALASKA: Girdwood, Aug. 17, 1969, V. Wells & P. Kempton no. 4102 (TRTC 47581), July 25, 1974, V. Wells & P. Kempton no. 6152 (TRTC 47580); Turnagain Pass, July 17, 1961, V. Wells & P. Kempton no. 812 (TRTC 47579), Aug. 27, 1970, V. Wells & P. Kempton no. 4816 (TRTC 47577). Aug. 24, 1972, V. Wells & P. Kempton no. 5878 (TRTC 47578). MICHIGAN: Isle Royale, Rock Harbor, Aug. 13, 1930, A. H. Povah Fp. 479 *p.p.* (MICH). MONTANA: Bitter Root Natl. For., Tin Cup Canyon, 5000 ft, Aug. 10, 1928, G. B. Cummins (MICH); Victor, Aug. 4, 1917, J. R.

Weir (NY), (BPI). ESTONIA: ex herb. Inst. Zool. Bot. Acad. Sci. R. Publ. Soviet. Social. Estonticae, Aug. 17, 1961 (CUP, Korf 3358).

EXSICCATI: Krieger: Fungi Saxonici no. 1581 *M. phalloides* (BPI, CUP, TRTC). Rehm: Ascomyceten no. 601 *M. paludosa* (K). Sydow: Mycotheca Germanica no. 2168 *M. phalloides* (BPI, CUP, K, TRTC).

Mitrula borealis is characterized by broad elliptical to ovoid ascospores (Figs. 9–11). In North America it is easily distinguished from the slender-spored *M. elegans* (Figs. 12–15) and the lunate-spored *M. lunulatospora* (Figs. 16–18). In Europe it is readily confused with *M. paludosa* because of the latter's broad ascospores (Figs. 19–21, 24, 25) and its tendency to produce abnormally broader ascospores that abort (cf. Figs. 22, 23*a*, 23*b*). Both *Mitrula norvegica* Rostrup (1904) and *M. phalloides* (Bull.) ex Chev. var. *aurantiaca* (Cumino)ex Boudier *sensu* Boudier (1905–1910) were based on *M. paludosa* ascocarps which produced abnormally large ascospores within the size range of *M. borealis* but failed to be ejected from the asci. With these two collections it was necessary to examine ascospores deposited on the stipes' apices for correct identification.

Mitrula borealis is the least collected species in the genus. The boreal and subalpine distribution (Fig. 1) of this species may partially explain the small number of collections made. These areas are seldom visited by mycologists as they are isolated from most laboratories and are notorious for the swarms of biting or sucking insects which inhibit collecting. *Mitrula borealis* may be very common in the boreal regions as all five *Mitrula* collections made by Mrs. Kempton and the late Mrs. Wells in Alaska were this species.

Mitrula elegans (Berkeley) Fries, Acta R. Soc. Sci., Upsal., Ser. 3, I. p. 119 (1851). Figs. 2, 6, 12–15

≡ *Leotia elegans* Berk. (1846).

≡ *Microglossum elegans* (Berk.)Underwood (1896).

ADDITIONAL ILLUSTRATIONS: Lloyd (1916, Fig. 796), Mains (1955, Fig. 42), Smith (1949, Reel 2, No. 11).

MACROSCOPIC CHARACTERISTICS: Ascocarps gregarious, solitary to caespitose, fleshy, 2–10 cm high. Clavula globose to cylindrical, cerebriform, clavate, pyriform or lobed, smooth to rugose, slightly tremullose, bright orange to bright yellow, becoming ochraceous orange with age or pinkish when submerged in acidic water, 1.5–15 mm wide. Stipes unbranched, glabrous and slightly lubricous above, 1.5–3 mm wide above, white to faintly pinkish, slightly enlarged above or below, moderately covered with matted hyphal hairs below.

MICROSCOPIC CHARACTERISTICS: Asci eight-spored, elongate-clavate, 115–123 × 5–7.5 μm. Apical pores amyloid. Croziers present. Paraphyses filiform, slightly enlarged above, 120–130 × 1.5–3 μm. Ascospores 11–17.5 × (1.5–)2–2.5(–3) μm, flexible, narrowly cylindrical or clavate, occasionally fusoid-cylindrical, one- or two-celled, lacking a gelatinous sheath. Subhymenial hyphae 1.5–5.5 μm wide. Clavula medulla hyphae 3.5–21 μm wide. Stipe medulla hyphae 1.5–10 μm wide. Stipe inner cortical hyphae 7–70 μm wide, inflated. Stipe outer cortical hyphae 3.5–12 μm wide. Basal mycelial hairs 3.5–10.5 μm wide.

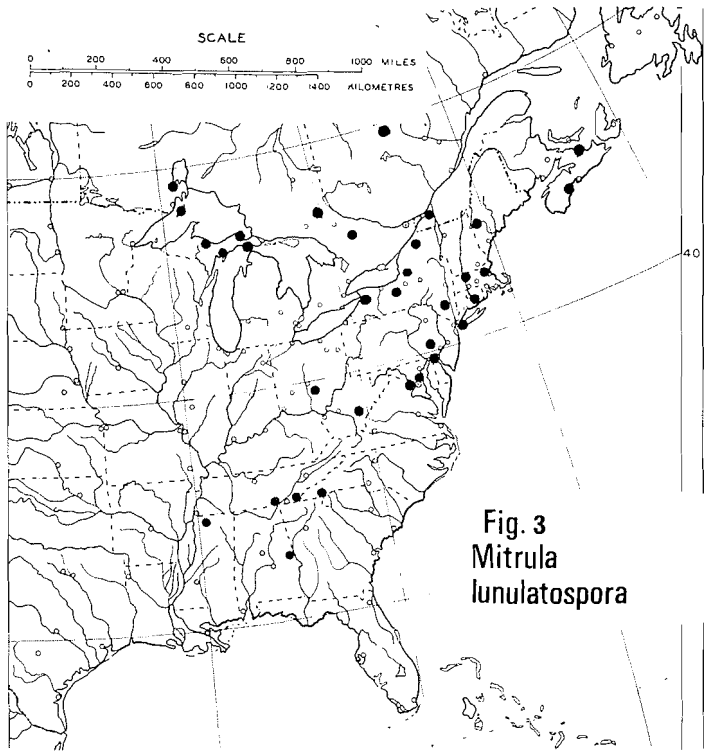
HABITAT: Gregarious in shallow water, on decaying wet needles, scales, twigs, leaves, or fruits of *Acer saccharinum* L., *Alnus rubra* Bong., *A. rugosa*, *Fagus grandifolia* Ehrh., *Liquidambar styraciflua* L., *Lysichitum americanum* Hultén & St. John, *Osmunda cinnamomea* L., *Pinus monticola* Dougl., *P. strobus* L., *Quercus borealis* Michx. (= *Q. rubra* L.), *Q. prinus* L., *Thuja occidentalis*, *T. plicata* Dougl.; mats of *Calliergonella cuspidatum* (Hedw.)Loeske and *Sphagnum recurvum* P.-Beauv.; and logs, mud, algal mats, or other unidentified vegetation.

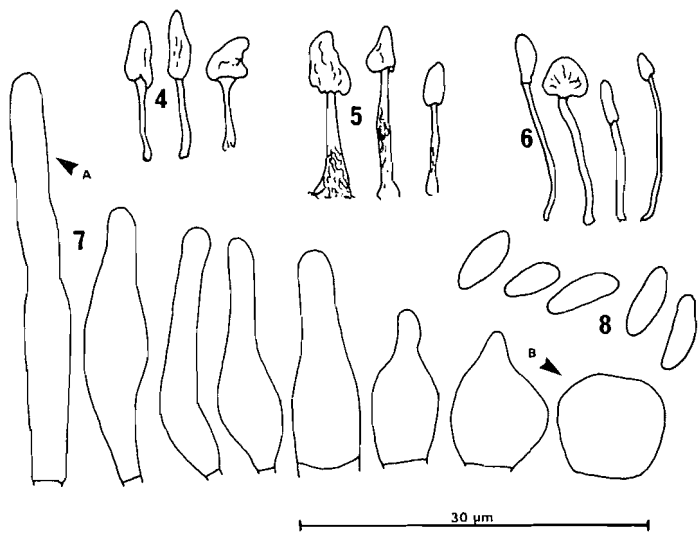
SPORULATING PERIOD: April–June (southeastern United States), April–September (northeastern United States, northwestern United States, and Canada).

