

On the structure, ecology and distribution of the species of *Mitrula* s.lat. (Ascomycetes, Geoglossaceae)

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Introduction

The matter under consideration is a part of my research including the larger fungi in arctic and subarctic regions. For eight years I have also collected *Mitrula* material, and some notes are published in KALLIO & KANKAINEN (1964, 1966). I have had the opportunity to participate on the excursions of Kevo, the Subarctic Research Station of the University of Turku under the leadership of Prof. Paavo Kallio. Our *Mitrula* collections from these trips to Spitsbergen in 1966 and northeastern Canada in 1967 are taken into consideration in the present paper. The specimens studied are preserved in the following herbariums:

H	Botanical Museum of the University of Helsinki
HFR	Finnish Forest Research Institute, Helsinki
HPP	Department of Phytopathology, University of Helsinki
KEVO	Collections of the Subarctic Research Station of the University of Turku, Utsjoki
OULU	Botanical Museum of the University of Oulu
S	Botanical Museum of Stockholm
TROMS	Department of Botany, Tromsø Museum
TUR	Botanical Museum of the University of Turku

Only unpublished finds are included in the enclosed lists of the studied specimens, but

the notes of KALLIO & KANKAINEN (1964, 1966) are also plotted on the maps (Figs. 1, 3).

I express my best thanks for direction and advice of great value to my teacher Prof. Paavo Kallio, for valuable notes and discussion to Phil. lic. Tauno Ulvinen, for determination of the mosses in question to Phil. mag. Unto Laine, and for the linguistic revision to Mrs. Linna Müller-Wille. I have received financial support from Suomen Kulttuurirahasto.

Mitrula Fr., Syst. Myc. 1, p. 491. 1821. (sensu strict.)

IMAI (1941) and MAAS GEESTERANUS (1964) have unravelled the history of the genus *Mitrula*, and we only ascertain the large variation in its content from one extreme to the other, from the wide opinion of KARSTEN (1871) and MASSEE (1897) to the narrow one of IMAI (1941, 1956) and MAAS GEESTERANUS (1964). IMAI (1956), divided *Geoglossaceae* into new subfamilies and tribes. Consequently the tribe *Mitruleae* includes only one monotypic genus *Mitrula* on the basis of that the ascocarp of *M. paludosa* is hemiangiocarpic. In the tribe *Gymnomitruleae* is included one genus *Gymnomitrula* with two species *G. abietis* and *G. gracilis* on the basis of that the ascocarp of *M. pusilla* is gymnocarpic. According to MAAS GEESTERANUS (1964) the genus *Mitrula* is also monotypic. He has renewed the old genus *Heyderia* which is in his opinion monotypic, because the place of *M. gracilis* is indistinct.

In the present paper we have taken the genus *Mitrula* in a larger sense than the last two authors, but sensu stricto compared with the opinion of e.g. FRIES (1821), NANNFELDT (1942) and ECKBLAD (1963).

1. *Mitrula paludosa* Fr., Syst. Myc. 1, p. 491. 1821.

Helvella laricina Vill., Fl. Dauph. 3, p. 1045, Tab. 56. 1786—1789.

Clavaria phalloides Bull., Champ. France, p. 214, Tab. 463, Fig. 3. 1791—1798.

Clavaria epiphylla Dicks., Plant. Crypt. 3, p. 22, Tab. 9, Fig. 10. 1793.

Leotia ludwigii, *dicksoni*, *bulliardii* Pers., Syn. Fung., pp. 611, 612, Tab. 3, Fig. 13. 1801.

Leotia laricina Pers., Syn. Fung., p. 614. 1801.

Helvella aurantiaca Cumino, Act. Acad. Sci. Tur., p. 221. 1805.

Mitrula aurantia Cumino, Fung. Vall. Pisii in Act. Tur. 1806.

Leotia uliginosa Pers., Myc. Eur. 1, p. 200. 1822.

Leotia uliginosa var. *aurantiaca* Pers., Ibid., p. 201. 1822.

Mitrula phalloides Chev., Fl. Paris, p. 114, Fig. 185. 1826—1827.

Leotia elegans Berk., London Journ. Bot. 5, p. 6. 1846.

Mitrula elegans Fr., Nov. Symb. Myc., p. 103. 1851.

Mitrula paludosa var. *pachyceps* Karst., Hedw. 22, p. 17. 1883. — Karst., Acta Soc. F. Fl. Fenn. 2, p. 110. 1885.

Mitrula phalloides var. *pachyceps* Sacc., Syll. Fung. 8, p. 33. 1889.

Microglossum elegans Underw., Minn. Bot. Stud. 1, p. 495. 1896.

Mitrula laricina Mass., Ann. Bot. 11, p. 271. 1897.

Mitrula norvegica Rostr., Vid.-Selsk. Skrift. 1: 4, p. 5. 1904.

Mitrula phalloides var. *aurantiaca* Boud., Icon. Myc. 3, Tab. 427. 1909.

External morphology. The size and form of the studied ascocarps of *Mitrula paludosa* are quite variable. The stipe is 2—5 centimetres high, smooth, transparent, whitish when fresh, orange yellow when dry. The base of the stem is generally thickened when grown in soft habitat, for instance in mud, forming a large white ball of hyphae. When growing on only a little decayed leaves the base of the stem is not at all thickened or very slightly.

The diameter of the ascigerous portion varies from 0.5 to over one centimetre. Mostly the cap is uneven, folded, but also even, almost spherical caps exist. Sometimes the caps resemble *Spathularia*. The colour of the cap is yellow — orange yellow when fresh becoming far darker when dried. The form with even,

cylindrical-spherical cap is pure yellow in colour (cf. var. *cylindrica* of VELENOVSKY 1934).

The ascigerous portion is connected to the stem without a sterile margin as seen in *Mitrula gracilis* and *Heyderia abietis*. The cap-stem relation varies very much depending on the habitat. In very rotten, soft places the specimens have thick, short, caespitose stems and small caps (cf. var. *pachyceps* of KARSTEN 1883); on a more solid substrate the stems grow slender and long, the height of them depending on the depth of the substrate in the water. The caps are generally large and variable in form.

Anatomy. The width of the hyphae in the central part of the stipe widens up to 15 μ , in the periphery of the stipe about 6 μ . The surface of the stem is smooth.

The size of the asci averages 75—110 \times 5—6 μ (measured in five specimens). The paraphyses are straight, not at all or very slightly enlarged above. The spores are hyaline, not punctate, nonseptate, cylindrical to clavate-cylindrical, in average larger than those in *M. gracilis*. The size of the spores in the following specimens is: Masku 4. 6. 1959 15.3 \times 3.5 μ (50 measurement); Lohja 12. 6. 1961 12.2 \times 2.5 μ (50 meas.); Kiiminki 25. 6. 1966 13.7 \times 2.6 μ (50 meas.); Inari 15. 7. 1968 11.1 \times 2.6 μ (30 meas.).

