

## **Behaviour in cultures and habitat requirements of species within the genera *Loreleia* and *Rickenella* (Agaricales)**

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The term eco-geogram is introduced for surveying (in logical order) ecological and geographical data connected with fungal species. The database PILZOEK was established for that purpose. Eco-geograms are provided in this paper as an example for data retrieval from PILZOEK concerning the agarics *Loreleia marchantiae*, *L. postii*, *Rickenella swartzii* and *R. fibula*. The potential degree of endangerment is discussed in regard to habitat requirements. European species of *Loreleia* are not regarded to be endangered in Central Europe, although the risk to get threatened, because of low frequency of fruit body occurrence and quite a narrow substrate specialization, could be higher than in case of *Rickenella fibula* and *R. swartzii*. Cultures of *Rickenella fibula*, *R. swartzii*, *Loreleia marchantiae* (= *Gerronema daamsii*) and *L. postii* were investigated in regard to pigment accumulation, chlamydospore formation and some other characters.

**Key words:** eco-geogram, *Rickenella*, *Loreleia*, habitats, substrates, cultures, endangerment

### INTRODUCTION

The genera *Loreleia* and *Rickenella* emerged taxonomically from the genus *Gerronema* in its broader sense, as it was originally interpreted by Singer 1986. Various contributions to the generic concept brought evidence to the assumption that *Gerronema* in the sense of Singer (1986) represents an artificial assemblage of species. *Gerronema* s. l. includes species with quite different requirements in regard to habitats and substrata. Some species are bryicolous (being transferred to *Loreleia* and *Rickenella*), some are lignicolous (being transferred to *Chrysobostrychodes*), some are lichenized (being transferred to *Lichenomphalia*), some are humicolous and finally some imply unknown or badly known habitat relations. For understanding the evolution and for being aware of the existence and of the endangerment of fungi, as well, it seems to be necessary to investigate substrate and habitat requirements in correlation to the phylogenetic position of the species in focus. In this contribution habitat requirements of selected fungal species will be arranged following a scheme

which has been designed for an ecological and geographical database for fungi (PILZOEK). A quite interesting question is, to what degree the endangerment of species is correlated with specialized habitat requirements. The chance for survival of a species depends largely on the availability of suitable habitats and substrates for growth and fructification. If such environmental prerequisites are restricted in any sense and if they are at the same time quite specialized, the risk of extinction might be much higher than in case of ambiguous ecological demands. That means that the endangerment of fungal species is largely to be understood in respect to their habitat relationships. In case of the macromycetes this fact is most important, since their predominating mycelial condition in the field is more or less invisible to the observer's eyes. The risk of endangerment is much higher in stenoecious species, which are restricted on very special and maybe vulnerable habitats, than it is in euryoecious species, which are able to survive under a variety of different environmental conditions, at least if some of them turn out to be well distributed, stable and not decreasing (Bresinsky et al. 2005). The possible correlations between the existing or not existing degree of endangerment on one side, and habitat specialization on the other side, will be discussed in this paper along the example of four bryicolous *Gerronema* s.l. – species assigned nowadays to the genera *Loreleia* and *Rickenella*, respectively.

## METHODS

The culture experiments with species of *Loreleia* and *Rickenella* have been performed by Angelika Achhammer (-Schötz) (1986) in the lab of the senior author.

The **strains of fungi** which have been cultivated list as follows:

- *Gerronema* (*Chrysobostrychodes*) *chrysophyllum* (Fr.) Singer, obtained from fresh material, Germany, Bavaria, Bayerischer Wald, Mauther Wald, 05.09.1984, leg. A. Bresinsky.

- *Gerronema daamsii* Marxmüller & Cléménçon: Culture-number Regensburg-455, Kortenhoef, NL. Submitted by J. Daams, The Netherlands.

- *Gerronema strombodes* (Berk. et Mont.) Singer, obtained from fresh material, Germany, Bavaria, Weiherholz, Ascholding, 18.08.1984, leg. A. Bresinsky et A. Einhellinger.

- *Loreleia* (*Gerronema*) *marchantiae* (Singer et Cléménçon) Redhead et al.: Culture-number Regensburg-442. Obtained from the culture collection in Hannover, Germany, number 7826.

- *Loreleia* (*Gerronema*) *postii* (Fr.) Redhead et al., culture obtained from fresh material (spores): Germany, Bavaria, valley of Weiße Laber, E of Matzenhof, swamp with *Polemonium caeruleum*, 13.05.1984, leg. O. Mergenthaler.

- *Rickenella fibula* (Bull.: Fr.) Raitelhel., cultures obtained from fresh material (spores): Germany, Bavaria, Berchtesgaden, Hintersee, on *Aulacomnium palustre*, 06.06.1984, leg. A. Bresinsky & W. Schmid-Heckel. - Germany, Bavaria, Geisental, N Regenstauf, on *Calliargonella cuspidata*, 06.08.1984, leg. N. Luschka. - Germany, Bavaria, Paintner Forst, Lkr. Kelheim, Rothenbügl, on *Dicranella heteromalla*, 10.10.1984, leg. G. Laaser & B. Meixner.

- *Rickenella swartzii* (Fr.) Kuyper, culture obtained from fresh material (spores): Germany, Bavaria, Deusmauer, Lengenfeld, alder swamp forest, on *Dicranella heteromalla*, *Plagiothecium latebricola*, 03.06.1984, leg. W. Paulus.

**Culture media.** Moser-b-medium modified (Moser 1960; Prillinger, Six 1983). Medium for cellulose-test (Tansey 1971): Moser-b-medium without maltose, however, with glucose (4g / 10g) and cellobiose (10 g / 4 g). Addition of 5.0 g swelled cellulose in form of a diluted suspension. Water was added as much as necessary to obtain a total volume of 1 liter; pH 6. No agar was added for preparation of a liquid medium.

Casein-Mb-medium: A) Moser-b-medium. Water was added as much as necessary to obtain a volume of 700 ml; pH 6. - B) 30 g powdered skim milk was diluted in 300 ml aqua dest. - A) and B) were autoclaved separately and then, at a temperature of 45°C, united (Anderson 1962; Weyland 1970).

Gujacol-Mb-medium: 0.05 g Gujacol was added to Moser-b-medium (Boidin 1951; Lyr 1958).

**Test for cellulase activity.** The medium for the cellulase test looks originally dull because of the nature of swelled cellulose; cellulase activity of inoculated fungus gets visible by a clarified zone around the inoculum. Cellulase activity was evaluated semi-quantitatively by measuring the diameter of the clarified zone.

**Confrontation tests with *Marchantia*.** Thalli of *Marchantia*, or parts of it (clones), were washed and sterilized with ethanol (96%) and then placed on a medium (see above “culture media”) in Petri dishes. The rhizoids were exposed to the surface of the medium which had been inoculated with the fungus in advance. Later, inocula were also placed close to or on the thallus of the liverwort. Then the Petri dishes (containing the liverwort and the fungus) were kept in a humid chamber.

In a modified arrangement *Marchantia* was grown in flower pods and then directly inoculated with the fungus. The inoculated pods with *Marchantia* were kept in a humid chamber which was, once a day for one hour, ventilated.

**Data base PILZOEK.** The ecological data connected with the species treated here have been collected by means of the data base PILZOEK (Bresinsky, Düring 2001). The input of data is at its preliminary stage. So far it includes, as a matter of fact, only a restricted number of the available data from Germany and its neighbouring countries. The database will be completed steadily by the senior author of this paper. Most valuable data came from publications on mycocoenological interrelationships which had been elaborated through mycologists in Poland, in the tradition of intensively and long lasting efforts in that country (going back to Skirgiełło, Nespiaak and other workers; for references see Wojewoda 2003 Ławrynowicz et al. 2004, a most valuable survey of mycocoenological literature from Poland).

At present about 11.000 sets of data are incorporated in the database PILZOEK. Each data set represents a linkage of fungal species with ecological / geographical factors (one fungus species with many factors or, respectively, one factor with many fungal species). The current over-all-number of connections established in the database is estimated to a rate of 160.000. The data, which are included and stored in the database, can be retrieved by different options. It is possible to start inquiries for ecological and geographical factors linked with a selected species in focus (i. e. pre-selection of one fungal species results in a list of ecological and geographical factors connected with that species). Another possibility is to ask for lists of fungal species connected with a selected ecological or geographical factor (i. e. pre-selection of an ecological or a geographical factor results in a list of fungal species connected with that factor). The database is accessible free of charge for everyone via internet (<http://www.pilzoek.de>; for details see Bresinsky, Düring and Ahlmer 2005).

The final design of the database PILZOEK and its presentation in the internet was made possible through a grant of the German Ministry of Education and Research in the context of the BIOLOG-program (BIOLOG = biodiversity and global change).