DISTRIBUTION: Canada: British Columbia, Nova Scotia, Ontario, Quebec. U.S.A.: Alabama, Connecticut, District of Columbia, Georgia, Idaho, Maine, Maryland, Massachusetts, Michigan, Montana, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Tennessee, Virginia, Vermont, Washington, West Virginia.

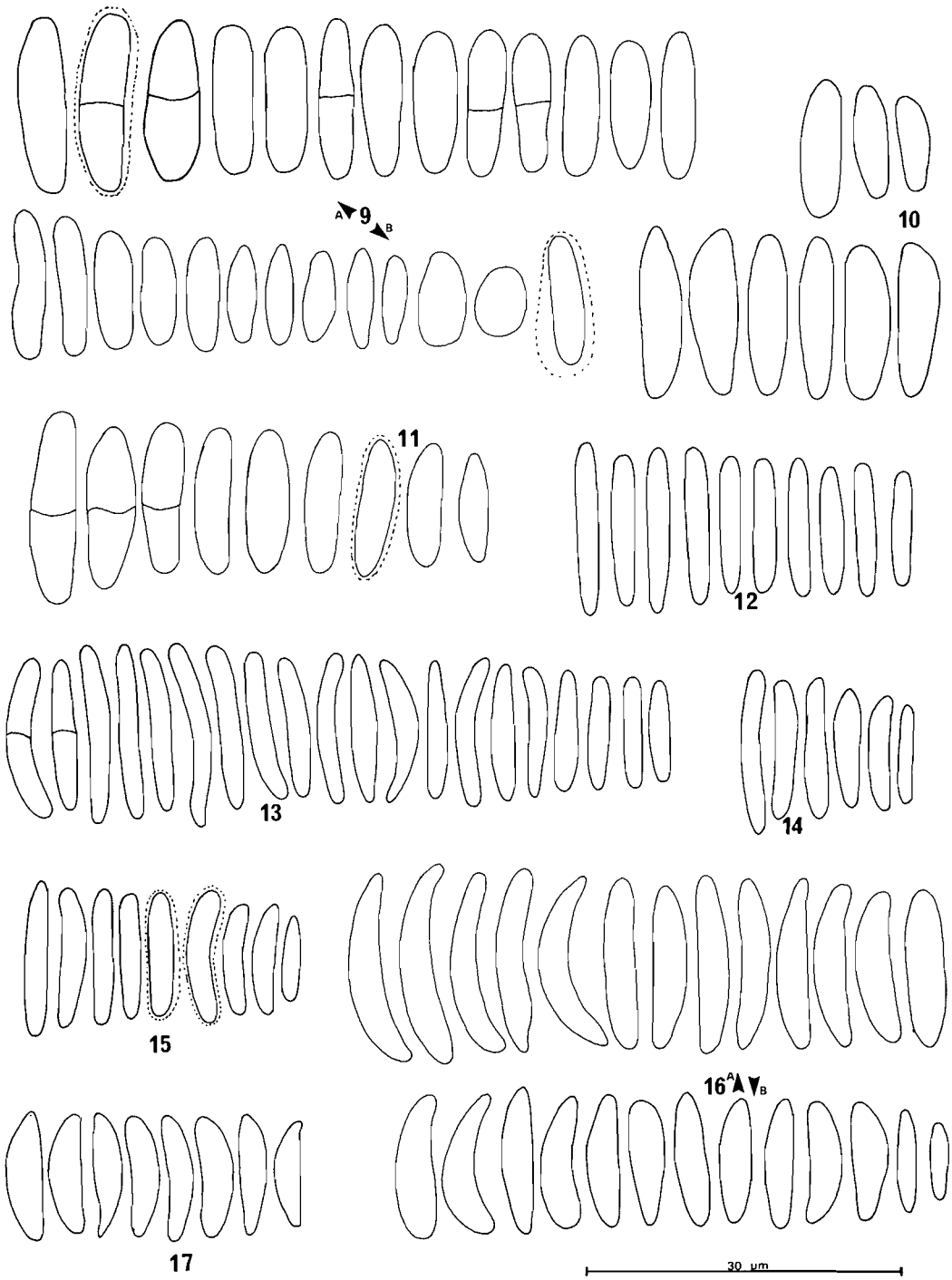
TYPE: U.S.A., Greene no. 66 (K) as *Leotia elegans* Berk.)

SPECIMENS EXAMINED: CANADA: BRITISH COLUMBIA: April 28, 1889, J. M. Macoun (NY); Burnaby, May 25, 1966, B. Fraser (DAOM





FIGS. 3 and 5. *Mitrula lunulatospora*. FIG. 4. *M. borealis*. FIG. 6. *M. elegans*. FIGS. 7 and 8. *Verpatinia morchelloides*, from type material. Fig. 3. Known world distribution. Fig. 4. Habitat sketch from type material, about ½ size. Fig. 5. Habitat sketch from type material, about ½ size. Fig. 6. Habitat sketch from TRTC 9707, about ½ size. Fig. 7. Apothecial surface cells ranging from marginal hairs (A) to ectal excipulum near the stipe apex (B). Fig. 8. Ascospores.



FIGS. 9–11. Ascospores of *Mitrula borealis*. FIGS. 12–15. Ascospores of *M. elegans*. FIGS. 16 and 17. Ascospores of *M. lunulatospora*. Fig. 9. Type material of *M. borealis*: (A) from stipe apex; (B) additional forms from the hymenium. Fig. 10. Krieger: Fungi Saxonici no. 16. Fig. 11. DAOM 62946. Fig. 12. Type material of *Leotia elegans*. Fig. 13. TRTC 46035. Fig. 14. TRTC 18516. Fig. 15. DAOM 7950. Fig. 16. Type material of *M. lunulatospora*: (A) from stipe apex; (B) additional forms from the hymenium. Fig. 17, DAOM 20039.