The morphological and anatomical features of the specimens studied correspond well with those recorded in the literature (FRIES 1821, KARSTEN 1871, 1883, REHM 1896, MASSEE 1897, DURAND 1908, LLOYD 1916, VELENOVSKY 1934, IMAI 1941, MAINS 1955, BENEDIX 1962, ECKBLAD 1963, MAAS GEESTERANUS 1964). Specimens belonging to var. *pachyceps* Karst., and possibly to var. *sphaerocephala* Boud. and var. *cylindrica* Vel. are included in the list of the studied specimens. Var. *castanea* Vel. is unknown to us as is f. *pallens* Eisfelder & Benedix. MAINS (1955, p. 873) has found three types of ascospores occurring in the *Mitrula paludosa* collections. We have found, however, spores of very variable form and size in the same specimen. The uniseptate spores are very rare in our collections (cf. MASSEE 1897, IMAI 1941, MAINS 1955).

Habitat. *Mitrula paludosa* grows in Finland preferably on decaying leaves of birch, but it is also found on leaves of *Alnus*, on needles and twigs of *Pinus silvestris* and *Picea*

abies, and among more rotten rests of plants (in mud and slime). Almost without exception the species is found along springs and spring brooks, and in bogs. Often its habitat is a puddle, but always a place where the water changes but does not flow. In such places the oxygen conditions are good. The habitat of our specimen collected in Canada was very similar to those in Lapland.

The habitats of the studied specimens agree with the notes presented in the literature (FRIES 1821, KARSTEN 1871, 1883, COOKE 1871, REHM 1896, MASSEE 1897, DURAND 1908, LLOYD 1916, VELENOVSKY 1934, IMAI 1941, NANNFELDT 1942, MAINS 1955, BENEDIX 1962). Var. *pachyceps* of KARSTEN (1883) is grown «Supra acus Pini sylvestris putrescentes». It is not yet understood, whether the caespitose form is caused by the quality of the substrate and/or only by the softness of it. BENEDIX (1962, p. 402) presents four «Varietäten» *sphaerocephala* Boud., *pachyceps* Karst., *castanea* Vel. and *cylindrica* Vel. only as habitat forms.

Phenology. *Mitrula paludosa* is earlier than *M. gracilis*, occurring from spring to early autumn. The studied unpublished collections are listed in order of occurrence in the following list (abbrev. K). For comparison the other columns are made according to observations of ULVINEN (abbrev. U) presented later on, and to collections mentioned by KALLIO & KANKAINEN 1964 and 1966 (abbrev. K & K; all specimens are from Lapland) and NANNFELDT 1942 (abbrev. N).

	Number of specimens			
	K	U	K & K	N
During May	1	—	—	5
« June	49	10	—	26
« July	25	14	2	16
« August	10	7	13	3
« September	2	—	—	2
« October	1	—	—	—

In Lapland the peak of occurrence of the species is July-August in normal years, in southern Finland June-July.

Most authors record the species to occur in spring and early summer (e.g. LLOYD 1916, VELENOVSKY 1934, MAINS 1955, ECKBLAD 1963). BENEDIX (1962) says that in the lowland the species occurs in May-June, in the highland in September.

Distribution. The specimens studied by the

writer are mostly from Finland (see Fig. 1). The species has never been found in the alpine regions of Lapland, thus above the *Betula tortuosa* tree limit. In other parts of Finland it seems to be common. Many collections and observations have been made along the Salpausselkä ridges. The species is common on this area because of the occurrence of springs at the foot of the ridges.

Mitrula paludosa occurs in all of Europe (SACCARDO 1889, IMAI 1941, BENEDIX 1962), in Greenland (LANGE 1957), North America (DURAND 1908, MAINS 1955), Japan (IMAI 1941), that is to say only in the northern hemisphere. ECKBLAD (1963, p. 153) has also noticed that this species does not occur above the tree limit. He says that «In southern Norway it shows a slight tendency to coastal distribution». Maybe the greater elevation of the inner parts of Norway leads to the aforesaid distribution.

List of the specimens studied (marked with dots on the enclosed map, Fig. 1):

FINLAND

Al. Eckerö Storby 17. 6. 1956 L. E. Kari (TUR); Lemland Slätskär 7. 6. 1946 Uno Vidlund (H).

Ab. Bromarv Kärböle 27. 6. 1945 Gunnar Marklund (H), Rilax 17. 8. 1945 H. Buch (H), Sandö 9. 8. 1936 Nicken Malmström (H); Karkalohja Karkali 30. 6. 1944 L. E. Kari (TUR) and 15. 6. 1962 Timo Koponen 4193 (H); Kustavi in 1863 E. Bonsdorff (H), Isokari (Enskär) 26. 6. 1967 Unto Laine (TUR); Lohja mlk Linnaniemi 27. 6. 1944 and 5. 7. 1944 L. E. Kari (TUR), Vaanila 12. 6. 1961 Harri T. Toppari (H); Masku Kareva 1. 6. 1943 A. V. Auer (TUR) and 4. 6. 1959 Paavo Kallio (TUR); Merimasku 23. 6. 1860 P. A. Karsten (H); Mietoinen Aarlahi 28. 6. 1967 Vesa Oittinen (H); Piikkiö Harvaluoto 14. 6. 1967 Vesa Oittinen (H); Pöytyä Paju 13. 8. 1962 Paula Siltanen (TUR).

N. Elimäki Mustila 30. 5. 1909 C. G. Tigerstedt (H); Espoo Bodom 4. 6. 1950 Viljo Kujala 521 (HFR); Kirkkonummi Bergsta, in 1905 F. W. Klingstedt (H); Pernaja Kälde, July, 1922 W. Nyberg (H); Pornainen Kirveskoski 26. 6. 1916 Tauno Putkonen (HPP); Porvoo 25. 6. 1860 P. A. Karsten (type material of *Mitrula paludosa* var. *pachyceps* Karst.; H) and Oct., 1926 W. Nyberg (H), Vessö 25. 6. 1938 W. Nyberg (H); Tammissaari mlk Tvärminne 15. 6. 1934 Nicken Malmström (H) and 30. 6. 1937 E. Häyrén (H); Tuusula Nummenkylä 16. 6. 1946 E. Häyrén (H), Ruotsinkylä 12. 7. 1941 E. Häyrén (H), 8. 7. 1957 Ann-Marie Malmström (H) and 4. 7. 1962 Veikko Hintikka (HFR).