## RESULTS

The available ecological data in regard to the species *Loreleia marchantiae*, *Loreleia postii*, *Rickenella swartzii* and *Rickenella setipes* are listed and discussed. Geographical data will be mentioned on the European and world-wide scale only; regional distributional patterns are neglected in this paper. The survey of species-bound ecological characters according to a scheme of order will be named ecogram (in analogy to the terms program, telegram, etc.) and for the survey of geographical (distributional) traits the term geogram is introduced here; for both together, the term eco-geogram is applied. The listed code numbers are identical with those which are implemented in the data base PILZOEK. The hierarchy of code numbers reflect a given scheme of order for the presentation of data (survey in Bresinsky, Kreisels and Primas 1995) which makes additions of new records or a search for special information easier. References on mentioned factors (f. e. in the discussion) may be given in short form by code numbers only. The data will be presented in different sections (A-I) which are part of the data presentation program of the data base PILZOEK; in the context of the species treated here, some of the sections will be found omitted (f. e. E, H). The sources of the data presented in the eco-geograms are indicated by the names of authors and contributors. The full citations of sources (of incorporated data) are given in the database PILZOEK and are accessible through the above mentioned internet address; therefore, these will be omitted here.

Abbreviations used for countries / regions:

A = Austria, B = Belgium, CH = Switzerland, CRO = Croatia, D = Germany, DK = Denmark, EST = Estonia, FAR = Faeröer, F = France, GB = Great Britain, H = Hungary, I = Italy, ISL = Island, LAT = Latvia, LIT = Lithuania, N = Norway, NL = Netherlands, P = Portugal, PL = Poland, RU = Russia; S = Sweden, SC = Sicily, SD = Sardinia, SF = Finland, SLQ = Slovakia, SLN = Slovenia, SPI = Spitsbergen / Svalbard, TCH = Tschechoslovakia, TQ = Turkey, UKR = Ukraina.

Indications within brackets like < > mean: not commonly realized in nature or even questionable.

***Loreleia marchantiae*** (Singer and Clémençon) Redhead et al.

Syn.: *Gerronema marchantiae* Singer et Clémençon, *Omphalina marchantiae* (Singer, Clémençon) Norvell, *Gerronema daamsii* Marxmüller et Clémençon.

**Observations.** Mycelial cultures of *Loreleia marchantiae* and *L. postii*, as well, can be established rather easily from fresh material (Achhammer 1986; see methods). Cultures of both species exhibit quite a high cellulase activity which can be interpreted as necessary in order to penetrate the cells of the bryophytes and to live as parasites. If mycelia of *L. marchantiae* are confronted with thalli of *Marchantia polymorpha*, the hyphae of the fungus penetrate into the host and are found then predominantly within the tuberculate rhizoids (Fig. 1B); later partly also within the tissue of the thallus (Fig. 1C). The hyphae of *L. marchantiae* develop on (= on rh), or, respectively, within the rhizoids (= in rh) of *Marchantia* different structures: appressoria (on rh), penetration hyphae (in rh), vesicular haustoria (in rh), chlamy-

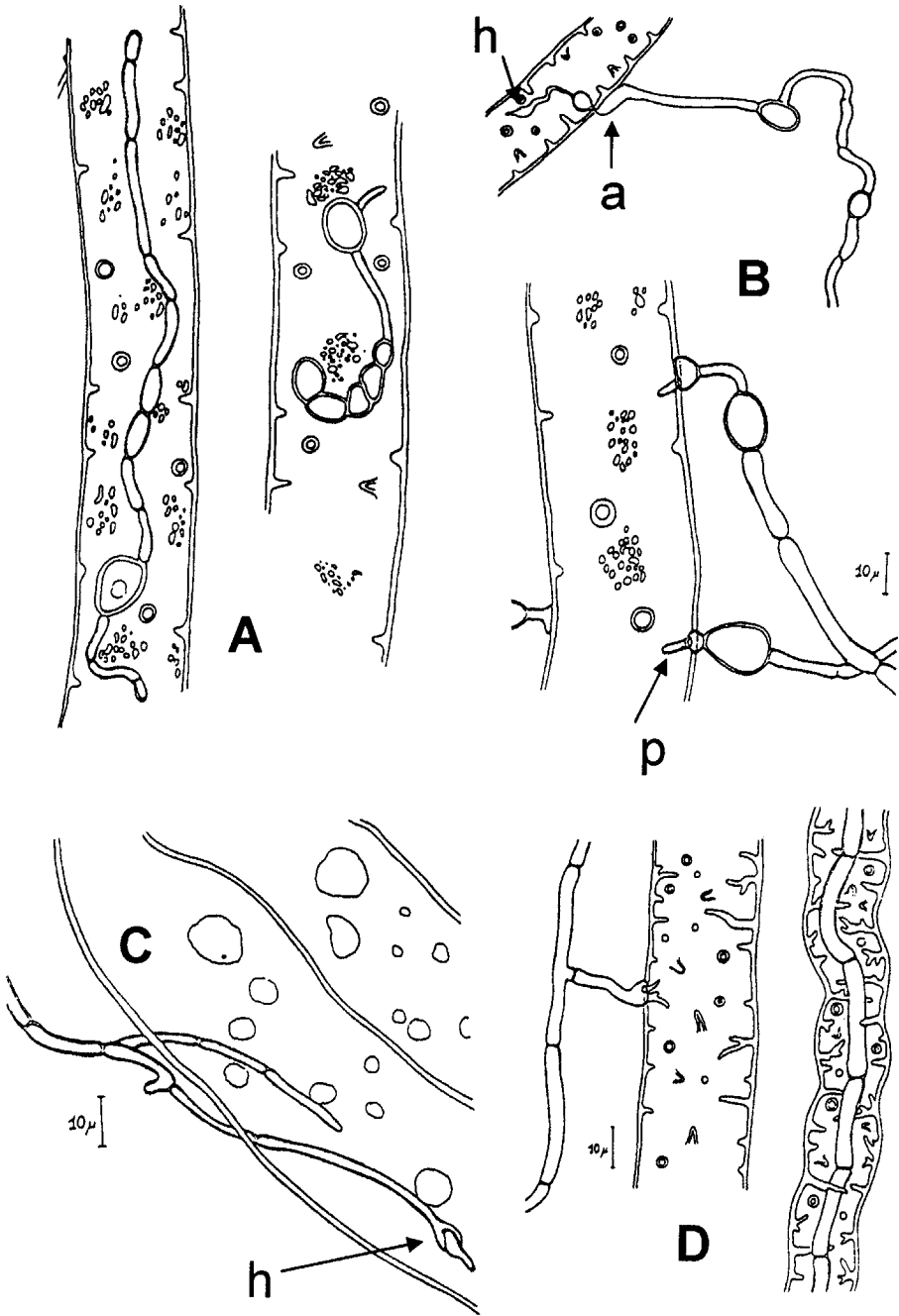


Fig. 1: A-C) *Loreleia marchantiae* (= *daamsii*) and D) *Loreleia postii* (cf. *marchantiae*) in confrontation with *Marchantia*: A) hyphae within rhizoids of *Marchantia*; B) appressoria (a), haustoria (h), penetrating hyphae (p) formed in contact with tuberculate rhizoids of *Marchantia*; C) haustorium (h) in a cell of *Marchantia*; D) mycelium penetrating a rhizoid (left side) and within a rhizoid (right side) of *Marchantia*.

dospores (in rh) and oidia (in rh). Since no damage or restricted growth of the infected thallus can normally be observed under natural conditions, some kind of symbiotic interrelationship between both organisms might exist, in analogy to (endo-) mycorrhizal interactions in higher plants.

In fresh material which had been collected in the Botanical Garden in Cracow, Poland, Gumińska and Mierzeńska (1992) observed an association of *L. marchantiae* not only with smooth and tuberculate rhizoids of *Marchantia* but also with coenobia of cyanobacteria belonging to the genera *Anabaena* and *Nostoc*. These cyanobacteria were not found in uninfected thalli of *Marchantia*. In thalli infected by the fungus they were observed in the lower parts of the thallus chambers, between the rhizoids and at the base of the stipe. The authors conclude that the fungus mediates between cyanobacteria and liverwort through hyphal connections making accessible nitrogen compounds produced by the former. Parasitism has to be excluded in the view of these authors.

Another interpretation is possible in the sense that *L. marchantiae* behaves as a weak parasite or as a saprobiont and, indeed, a record made by the senior author exhibited a necrotic area of *Marchantia polymorpha* around the attachment of the stipe of the fungus (notes on the record in Schmid-Heckel 1985).

**Eco-geogramm for *Loreleia marchantiae*** (using database PILZOEK):

**Sources:** Gumińska & Mierzeńska (1992); Klán (1992); Kühner & Lamoure (1986); Legon & Henrici 2005; Lüderitz 2003; Schmid-Heckel (1985); Wöldecke (1998). For references see <http://www.pilzoek.de>

**A. Nutrition:** 0.1 bryicolous parasite (?), 0.32 bryicolous endotrophic mycorrhiza (?), 0.4 lichenized (?), 0.5 bryicolous saprobiont (?)

**B. Substrates:** 5.1 liverworts. - 5.72 (living, dying, dead): *Conocephalum*, *Lunularia*, *Marchantia polymorpha*, *M. alpestris*, *M. paleacea*! [D, GB, PL, TCH]. - 5.41 associated with Cyanobacteria: *Anabaena*, *Nostoc* [PL].