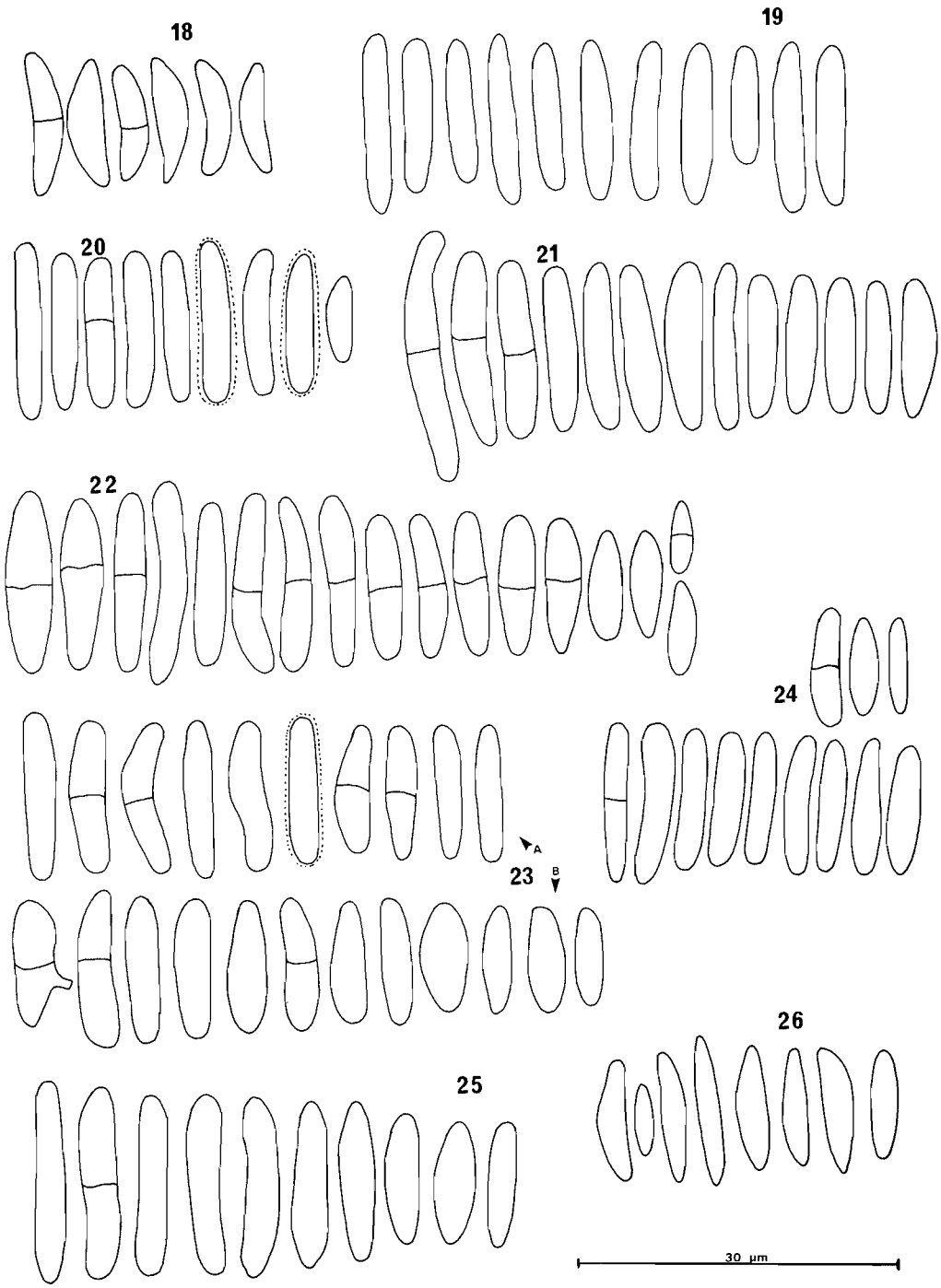


FIG. 18. Ascospores of *Mitrula lunulatospora*. FIGS. 19–25. Ascospores of *M. paludosa*. FIG. 26. Ascospores of *Bryoglossum gracile*. Fig. 18. DAOM 89738. Fig. 19. Neotype material of *M. paludosa*. Fig. 20. DAOM 67478. Fig. 21. Type material of *M. omphalostoma*. Fig. 22. Type material of *M. norvegica*. Fig. 23. Voucher specimen for Boudier (1905–1910, pl. 427 bis). Fig. 24. DAOM 107805. Fig. 25. Boudier collection, PC (cf. Boudier 1905–1910, pl. 427). Fig. 26. Seaver and Bethel collection from Colorado.

129751); Haney, June 6, 1959, V. J. Krajina (UBC); Prince Rupert, June 16, 1965, A. Funk (DAOM 113867); Queen Charlotte Islands, Anna Inlet, 1964, R. L. Taylor (DAOM 109189), above Mclinton Creek, June 18, 1957, J. A. Calder, D. B. O. Savile, R. L. Taylor (DAOM 56626); New Westminster, May 5, 1905, A. I. Hill (NY), (CUP-D-3-264); N. Vancouver, Lynn Valley Park, May 6, 1959, R. J. Bandoni (UBC 381), May 6, 1959, F. Waugh (UBC), Mt. Seymour Park, June 3, 1951, M. E. Barr (UBC 1734), June 2, 1959, R. J. Bandoni, L. Magasi (UBC 432), May 6, 1960, F. Waugh (UBC), June 4, 1972, A. Rossman 785, N. K. Nagpal (OSC); near Squamish, Murrin Park, April 29, 1961, C. Gough (DAOM 114402); Teanook Lake, May 1, 1961, R. J. Bandoni (UBC 1796); Vancouver, Univ. Endowment Lands, May 17, 1968, S. G. Brough 636 (UBC); Vancouver Island, July 1903, F. K. Batters (CUP-D-3-240), Ucluelet, June 10, 1957, W. G. Ziller (DAOM 56604), Victoria, Millstream Road, May 20, 1968, J. H. Ginns 1316 (DAOM 128826); W. Vancouver, Hollyburn Mt., June 4, 1966, L. L. Kennedy 750 (ALTA 528), Lost Lake Trail, June 4, 1966, R. J. Bandoni (UBC). NOVA SCOTIA: Annapolis Co., Kejmekujike Natl. Park, June 28, 1968, K. A. Harrison 7596 (MICH); Baddeck, June 1, 1952, W. L. Klawe (TRTC); Baddeck Bay, July 18, 1965, Petersen & Olexia (TENN 28658); Coldbrook, June 10, 1942, R. M. Lewis 42-87 (DAOM 7950); Kings Co., North Alton, June 28, 1968 (MICH), South Alton, July 4, 1968, K. A. Harrison 7636 (MICH); Lunenburg Co., Alderville, June 27, 1968, K. A. Harrison 7584 (MICH), July 10, 1968, K. A. Harrison 7676 *p.p.* (MICH). ONTARIO: Algoma Dist., Sand River, Aug. 6, 1958, R. F. Cain (TRTC 46035); Algonquin Park, Found Lake, June 1, 1976, P. D. Johnson 120 (TRTC 47575), P. D. Johnson 121 (TRTC 47576), Little Macaulay Lake, Aug. 10, 1940, R. F. Cain (TRTC 18515 *p.p.*), W of Lake of Two Rivers, June 24, 1939, H. S. Jackson (TRTC 18516); Lake Timagami, Bear Island, July 24, 1929, G. Thompson (TRTC 1160), June 23, 1932, H. S. Jackson et al. (TRTC 3573 *p.p.*) Aug. 18, 1935, J. R. Hansbrough 2383 (BPI), July 17, 1936, H. S. Jackson (TRTC 9707), July 1936, H. S. Jackson (TRTC 9688), Friday's Clearing, Aug. 21, 1930, C. S. Parker 2010 *p.p.* (BPI), Gull Lake Portage, June 25, 1929, H. S. Jackson (TRTC 1037), June 27, 1932, H. S. Jackson et al. (TRTC 3511), Metagama Point, Aug. 21, 1930, H. S. Jackson (TRTC 1735 *p.p.*), Obabika Inlet, June 25, 1932, S. M. Pady (TRTC 3391), Spawning Lake Portage, June 25, 1932, R. F. Cain (TRTC 3572); Muskoka Dist., June 24, 1890, J. Dearness 1742 (CUP-D-3-238), Muldrew Lake, June 3, 1954, R. F. Cain (TRTC 30129), 10 mi N of Port Severin, May 31, 1958, R. F. Cain (TRTC 33745). QUEBEC: Gatineau Co., Camp Fortune, June 2, 1960, M. Pantidou (DAOM 71913), Cantley, June 10, 1971, J. H. Ginns 1611 (DAOM 134576); Mt. Johnson, near St. Gregoire, June 1957, M. E. & H. E. Bigelow 4950 (DAOM 55749); Rawdon, June 21, 1969, J. W. Groves (DAOM 128444). U.S.A.: ALABAMA: Beaumont no. 4630 (K). CONNECTICUT: Marlboro, May 22, 1903, C. C. Hammer *p.p.* (BPI) (CUP-D-3-245); Norwalk, May 13, 1939, E. T. Butler (NY). DISTRICT OF COLUMBIA: Washington, May 14, 1898, C. L. Shaw (BPI). GEORGIA: Alexander, J. B. Ellis 33 (K). IDAHO: Shoshone Co., St. Joe Natl. For., Homestead Road, near Marble Creek, Aug. 18, 1967, R. E. Williams (WSP 57600). MAINE: Mt. Katahdin, Roaring Brook, June 10, 1965, R. H. Petersen (TENN 28654). MARYLAND: Elk Ridge, 1919, O. C. Heard (MICH); Frederick Co., Cunningham Falls State Park, May 2, 1973, L. R. Batra 13497 (BPI); Pasadena, April 23, 1922, L. C. Cash (BPI); Prince George Co., Silver Hill, May 10, 1914, K. Bryan (BPI), Patuxent Res. Refuge, May 1961, P. L. Lentz (BPI); Riptorn, June 26, 1897, Rev. A. B. Langlois (BPI); Sugar Loaf Mt., May 30, 1924, L. C. Cash (BPI); Suitland, June 2, 1928, L. H. & C. J. Weld & W. W. Diehl (BPI), May 19, 1929, W. W. Diehl, R. W. Davidson & Lambert (BPI); Takoma, May 17, 1899, C. L. Shear *p.p.* (BPI). MASSACHUSETTS: Amherst, May 23, 1891, J. E. Humphrey (BPI); Berkshire Co., Mt. Greylock, May 30, 1910, S. H. Burnham (CUP 22989); Chester State Forest, June 21, 1950, W. C. Denison 132 (OSC 20440); 40 mi NE of Amherst, Harvard Forest, June 1973, H. C. Aldrich (FLAS 50284); Franklin Co., Ruggles Pond, June 16, 1973, J. Ammirati 6267 (BPI); Manchester, June 26, 1889 (NY); Medford, Middlesex Fells, May 19, 1935, G. D. Darker 5312 (DAOM 89120), June 2, 1935, G. D. Darker 5319 (DAOM 89119); N. Weymouth, May 23, 1886, J. E. Humphrey (BPI); Stow, June 1917, S. Davis (CUP-D); Waverly, May 18, 1892, L. N. Johnson 786 (NY); Worcester Co., Peter-