St. Kankaanpää Venesjärvi 5. 6. 1934 Matti Laurila (TUR, HPP) and 16. 6. 1935 Matti Laurila (HPP); Laitila Leimäki 26. 6. 1949 Holger Sältin (H) Mäentaka 21. 7. 1955 Holger

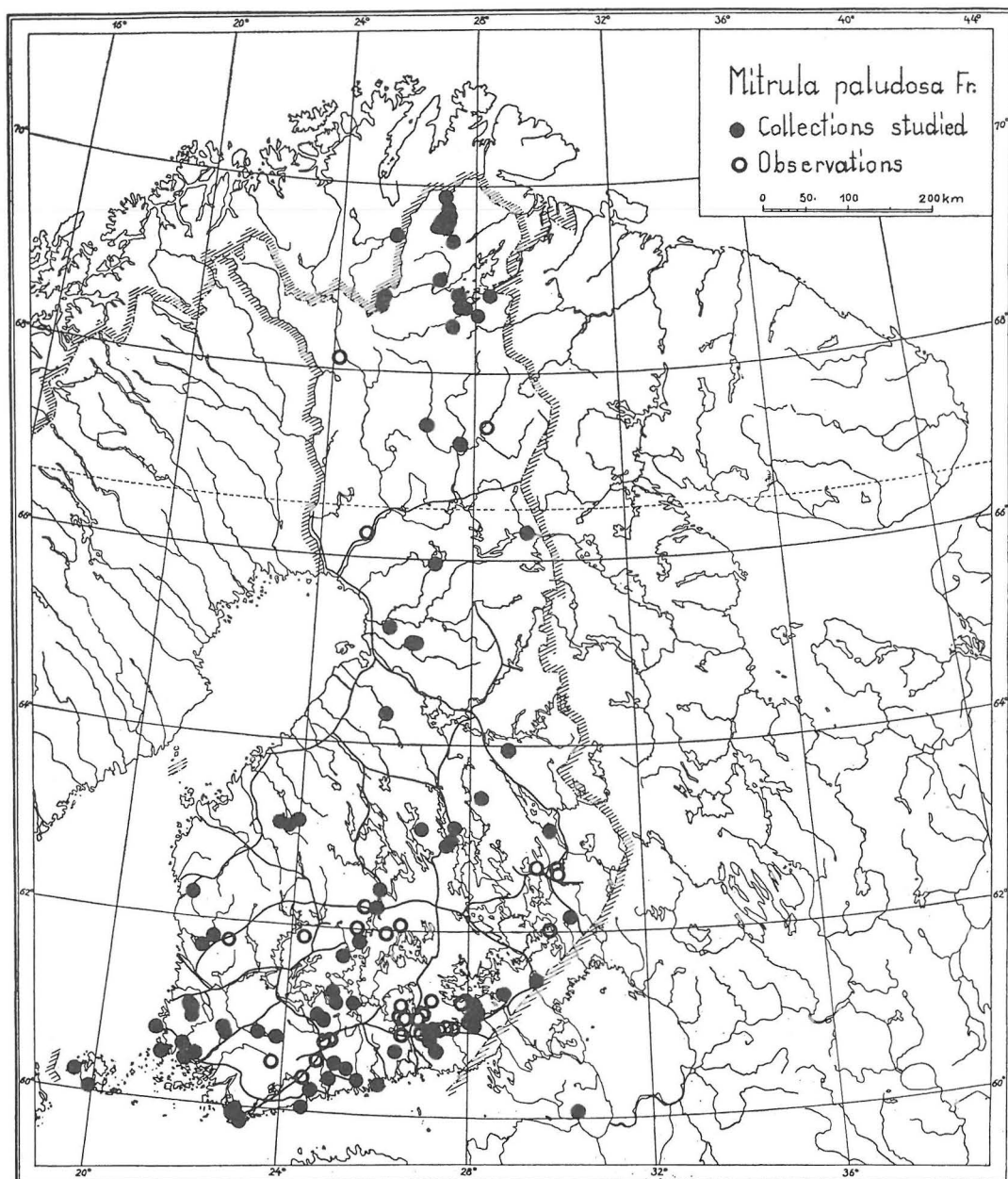


Fig. 1. The studied collections and observations of *Mitrula paludosa* Fr.

Sältin (TUR); Oripää Myllylähde 13. 7. 1956 L. E. Kari (TUR), 30. 6. 1968 Martti Kemilä (OULU); Pomarkku Uusikylä 19. 6. 1939 Matti Laurila (HPP).

Ta. Asikkala 15. 6. 1863 J. P. Norrlin (H); Janakkala Koljala Suurisuo 5. 7. 1968 Pertti Uotila (H); Jokioinen 22. 6. 1910 S. Salmenlinna (H); Jämsä Jämsänniemi Myllyjärvi 26. 7. 1964 Raiikko Ruotsalo (H); Kuhmoinen Puukkoistenkoski 22. 6. 1965 Yrjö Mäkinen (TUR); Lammi Evo 24. 6. 1965 Harri T. Toppari (H),

Porraskoski 19. 8. 1952 Otto v. Schulmann (H); Tammela Mustiala 30. 7. 1866, 23. 7. 1869, 24. 7. 1869 P. A. Karsten (H) and 27. 6. 1867 A. L. Borenius (H); Vanaja Isojärvi 8. 7. 1965 Harri T. Toppari (H).

Tb. Laukaa Seppälä 14. 6. 1915 Anne-Marie Häyrén (H), Valkola 18. 9. 1949 E. J. Valovirta (H).

Kol. Parikkala Kasuri 21. 6. 1955 Otto v. Schulmann (HFR).

Ka. Sippola Enäjärvi 6. 7. 1948 Viljo Ku-

jala (HFR), Kaipainen 26. 6. 1949 Viljo Kujala 428 (HFR); Vehkalahti Pyhältö 19. 6. 1947 Lars Fagerström (H).

Kb. Pielisjärvi Koli 24. 8. 1956 Viljo Kujala (HFR); Rautavaara Suojärvi 8. 7. 1952 Albert Korhonen (H); Tohmajärvi Hernevaara 27. 6. 1966 Esteri Kankainen (TUR).

Sa. Lappee Korkeamäki 8. 6. 1906 Hans Buch (H), Vehkasalo 26. 6. 1957 collector unknown (H) and 20. 6. 1959 Kirsti Sandberg (H); Ruokolahti Inkilänmäki 24. 6. 1967 Terho Poutanen (TUR); Taipalsaari Halila 1. 7. 1966 Orvo Vitikainen 206 (H).

Sb. Kuopio Pitkälähti 30. 6. 1949 Ritva Ruotsalo (HFR), Särkilähti 9. 6. 1909 K. Linkola (TUR); Siilinjärvi Kasurila 14. 6. 1912 Lauri Korhonen (HFR); Tervo Talluskylä, in 1938 Anu Malinen (H).