**C. Habitats:** 11.1 humid woods with maple (*Aceri-Fagenion*). 14.14 ash-alder- and alder-ash-woods along brooks. - 18.3 paths in woods. - 19.2 park woodlands / parks. - 19.5 botanical gardens; outdoor areas. - 21.0 paludal areas around springs / vegetation around headwaters. - 22.3 transitional bogs. - 29.2 shores / alluvial plant communities [NL]. - 30.7 gardens. - 31.1 ruderal sites / weed vegetation. - 32.3 field-paths / meadow-paths.

**D. Soil characters:** 45.2.7 rather humid, not wet.

**G. Phenology, persistence and sociability of fruit bodies:** < 52.1 spring >, 52.2 summer, 52.3 autumn. - 53.2 short living fruit bodies.

**I. Distribution:** 59.11 Europe, North: N, DK, SF. - West: GB, F, NL, B. - Central: CH, D, A, TCH, SLQ, PL, DK. - 59.13 North America (Alaska). - 59.16 Greenland.

**K. Distribution and endangerment in Central Europe:** 62.1 planar, 62.2 colline, 62.3 montane (1300 m; D), 62.6 alpine (2300 m; F). - **65.0 endangerment:** 65.4 rarity, latent endangered?

**Comments.** Fruit bodies of *Loreleia marchantiae* are observed only seldom. Nevertheless the species might be distributed quite well and shall be expected at any place where thallose liverworts are forming expanded mats. The specialization on few genera of liverworts for fructification and the presumed interrelationship with Cyanobacteria (Gumińska, Mierzeńska 1992) could be the reason for a potential endangerment of the fungus. On the other side, the occurrence of *Marchantia* is

favoured by human activities (greenhouse culturing, fire places, nitrification, application of herbicides) and it might be quite likely that *L. marchantiae* is able to follow its host everywhere. The fungus is “growing in disturbed habitats, e. g. soil treated with herbicides (Lisiewska, Balcerkiewicz 1991), on mud along ditches, between bricks along roads etc.” (Bas et al. 1995). It has to be considered, that the fungus might be much more frequent and distributed in its mycelial stage than it is indicated by its rare fructification, thus being mostly not apparent to the observer. Generally, rhizoids and thalli of liverworts have been found to be quite regular infected by fungal hyphae (Nicolas 1967). In case of *L. marchantiae* a higher humidity is apparently afforded to enable fructification of the hosted fungus. Thus, fructification in countries and areas with humid climatic conditions is more likely to be expected (oceanic climatic regime) than under more dry conditions of a continental climate. Maybe, that this is the reason why this species has been recorded as being not so rare in Western Europe (Bas et al. 1995) and why it is so far missing or rare in the Eastern European countries.

*Loreleia postii* (Fr.) Redhead et al.

Syn.: *Gerronema postii* (Fr.) Singer, *Omphalina postii* (Fr.) Singer, *L. marchantiae* (Singer et Clémenton) Redhead et al. pr. p.

**Observations.** The species in its broader sense has been reported to be bound to thallose liverworts (f. e. *Marchantia*), peat mosses (*Sphagnum*) and mosses (*Ceratodon*, *Funaria*, *Polytrichum*), as well. The distinction of *Loreleia postii* s. str. from *L. marchantiae*, in the sense of Clémenton 1982, on behalf of the association with thallose liverworts on one side (in case of *L. marchantiae*) and with mosses on the other side (in case of *L. postii* s. str.) seems to be quite hypothetical at the moment. The discriminating morphological characters between both species are minute and intergrading (Derbsch 1977); moreover, it is not clear if any kind of correlation does exist between the choice of hosts (liverworts versus mosses) and genetic or morphological characters. In recent studies (Klán 1992; Bas et al. 1995) the separation of both species is not based on different hosts rather than exclusively on morphological characters: the pileus in *L. marchantiae* is claimed to be not striate, in *L. postii* it is striate. Other differing features are mentioned for the margin (crenulated in *L. marchantiae*; entire in *L. postii*), for the gills (distant and forked in *L. marchantiae*; close and not forked in *L. postii*) and for the spores with slightly differing, however, overlapping sizes. All these differences could simply reflect different developmental stages of one and the same species.

The pigmentation and morphological appearance of cultures (*L. marchantiae* and *L. postii*) were very similar to each other. Confrontation of dicaryotic mycelia of both species did not result in any kind of barrage neither in a marked confrontation zone. Instead of such expected behaviour, the mycelia of both species intermingled with each other. In the area of first interspecific hyphal contacts quite a number of anastomoses between intermingling hyphae could be observed, much more than near inocula of both species. However, it could actually not be decided if the anastomoses were inter-specific or intra-specific. From these observations it might be suggested that *L. marchantiae* and *L. postii* are very close to each other, if not even conspecific.

Evaluating the experimental observations, one should be aware of the fact, that the results are as good, or as bad, as the strains being used were correctly identified

ore not. It is possible that the strains which were cultivated as “*postii*” and “*marchantiae*” represented only one species, eventually only *L. postii*. Such an identity would explain the observation that the mycelial culture of *G. daamsii* (= *L. marchantiae*) behaved quite different from those labeled as “*postii*” and “*marchantiae*”. Another possibility explaining the different behaviour of *G. daamsii* (as compared to *L. marchantiae* and *L. postii*) could be a contamination of its culture with another fungal species. In this case, however, it is surprising enough that in confrontation tests the hyphae of *G. daamsii* were found to penetrate into the rhizoids of *Marchantia* as one would expect it for true *G. daamsii* and *L. marchantiae*.

At the time being, *L. postii* should be interpreted as a taxon which is bound to mosses (*Sphagnum*, *Funaria* etc.) and *L. marchantiae* as a taxon restricted on liverworts (this is in accordance with the interpretations of Clémenton 1982 and Horak 2005). Experimental studies, including DNA-analysis, should make it possible, to reveal whether this provisional concept holds true or not in the future.

**Eco-geogramm for *Loreleia postii*** (using database PILZOEK):

**Sources:** Horak 2005; Klán 1992; Kreisel 1987; Krieglsteiner 1991; Legon & Henrici 2005; Schroeter 1889; Singer 1964; Wöldecke 1998. For references see <http://www.pilzoek.de>

**A. Nutrition:** 0.1 bryicolous parasite (?), 0.32 bryicolous endotrophic mycorrhiza (?), 0.5 bryicolous saprobiont (?).

**B. Substrates:** < 5.1 liverworts [GB]; cf. *Loreleia. marchantiae?* >, 5.2 mosses!, 5.3 peat mosses! [GB]. 5.72 (living): < *Lunularia, Marchantia?* >, *Ceratodon purpureus*, *Funaria hygrometrica*(!), *Polytrichum*, *Sphagnum* (!) [GB].

**C. Habitats:** 13.0 ombrogenous bogs and associated plant communities. - 16.12 spruce forests: 16.42 rich on bryophytes. - 18.0 clearances and open areas within woods. - 19.2 park woodlands / parks. - 30.91 flower pods [GB]. - 31.7 pits (sand-, loam-, clay-). - 31.8 outdoor fire places [GB]. - 34.1 greenhouses [NL]. - 37.5.2.1.0 *Funarietum hygrometricae*.

**D. Soil characters:** 40.4 sand, 40.9 peat [GB]. - 44.3 rich on nutrients (nitrogen). - 45.2 humid, mesic; 45.3 wet.

**I. Distribution:** 59.11 Europe, North: N, DK, S, SF, LIT, EST. -West: GB, F, NL. - Central: D, TCH, PL, DK. - East: LIT. - South: I. - 59.13 North America.

**K. Distribution and endangerment in Central Europe:** 62.2 colline, 62.3 montane, 62.5 subalpine, 62.6 alpine. - **65.0 Endangerment:** 65.4 rarity, latent endangered?

**Comments.** The data concerning distribution of the species belonging to *Loreleia* in Europe are probably not always correct since separation between *L. postii* s. str. and *L. marchantiae* (including *G. daamsii*) is still quite obscure, depending on different interpretations of taxa. *L. postii* s. str. seems to be rather rare, however, eventually not endangered, since it is reported to occur also in man made habitats like burnt places (31.8) and on flower pods (30.91). However, it is not absolutely clear if all of these indications apply only on *L. postii*, and not partially also on *L. marchantiae*. Low frequency of distribution and specialization on few habitats may cause indeed a higher risk of endangerment. If *L. postii* should exclusively be restricted to mosses as substrate, then the grade of endangerment might appear to be higher. On the other hand, some of the mentioned host species among the mosses are widely distributed and common: *Funaria hygrometrica* is growing everywhere on fire places (31.8) and *Ceratodon purpureus* is by no means rare.



***Rickenella swartzii*** (Fr.) Kuyper

Syn.: *R. setipes* (Fr.) Raithelh., *Gerronema setipes* (Fr.) Singer

**Observations.** Spores of this species and of *Rickenella fibula*, respectively, germinated on suitable media, but not reliable and not always to a high percentage (as it has been already stated by Lamoure 1979). The cultures of *Rickenella swartzii* and *R. fibula* showed identical or very similar characters. The readiness of spores to germinate depended on the season. If spores were collected in early summer (July) or in late fall (October), then the readiness to germinate and the speed of growth of arising hyphae was much higher than in the case that spores had been obtained in the time between these months. The regular pigmentation of cultures was whitish, ochraceous, or brownish, varying in intensity and colour from strain to strain. In some cultures pigments similar to those of the fruit-bodies accumulated if the cultures were grown in the spring and kept in day light.