sham, Tom Swamp Tract, June 17, 1973, C. T. Rogerson (NY). MICHIGAN: June 11, 1933, A. H. Smith & E. B. Mains 33–173 (BPI); Big Bay, Big Garlic River, Beaver Dam, June 13, 1933, A. H. Smith (MICH); Burt Lake, July 3, 1953, Singer & Smith 41459 (MICH); Cheboygan Co., Mud Lake Bog, A. H. Smith & T. E. Brooks 1201 (MICH), Steven's Bog, June 30, 1947, G. W. Prescott (MICH); Garden Co., July 14, 1961, Dublin 129 (BPI); Garden Peninsula, July 14, 1961, D. A. Reid (K); Hermits Bog, June 30, 1963, S. G. Brough 325 (UBC); Isle Royale, Jobin Harbor, July 10, 1930, A. H. Povah 145 (MICH), Rock Harbor, July 11, 1930, A. H. Povah Fp. 176 (MICH); Laughing Whitefish Point, June 11, 1933, A. H. Smith & E. B. Mains 33–173 (MICH); Mackinac Co., NW of St. Ignace, Half Lake dune area, June 28, 1971, M. Gilliam 1119 (MICH); Marquette Co., Canyon Lake, July 12, 1971, K. A. Harrison 10364 (MICH), K. A. Harrison 10365 (MICH), K. A. Harrison 10366 (MICH), K. A. Harrison 10367 (MICH), July 19, 1971, M. Gilliam 1150 (MICH), Big Garlic River, June 15, 1933, E. B. Mains 33–342 (MICH), Lily Pond, June 20, 1970, J. F. Ammirati 4093 (MICH); Rock River, June 14, 1933, A. H. Smith (MICH); Silver Creek, June 5, 1935, A. H. Smith 1295 (MICH); South Sand River, June 16, 1933, E. E. & E. B. Mains 33–358 (MICH), (BPI); Tahquamenon Falls State Park, April 19, 1951, Thiers & Smith 36372 (MICH), July 2, 1952, C. R. Leathers 478 (MICH), June 13, 1963, S. G. Brough 384 (UBC), June 24, 1963, S. G. Brough 303 (UBC); Whitefish, June 16, 1933, E. B. Mains 33–362 (MICH). MONTANA: Cabinet Mts., Libby, Hanging Valley, July 27, 1955, G. B. Cummins (BPI). NEW HAMPSHIRE: Chocora, no. 1955 (MICH), July 19, 1907, W. G. Farlow (CUP-D-3-259); Mt. Washington, Tuckerman's Ravine, Sept. 5, 1932, L. E. Wheymeyer 233 (DAOM 120411). NEW JERSEY: Netherwood (Plainfield), May 1883, G. F. Meschutt (CUP 7128); Newfield, J. B. Ellis (BPI). NEW YORK: Adirondack Mts., June, C. H. Peck (CUP-D-3-260), Hart Lake & Marcy Dam, June 13, 1953, R. P. Korf 53-4 (CUP), near Marcy Dam, June 13, 1953, R. L. Shaffer (CUP, Korf 53-5); Arethusa Lake, June 1901, Britton (NY); Buffalo, G. H. Clinton (BPI); Cattaraugus Co., Allegany Indian Reserve, Hotchkiss Hollow, June 10, 1961, C. T. Rogerson & S. J. Smith (NY); Cayuga Lake Basin, South Hill Marsh, June 2, 1897, H. Hasselbring (CUP-D-3-237), June 7, 1900, E. J. Durand (CUP-D-3-237), May 21, 1904, H. S. Jackson (CUP-D-3-242), June 3, 1906, Reddick & Reade (CUP 35891); Cortland Co., Labrador Lake, June 5, 1919, H. M. Fitzpatrick 1731 (CUP 30741), June 5, 1919, E. M. Smiley 115 (CUP), May 6, 1919, H. A. Purdy (UBC 88), June 2–7, 1919, F. J. Seaver (CUP 3159), June 9, 1946, H. M. Fitzpatrick & class (NY), (CUP 36398), Fitzpatrick, Rader & Rogerson (CUP, Korf 257 *p.p.*); Erie Co., May 22, 1963, R. H. Petersen (TENN 26734), May 25, 1963, N. G. Miller (TENN 26759); Essex Co., Keene Valley, Bushnell Falls, July 27, 1969, G. J. Samuels (NY), Marcy Dam, June 13, 1953, R. L. Shaffer (MICH); Greene Co., Catskills Mts., Hunter, N slope of High Peak, June 5, 1947, R. T. Clausen 7057 (CUP 36940); Hamilton Co., Cortland St. Univ., Antler's Camp, SW side Raquette Lake, June 16, 1969, C. T. Rogerson (NY); Hammondsville, W. C. Denison 626 (OSC 20751); Ithaca, May 20, 1904, H. S. Jackson (MICH), May 30, 1973, A. Wilkes (DAOM 144122); Long Island, Riverhead, May 15, 1949, R. Latham 28408 (BPI), near Smithtown, May 10, 1912, R. A. Gorter (NY), Wyandanck, May 28, 1902, W. C. Ferguson (NY); Madison Co., 1 mi SW of Cazenovia, June 6, 1948, D. G. Huttleston & C. T. Rogerson 2206 (NY); Oneonta, The Vly Swamp, June 24, 1947, W. C. Muenscher & B. Brown (NY); Tahawas, June 18, 1954, W. C. Denison 618 (OSC 20747); Washington Co., Lake George region, Rich's swamp, SW of Shushan, June 16, 1907, F. Dobbin & S. H. Burnham (CUP) 22993), W. Fort Ann, June 8, 1917, S. H. Burnham (CUP 26645). NORTH CAROLINA: Bennett Gap Road, May 25, 1926, J. S. Cooley & W. W. Diehl (BPI); Highlands, May 20, 1953, L. R. Hesler (TENN 20845 *p.p.*), May 21, 1954, L. R. Hesler (TENN 21377); near Highlands, Bearpin Mt., June 12, 1952, M. A. Rosinski & R. P. Korf (CUP, Korf 2573); Pisgah, May 25, 1926, W. W. Diehl (BPI). OHIO: Cleveland, May 1, 1938, W. B. Walters 116 (NY), (MICH). OREGON: Klickitat Lake, April 1968, W. C. Denison 3587 (OSC 24324); Mt. Hood Natl. Forest, Skyline Road, July 1946, Wm. B. Gruber 764 (MICH, see Smith (1949)); The Dalles, April 1947, S. M. Zeller (NY). PENNSYLVANIA: Center Co., Bear Meadows, June 12, 1920, F. J. Seaver (CUP 86). RHODE ISLAND: U. Providence, 1850, J. L. Bennett 1904 (CUP-D-3-234). TENNESSEE: Great Smoky

Mts. Natl. Park, Alum Cave, June 8, 1959, N. Chopra (TENN 7347), Greenbrier, April 14, 1946, L. R. Hesler (TENN 17425), May 9, 1937, A. Caton (TENN 9684), Rich Mt., L. R. Hesler 2053 (MICH), April 30, 1929, L. R. Hesler (NY), April 22, 1934, L. R. Hesler (TENN 4138), May 5, 1940, L. R. Hesler & A. J. Sharp (TENN 12553); Monroe Co., Tellico River, May 30, 1940, A. J. Sharp (TENN 12544). VIRGINIA: Bull Run Mts., May 12, 1935, H. A. Allard *p.p.* (BPI); George Washington Natl. Forest, Camp Todd, June 20, 1934, R. W. Davidson (BPI); Grayson Co., White Top Mt., June 9, 1956, A. J. Sharp (TENN 19667); Mt. Lake, May 31, 1936, C. L. Shear (BPI); Page Co., Massanutten Mt., May 30, 1933, W. W. Diehl (BPI). VERMONT: Riptorn, June 28, 1897 (CUP-D-3-239); Mt. Mansfield, Long Trail, June 18, 1951, R. F. Cain (TRTC 13222, see Gilman (1952)); Underhill, June 20, 1951, R. F. Cain (TRTC 13213, see Gilman (1952)). WASHINGTON: King Co., June 5, 1964, R. Hicks 103 (BPI); Olympic Peninsula, Kalaloch, May 10, 1939, A. H. Smith 13701 (MICH, see Kanouse (1947)); Seattle, J. W. Hotson (NY). WEST VIRGINIA: Fayette Co., Materson's Glade, June 11, 1893, L. N. Nuttall 935 (MICH) (BPI); Monongalia Co., Dellslow, May 28, 1907, J. L. Sheldon (CUP-D-3-263).