Oa. Lapväärtti Pyhävuori 1. 7. 1948 Arturi Railonsala (TUR) and 4. 7. 1957 G. Nordström (H).

Om. Lappajärvi Savo 21. 7. 1904 A. L. Backman (HFR); Pulkkila Niskankylä 5. 8. 1966 Tauno Ulvinen (OULU); Vimpeli Koskela 17. 6. 1904 A. L. Backman (HFR), Pyhävuori 22. 7. 1903 A. L. Backman (HFR).

Ob. Haukipudas Martimo 10. 7. 1966/XXVI Martti Ohenoja (OULU); Kiiminki Haara 25. 6. 1966/III Martti Ohenoja (OULU), Juuansydänmaa 25. 6. 1967/V Martti Ohenoja (OULU).

Kn. Sotkamo Lontta 29. 6. 1945 Jaako Jalas (H).

Ks. Kuusamo Juuma 6. 8. 1948 L. E. Kari (TUR).

Lkem. Pelkosenniemi Kairala 15. 6. 1937 Richard Frey (H); Sodankylä 24. 8. 1947 Viljo Kujala (HFR).

Li. Inari Kyrö, in about 1920 A. R. Ruoranen (H), 5 km west of Ivalo 15. 7. 1968 Yrjö Mäkinen (68-262) & Marja-Leena Halme & Leena Laitinen (TUR, KEVO), along Ivalo-Inari road south of Myösäjärvi 9. 8. 1968 Yrjö Mäkinen (TUR), 4 km south of Tolonen 20. 7. 1968 Yrjö Mäkinen & Esteri Kankainen (TUR), Tsharminturit Laanaskä 1. 8. 1968 Esteri Kankainen (TUR); Utsjoki Jesnalvaara 3. 9. 1968 Paa-vo Kallio (KEVO).

USSR

Lim. Kantalahti in 1843 Fr. Nylander (H).
Lpets. Petsamo Alaköngäs 13. 7. 1932 E. Häyrén (H).

Prov. Petropolitanae. Jukki prope Pargala 26. 5./7. 6. 1898 legit Tranzschel (S). (See NAUMOV 1964, p. 230).

CANADA

Newfoundland-Labrador. Esker east shore of Menihok Lakes west of Esker, 53°52'n.lat., 66°26'w.long., elevation 1600 ft. 23. 7. 1967 Esteri Kankainen (TUR).

List of the observations of Tauno Ulvinen (marked with rings on the enclosed map, Fig. 1):

Ab. Bromarv Hankoniemi 7. 8. 1955; Vihti Nummela Kotokorpi 11. 6. 1960.

N. Nurmijärvi Noppo Petkelsuo 16. 6. 1958.

St. Kankaanpää Kuninkaanlähde 18. 6. 1957.

Ta. Hausjärvi church village 16. 6. 1958; Jaala church village Iso Ruhmasjärvi 30. 7. 1956, Retusjärvi 31. 7. 1957, «Ritti» 7. 7. 1963, Hartola 6. 7. 1963; Kuusankoski Keltti 10. 6. 1959; Riihimäki 21. 7. 1956; Ruovesi Jäminkipohja 30. 6. 1957; Somerniemi Mäyrämäki 13. 6. 1957.

Ka. Sippola Kaipainen 19. 6. 1953, Pajari 29. 6. 1953.

Kb. Kitee Juurikka-aho along Kaarlola road 18. 7. 1957; Kontiolahti Kulho 15. 7. 1957, Paihola 14. 7. 1957; Liperi Vaivio 12. 7. 1957.

Sa. Kangasniemi Paappala 3. 7. 1963; Lappee Myllylä 20. 8. 1953; Leivonmäki church village 1. 7. 1963; Luumäki Somerharju 22. 6. 1953, between Somerharju and Taavetti in 1953, Uro 16. 8. 1953; Mäntyharju Partsimaa 8. 7. 1963; Taipalsaari Karhula 12. 8. 1956, Leväinen 12. 8. 1956; Valkeala Anttila 4. 8. 1956, Hevosoja 5. 8. 1956, Mankki 2. 7. 1953, Utti 8. 7. 1957.

Ob. Kiiminki Joutenojanpalo 19. 6. 1963.

Lkem. Savukoski Martti in 1961 (cf. ULVINEN 1963, p. 54).

Observations of Lauri Teivainen in HFR (marked with rings on the enclosed map, Fig. 1):

Ta. Korpilahti Oittila, in 1946.

Tb. Jyväskylä Vesanka, in 1945.

Ob. Rovaniemi Pisavaara (two finds), in 1946-47.

Lkem. Kittilä-Enontekiö Pallas-Ounas-tunturi (three finds), in 1948-49.

All observations of Lauri Teivainen are from wet copse fen. We must, however, be critical with the observations in *Ob* and *Lkem*, because there is a possibility of confusing *Mitrula paludosa* and *M. gracilis*.

2. *Mitrula gracilis* Karst., Hedwigia 22, p. 17. 1883.

Mitrula muscicola E. Henn., Öfvers. Kongl. Vet.-Akad. Förhandl. 1885, p. 71, Tab. 8, Figs. 6—8. 1885.

Mitrula rehmi Bres., Fung. Trid. 2, p. 41, Tab. 147, Fig. 2. 1892.

Mitrula gracilis var. *flavipes* Peck, Ann. Rep. N. Y. State Mus. 49, p. 32. 1896.

Gymnomitrula gracilis Imai, Journ. Fac. Agric. Hokkaido Imp. Univ. 45, p. 175. 1941.

Gymnomitrula rehmi Favre, Ergebn. wiss. Unters. schweiz. Nationalparks 5:42, p. 383. 1960.

Typus: In Herb. KARSTEN, Mus. Bot. Univ. Helsingfors. Knäsä-guba 5. 8. 1961 P. A. Karsten.

Exsiccate: Fungi exs. Suec., No. 1784.

External morphology. *Mitrula gracilis* is a rather inconspicuous species in so far as it does not grow in abundance. It differs from *M. paludosa* and *Heyderia abietis* chiefly in



Fig. 2. A circular population of *Mitrula gracilis* Karst. on the *Caliergon sarmentosum* mat. Spitsbergen, Kongressdalen, in 1966.

colour, in size of asci and spores, and in habitat.

The height of the studied ascocarps varies from 0.7 to five centimetres. The stipe is yellowish or ochraceous in fresh material, but in some specimens it is whitish because of the presence of white, partly hyaline scales and hyaline hairs. The scales are poorly seen in dry material. The base of the stem is rugged, somewhat thickened, and divided into many fibres crossing the rhizoids of the host moss. The form of the ascigerous portion and its connexion with the stipe varies between that of *Mitrula paludosa* and *Heyderia abietis*. The head and stipe are, however, almost the same colour when fresh.