Cultures of *R. swartzii* (03-06-84) on Casein-Mb-medium exhibited violet pigments, and on Gujacol-Mb-medium violet and orange pigments. In other words, both components of pigmentation were evident which are typical for the carpophores. A transfer of the cultivated mycelia from liquid culture medium to a solid culture medium (in this case prepared by adding an extract of *Hypnum cupressiforme* to the standard ingredients) increased the intensity of pigmentation sometimes.

**Eco-geogram for *Rickenella swartzii*** (using database PILZOEK):

**Sources:** Achhammer 1986; Antonin, Noordeloos 2004; Arnolds 1977, 1981; Babos 1989; Bas et al. 1995, Besl et al. 1982; Bresinsky 2000; Bujakiewicz 1973, 1979, 1982, 1986; Courtecuisse 1994; Derbsch, Schmitt 1987; Einhellinger 1964, 1976, 1977, 1982; Gulden, Torkelsen 1996; Gumińska 1976; Hallgrímsson 1981; Hansen, Knudsen 1992; Haeupler et al. 1981; Horak 1963; Jahn et al. 1967; Kalamees, Vaasma 1981; Kost 1984; Kreisel 1957, 1970, 1987; Krieglsteiner 1991, 2000; Krieglsteiner L. 1999, 2001; Kühner, Lamoure 1986; Lambinon et al. 1977; Legon, Henrici 2005; Luschka 1993; Malençon, Bertault 1975; Miller, Farr 1975; Neuhoff 1949; Nuß 1999; Paulus 1981; Ricek 1989; Schmid-Heckel 1985; Sedlmeir 1985; Skirgiełło 1998; Šmarda 1973; Sonneborn, Stangl, Sedlmeir and Geh 1987; Urbonas, Kalamees and Lukin 1986; Watling, Rotheroe 1989; Winterhoff 1993, 1993b, 1994, 2001b, 2002; Wojewoda 2003; Wöldecke Kn. 1990; Wöldecke 1998; Wöldecke, Wöldecke 1988; Wöldecke 2001. For references see <http://www.pilzoek.de>

**A. Nutrition:** 0.1 bryicolous parasite (?), 0.32 bryicolous endotrophic mycorrhiza (?), 0.5 bryicolous saprobiont (?).

**B. Substrates: 5.0 Interrelationship with bryophytes as substrates:** 2.33 bryophyte covered wood on the ground (*Abies*, *Fagus*). - 5.2 mosses. - 5.71/5.72 (living): *Atrichum undulatum*, *Aulacomnium palustre*, *Brachythecium albicans*, *Brachythecium rutabulum*, *Brachythecium starkei* [PL], *Calliergonella cuspidata*, *Campylopus*, *Ceratodon purpureus*, *Climacium dendroides*, *Dicranella heteromalla*, *Dicranum bonjeanii*, *Dicranum scoparium*, *Drepanocladus vernicosus*, *Eurhynchium angustirete* [PL], *Eurhynchium praelongum*, *Eurhynchium striatum*, *Hylocomium splendens*, *Hypnum cupressiforme*, *Isopterygiopsis*, *Mnium hornum*, *Orthodicranum montanum*, *Philonotis*, *Plagiomnium affine*, *Plagiomnium cuspidatum*, *Plagiomnium elatum*, *Plagiomnium rostratum* [PL], *Plagiomnium undulatum*, *Plagiothecium latebricola*, *Pleurozium*

*schreberi*, *Polytrichum formosum*, *Polytrichum juniperinum*, *Polytrichum piliferum*, *Rhizomnium punctatum*, *Rhytidiadelphus squarrosus*, *Scleropodium purum*, *Thuidium tamariscinum*.

**C Habitats: Woods / copses: 10.0 beech woods, mixed beech forests** (*Fagion silvaticae* pr. m. p.): 10.11.01 *Galio odorati-Fagetum*, 10.11.02 *Hordelymo-Fagetum*. - 10.12 beech woods with share of white wood fir (*Abies*; *Dentario glandulosae-Fagenion*) [PL]. - 10.3.01 *Luzulo-Fagetum*. - **11.0 mixed frondose woods without (dominating) beech:** 11.1 humid mixed woods with maple or with ash: 11.1.03 *Sorbo ariae-Aceretum pseudoplatani* [PL]. - 11.1.04 *Fraxino-Aceretum pseudoplatani*. - 11.3 oak-hornbeam woods (*Carpinion betuli*): 11.3.01 *Galio sylvatici-Carpinetum*, 11.3.02 *Stellario holosteeae-Carpinetum betuli*. - 11.5 mixed oak woods on acid soils (*Genisto tinctoriae-Quercenion robori-petraeae*): 11.5.01 *Holco mollis-Quercetum*, 11.5.03 *Genisto tinctoriae-Quercetum petraeae*. - **12.0 conifer dominated woods (natural):** 12.2 spruce woods outside bogs (*Piceion abietis*): 12.2.03 *Homogyno-Piceetum* [CH]. - 12.51.06 *Pyrolo-Pinetum sylvestris*. - **13.0 ombrogenous bogs and associated plant communities:** 13.32 woods on bogs with scots pine, 13.34 woods on bogs with birch: 13.34.01 *Vaccinio uliginosi-Betuletum pubescentis*. - **14.0 woods of river lowlands and swamps: 14.1 flood-plain woods:** 14.12.01 *Alnetum incanae*. - 14.13 softwood riparian forests, willow beds (*Salicion albae*). - 14.14 mixed woods with ash and alder along brooks: 14.14.03 *Carici remotae-Fraxinetum*, 14.14.04 *Stellario nemorum-Alnetum glutinosae*, 14.14.06 *Pruno-Fraxinetum*. - 14.15 hard-wood flood plain forests: 14.15.01 *Quercu-Ulmetum minoris*. - **14.2 paludal forests:** 14.21 alder swamp forests (*Alnion glutinosae*): 14.21.01 *Carici elongatae-Alnetum glutinosae*, 14.21.03 *Caltha palustris-Alnus glutinosa*-community [PL]. - 14.22 grey willow swamps: 14.22.03 *Salicetum auritae*, 14.22.04 *Salicetum cinereae*. - **15.0 mantles of woods / bushes / hedges:** 15.1.03 *Pruno-Ligustretum*. - 15.33 green alder bushes (*Adenostylin alliariae*): 15.33.01 *Alnetum viridis*. - **16.0 man made forests / non-natural wood communities: 16.1 coniferous forests:** 16.11 pine forests: 16.111 scots pine forests, 16.11.01 pure scots pine forests. - 16.12 spruce forests: 16.12.01 typical *Oxalis*-spruce forests [TCH], 16.12.12 nude spruce forests without herbaceous layer [TCH], 16.12.25 spruce forests on basic (lime stone) soils. - 16.14 larch forest plantations. - **16.2 deciduous forests. - 18.0 Clearances and open areas within woods:** 18.3 paths through forests, 18.31.16 *Calluno-Sarothamnetum*. - **19.4 garden copses.**

**Outside woods and copses: 21.0 paludal areas around springs / vegetation around headwaters [A]. - 22.0 soligenous bogs / transitional bogs:** 22.2 acidophilous, non-calcareous reed marshes with dwarf sedges (*Juncion acutiflori*): 22.2.05 *Juncetum acutiflori* [NL]. - **24.0 dunes / dry grassland on sand:** 24.13 grey dunes. 24.2 inland dunes and associated grassland communities (*Thero-Airion, Corynephorion canescentis*): 24.2.05 *Airo caryophylleae-Festucetum ovinae* [NL], 24.2.06 *Thymo-Festucetum ovinae* [NL], 24.2.13 *Diantho deltoidis-Armerietum elongatae*. - **25.1 subalpine / alpine grasslands on limestone. 25.4 snow pockets:** 25.42.01 *Salicetum herbaceae*. - **25.54 calcareous fens** (*Caricion davallianae*). - **27.0 grassland / drifts:** 27.1 dry and medium dry grasslands: 27.12.03 *Gentiano-Koelerietum*. - 27.23 matt-grass areas in lower (colline) elevations: *Nardo-Callunetea* [NL], *Juncion squarrosi* [NL]. - **28.0 meadows / pastures:** *Arrhenatherion elatioris*: 28.11.01 *Arrhenatheretum elatioris*. - 28.12.02 *Geranio-Trisetetum*. - 28.13 rich

pastures / trampling resistant grassland: 28.13.03 *Festuco-Cynosuretum*, 28.13.04 *Lolio-Cynosuretum*, 28.13.14 *Prunella vulgaris-Plantago major*-community. - 28.14 oligotrophic grassland. - 28.15 park lawns. - 28.16 garden lawns. - 28.21 moist and wet meadows (*Calthion*): 28.21.02 *Angelico-Cirsietum oleracei*, 28.21.06 *Scirpetum sylvatici* [NL], 28.21.10 *Bromo-Senecionetum aquaticae* [NL]. - 28.22 litter meadows (*Molinion caeruleae*): 28.22.01 *Molinietum caeruleae*, 28.22.03 *Cirsio tuberosi-Molinietum arundinaceae* [NL]. - **29.2 shores / alluvial plant communities. - 30.7 gardens. - 30.91 flower pods. - 32.3 field-paths / meadow-paths: *Plantaginetea majoris* [NL].**

**Fungal communities:** 38.42.41 *Geastro (quadrifidi)-Agaricetum semotae* [TCH]

**D. Soil characters:** 42.1 calcareous soils. - 42.22 sand soils, siliceous sands. - 43.0 acidity of soil: 43.1 acid, pH 4.1-4.8 [TCH]; 43.2 neutral, pH 5.7-6.5; 43.3 basic, pH 6.6-7.5. - 45.2 humid, mesic; 45.3.9 wet, water soaked, with poor aeration. - 45.1 dry, xeric.