EXSICCATI: Ellis: North American Fungi no. 433 as *M. paludosa* (BPI, K, MICH, OSC, TRTC). Ellis and Everhart: Fungi Columbiana no. 16 as *M. paludosa* (BPI, CUP, FLAS, TRTC, WSP).

Leotia elegans Berkeley (1846) was described from material sent to Berkeley from Mr. Greene, U.S.A. It was later transferred to *Mitrula* by Fries (1851) where it was treated by Berkeley (1875) and Massee (1897). Durand (1908) stated that Mr. Greene was a well known physician from Boston (Massachusetts). Durand felt that *M. elegans* was an unusually etiolated form of *M. phalloides* (= *M. paludosa*) growing among *Sphagnum*. Ascocarps of the type collection deposited at Kew (K) are indeed very slender and in contact with some *Sphagnum* but more importantly the ascospores are identical with those of the commonest North American species of *Mitrula* (cf. Fig. 12 with Figs. 13–15).

Mitrula elegans is characterized by slender cylindrical to clavate but not filiform ascospores (Figs. 12–15). It is closely related to *M. paludosa* (Figs. 19–25). The ascospores of both species differ mainly in their average widths (see key). Thus far *M. elegans* is only known from North America and *M. paludosa* from Europe, a fact which makes their casual identifications easier.

Mitrula elegans is the most commonly collected and the most widely distributed North American species of *Mitrula* (Fig. 2). It has not been observed in Florida (Dr. J. W. Kimbrough, personal communication) or in Louisiana (Dr. A. L. Weldon, personal communication). Its southern limits appear to be well known, as are those of *M. lunulatospora*, to judge from the lack of reports from these two states. The same cannot be said for the northern limits as collecting trips to the Canadian boreal forests are rare.

Mitrula lunulatospora S. A. Redhead sp. nov.
Figs. 3, 5, 16–18

Ascoma gregaria, solitaria, mollia, 2.4–5.2 cm altum. Clavula forma varia, oblongato-ovoidea vel pyriformis, inflata, obtusa, laevis, crocea, 2–10 mm latum. Stipes subaequalis, cavus, albus vel roseo-albus, 1–4 mm crassus. Asci cylindraceo-clavati, apice attenuati, jodo obtuaculo minutissimo carulescentes, 91–135 × 6.5–8.5 μm. Paraphyses filiformes, 129–164 × 1.5–3 μm. Sporea 8: distichae vel oblique monostichae, lunata, 11–17 × 3–3.5 μm.

Ad folia putrida in paludosis.

HOLOTYPUS: On dead foliage of *Thuja occidentalis* and *Alnus rugosa*. Black Sturgeon Lake, Thunder Bay District, Ontario, Canada, Aug. 16, 1974; leg. S. A. Redhead no. 1329 (TRTC 47281).

ISOTYPUS: CUP, DAOM, K, UBC.

ADDITIONAL ILLUSTRATIONS: Mains (1955, Fig. 41).

MACROSCOPIC CHARACTERISTICS: Ascocarps gregarious or solitary, fleshy, 2.4–5.2 cm high. Clavula ovoid to pyriform or clavate, smooth to rugose, slightly tremullose, tasteless, saffron, buff, flesh or pinkish aurantiaca coloured, 2–10 mm wide. Stipes unbranched, glabrous and slightly lubricous above, 1–4 mm wide above, white or tinted pink, enlarged below, moderately covered with matted hyphal hairs below.

MICROSCOPIC CHARACTERISTICS: Asci eight-spored, elongate-clavate, 91–135 × 6.5–8.5 μm. Apical pores amyloid. Croziers present. Paraphyses filiform, slightly enlarged above, 129–164 × 1.5–3 μm. Ascospores 11–19 × (2–)2.5–3.5(–4) μm in deposits, lunate to allantoid or cymbiform, usually with a gelatinous sheath, one- or two-celled. Subhymenial hyphae 1.5–7.5 μm

wide. Clavula medulla hyphae 5–26 μm wide. Stipe medulla hyphae 5–10.5 μm wide. Stipe inner cortical hyphae 10.5–40.5 μm wide, inflated. Stipe outer cortical hyphae 3–7.5 μm wide. Basal mycelial hairs 3–8.5 μm wide.

HABITAT: Gregarious in shallow water, on decaying wet scales, twigs, cones, or leaves of *Alnus rugosa*, *Liquidambar styraciflua*, *Quercus* sp., *Symplocarpus foetidus* (L.)Nutt., and *Thuja occidentalis*; mats of *Sphagnum* and algae; and mud.

SPORULATING PERIOD: April–May (southeastern United States), May–August (northeastern United States and Canada).

DISTRIBUTION: Canada: Nova Scotia, Ontario, Quebec. U.S.A.: Alabama, Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, Michigan, Mississippi, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, Vermont, West Virginia.

SPECIMENS EXAMINED: CANADA: NOVA SCOTIA: Lunenburg Co., Aldersville, July 10, 1968, K. A. Harrison 7676 *p.p.* (MICH); Pictou, July 1, 1910, W. P. Fraser (CUP-D-3-269). ONTARIO: Algonquin Park, Found Lake Trail, about Mile 13 of Highway 60, June 27, 1974, P. D. Johnson (TRTC 47518), Little Macauly Lake, Aug. 10, 1940, R. F. Cain (TRTC 18515 *p.p.*); Lake Timagami, Bear Island, June 23, 1932, H. S. Jackson et al. (TRTC 3273 *p.p.*), Friday's Clearing, Aug. 21, 1930, C. S. Parker 2010 *p.p.* (BPI). Ko-Ko-Ko Bay, July 19, 1938, R. F. Cain (TRTC 13229), Metagama Point, Winter Tote Road, Aug. 21, 1930, H. S. Jackson (TRTC 1753); Thunder Bay Dist., Black Sturgeon Lake, July 1965, R. F. Cain (TRTC 43685), Aug. 16, 1974, S. A. Redhead 1329 (TRTC 47281, Type). QUEBEC: Chibougamau Park, N of Lac Alfred, near Lac Nicabau, Sept. 6, 1976, S. A. Redhead 2217 (TRTC). Granby, July 5, 1947, F. Fabius (DAOM 20039); St. Hilaire, June 23, 1962, G. A. Petrie (DAOM 89738). U.S.A.: ALABAMA: Lee Co., Auburn, May 1, 1896, L. M. Underwood (NY), April 24, 1897, F. S. Earle (NY), April, 1899, F. S. Earle (NY). CONNECTICUT: Cos Cob, May 20, 1945, H. Ahles (NY); Marlboro, May 22, 1903, C. C. Hammer *p.p.* (BPI). DELAWARE: N of Newmark, May 29, 1907, H. S. Jackson 1581 (CUP-D-3-257) (BPI). DISTRICT OF COLUMBIA: NE of Washington, May 25, 1930, C. S. Parker (BPI); Randal Heights, May 21, 1931, C. S. Parker & A. L. Parker (BPI). MAINE: Oxford Co., Canton Point, June 20, 1940, J. C. Parlin (MICH). MARYLAND: Anne Arundel Co., May 10, 1930, C. S. Parker 1703 (BPI); Beltsville, June 16, 1940, C. L. Shear (BPI), May 31, 1942, R. E. Snodgrass (BPI), May 20, 1944, L. Shanor (BPI); Landover, Smith's spring, May 31, 1931, A. L. Parker (BPI); Prince George Co., Patuxent Res. Refuge, June 10, 1950, J. A. Stevenson (BPI); Takoma Park, May 17, 1899, C. L. Shear *p.p.* (BPI). MASSACHUSETTS: Franklin Co., Sunderland, Mt. Toby, June 16, 1973, R. L. Shaffer 6941 (MICH); Medford, Middlesex Fells, May 30, 1891, L. M. Underwood & A. B. Seymour 2803 (NY), June 2, 1935, G. D. Darker 5318 (DAOM 89118); Norwood, May 30, 1934, G. D. Darker 5011 (DAOM 114836); Waltham, June 4, 1908, A. B. Seymour (BPI). MICHIGAN: Delta Co., Garden Peninsula, near Manistique, July 3, 1963, A. H. Smith (UBC); Isle Royale, Blake's Point, July 20, 1930, J. L. Lowe Fp 137 (MICH), Rock Harbor, Aug. 13, 1930, A. H. Povah Fp 479 *p.p.* (MICH), July 7, 1930, A. H. Povah Fp 87 (MICH); Luce-Chippewa Co., Tahquamenon Falls State Park, July 9, 1951, A. H. Smith 34798 (MICH), S. C. Hoare (DAOM 26928), July 8, 1957, A. H. Smith 57170 (MICH); Mackinac Co., Hay Lake area, Aug. 1, 1974, N. S. Weber 4014 (MICH); Marquette Co., near Howe Lake, July 14, 1970, J. F. Ammirati 4386 & S. J. Mazzer (MICH), Upper Falls, July 30, 1970, J. F. Ammirati (MICH). MISSISSIPPI: Marshall Co., S. Holly Spring, R. M. Johns (MICH). NEW JERSEY: Newfield, June 1880 (NY); Paterson, May 1938, F. R. Lewis (NY). NEW YORK: Arethusa Lake, June 1901, Britton (NY); Bear Mt. Park, June 5, 1954, W. C. Denison 595 (OSC 20732); Buffalo, before 1901, G. W. Clinton (BPI); Cortland Co., Labrador Lake, June 2–7, 1919, F. J. Seaver (BPI), June 9, 1946, Fitzpatrick, Rader & Rogerson (CUP, Korf 257 *p.p.*) June 23, 1953, W. C. Denison 265, Korf, Shoemaker & Shaffer (OSC 20463); Essex Co., near Chilson Lake, June 16, 1901 (BPI); Hammondsville, June 9, 1954, W. C. Denison 627 (OSC 20752); Lewis Co., 4 mi W of Westleyden, May 28, 1946, B. Wynne (NY); Potsdam, J. B. Ellis (BPI); Sandlake, June 18, C. H. Peck (CUP-D-3-262); Ulster Co., Clintondale Stn., June 15, 1949, S. J. Smith & D. G. Huttleston (CUP, Korf 1690). NORTH CAROLINA: Highlands, May 20, 1953, L. R. Hesler (TENN 20845 *p.p.*). OHIO:

Hocking Co., Ash Cave State Park, June 12, 1935, W. B. Cooke (OSC 14011), (MICH). PENNSYLVANIA: Bethlehem, E. A. Barr (BPI); Buchanan State Park, Collins Gap Picnic Grounds, June 22, 1940, J. A. Stevens (BPI); West Chester, 1897, Ellis (NY). SOUTH CAROLINA: 40 Acre Rock, April 20, 1959, W. C. Denison 1737 (OSC 21355). TENNESSEE: Polk Co., May 21, A. J. Sharp (TENN 23747); Sewanee, April 21, 1946, R. E. Shanks (TENN 17422). VIRGINIA: Arlington, May 7, 1922, C. L. Shear 4026 (BPI), June 5, 1927, C. L. Shear (BPI); Bull Run Mts., May 12, 1935, H. A. Allard *p.p.* (BPI); Claredon, May 25, 1918, H. Allard (BPI), May 30, 1923, J. R. Weir (BPI); N of James City Co., May 6, 1952, J. T. Baldwin Jr. (BPI); Radnor, May 28, 1922, C. L. Shear (BPI). VERMONT: Newfane, July 12, 1906, G. B. Burlingham (NY). WEST VIRGINIA: Nettie, June 22, 1940, A. J. Sharp (TENN 12728).

EXSICCATI: Wilson and Seaver: Ascomycetes and Lower Fungi no. 38 as *M. phalloides* (BPI, CUP, OSC, TRTC).

Mitrula lunulatospora is characterized by lunate to cymbiform ascospores (Figs. 16–18) which readily distinguish it from the other three species of *Mitrula*. Ascocarps with unusually small ascospores and growing in mossy pools could be confused with *Bryoglossum gracile* (q.v.) (Fig. 26), a species growing on arctic or alpine mosses. *Mitrula* species lack the minute cauloscales and the gelatinized hymenium margin of *B. gracile*. They also react differently in KOH solution.

Mitrula lunulatospora is restricted to eastern North America (Fig. 3) where it is almost as common as *M. elegans* (Fig. 2). Both species' ranges extend down the Appalachian mountain range to the northern parts of the gulf states. In the southeastern United States *M. lunulatospora* sporulates slightly earlier than *M. elegans* most years. In the northeastern United States and Canada both species sporulate later in the year and the differences in sporulating time disappear. A similar phenomena was reported for *Peziza badia* Pers. ex Mérat and *P. badio-confusa* Korf by Elliott and Kaufert (1974).

Mitrula paludosa Fries, Syst. Mycol. 1: 491–492 (1821). Figs. 19–25
= *Mitrula norvegica* Rostrup (1904).
= *M. phalloides* (Bull.) ex Chev. var. *aurantiaca* (Cumino) ex Boudier, sensu Boudier (1905–1910).
= *M. omphalostoma* Benedix (1962).
?= *Leotia uliginosa* Persoon (1822–1828).
?= *M. phalloides* (Bull.) ex Chevallier (1826–1827).
?= *M. laricina* (Vill.) ex Massee (1897).

ADDITIONAL ILLUSTRATIONS: Boudier (1905–1910, Pl. 427, 427 bis), Bresadola (1932, Tab. 1184 (1)), Dennis (1960, 1968, Pl. Xg).

MACROSCOPIC CHARACTERISTICS: Ascocarps gregarious to caespitose, fleshy, 2–8 cm high. Clavula globose to pyriform, clavate, cylindrical or lobed, smooth to rugose, slightly tremullose, orange to yellow-orange, becoming pinkish with age when submerged, 2–20 mm wide. Stipes unbranched, glabrous and slightly lubricous, 2–4 mm wide above, white to reddish tinted, enlarged above or below, moderately covered with densely matted hyphal hairs below.

MICROSCOPIC CHARACTERISTICS: Asci eight-spored, elongate-clavate, 98–138 × 5.5–7 μm. Apical pores amyloid. Croziers present. Paraphyses filiform, slightly enlarged above, 136–140 × 1.5–3 μm. Ascospores 11–19(–24) × (2–)2.5–3.5(–4) μm, flexible, cylindrical to clavate, occasionally fusoid-cylindrical, rarely with a thin gelatinous sheath. Subhymenial hyphae 3.5–5.5 μm wide. Clavula medulla hyphae 3–21 μm wide. Stipe medulla hyphae 3.5–8.5 μm wide. Stipes inner cortical hyphae 7.5–43.5 μm wide. Stipe outer cortical hyphae 3.5–10.5 μm wide. Basal mycelial hairs 4–8.5 μm wide.

HABITAT: In shallow water, on decaying needles or leaves of *Alnus glutinosa* Medic., *Betula alba* L., *Larix* sp., and *Picea* sp.; *Sphagnum* mats; mud and other unidentified organic matter.

SPORULATING PERIOD: March–September.

DISTRIBUTION: Austria–Hungary, Belgium, Czechoslovakia, Denmark, East Germany, England, Finland, France, Italy, Japan, Latvia, Netherlands, Norway, Scotland, Sweden, and West Germany.

NEOTYPE: SWEDEN: Småland, Femsjo, E. Fries (UPS) as *Mitrula paludosa* Fr., selected here.

TYPE DESCRIPTION: Ascocarps 12–32 mm high, solitary to partially fasciculated. Clavula 1–5 mm wide, clavate to ovoid or bifid, dull Sepia to dull Sienna (dried). Stipes 0.5–1.5 mm wide at apices, concolourous or paler than clavula to dull Ochreous, straight or undulating. On fragments of dead leaves.

Asci eight-spored, elongate-clavate, 119–133 × 6.5–7.5 μm. Apical pores amyloid. Croziers present. Paraphyses filiform, equal or slightly enlarged above, exceeding the asci, 2–3 μm wide, septate, thin-walled. Ascospores irregularly biseriate, one- or two-celled, hyaline, thin-walled, cylindrical, oblong-elliptical to elongate-clavate, 11–17.5 × 2–3 μm, inamyloid. Subhymenial hyphae much branched, septate, not inflated. Clavula medulla hyphae thin-walled, septate, inflated.

