
Scopelophila cataractae – indigenous in Europe ?

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Abstract: *Scopelophila cataractae*, a species on heavy metal rich substrates, was first recorded for Europe in 1967 from Britain and subsequently recorded from many localities contaminated with heavy metal especially around zinc works. It was found in Germany on schist-walls nearby mines from the nineteenth century. This could indicate that the species was present in Europe already prior to 1967 but overlooked. Records even from solid rock nearby mines suggest a status as native species, however, the species had not been observed in the intensively floristically studied region before 1870.

Scopelophila cataractae (Mitt.) Broth. is a moss from heavy metal enriched substrates. The range includes the southern Appalachians and Arizona in North America, Mexico, Guatemala, Ecuador and Bolivia in Latin America, Taiwan, Japan and Korea in E-Asia, and the Philippines, Java, South India and Sikkim in S-Asia (Zander 1967). It is not known from Africa and was not known from Europe. Sporophytes are only known from tropical Asia and South America. In spite of the wide distribution there are almost no differences between the populations in the different parts of the world (Shaw 1993b).

The species was collected first in Europe in 1967 in Wales close to an old zinc melt but identified not before 1981, when the new moss flora by Crum & Anderson (1981) allowed an identification. In 1985, a second collection was made by A.C. Crundwell, A.J. Shaw and W.R. Buck on heavy metal enriched soil in South Devonshire (Crundwell 1986). Subsequently, the species was found on the European continent in SW and NW France, Belgium, southern Netherlands and one locality in Germany close to the Dutch border from in total 12 localities (Sotiaux et al. 1987). Another record in Germany was made close to the first by Frahm (1990). All records were from the surroundings of zinc works. In the Netherlands, further collections were made by van Melick (1987), not only near a zinc works but also on bike paths and foot paths on cemeteries made from zinc slag. In 1988, a third record was made in Briatin (Rumsey & Newton 1989), another in Normandie (Lecointe & Schumacker 1988) and in Spain (Schumacker & Bruges 1991).

Generally there was no doubt that the species was introduced in Europe, probably with zinc ore from overseas, which is added to the qualitatively less valuable zinc ore from Europe.

In 1994, a second record was made in Germany by Meinunger & Schröder (1996) in the Gründelbach valley near St. Goar (Middle Rhine). In 2000, G. Schwab collected the species nearby on walls in the abandoned remnants of another factory in Fellen, in which the core mined in the surroundings was concentrated. According to Brademann et al. (1992), the mining activities in this area, which begun in 1753, but were closed down in 1958. This was, however, eleven years before the first record of *Scopelophila* in Europe. This raised the question about the status of

Scopelophila in St. Goar (Frahm 2001a). It is hardly understandable that this species, which was said to be introduced in Europe with zinc ore from overseas, should have reached St. Goar after 1967, although the mines were abandoned and there was never metal melted or ore introduced. And if the species was not introduced there after 1967, it must have been there before. But how long? By chance, there exists a local bryoflora of St. Goar and surroundings by Herpell (1870) and there is no indication of this species, which, was, however, not known from Europe at that time.

A third collection of *Scopelophila cataractae* in Germany was made in 2002 in Freiburg-Kappel on the ground of a abandoned factory, which processed ore extracted in the Black Forest (Lüth 2002). Also this factory was given up in 1953. It can hardly be imagined that this species, which is sterile in Europe and propagates by rhizoidal tubers (Arts 1988), has reached this locality recently and with introduced ore. Interestingly, all zinc works in Germany were owned by the same company (Stolberger Zink AG). This could mean nothing but also that *Scopelophila* was dispersed between the different factories with machinery. However, it had to be kept in mind that all factories closed down before 1958 and thus before the first record of the species in Europe.