**F. Temperature and light at the stand:** 50.2.3 cool, 50.4.7 warm. - 51.1 shadow, 51.7 half light, 51.8 light.

**G. Phenology, persistence and sociability of fruit bodies:** < 52.1 spring >, 52.2 summer, 52.3 autumn, < 52.4 winter >. - 53.2 short living fruit bodies. - 54.1 single, 54.2 in groups.

**I. Distribution:** 59.11 Europe, North ISL, SPI, N. DK, S, SF, LIT, EST. - West: GB, F, B, NL. - Central: CH, D, A, TCH, SLQ, PL, DK. - East: H, UKR, LIT. - South: SD, I, CRO. - 59.12 Asia (Kamchatka). - 59.13 North America.- 59.15 North Africa: Marocco.

**K. Distribution and endangerment in Central Europe:** 61.3 alpid, 61.5 temperate, Central European, 61.6 boreal. - 62.1 planar, 62.2 colline-submontane, 62.3 montane (600-1000 m; D, PL, TCH), 62.4 high-montane (1040-1100 m; D, PL), 62.6 alpine (2500 m; F). - **65.0 endangerment:** predominantly not threatened.

**Comments.** In case of *Rickenella swartzii* the frequency of distribution in terms of observed carpophores in the field is much lower than in *R. fibula*. Nevertheless, the species is most likely not threatened, because it grows and fruits in numerous and various habitats which are to a greater extent (so far) not endangered. The occurrence in man made habitats which sometimes are rich in nutrients demonstrates that the species has quite a high capability to survive the decrease of vulnerable, nutrient poor habitats. The readiness of spores to germinate and to establish mycelia under not absolutely fixed biotic and abiotic conditions is also in favour for quite a high probability to survive and to fruit in sufficient frequency. These conditions altogether contributed apparently to the evaluation of a not threatened species; it is f. e. not included in Red Data Lists of Poland (Wojewoda, Ławrynowicz 1992) or of Germany (Benkert et al. 1996). In regard to host selection its inter-relationship to genera and species of bryophytes (see 5.71 / 5.72) appears not very much specialized. The occurrence on few genera of bryophytes only would result in a higher risk for its existence. According to our present knowledge *R. swartzii* does not occur on *Sphagnum* and not on foliose or thallose liverworts. The host selection is somewhat narrower than in case of *R. fibula*, however, much broader than in case of *Loreleia*-species.

***Rickenella fibula*** (Bull.: Fr.) Raithehlh.

Syn.: *Gerronema fibula* (Bull.: Fr.) Singer, *Rickenella aulacomniophila* Kost

**Observations.** Mycelial cultures produce in accordance with the colour of the fruit bodies an orange pigment, at least under lucky circumstances. In all other cultural characters *R. fibula* is similar to *R. swartzii*.

In addition to the observations of Lamoure (1979) on dispersed growing colonies some microscopic features could be observed which are characteristically for colonies of *Rickenella* growing in more or less dense clusters. In such a situation the dicaryotic hyphae are composed of rather short cells and clamps are often missing at the septa (Fig. 2A). Hyphal branches show often chains of chlamydospores. These germinate sometimes in situ with clamped hyphae (Fig. 2E). It seems that chlamydospore formation is induced by the existence of many zones of inhibition created by dense growth of numerous colonies on restricted space. In contrast to this crowded situation, typical chlamydospores are not developed from isolated growing mycelia. Many weeks later, *Peziza*-like structures occasionally appeared between the densely growing dicaryotic colonies. These *Peziza*-like structures are in terms of their hyphae similar to dicaryotic hyphae, however, clamp-less and with uninucleate instead of binucleate cells (Fig. 2F). In freshly isolated cultures the mycelial growth exceeded with diameters of colonies up to 25 mm (in our experiments) that of older strains with diameters between 4 and 16 mm after 6 weeks (Lamoure 1979).

The cellulase activity appeared in *Rickenella* to be lower than in *L. marchantiae* and *L. postii* [and of course lower than in the wood inhabiting species *Gerronema (Chrysobostrychodes) chrysophyllum* and *G. strombodes*]. This observation is in agreement with the assumption that *Rickenella*-species do not cause any damage to their bryophyte hosts by virulent attack of the cell walls of living cells. *Rickenella*-species are not strong parasites rather than either saprobionts (living from the death parts of their hosts which in this case are not severely influenced by the hosted fungus) or even symbionts (establishing some kind of endomycorrhizal interrelationship as assumed by Kost 1984). The latter assumption is supported by field observations: *Rickenella* fruited year by year on the same bryophyte thallus without setting a remarkable harm to its host. Fruiting began according to our observations on *Hylocomium splendens* in the mid of August when fresh green branches arised from the cauloids of the preceding year; then the fruit bodies of *Rickenella fibula* were fixed just underneath the fresh green sections on those parts of the cauloids which were bearing dead leaflets only.

**Eco-geogramm for *Rickenella fibula*** (using database PILZOEK):

**Sources:** Achhammer 1986; Albers, Grauwinkel 2005; Antonin, Noordeloos 2004; Arnolds 1977, 1981; Bas et al. 1985; Besl et al. 1982; Bresinsky 1997a, 1998, 1999, 2000, 2001; Bresinsky, Einhellinger 1987; Bujakiewicz 1973, 1979, 1986, 1993; Bujakiewicz, Fiebich 1991/92; Courtecuisse 1994; Dehnert 2002; Derbsch, Schmitt 1987; Dyląg, Gumińska 1997; Einhellinger 1973, 1976, 1977, 1981, 1982; Favre 1955; Garrido 1985; Grauwinkel 1987; Gulden, Torkelsen 1996; Gumińska 1976, 1992; Haeupler et al. 1981; Hallgrimsson 1981; Hansen, Knudsen 1992; Hauck 1993; Helfer 2001; Imazeki, Hongo 1984; Jahn et al. 1967; Jelik, Tortic 1973; Kalamees, Vaasma 1981; Karasch 2001; Kost 1984; Kreisel 1957, 1970, 1987; Krieglsteiner 1977, 2000; Krieglsteiner L. 1999, 2001; Krieglsteiner, Luschka 2000; Krisai 1987; Kühner, Lamoure 1986; Kummer 1997; Lange 1957; Ławrynowicz, Szkodzik 1998; Legon, Henrici 2005; Lisiewska