SPECIMENS EXAMINED: BELGIUM: Hainaut Prov., Casteau, mid-May, 1910, Lake Delvoselle (LG); Liège Prov., Vecquée-Seraing, June 6, 1942, F. Darimont 69 (LG), 93 (LG), 106 (LG). ENGLAND: Berkshire Co., Crowthorne, May 19, 1946 (BPI), Windsor, Great Park, June 5, 1958, E. M. Wakefield (DAOM 88840); Cumberland Co., Barrowdale, June 4, 1956, D. A. Reid (BPI); Lancashire Co., between Grange and Nothwaite Lake Dist., May 26, 1954, D. A. Reid (DAOM 44799), Hawkhead, Tam Hous, May 25, 1962, D. A. Reid (DAOM 107805); Surrey Co., Brookwood, May 5, 1952, J. Taylor (DAOM 39030). FINLAND: Nylandia, Espoo, Bodom, June 4, 1950, V. Kujala HFR 521 (DAOM 134527); Viipuri Prov., Sippola, Kaipiainen, June 26, 1949, V. Kujala (DAOM 134482). FRANCE: Ardennes Prov., Hauts-Bultes, May 15, 1966, J. Remache (LG); Corsica Prov., Vizzavona, June 3, 1965, D. A. Reid (K, see Reid 1968); near Gironde-Landes Prov. border, Mar. 28, 1961, V. Demoulin 516 (LG); Loire Prov., Montagne de la Madeleine près Roanne, June 1909, Biel (PC, ex Herb. Boudier); Montmorency, *in aquosis turfosis*, May 1890, *M. paludosa* var. *sphaerocephala*, = *aurantiaca* Cum. (PC, ex Herb. Boudier); Pyrénées Orientales Prov., June 14, 1975, V. Demoulin (LG). GERMANY: Bayern State (Bavaria), Bayreuth, 1879, A. Walther (BPI); Dresden, July 26, 1955, Kaden and Kunze (TRTC, Isotype of *Mitrula omphalostoma* Benedix). NETHERLANDS: Noord-Brabant Prov., Woensdrecht, June 7, 1954, C. Bas (K). NORWAY: Aust-Agder Prov., Barbo pr., Arendal, May 13, 1948, L. H. Jordal (MICH); Hordaland Prov., Eide, 1903, Gamble (K); Sogn og Fjordane Prov., Nordfjord, June 6, 1967 (K); Sunelven, Fibelstadhaugen, Aug. 8, 1881, A. Blytt (O, Type of *Mitrula norvegica* Rostr.). SCOTLAND: Perth Co., Crianlarich, June 13, 1951, B. McFarlane (CUP, Korf 2293). SWEDEN: Jämtland Prov., Storlien, July 24, 1950, M. Lange (DAOM 24208); Uppsala Prov., Uppland, close to Läbyvad, Sept. 27, 1947, A. Melderis (DAOM 67478), Laggar pr., 400 mi ENE of Orrslätt, June 18, 1961, R. Santesson 1411 (BPI), (K).

EXSICCATI: Desmazieres: Cryptogames France, Ser. *i* no. 606, *M. paludosa* (K). Flora Exsiccati Austro-Hungarica no. 175, *M. paludosa* (CUP, DAOM, K). Flora Galliae et Germaniae exsiccati no. 796 et 796 bis, *M. phalloides* (K). Fuckel: Fungi Rhenani no. 1236, *M. paludosa* (K). Jaczewski, Komarov and Tranzschel: Fungi Rossiae Exsiccati no. 200, *M. phalloides* (BPI, DAOM). Karsten: Fungi Fenniae Exsiccata no. 24, *M. paludosa* (K). Klotzsch: Herbarium vivum mycologicum sistens fungorum per totam germaniam cresentium collectionem perfectam no. 132, *M. paludosa* (K). Mougeot and Nestler: Stirpes Cryptogamae vogesrhenanae no. 685, *Leotia uliginosa* (CUP, Korf 408, DAOM, K). Petrak: Flora Bohemiae et Moraviae exsiccata no. 1413, *M. phalloides* (BPI). Phillips: Elvellacei Britannici no. 2, *M. paludosa* (BPI, CUP-D-3-274). Rabenhorst-Winter: Fungi europaei no. 2844, *M. phalloides* (K). Rehm: Ascomyceten no. 601 b., *M. phalloides* (BPI, CUP-D-3-276). Romell: Fungi Exsiccati prasertim scandinavici no. 195, *M. phalloides* (BPI, CUP). Roumeguere: Fungi Selecti Galliaei Exsiccati no. 160, *L. uliginosa* (K). Roumeguere: Fungi Gallici exsiccati no. 3722, *M. paludosa* (K). Smarods: Fungi latvici exsiccati no. 1374, *M. paludosa* (K). Sydow: Mycotheca germanica no. 2169, *M. phalloides* (BPI, CUP, K, TRTC), no. 2364, *M. phalloides* (BPI, CUP, K, TRTC). De Thümen: Mycotheca Universalis no. 111, *M. paludosa* (K). Zopf et Sydow: Mycotheca Marchica no. 31, *M. paludosa* (K).

The genus *Mitrula* Fries (1821) was described with five species in two subgenera as follows: subgenus *Genuinis*, *M. paludosa*, *M. minuta* and *M. mucerdae*; and subgenus *Heyderia*, *M. abietis* and *M. pusilla*. Subgenus *Heyderia* was elevated to the generic level by Link in 1833 (fide Maas Geesteranus 1964). *Mitrula mucerdae* Fr. was later considered to be a species of *Hydrophora* Tode ex Fr. (Fries 1829, p. 315) = *Mucor*, or a *Stilbum* (Fries 1828; Massee 1897). *Mitrula minuta* Fr. was thought to be a species of *Pistillaria*, either *P. micans* Fr. (Massee 1897) or *P. fulgida* Fr. (Corner 1950, as *Clavaria minuta* Pers. but clearly the same species). The remaining species, *M. paludosa*, was chosen as the type and

only species for *Mitrula* by Imai (1941) and recognized as such by Maas Geesteranus (1964).

The *neotype* described above was the only collection of *M. paludosa* by E. Fries deposited in Uppsala (UPS). It had previously been cited by Nannfeldt (1942) in the list of collections that he examined but no description was given then. Except for the specimen's darker colours, a result of drying and aging, its macroscopic features matched Fries's description of *M. paludosa*. The chosen collection also represents the commonest European species of *Mitrula* which is normally referred to as *M. paludosa*. The specimen cannot be designated as a lectotype because of the lack of a collecting date, thus making it impossible to know if Fries examined it before his publication. Femsjo was Fries's birth place and he frequently collected there.

As stated earlier both *Mitrula norvegica* and *M. phalloides* var. *aurantiaca* sensu Boudier were based on abnormal forms of *M. paludosa*. *Mitrula omphalostoma* Benedix (1962) is also a synonym of *M. paludosa*. It was based on a collection of apically perforated, large, pinkish ascocarps growing in *Sphagnum*. Microscopically (Fig. 21) it does not differ from *M. paludosa* including the amyloid reaction of the apical pore (cf. Maas Geesteranus 1964). The combination of a pinkish hymenium, perforated hymenophore, and a habitat on *Sphagnum* is unusual but is to be expected in the normal range of macroscopic variation shown by *Mitrula* species. All four recognized species have been collected in association with *Sphagnum* at some time. In one collection of *M. elegans* on wet leaves in *Sphagnum* the emergent ascocarps were orange whereas the submerged ascocarps were pinkish (unpublished notes in M. Gilliam no. 1150, MICH). Another collection of *M. elegans* on decaying leaves in swampy ground consisted of large clavate perforated ascocarps (M. B. Walters no. 116, MICH). These variations are rare for *M. elegans*, a species for which I have examined numerous collections, and can be expected for *M. paludosa* when enough collections are examined. A large number of bacteria were present on the portion of the type of *M. omphalostoma* studied. This indicated that it was overmature and deteriorating or submerged or both.

Discussion

The genus *Mitrula* as first conceived by Fries was an unnatural assemblage of species. Numerous species have been described in the genus or transferred to it only to be placed in synonymy with *M. paludosa* or to be placed in other genera (Imai 1941; Durand 1908; Massee 1897). Attempts to divide *M. paludosa* into varieties or species have been based on macroscopic and variable characters (Benedix 1962; Massee 1897; Velenovský 1934), which are now known to be affected by the environment. Unfortunately even when microscopic characters were used to divide *M. paludosa* (Rostrup 1904; Boudier 1905–1910) the divisions were based on abnormal spore forms.