Two extreme morphological forms can be distinguished in *Mitrula gracilis* material. In some specimens the fertile, capitate, more or less folded head continues to the stipe without a distinct sterile zone. In very young ascocarps of this type, however, a free margin, filled with mucilaginous matter and hanging over the apex, can be seen (Tauno Ulvinen, by letter).

The specimens of the other type have a pileate, unfolded head with a sharp overhanging margin. The surface of the broad sterile area is somewhat reticulated. These

kinds of specimens are as a rule smaller and paler, and the stipe is more scaly than in the former type. They have features, even when adult, similar to the juvenile stage of *M. gracilis*.

Though the extreme specimens among the studied material differ very conspicuously from each other it is not necessary to attach great importance to them as separate species, or even as variations, because mediator specimens exist in this material. For instance most specimens from Canada indicate an infraspecific series. Some of these are also from Lapland, although it is very difficult to distinguish this group. Most material from northern Fennoscandia is of the capitate form. Some specimens from the northernmost Fennoscandian research area and all material from Spitsbergen are of the extreme pileate form.

Particularly in dry material from Canada, but also in the pileate specimens rests of a veil between the stem and the head can be seen. When dried or preserved in alcohol the colours of *M. gracilis*, like *M. paludosa* become far darker, and the stipe and the head are no longer uniformly coloured the stipe being (lemon) yellow, and the head reddish brown.

Anatomy. The anatomy does not vary like the external morphology of the species in question. The hyphae in the axis of the stipe are up to $8\ \mu$ wide, in the periphery $4\text{--}5\ \mu$ wide. The hairs are hyaline, one- and two-celled, up to $30\ \mu$ long. The scales extend upward, and they turn dark blue with cotton blue.

The asci average $65\text{--}85 \times 6\text{--}7\ \mu$ (measured in five specimens). The tips of the asci turn blue with iodine. The paraphyses are numerous and slightly thickened above. The spores are hyaline, somewhat punctate (best seen with oil immersion), often uniseptate, more or less straight, fusiform. The size of the spores in the following collections is: Ranua 22. 7. 1943 $9.2 \times 2.4\ \mu$ (50 measurements); Kuusamo 6. 8. 1948 $9.8 \times 2.0\ \mu$ (50 meas.); Kiiminki 21. 7. 1966 $11.2 \times 2.8\ \mu$ (30 meas.); Utsjoki 14. 8. 1963 $12.5 \times 2.7\ \mu$ (30 meas.); Spitsbergen Kongressdalen 16. 8. 1966 $11.1 \times 2.6\ \mu$ (50 meas.); Canada: Beam Lake 6. 8. 1963 $11.6 \times 2.6\ \mu$ (25 meas.), Attikamagen Lake 5. 8. 1967 $11.7\ \mu \times 2.6\ \mu$ (30 meas.), Highfall Creek 2. 8. 1967 $11.2 \times 2.5\ \mu$ (25 meas.). The specimens from Ranua, Kuusamo and Kiiminki are of the capitate form, the specimens from Utsjoki and Spitsbergen of the pileate form.

Many different observations and opinions have been presented on *Mitrula gracilis* and the related species. The notes on the anatomical features do not vary greatly, but the morphology has caused much confusion.

KARSTEN (1883) considers this species to be between *M. elegans* and *M. paludosa*. DURAND (1908) however, has combined the mentioned two species as one species *M. phaloides*. MASSEE (1897) says that *M. rehmi* in many points resembles *M. muscicola* — which subsequently is enclosed with *M. gracilis* — but has a «somewhat longer stem and more uneven hymenium» (p. 280). REHM (1896) assumes *M. gracilis* and *M. rehmi* to be variants of same species. DURAND (1908) has studied the type of Karsten, and he writes that the American specimens agree well with the type. He has found that «*M. gracilis* agrees with *M. muscicola* and *M. rehmi* in habitat and differs from them principally in the smaller size and more even hymenium» (p. 404). SEAVER (1911) observed the large variability of the ascocarps of *M. gracilis*.

The morphology and anatomy of our ma-

terial correspond to those of *M. rehmi* of BRESADOLA (1892, p. 41). HEIM & REMY (1932, p. 68) widen *M. rehmi* and describe the «forme alpine», which according to NANNFELDT (1942, p. 50) is *M. gracilis*, while the «forme sylvatique subalpine» — Bresadola's original type — should perhaps be different. According to HEIM & REMY both forms have much larger asci and spores than the type described by BRESADOLA. The spores are also very irregular in form.

NANNFELDT (1928) has studied herbarium material of *M. rehmi*, and he says that it is a good deal larger than *M. gracilis*. The author has seen a specimen of the exsiccate material of LUNDELL & NANNFELDT, and it corresponds well with the capitate type described above.

IMAI (1941) on the basis of DITTRICH's (1898) and CORNER's (1930) investigations separated *M. gracilis* and *M. cucullata* to his own genus *Gymnomitrula* instead of *Heyderia*, which according to IMAI is already occupied. Thus also *M. gracilis* should be gymnocarpic like *M. pusilla*. But the developmental phases of *M. gracilis* have not yet been clarified, and the possibility that *M. gracilis* might be angiocarpic is not excluded. That is why we for the present place the species in *Mitrula*. For instance rests of a veil in our specimens may resemble those seen in *M. paludosa* (DURAND 1908, p. 389, NANNFELDT 1932, p. 317).

In 1949 FAVRE has united *M. rehmi* in *M. gracilis* and *M. muscicola*. In 1960 FAVRE recorded *Gymnomitrula rehmi* as synonym of *Gymnomitrula gracilis*. MAINS (1955, p. 871) has observed some variation in *M. gracilis* in America. He writes that «In some ascocarps the stipe gradually widens above, forming a sterile area on the lower portion of the head». LANGE (1957) assumes that *M. gracilis* is possibly confused with *M. multiformis*.

SKIRGIELLO (1961) has studied material collected from Spitsbergen, and she reports those specimens to have an overhanging margin. ECKBLAD (1963, p. 151), however, writes that SKIRGIELLO's illustration «seems to indicate another plant». In our opinion the material described by SKIRGIELLO agrees entirely with our specimens from Spitsbergen, in other words with the pileate form described above. Similarly the finds from Jan Mayen (LARSEN 1924) may be of this type.

BENEDIX (1962) and SVRČEK (1962) record from the Tatra *Mitrula* material the place of which in their opinion is uncertain as regards *M. rehmi* and *M. gracilis*. According to BENEDIX (p. 404) *M. gracilis* has a shorter stipe than *M. rehmi*. About his own Tatra material BENEDIX says that those specimens have no sharp overhanging margin, but they have the uneven head typical of *M. rehmi*. We assume that *M. rehmi* and *M. gracilis* sensu BENEDIX perhaps correspond in some degree to the variation described above. BENEDIX does not exclude the standpoint of REHM (1896) who considers *M. gracilis* and *M. rehmi* variants of the same species. BENEDIX, however, placed *M. rehmi* together with *M. paludosa* and *M. omphalostoma* in the subgenus *Physomitrla* and *M. gracilis* together with *M. abietis* in the subgenus *Heyderia*.