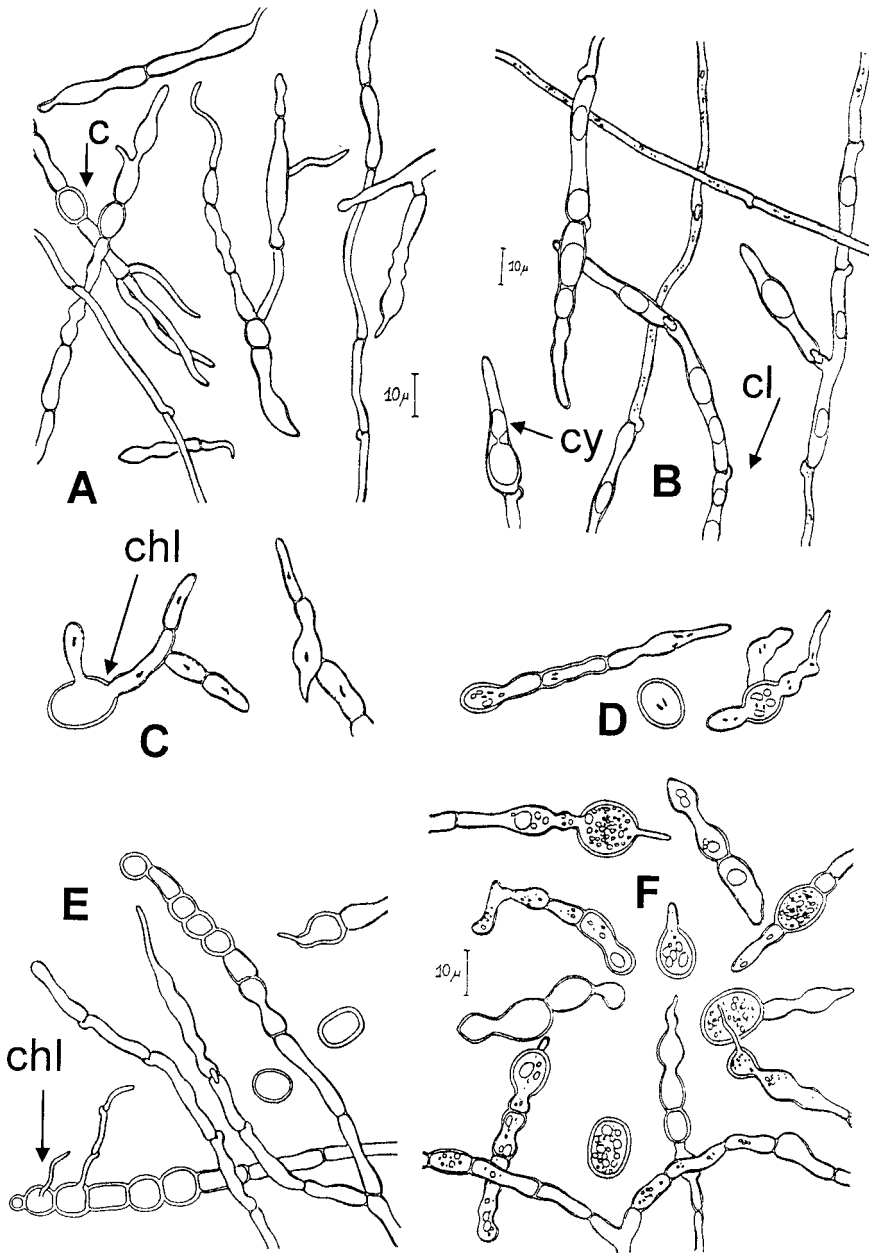


Fig. 2: *Rickenella fibula* in mycelial culture: A) dicaryotic mycelium; some clamps are visible at the septa of hyphae. In some hyphae a transition to short, rather broad and clamp-less hyphae occurred; some of them form thick-walled elliptic chlamydospores (chl); B) dicaryotic, clamped hyphae (cl); some of them inflated and vacuolized. Terminal elements sometimes similar to cystidia (cy); C) monocaryotic hyphal segments formed by germinating chlamydospores (chl); D) dicaryotic hyphae formed by germinating chlamydospores; E) chains of chlamydospores partially germinating with dicaryotic hyphae; F) chlamydospores and their hyphal outgrowths; taken from a culture with *Peziza*-like structures.

1987; Lisiewska, Reszel 2000; Luschka 1993; Łuszczynski 1998; Malençon, Bertault 1975; Miller, Farr 1975; Möller 1945; Monthoux, Röllin 1993; Neuhoff 1949; Nuss 1999; Oertel, Fuchs 2001; Paulus 1991; Pearson 1950; Ricek 1989; Rimóczi 1994; Rucker 1990; Rucker, Wittmann and Peer 1989; Sedlmeir 1985; Schmid-Heckel 1985, 1988, 1989; Senn-Irlet 1987c; Skirgiełło 1998; Šmarda 1972, 1973; Sonneborn, Stangl 1970; Stangl, Sedlmeir and Geh 1987; Stasińska, Sotek 2004; Tejera 1980; Urbonas, Kalamees and Lukin 1986; Vaasma, Kalamees and Raitviir 1986; Watling, Gregory 1977; Watling, Rotheroe 1989; Winterhoff 1980, 1993, 1993b, 1994, 1995, 2001, 2002; Wojewoda 2003; Wöldecke Kl. 2001; Wöldecke 1990, 1998; Wöldecke, Wöldecke 1988, 1992; Zehfuß, Ostrow 2004. For references see <http://www.pilzoek.de>

**A. Nutrition:** 0.1 bryicolous parasite (?), 0.32 bryicolous endotrophic mycorrhiza (?), 0.5 bryicolous saprobiont (?).

**B. Substrates:** 2.12 bryophyte covered wood of conifers: dead. - 2.32 bryophyte covered wood on soil surface (*Alnus*). - < 2.6 carbophilous, on or near charcoal > [PL]. - 2.711 standing stem wood. - 2.72 fallen stem wood, fallen knot wood. - 3.4 between litter from grasses and herbals [A].

**5.0 Interrelationship with bryophytes as substrates:** < 5.1 liverworts >, 5.2 mosses, 5.3 peat mosses. - 5.71/5.72 (connected to living bryophytes): *Atrichum undulatum*, *Aulacomnium palustre*, *Barbula convoluta*, *Brachythecium albicans*, *Brachythecium rutabulum*, *Bryum capillare*, *Bryum pseudotriquetrum*, *Calliergonella cuspidata*, *Campylopus*, *Ceratodon purpureus*, *Cirriphyllum piliferum*, *Climacium dendroides*, *Dicranella heteromalla*, *Dicranoweisia cirrata*, *Dicranum bonjeanii*, *Dicranum majus*, *Dicranum scoparium*, *Distichum capillaceum* [PL], *Eurhynchium angustirete*, *Eurhynchium prae-longum*, *Eurhynchium striatum*, *Homalothecium lutescens*, *Hylocomium splendens*, *Hypnum cupressiforme*, *Hypnum cupressiforme* var. *lacunosum*, *Hypnum jutlandicum*, *Hypnum lindbergii*, *Leucobryum glaucum*, < *Lophocolea bidentata* >, < ? *Marchantia polymorpha* [PL]; cf. *Loreleia marchantiae* as possible fungus in this context >, *Mnium hornum*, *Philonotis fontana* [PL], *Plagiomnium affine*, *Plagiomnium undulatum*, *Pleurozium schreberi*, *Pogonatum urnigerum*, *Pohlia nutans*, *Polytrichum formosum*, *Polytrichum juniperinum*, *Polytrichum piliferum*, < *Ptilidium ciliare* >, *Rhytidiadelphus squarrosus*, *Rhytidiadelphus triquetrus*, *Rhytidium rugosum*, *Scleropodium purum*, *Sphagnum compactum*, *Sphagnum contortum*, *Sphagnum inundatum*, *Sphagnum nemoreum*, *Sphagnum papillosum*, *Sphagnum rubellum*, *Sphagnum warnstorffii*, *Thuidium tamariscinum*.

**C. Habitats: Woods / copses: 10.0 beech woods, mixed beech forests, (*Fagion sylvaticae* pr. m. p.):** 10.1 beech woods on (moderately) rich brown earth: 10.11 *Galio odorati-Fagenion*: 10.11.01 *Galio odorati-Fagetum*, 10.11.02 *Hordelymo-Fagetum*. - 10.12 beech woods with share of white wood fir (*Abies*; *Lonicero alpigenae-Fagenion*): 10.12.01 *Dentario enneaphylli-Fagetum* [TCH, PL], 10.12.04 *Lonicero alpigenae-Fagetum*. - 10.2 beech woods on rendzina and pararendzina soils (*Cephalanthero-Fagenion*): 10.2.01 *Carici-Fagetum*. - 10.3 beech woods and mixed woods with oak and beech on acid soils (*Luzulo-Fagenion*): 10.3.01 *Luzulo-Fagetum*, 10.3.02 *Luzula pilosa-Fagus sylvatica*-community [PL]. **11.0 mixed frondose woods without (dominating) beech:** 11.1 humid woods with maple (*Aceri-Fagenion*): 11.1.04 *Fraxino-Aceretum pseudoplatani*. - 11.2 mixed lime-tree woods [PL], 11.3 oak-hornbeam woods (*Carpinion betuli*): 11.3.01 *Galio sylvatici-Carpinetum*, 11.3.02 *Stellario holosteae-Carpinetum betuli*. - 11.4 termophilic mixed oak woods (*Quercetalia pubescentis*; *Quercion pubescenti-petraeae* [H], *Potentillo albae-Quercion petraeae*): 11.4.02 *Quercetum pubescenti-petraeae* [H], 11.4.05