The system of dividing *M. paludosa* sensu lato into four species based on ascospore morphology and size in spore deposits, as used here, has revealed previously obscured patterns of geographic distribution and sporulating periods. This method also supports a separation based on pigmentation, a character influenced by the environment and only to be used cautiously. The correlations of these characteristics indicate that the species as recognized here are natural taxonomic units.

A number of other species placed in *Mitrula* have been reported from North America although most have since been assigned to other Geoglossaceous genera. Massee (1897) reported the following species: *Mitrula serpentina* Massee, *M. laricina* Massee, *M. elegans* (Berk.) Fr., *M. luteola* Ellis, *M. rufa* (Schw.)Sacc., *M. cucullata* (Fr.)Fr., *M. microsporon* (Cke. et Pk.) Massee, and two doubtful species, *M. alba* (Johnson) Massee and *M. exigua* (Schw.) Fr. Durand (1908) and Seaver (1951) reported *M. irregularis* (Pk.)Durand, *M. vitellina* (Bres.) Sacc., *M. phalloides* Chev., *M. cucullata*, *M. gracilis* Karst., and *M. muscicola* P. Henn. Additional species of *Mitrula* placed in synonymy are listed by Durand. Mains (1955) gives *M. paludosa*, *M. abietis*, *M. gracilis*, and *M. morchelloides* Mains. Kankainen (1969) also recognized *M. paludosa* and *M. gracilis* from North America.

Mitrula laricina and *M. phalloides* are synonyms of *M. paludosa*. *Mitrula cucullata* is a synonym of *Heyderia abietis* (Fr.)Link based on *M. abietis* (Dennis 1968; Maas Geesteranus 1964). *Mitrula irregularis* and *M. vitellina* have been transferred to *Neolecta* (Korf 1971) and *M. luteola* is a synonym of one of these (Durand 1908). *Mitrula rufa* and *M. serpentina* are *Microglossum* species (Durand 1908). *Mitrula microsporon* is a synonym of *Thuemenidium atropurpureum* (Batsch ex Fr.) O. Kuntze (Durand 1908; Maas Geesteranus 1964). *Mitrula muscicola* is a

synonym of *M. gracilis* (Favre 1949; Kankainen 1969). *Mitrula alba* and *M. exigua* are poorly described and doubtful species for which no type collections are known (Durand 1908).

Four species of *Mitrula* previously reported from North America have remained in the genus to date: *M. elegans*, *M. gracilis*, *M. morchelloides*, and *M. paludosa*. The North American reports of *M. paludosa* were based on collections of *M. elegans*, *M. borealis*, or *M. lunulatospora*. *Mitrula morchelloides* is a species of *Verpatinia*. It was described as growing on wet earth (Mains 1934, 1955), however a note with the type collection (MICH) states that it was growing on wet leaves. A description of the type collection follows:

Verpatinia morchelloides (Mains) S. A. Redhead comb. nov. Figs. 7, 8

BASIONYM: *Mitrula morchelloides* Mains, Pap. Mich. Acad. Sci. Arts Lett. 20: 83 (1934).

MICROSCOPIC CHARACTERISTICS (from type): Ascospores fusoid-elliptical to cymbiform, usually flattened on one side, 5.5–7 × 2 μm, nonseptate, hyaline, thin-walled, inamyloid, mostly biseriate. Asci eight-spored, short cylindric, 38–46 × 5–6.5 μm, short pedicillate, croziate, apically thickened, with an amyloid apical pore. Paraphyses abundant, hyaline, thin-walled, nonseptate, 38–42 × 1.5–2 μm, equal or slightly enlarged apically. Excipulum textura globosa near the stipe, hymeniform near the margin, cells subglobose to clavate, 11–12.5 × 7.5–10.5 μm, developing apical papillae near the apothecial margin and grading into marginal hairs. Marginal hairs unicellular, crowded, ventricose to flexulose-cylindric, 19–34 × 3–5 μm. Medullary and excipulum hyphae pigmented, brown. Stipe hyphae parallel, not inflated, pigmented, incrusted, slightly constricted at septa, 4–9 μm wide. Caulocystidia none.

MACROSCOPIC CHARACTERISTICS: see Mains (1934); substrate and stipe bases missing in type collection.

SPECIMENS EXAMINED: U.S.A.: MICHIGAN: Munising, Wagner's Falls, June 12, 1933, E. B. Mains 33–193 (MICH, type).

Verpatinia morchelloides is closely related to *V. calthicola* Whetzel and *V. spiraeicola* Dennis and may be conspecific with either of them. It was described before both species.

Mitrula gracilis differs in a number of ways from the four closely related species of *Mitrula* recognized and described above. It produces minute cauloscales consisting of fasciculated hyphal ends (Kankainen 1969), a gelatinized free margin clearly visible in young ascocarps (Kankainen 1969), and a yellowish stipe (Eckblad 1963; Favre 1949; Heim and Remy 1932; Imai 1941; Kankainen 1969). As noted by Eckblad (1963) the stipe hyphae of *M. gracilis* rarely exceed 7 μm in diameter in contrast with the broader hyphae of *M. paludosa*. The maximum diameters reached in the four *Mitrula* species were as follows: *M. borealis*, 33.5 μm; *M. elegans*, 70 μm; *M. lunulatospora*, 40.5 μm; and *M. paludosa*, 43.5 μm. The diameters of the basal mycelial hairs of each of these species were 3.5–7.5 μm, 3.5–10.5 μm, 3–8.5 μm, and 4–8.5 μm, respectively, in contrast with the diameter of the basal mycelial hairs of *M. gracilis*, 1.5–3.5 μm. In 10% KOH solution ascocarps of *M. gracilis* released a yellow to reddish brown pigment in considerable quantities whereas the four related *Mitrula* species did not. Finally *M. gracilis* is only found associated with mosses in arctic or alpine environments whereas the other *Mitrula* species are found associated with decaying leaves or needles in subalpine to temperate environments. For these reasons a new genus is proposed to differentiate *Mitrula gracilis* from the *Mitrula* species admitted above.

Bryoglossum S. A. Redhead gen. nov.

Ascoma gregaria, solitaria, mollia. Clavula forma varia, campanulata vel clavata, laevia vel rugosa, gelatinosa marginiba. Stipes aequalis vel subaequalis, pruinato-glabrescens. Asci clavato-subfusoidei, jodo obturacolo minutissimo caerulescentes. Sporae 8: distichae vel oblique monostichae, subfusoideae, continuae vel septatae. Paraphyses filiformes. Ad muscos; alpinus vel arktios.

TYPUS GENERIS: *Bryoglossum gracile* (Karsten) S. A. Redhead comb. nov. Basionym: *Mitrula gracilis* Karsten, Hedwigia 22(2): 17 (1883). Fig. 26.

SPECIMENS EXAMINED: CANADA: NEWFOUNDLAND: Labrador, The Strait of Belle Island, Capisan Island, Aug. 17, 1894, Rev. A. C. Waghorne (BPI). NORTHWEST TERRITORIES: Mackenzie Dist., Mackenzie Mts., a small unnamed lake 9 mi SES of Hole-in-the-wall Lake, 61°42′ N, 127°10′ W, Aug. 10, 1967, W. J. Cody & K. W. Spicer (DAOM 117574). ONTARIO: Cochrane Dist., Fort Albany, Aug. 2, 1972, D. Malloch 2.8.72/17 (DAOM 145220). SWEDEN: Norrbotten Prov., Pajala, Sept. 1859, C. P. Lastuctius (BPI).

U.S.A.: ALASKA: Turnagain Pass, Sept. 9, 1969, V. Wells & P. Kemton 4221 (TRTC 47582). COLORADO: Geneva Cr. Canyon, 8 000 – 14 000 ft, Sept. 3–12, F. J. Seaver & E. Bethel (TRTC). WASHINGTON: Pierce Co., Mt. Rainier Natl. Park, Sept. 25, 1968, W. C. Denison 4296 (OSC 25016).

EXSICCATI: Lundell & Nannfeldt: Fungi Exsiccati Suecici, Praesertim Upsalienses no. 1784, *Mitrula gracilis* (DAOM).

Bryoglossum gracile is described in a number of papers which are reviewed in Kankainen (1969), who also summarizes the ecology of this species. It has been reported from the following areas: North America: Alberta, Newfoundland (Labrador), Quebec, Colorado, Idaho, Montana, Washington (Mains 1955); Europe: northern Fennoscandia, the Carpathian Mountain range, and the Alps; Greenland; Iceland (Kankainen 1969).

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