ECKBLAD (1963) and MAAS GEESTERANUS (1964) have studied the anatomy of the stipe of *Mitrula* species. MAAS GEESTERANUS (p. 89) says that «the very different structure of the stipe in itself is sufficient proof that *Mitrula gracilis* is not a *Heyderia*. I am not sure, however, as to its relation to *Mitrula*.» The anatomy of the stipe in our specimens nearly corresponds to that presented by ECKBLAD (1963) and MAAS GEESTERANUS (1964) except that neither author has observed any hairs or scales on the stem. ULVINEN (by letter) has seen scales in his *M. gracilis* material from Enontekiö. Though the existence of such special structures brings *M. gracilis* in some way closer to *Heyderia* (sensu MAAS GEESTERANUS), it is not justifiable to place it in *Heyderia*. In our opinion it is thus reasonable to keep *M. gracilis* in *Mitrula*, but the study of the juvenile development is necessary.

Habitat. *Mitrula gracilis* grows on wet mossy places between hummocks in bogs. The studied specimens have been found on many different moss species. It is surprising that the extreme morphological forms presented above have no notable preference concerning to the mosses on which they live. Both forms are found on *Aulacomnium palustre*, *Drepanocladus revolvens*, and on *Paludella squarrosa*. In Lapland *Paludella* seems to be the most common host moss for the larger, capitate form. In addition it has been found connected with *Bryum pseudotriquetrum*, *Calliergon stramineum*, *Campylium stella-*

tum, *Helodium blandowii*, *H. lanatum*, and with *Philonotis tomentella*. The gracile, pileate form in our collections is connected also with *Calliergon sarmentosum*, *Oncophorus wahlenbergii*, and with *Tomentypnum nitens*.

Very often brown dead patches on moss mats around *M. gracilis* populations have been found. The phenomenon is most obvious when a bright green moss species (for instance *Paludella squarrosa* or *Calliergon sarmentosum*) forms a more or less pure growing unit, and when the fungus grows in abundance. The most regular growing units we have seen in Spitsbergen (Fig. 3) where such brown rings are very conspicuous in some bogs (KANKAINEN & KARLSTRÖM & HEIKKILÄ 1967). The fungus widens its growth area centrifugally while in the centre of the dead ring new, vigorous, bright green moss begins its growth.

In the literature *M. gracilis* is recorded growing on *Aulacomnium palustre*, *Bryum pseudotriquetrum*, *Calliergon sarmentosum*, *C. stramineum*, *Dicranum majus* (!), *Drepanocladus badius*, *Dr. exannulatus*, *Helodium lanatum*, *Hylocomium splendens*, *Paludella squarrosa*, *Philonotis fontana*, *Ph. tomentella*, *Rhacomitrium canescens*, *Rh. fasciculare*, *Tomentypnum nitens*, and on *Webera nutans* (HENNING 1885 concerning *M. muscicola*, BRESADOLA 1892 concerning *M. rehmi*, DURAND 1908, HEIM & REMY 1932 concerning *M. rehmi*, NANNFELDT 1942, MAINS 1955, BENEDIX 1962 concerning *M. rehmi* and *M. gracilis*, ECKBLAD 1963, KALLIO & KANKAINEN 1964).

Some authors have reported that the moss underneath the fungus is dead (KARSTEN 1883, ECKBLAD 1963, KALLIO & KANKAINEN 1964). Some authors assume that the fungus is a parasite (BRESADOLA 1892, DURAND 1908, IMAI 1941, MAINS 1955). NANNFELDT (1942) had seen only healthy moss below the fungus. ECKBLAD (1963) writes that he and Mr. S. Sivertsen have observed almost circular brown patches on the moss mats. ULVINEN (by letter) has found *M. gracilis* (the pileate form from Enontekiö) killing *Aulacomnium palustre*.

ECKBLAD (1963, p. 152) says that «If such (infraspecific) taxa exist they will probably exhibit some specialization as regards the substratum, in the way that different taxa occur on different mosses. This does not mean