*Potentillo albae-Quercetum petraeae*. - 11.5 mixed oak woods on acid soils (*Quercenion robori-petraeae* [PL], *Genisto tinctoriae-Quercenion robori-petraeae*): 11.5.01 *Holco mollis-Quercetum*, 11.5.02 *Betulo-Quercetum petraeae*, 11.5.03 *Genisto tinctoriae-Quercetum petraeae*. - **12.0 conifer dominated woods (natural)**: 12.1 woods with high share of silver fir (*Vaccinio-Abietenion*): 12.11.01 *Galio-Abietetum* [PL], 12.12.01 *Vaccinio-Abietetum*. - 12.2 spruce woods outside bogs: 12.2.01 *Bazzanio-Piceetum*, 12.2.02 *Calamagrostio villosae-Piceetum*. - 12.5 scots pine woods outside bogs: 12.51.02 *Molinio-Pinetum*, 12.51.03 *Calamagrostio-Pinetum*, 12.51.06 *Pyrolo-Pinetum sylvestris*. - 12.52 *Dicrano-Pinion*: 12.52.01 *Leucobryo-Pinetum*. - **13.0 ombrogenous bogs and associated plant communities** (*Oxycocco-Sphagneteta*; *Rhynchosporion albae*): 13.1.03 *Sphagnum cuspidatum-Eriophorum angustifolium*-community [PL]. - 13.2.03 *Sphagnetum magellanici*, 13.2.04 *Eriophoro-Trichophoretum cespitosi*. - 13.32 woods on bogs with scots pine: [PL]: 13.32.01 *Vaccinio uliginosi-Pinetum sylvestris*. - 13.33 woods on bogs with spruce. - 13.34 woods on bogs with birch [PL]: 13.34.01 *Vaccinio uliginosi-Betuletum pubescentis*, 13.34.03 *Betula pubescens-Sorbus aucuparia*-community. - **14.0 woods of river lowlands and swamps**: **14.1 flood-plain woods**: 14.11 *Salicion elaeagni*: 14.11.03 *Salici-Hippophaëtum rhamnoidis* [CH]. - 14.14 mixed woods with ash and alder along brooks: 14.14.03 *Carici remotae-Fraxinetum*, 14.14.04 *Stellario nemorum-Alnetum glutinosae*, 14.14.06 *Pruno-Fraxinetum*. - 14.15 hard-wood flood plain forests: 14.15.01 *Quercu-Ulmetum minoris*. - **14.2 paludal forests**: 14.21 alder swamp forests (*Alnenion glutinoso-incanae*, *Alnion glutinosae*): 14.21.01 *Carici elongatae-Alnetum glutinosae*, 14.21.03 *Caltha palustris-Alnus glutinosa*-community. - 14.22 downy birch swamps and grey willow swamps: 14.22.03 *Salicetum auritae*, 14.22.04 *Salicetum cinereae*. - **15.0 mantles of woods / bushes / hedges incl. herbal fringes**: 15.22.07 *Urtico-Aegopodium podagrariae*. - **16.0 man made forests / non-natural wood communities**: 16.1 coniferous forests: 16.11 pine forests: 16.11.01 pure scots pine forests: 16.11.05 scots pine forests with *Empertum* [PL]. - 16.111.15 scots pine forests on lime stone soils. - 16.112 plantations of Austrian pine (*Pinus nigra*). - 16.12 spruce forests: 16.12.01 typical *Oxalis*-spruce forests [TCH], 16.12.12 nude spruce forests without herbaceous layer [TCH], 16.12.25 spruce forests on basic (lime stone) soils. - 16.14 larch forest plantations. - 16.2 deciduous forests: 16.24 birch forests, 16.25 robinia forests, 16.26 poplar forests / plantations, 16.27 plantations of willows. - **18.0 open areas within or near woods**: 18.1 forest clearances: 18.12.01 *Rubetum idaei*. - 18.2 margins of forests [A], 18.3 paths through forests; 18.31.16 *Calluno-Sarothamnetum*. - **19.4 garden copses**.

**Outside woods and copses**: **21.0 paludal areas around springs / vegetation around headwaters** (*Cratoneurion commutati*): **21.2 tuff beds**. - **22.0 soligenous bogs / transitional bogs** (*Scheuchzerio-Caricetea fuscae*, *Caricion davallianae*): 22.1.01 *Orchio-Schoenetum nigricantis*, 22.1.02 *Primulo-Schoenetum ferruginei*. - 22.2 acidophilous, non-calcareous reed marshes with dwarf sedges (*Juncion acutiflori*): 22.2.05 *Juncetum acutiflori* [NL]. - 22.3 transitional bogs [A]: 22.3.01 *Caricetum lasiocarpae* [A, PL]. - **24.0 dunes / dry grassland on sand**: 24.12 *Ammophiletae arenariae*. - 24.13 grey dunes, 24.15 bush communities on dunes. - 24.2 inland dunes and associated grassland communities (*Thero-Airion*, *Corynephorion canescentis*): 24.2.01 *Spergulo vernalis-Corynephorum canescentis*, 24.2.05 *Airo caryophylleae-Festucetum ovinae* [NL], 24.2.06 *Thymo-Festucetum ovinae* [NL], 24.2.13 *Diantho deltoidis-Armerietum elongatae*, 24.2.14 *Armerio-Festucetum trachyphyllae*. - **25.4 snow pockets**: 25.42.01 *Salicetum herbaceae*. - **25.54 calcareous fens** (*Caricion davallianae*). - **27.0 grasslands / drifts**: *Ses-*

*lerion albicantis* [PL]. - 27.1 dry and medium dry grasslands: 27.11 continental steppe grasslands (*Festucion valesiaca*): - 27.11.04 *Adonido-Brachypodietum pinnati*. - 27.12 submediterranean steppe grassland (*Mesobromion, Xerobromion*): 27.12.03 *Gentiano-Koelerietum*, 27.12.06 *Viscario-Festucetum heteropachyos*, 27.12.09 *Trinio-Caricetum humilis*, 27.12.10 *Pulsatillo-Caricetum humilis*. - 27.2 dwarf shrub heathes, drifts, matt-grass areas on acid soils (*Genistion pilosae, Nardion*): 27.21.02 *Genisto pilosae-Cal-lunetum* [NL], 27.21.09 *Aveno-Genistetum sagittalis*. - 27.23 matt-grass areas on lower (colline) elevations (*Violion, Juncion squarrosi*): 27.23.01 *Polygalo-Nardetum*, 27.23.03 *Juncetum squarrosi* [NL]. - **28.0 meadows / pastures:** 28.1 rich meadows / pastures / cultivated grassland (*Arrhenatherion elatioris*): 28.11.01 *Arrhenatheretum elatioris*. - 28.12.02 *Geranio-Trisetetum*. - 28.13 rich pastures / trampling resistant grassland: 28.13.03 *Festuco-Cynosuretum*, 28.13.04 *Lolio-Cynosuretum*, 28.13.14 *Prunella vulgaris-Plantago major*-community. - 28.14 oligotrophic grassland. - 28.16 garden lawns. - 28.2 moist and wet meadows (*Calthion*): 28.21.01 *Juncetum subnodulosi*, 28.21.02 *Angelico-Cirsietum oleracei*, 28.21.06 *Scirpetum sylvatici* [NL], 28.21.08 *Epilobio-Juncetum effusi*. - 28.22 litter meadows / meadows under condition of changing moisture (*Molinion caeruleae, Cnidion dubii*): 28.22.01 *Molinietum caeruleae*, 28.22.03 *Cirsio tuberosi-Mo-linietum arundinaceae* [NL]. - **29.0 river marshes / river banks / alluvial meadows:** 29.21 reeds (*Magnocaricion, Caricion elatae*): 29.21.18 *Caricetum paniculatae*, 29.21.19 *Caricetum rostratae* [A]. - 29.22 *Filipendulion*: 29.22.02 *Filipendulo-Geranietum palustris*. - **30.0 cultivated land / waste land / depositions:** 30.7 gardens. - 31.1 ruderal sites / weed vegetation, 31.4 slag-dumps / coal-dumps, 31.7 pits (sand-, loam-, clay-), < 31.8 outdoor fire places [PL]; cf. *Loreleia postii; L. marchantiae* >. - 32.3 field-paths / meadow-paths: *Plantaginetea majoris* [NL], *Agropyretea intermedio-repentis*.

**Fungal communities:** 38.42.11 *Boleto (aerei)-Russuletum luteotactae* [TCH]. - 38.42.41 *Geastro (quadrifidi)-Agaricetum semotae* [TCH], 38.42.42 *Clitocybe (brumali)-Phellodonetum nigri* [TCH]

**D. Soil characters:** 40.1.1 basalt [TCH], 40.3 loess [TCH], 40.4 sand, 40.8 coal / coal stacks: 40.8.1 brown coal [PL]. - 41.1 mull, 41.5 peat. - 42.1 calcareous soils; 42.22 sand soils, siliceous sands; 42.3 brown soils, 42.61 alluvial soils. - 43.0 acidity of soils: 43.1 acid, pH 3.0-5.6; 43.1.2 pH 3.4-4.0 [TCH]; 43.1.3 acid, pH 4.1-4.8; 43.1.5 moderately acid, pH 4.9-5.6 [PL]. - 43.2 neutral, pH 5.7-6.5 [TCH]: 43.2.7 weakly acid / weakly basic, pH 5.7-6.5 [H]. - 43.3 basic, pH 6.6-7.5 and higher [TCH]. - 44.2 moderately rich on nutrients, 44.3 rich on nutrients (nitrogen). - 45.1 dry; 45.2 humid, mesic; 45.3 wet.

**F. Temperature and light at the stand:** 50.2.3 cool, 50.4.7 warm. - 51.1 shadow [A], 51.7 half light, 51.8 light.

**G. Phenology, persistence and sociability of fruit bodies:** < 52.1 spring >, 52.2 summer, 52.3 autumn, < 52.4 winter >. - 53.2 short living fruit bodies. - 54.1 single, 54.2 in groups, 54.3 in herds.

**I. Distribution:** 59.11 Europe, North: ISL, FAR, SPI, N, DK, S, SF, LIT, LAT, EST, RUS. - West: GB, F, B, NL. - Central: CH, D, A, TCH, PL, H, DK. - East: H, UKR, RUS, LIT, LAT. - South: P, SD, I, SC, CRO, TQ. - 59.12 Asia: Caucasus, Kamchatka, Japan. - 59.13 North America. - 59.15 North Africa: MARroco, Tunisia. - 59.16 Oceanic islands north of the equator: Canaries, Greenland. - 59.2 Southern hemisphere: 59.22 South America, outside tropics: Chile; 59.23 Australia, New Zealand? - 59.3 Tropics (South America, Venezuela).