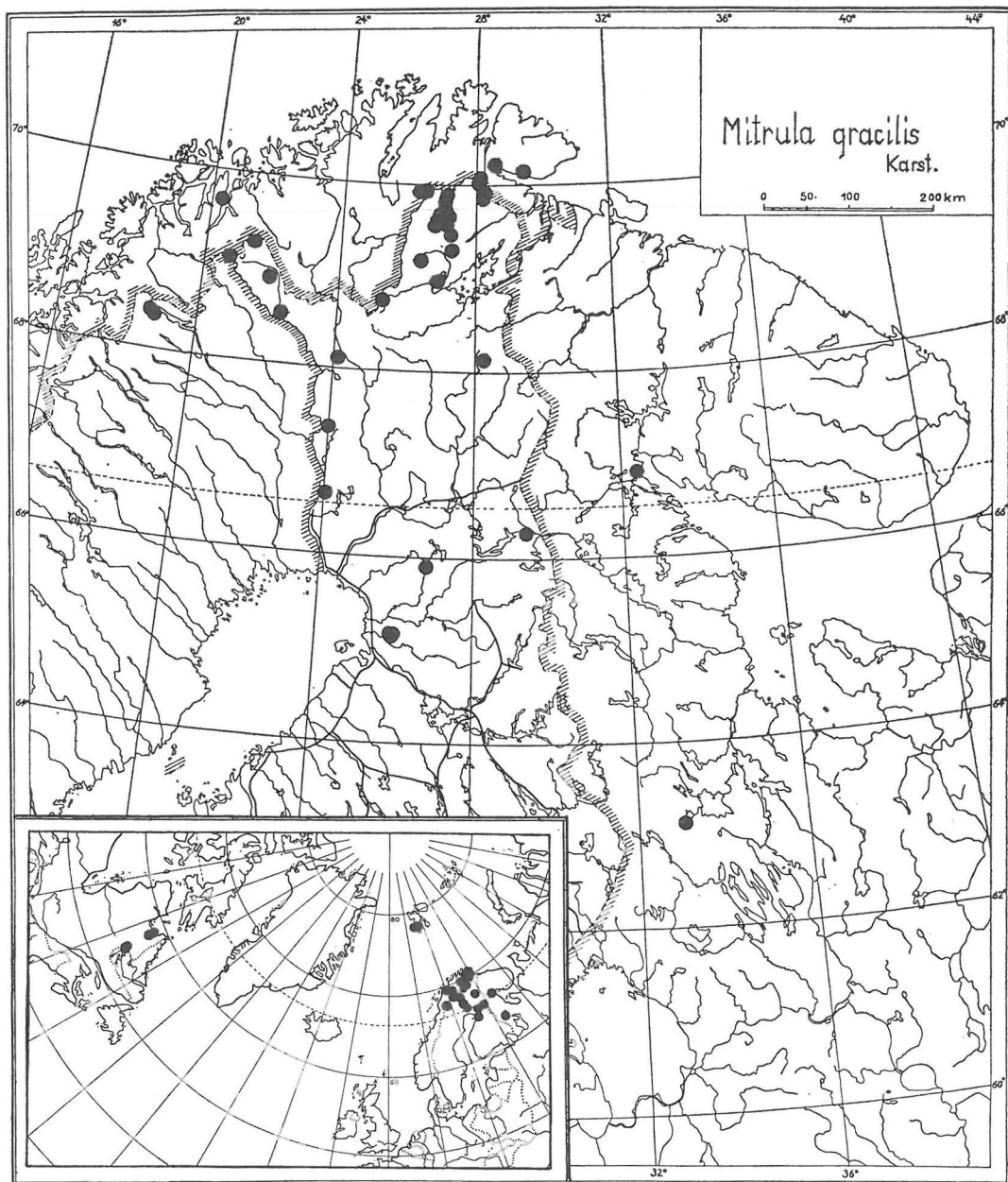


Fig. 3. The studied collections of *Mitrula gracilis* Karst.

that we should expect a usual host — parasite relation». Further on ECKBLAD reports he has not seen any fungal hyphae within the cells of the moss. Neither have we observed fungal hyphae penetrating the moss cells. We are of the opinion that the fungus gets nutrients diffused from the exuding liquid of the moss. The toxic effect of the fungus is an axiom but it can be a secondary handicap

effect which does not necessarily have to do with the nutrition of the fungus (cf., too, ECKBLAD 1963, p. 152). On the other hand the toxic effect may be also a primary effect increasing the permeability of the cell membranes in the host moss.

As seen above there is very large variation which does not seem to depend noteworthy on the moss substrate. The variation does not

obviously correspond to the «biologic variation» of *Mitruula abietis* (VELENOVSKY 1934, ULVINEN 1966) because the nutrition is different in *M. gracilis* and *M. abietis*. It is necessary to know more about the nutrition in *M. gracilis* and about the influence of e.g. the temperature on the morphogenesis of this species before the problem of variation is solved.

Phenology. *Mitruula gracilis* is a species between *M. paludosa* and *Heyderia abietis* as regards the period of growth, for it is a species of summer and autumn. The capitata specimens in the studied material seem to be earlier than the pileate types. The former is found to occur from the middle of July to August 21, the latter from August 6 to September 12. The specimens from Canada are collected between July 31 and August 6. The climate fluctuates very much from year to year. For instance the summer and autumn in Finland in 1967 was warmer than average. In 1968 the summer was exceptional cold in Lapland.

In Fennoscandia the peak of occurrence of *M. gracilis* is clearly in August, as seen in the following table, which presents the collections reported by KANKAINEN in this article (abbrev. K), by KALLIO & KANKAINEN 1964, 1966 (K & K), NANNFELDT 1942 (N) and ECKBLAD 1963 (E).

	Number of collections			
	K	K & K	N	E
During June	1	—	—	—
« July	2	4	2	4
« August	16	26	8	10
« September	6	—	1	1

Also the notes of the other authors nearly conform to that reported above as regards the period of growth in *M. gracilis* (KARSTEN 1883, IMAI 1941, MAINS 1955). DURAND's note (1908, p. 403) «March(?) — September» is really doubtful. In the Alps and in the Tatra the species is found in September (HEIM & REMY 1932 concerning *M. rehmii*, BENEDIX 1962).

Distribution. (Fig. 3) The distribution of the different forms of *M. gracilis* is already treated above. The capitata form is found to occur from 63°20' to 70° n.lat. and the pileate form from 68° to 78° n.lat. The

collections in Canada are made in the latitudes of 54° and 58° n.lat.

Mitruula gracilis is a subarctic-arctic-alpine fungus. It is recorded from the Kola Peninsula (KARSTEN 1883), from northern Fennoscandia (HENNING 1885: *M. muscicola*, ROSTRUP 1904, NANNFELDT 1928, 1942, IMAI 1940, ECKBLAD 1963, KALLIO & KANKAINEN 1964, 1966), from Spitsbergen (SKIRGIELLO 1961, KANKAINEN & KARLSTRÖM & HEIKKILÄ 1967), Jan Mayen (LARSEN 1924), Iceland (LARSEN 1932), Greenland (ROSTRUP 1891, 1894, LANGE 1957), from North America (DURAND 1908, MAINS 1955), Japan (IMAI 1941), from the Alps (BRESADOLA 1892: *M. rehmii*, HEIM & REMY 1932: *M. rehmii*, FAVRE 1949, 1955, 1960, SKIRGIELLO 1961, EISFELDER 1962), and from the Tatra (BENEDIX 1962, SVRČEK 1962).

List of the specimens studied (marked with dots on the map, Fig. 3, together with the collections reported by KALLIO & KANKAINEN 1964, 1966):

FINLAND

Ob. Kiiminki rich fen between old Kuusamo road and Jolosjoki river (on *Aulacomnium palustre*, *Bryum pseudotriquetrum*, *Drepanocladus revolvens* etc.) 21.7.1966 Tauno Ulvinen (OULU), and 2.8.1966 Tauno Ulvinen (OULU, TUR), (on *Bryum pseudotriquetrum*) 5.9.1968 M. Ohenoja & T. Ulvinen (OULU), southwest of the central swamp of Murtoinsaaret 8.9.1968/XXXV Martti Ohenoja (OULU); Rana Iso-palo (on *Helodium blandowii*, *Paludella squarrosa*) 22.7.1943 A. V. Auer (TUR).

Ks. Kuusamo Juuma (on *Paludella squarrosa*) 22.8.1923 Harry Warén, det. Matti Laurila 1938: *Mitruula gracilis* Karst. = *M. muscicola* E. Henning (TUR).

Le. Enontekiö Hirvasvuopio (on *Helodium blandowii*) 12.8.1961 H. Roivainen (H) and (on *Paludella squarrosa*) 10.8.1961 Laila & H. Roivainen (H), Markkina (on *Aulacomnium palustre*) 12.9.1967 and 16.9.1967 Tauno Ulvinen (OULU), Toskaljärvi (on *Calliargon sarmentosum*, *Drepanocladus exannulatus*) Aug., 1967 A. J. Huuskonen (TUR), Kilpisjärvi Saana (on *Bryum*) 18.9.1968 Tauno Ulvinen (OULU).

Li. Utsjoki Pulmanki Ruossavaara (on *Calliargon stramineum*) 14.8.1963 Yrjö Mäkinen (TUR), east side of the lake Kevujärvi (Kevujärvi) (on *Paludella squarrosa*) 21.8.1965 P. Kallio & E. Kankainen & O. Skifte (TROMS), southwest slope of Kenishpakte (Kenespahta) cliff 18.8.1965 Ola Skifte (TROMS).

NORWAY

Troms. Lyngseidet Rättenvikfjellet (on *Helodium lanatum*, *Paludella squarrosa*) 25.7.1968 Reino Alava & Kalevi Alho (TUR).

Finnmark. Polmak palsa bog west of Varangerbotn (on *Paludella squarrosa*, *Drepanocladus*) 12. 8. 1968 Esteri Kankainen (TUR) and 20. 8. 1968 Anja Niskanen (TUR, KEVO).

Svalbard. Vestspitsbergen Isfjorden southwest of Festningen 14. 8. 1966 Paavo Kallio & Esteri Kankainen (TUR), near the Isfjord Radio Station (on *Drepanocladus revolvens*, *Oncophorus wahlenbergii*) 13. 8. 1966 Heli Heikkilä (TUR, KEVO) and (on *Calliargon sarmentosum*) 17. 8. 1966 Paavo Kallio (TUR), Kongressdalen (on *Calliargon sarmentosum*) 16. 8. 1966 Esteri Kankainen (TUR, KEVO), southwest side of Linnévatnet (on *Drepanocladus*) 12. 8. 1966 Heli Heikkilä (TUR), west side of Linnévatnet (on *Calliargon sarmentosum*) 13. 8. 1966 Heli Heikkilä (TUR), Vardäsen (on *Tomentypnum nitens*) 18. 8. 1966 Esteri Kankainen (TUR).

SWEDEN

Torne Lappmark. Jukkasjärvi Abisko (on *Paludella*, *Drepanocladus*?) 5. 6. 1943 Rolf Santesson (S), Kopparåsen (on *Paludella*, *Drepanocladus*) 6. 8. 1943 Rolf Santesson (S).

USSR

Kpoc. Paaatene (on *Philonotis tomentella*) 15. 7. 1869 J. Sahlberg (TUR).

CANADA

Newfoundland-Labrador. Schefferville area, southeast of Mike Lake 54°40' n.lat., 66°37' w.long., elevation 1650 ft. 4. 8. 1967 Esteri Kankainen (TUR), southwest shore of Attikamagen Lake 54°54' n.lat., 66°37' w.long. (on *Aulacomnium palustre*) 5. 8. 1967 Esteri Kankainen (TUR), northwest shore of Petitsikapau Lake (on *Paludella squarrosa*) 6. 8. 1967 Paavo Kallio (TUR, KEVO), north shore of Beam Lake 54°45' n.lat., 66°49' w.long., elevation 1700 ft. 6. 8. 1963 Paavo Kallio (TUR).

Quebec-Labrador. Fort Chimo area, Highfall Creek, north of the falls 58°01' n.lat., 68°29' w.long. (on *Drepanocladus revolvens*) 2. 8. 1967 Esteri Kankainen (TUR), Old Fort Chimo 58°09' n.lat., 68°18' w.long. (on *Paludella squarrosa*) 31. 7. 1967 Esteri Kankainen (TUR).

Heyderia Weinmann, Syll. Pl. nov. 2, p. 108. 1828.

3. *Heyderia abietis* (Fr.) Weinmann, Syll. Pl. nov. 2, p. 108. 1826. — Link, Handb. Erkenn. Gewächse 3, p. 311. 1833.

In 1966, ULVINEN wrote about this species and renewed FRIES' (1828) «*Mitru-la Heyderia Abietis*» and *M. Heyderia pusilla*». We

only list the unpublished notes. For the information as regards the nomenclature of this genus we thank Dr. R. A. Maas Geesteranus and Phil. lic. Tauno Ulvinen.

Heyderia abietis is a species of the autumn. It can be found even during November. It is recorded to occur except in the northern hemisphere also in Australia (IMAI 1941).

List of the specimens studied:

Heyderia abietis var. *abietis*

FINLAND

St. Lappi Lapinkylä 20. 10. 1957 Holger Sältin (TUR), Simasalo 8. 11. 1954 Holger Sältin (TUR).

Ta. Jokioinen Minkio Nummela (fqg) 22. 10. 1967 Esteri Kankainen (TUR); Ylöjärvi Mäkkylä 15. 9. 1968 Esteri Kankainen (TUR), Teivaala 15. 9. 1968 Yrjö Mäkinen (TUR).

Tb. *Toivakka* Huikko Riihimäki (also on pine needles) 19. 9. 1968 Esteri Kankainen (TUR).

Sa. Taipalsaari Karhunpää 19. 9. 1965 Orvo Vitikainen (TUR).

Ob. *Kiiminki* Kalkkialue 5. 9. 1968 Tauno Ulvinen (OULU).

CANADA

Newfoundland-Labrador. Schefferville area, southeast of Mike Lake (on the needles of *Picea mariana* and/or *P. glauca*) 54°40' n.lat., 66°37' w.long., elevation 1650 ft. 4. 8. 1967 Esteri Kankainen (TUR).

Heyderia abietis var. *pusilla* (Fr.) Ulv.

FINLAND

St. Kokemäki Kuivasaari 28. 9. 1967 Aira & Kalevi Pohjola (TUR).

Ta. Tammela Saloisjärvi 15. 10. 1967 Esteri Kankainen (TUR).

Ob. *Kiiminki* Juuansydänmaa (also on spruce needles) 28. 9. 1968/XII Martti Ohenoja (OULU); Muhos Muhosperä 14. 9. 1968/XV and 14. 9. 1968/XLII Martti Ohenoja (OULU).

Le. Enontekiö 12 km northeast of Paljoensuu 12. 9. 1967 Tauno Ulvinen (OULU). This is the northernmost collection and it is made in the area where the spruce is completely lacking.

As seen above there is hardly a basis for the separation of different taxa. The cultivation of the species in different circumstances is needed.

SUMMARY

Mitru-la paludosa Fr. is a species of spring and early summer. It is common in Finland up to the birch forest limit.

Mitru-la gracilis Karst. is a subarctic-arctic-alpine species. Its external morphology varies very much. Except the extreme capitate and pileate forms also infraspecific

forms exist. The basis of the variation is not yet solved.

Heyderia abietis (Fr.) Weinm. grows on pine and spruce needles, but the separation of var. *abietis* and var. *pusilla* is not fully founded. The species is found in Finland up to the limits of the pine and spruce forest.

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