**K. Distribution and endangerment in Central Europe:** 61.3 alpid, 61.4 arctic-alpid, 61.5 temperate-Central European, 61.6 boreal, 61.7 arctic.- 62.1 planar, 62.2 colline incl. submontane (330-350 m), 62.3 montane (575-650 m), 62.4 high-montane, 62.5 subalpine, 62.6 alpine (CH, F: 2500 m; PL: 1340-1520 m). – **65.0: endangerment:** not threatened.

**Comments.** Fruit bodies of *Rickenella fibula* appear on all major groups of mosses including peat mosses (*Sphagnum*) and even few representatives of foliose Hepaticae (*Plagiochila*, *Ptilidium*). On the latter group of bryophytes the fungus occurs only exceptionally and it might remain doubtful if foliose Hepaticae really are taken as a substratum or if the mycelium of the fungus is attached to them loosely and then by chance only.

Besides many species and genera of mosses also the liverwort *Marchantia polymorpha* has been listed once to be associated with *Rickenella fibula* (“among specimens of *Marchantia polymorpha*”; Dyląg, Gumińska 1997). It is uncertain if in this case *Marchantia* really served as substrate. Especially if the fungus is found on burnt places (31.8) in association with *Marchantia*, it is not unlikely that *Rickenella fibula* might be mistaken for *Loreleia marchantiae*. Attention should also be paid to *R. pseudogrisella* (A.H. Smith) Gulden. This species is bound to the liverwort *Blasia pusilla* and was found in arctic-montane habitats of Scandinavia (N, S, SF), of Island and of Greenland (Hansen, Knudsen 1992; Ludwig 2001); it has not been recorded so far from Poland neither from Germany where it could, however, be expected in the alpine zone. Records resembling *R. fibula*, but exhibiting more dull ochraceous instead of vivid orange colours of fruit bodies, should be identified as *R. mellea* (Singer et Cléménçon) Lamoure. This taxon has been observed among mosses of the genera *Bryum* and *Philonotis*; it has been found recently in Germany (Ludwig 2001) and may occur in Poland too. Attempts to distinguish other taxa on the species level bound to special host species of bryophytes (f. e. *Rickenella aulacomniophila* Kost on *Aulacomnium palustre*) failed. The discriminating characters like different size and shape of cystidia turned out to be extremely variable within a rather broad range of continuous variation; this might also apply on differences in spore sizes in *R. mellea* as compared to *R. fibula*.

In Bavaria the highest frequency of fruit bodies of *Rickenella fibula* had been observed by us 1985 on *Hypnum cupressiforme*, *Dicranella heteromalla*, *Rhytidiadelphus squarrosus*, *Brachythecium rutabulum*, *Plagiomnium affine*, *Hylocomium splendens* and *Pleurozium schreberi*. On a single patch of moss, measuring approx. 10 cm in diameter, 10 or even more fruit bodies have been counted in case of *Hypnum cupressiforme*, *Dicranella heteromalla* or *Plagiomnium affine*. In different months of the season different species of bryophytes were preferably carrying fruit bodies. In the area of Regensburg, Bavaria (125 records evaluated), *Hylocomium splendens* was observed to bear fruit bodies mainly in August, *Plagiomnium affine* and *Pleurozium schreberi* mainly in September and *Dicranella heteromalla* mainly in October at the end of the mushroom season (then being the most important host to carry carpophores of the fungus). The fungus can be attached to different parts of the host: main axis and lateral branches of cauloids, rhizoids and leaflets.

In Central and Western European countries *Rickenella fibula* shows a high overall frequency of occurrence. It is far from being endangered because of its adaptation to a great variety of quite different habitats [dry (27.11, 27.12) or wet (13.0, 14.2,

21.0, 22.0), poor or rich in nutrients (24.2, 27.2 versus 28.1, 30.7, 31.1, 32.3) on acid or on neutral or even basic soils (27.23 versus 27.11), in man made sites (31.4, 31.7), etc.] and because of its association with numerous bryophytes serving as substrates and growing under many different circumstances (5.71 / 5.72: f. e. the ubiquitous and nitrotolerant *Rhytidiadelphus squarrosus*).

## DISCUSSION

The species of the genera *Loreleia* and *Rickenella* are not regarded to be endangered in general. This applies to some extent even on species which are quite rare or only occasionally observed.

*Rickenella swartzii* with a low grade of frequency as compared to *R. fibula* is nevertheless not threatened. Its low frequency of records may be caused by a lower rate of readiness for fruiting. This does not necessarily mean endangerment since a high potential is inherent in *Rickenella* (and *Loreleia*) to disperse by asexual germ cells (oidia, chlamydospores). The habitat requirements are broad enough to include sites with higher contents of nutrients in the soil (28.11.01, 28.13, 30.7, 30.91), and the association to bryophytes as substrates is wide enough to permit the fungus to be present on bryophytes which are not sensitive against man made environmental changes and restrictions (5.71 / 5.72: f. e. *Hypnum cupressiforme*, *Rhytidiadelphus squarrosus*).

The estimated rarity of the *Loreleia* species may be the result of inadequate observation. In case of *L. marchantiae* the host plants, mats of thallose liverworts, are not checked intensively and regular enough by mycologists over a greater period throughout the whole year. Thus the fructification of *L. marchantiae*, if it occurs for a short time, may be overlooked quite often. One has to consider that the fungus might be well distributed in its mycelial stage. It is, however, seemingly rare since observations are based on fruit bodies only. It is hard to believe that a fungus which is easily growing in cultures and which is provided by different, readily germinating propagules should not be fit enough to find spontaneously its hosts in order to develop mycelia and asexual diaspores. The low range of hosts and the specialization on genera with only few species (as in *Marchantia* and in *Lunularia*) does apparently not afford a higher rate of genetic variation which would be warranted by sexual reproduction in fruiting bodies. Once being adapted to its few (in terms of evolution more or less stabilized) hosts, such fungal species may be not dependent on sexual reproduction in fruit bodies for their survival. This might be one reason for rare fructification. Again the rating of being not endangered is based on the evaluation of habitats and substrates. These (i. e. the substrates for *Loreleia marchantiae*) are not recorded to decrease or being threatened; in other words, the species within *Marchantia* and *Lunularia*, serving as substrates, are not listed as being endangered. *Lunularia cruciata* is quite often found in man made habitats like parks, green houses, flower pods etc. It shows an increasing tendency to expand and to invade also natural habitats in Central Europe. It is, however, susceptible to freezing temperatures and may die back in a cold winter; its distribution is much more oceanic than continental. Within *Marchantia polymorpha* it is ssp. *ruderalis* which is the most distributed infraspecific taxon, whereas ssp. *polymorpha* is more restricted in its distribution. It is not likely that *Loreleia marchantiae* does prefer one of the both subspecies as a host.

Wide availability of suitable substrates is warranted also in this case of substrate interrelationship, because of a sufficient wide range of appropriate habitats and because of the synanthropic and nitrotolerant character of the host species (especially *Marchantia polymorpha* ssp. *ruderalis*). The evaluation of endangerment in case of *L. marchantiae* gets a new dimension in the light of a possible interrelationship with two partners. The dependence from Cyanobacteria in connection with liverworts complicates the existence of the fungus in a sense that the chain of nutrition is not easily established and if so, then it is more vulnerable. Such complex interdependence causes a higher degree of possible endangerment.

Finally it has to be taken into account that unclear taxonomic concepts on the species level complicate the evaluation of the endangerment of species. A narrow species concept within *Rickenella* (*fibula*) would distinguish separate micro-species on special bryophytes serving as substrates (f. e. *R. aulacomniophila* on *Aulacomnium*). Some of the taxa to be distinguished in a narrower sense could fulfil the criteria of being threatened because of their more restricted range of substrates and habitat conditions. The transfer of *R. aulacomniophila* into the synonymy of *R. fibula*, as it has been advocated in this paper, includes the risk of getting sightless against the situation of actually threatened organisms. In the context of *Loreleia marchantiae* the risk of endangerment would be lower if this species would fall into synonymy with *L. postii*. In this case the range of substrates, including mosses and thallose liverworts as well, and the habitat requirements would be quite wider than it is supposed in the view of a narrow species concept.

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## Rozwój w kulturach i wymagania siedliskowe gatunków z rodzajów *Loreleia* i *Rickenella* (Agaricales)

### Streszczenie

Termin eko-geogram został wprowadzony dla uwidocznienia danych ekologicznych i geograficznych w powiązaniu z poszczególnymi gatunkami grzybów. W tym celu opracowano bazę danych PILZOEK.

W pracy zaprezentowane są przykłady możliwości odtworzenia eko-geogramów za pomocą bazy danych PILZOEK dla agarikoidalnych grzybów: *Loreleia marchantiae*, *L. postii*, *Rickenella swartzii* i *R. fibula*. W odniesieniu do wymagań siedliskowych dyskutowany jest stopień potencjalnego zagrożenia gatunku. Europejskich gatunków *Loreleia* nie uważa się za zagrożone w środkowej Europie, jednak istnieje ryzyko pojawienia się zagrożenia z uwagi na niski stopień frekwencji owocników i wąską specjalizację w odniesieniu do substratu. Kultury *Rickenella fibula*, *R. swartzii*, *Loreleia marchantiae* (= *Gerronema daamsii*) and *L. postii* były badane pod względem akumulacji pigmentu, tworzenia się chlamydospor i niektórych innych cech.