Further search for *Scopelophila* in the surroundings of St. Goar revealed additional records in the Gründelbach valley at the entrance of a closed mine (figs. 4-7), a wall along the Gründelbach stream (fig. 1) and a nearby schist wall in the forest (fig. 8-9, Frahm 2001b) as well as recent discoveries of the moss at the entrance of another mine, below a bridge made from schist over the Gründelbach stream, and most confusing in solid rock behind the zinc works in Fellen, where the species was found before in ruins. Larger populations were found in the area of the former mine Rosenbach near Braubach (figs. 12-15), several kilometres downstream the Rhine from St. Goar, where the species grows in ruins, on barren ground of slagheaps but also on rock. A small population exists in the Sieg valley NE of Bonn, where *Scopelophila* covers only some squaredecimetres on a small slagheap from the 19th century, and also on a slag heap of the mine Leopoldine-Luise (figs. 2-3, Westerwald).

There is one possibility of a former introduction of *Scopelophila* in St. Goar. The core extracted from the mines was shipped from St. Goar down the Rhine and up the Lahn to Bad Ems, where a metal works was built in 1859, which melted the metals (silver, lead, zinc, copper) from the mines in the Westerwald region. So it could have been that zinc core from overseas was also brought to Bad Ems. This hut used local ore until the end of the second world war and continued to process material from St. Goar until 1959 (Haple 1990). In this case *Scopelophila* could only have reached St. Goar on empty ships coming back from the metal works in Bad Ems. This would, however, not explain the presence of *Scopelophila* in the Gründelbach valley, 5 km away, at the remnants of the 19th century mining.

Scopelophila has been found in Germany once on residues of milled core (in Freiburg), twice on slag (in Stolberg near Aachen), twice on slagheaps (Gelbachtal, Braubach) but in the Rhine valley frequently on walls of schist and even on rocks of schist. The latter contains no heavy metal but can be soaked with water rich in heavy metals. The latter is definitely not the fact in the ceiling of the mine (fig.) consisting of blocks of schist. Shaw (1987) proved that at least *Scopelophila cataractae* grows better on soil contaminated with copper, lead or zinc. In contrast, analyses of soil samples from habitats of *S. ligulata* proved no abnormally high concentrations of copper (Shaw & Anderson 1988).

The question of a possible indigeneity of *Scopelophila cataractae* in Europe has been raised before by other authors. Schumacker & Brugues (1991) stated that there were mines in a Spanish locality but no ore melting and thus no direct reference to an import of ore from overseas. Also the locality in North Wales (Rumsey & Newton 1989) consisted of a longly abandoned mining area.

An explanation could be that *Scopelophila* was, although sterile, dispersed within Europe after its introduction. In locations like in Budel, the Netherlands, the species grew in masses on slag, from where fragments could have been dispersed by wind. The chance for *Scopelophila* to reach suitable habitats by this way seems minimal. However, it has to be taken in account that other heavy metal mosses such as *Ditrichum plumbicola* are also sterile, occur in localities in the size of

a few squaremeters and in places which are hundred kilometres distant but are nevertheless present in at least half of the potential habitats. Another example for the almost unbelievable omnipresence of mosses is *Desmatodon heimii*, although this species is fertile. This halophytic coastal species is found in almost all potential habitats in the interior of Europe, although the salt enriched habitats (beside natural springs or more frequently around salines measure by squaremeters).

It can be concluded from the circumstances of the incidence in St. Goar and Freiburg in Germany and possibly also from the localities in Wales and Spain that the species existed in Europe prior to its first collection in 1967 but was overlooked or remained unidentified because it was not included in any European flora. To test, whether the population in St. Goar could be indigenous or has at least existed long time before an introduction to the surroundings of the zinc works in France, Belgium and the Netherlands, a molecular approach would be desirable.

Conclusions

The interpretation of the localities in which *Scopelophila cataractae* was so far found in Germany suggests the following conclusions:

1. All records in Europe were observed after 1967, especially after the first collections, when the attention was drawn on this species.
2. The species was found in remnants of mining activities from the 19. century.
3. This implies that the species was either present in Europe prior to 1967 or has colonized these habitats after its introduction.
4. The species could have been long time in Europe before its first discovery in 1967, but was overlooked.
5. However, the Gründelbach valley along the Middle Rhine, where the species is found today, was subject to an intensive floristic research in the 19. century but the species was not recorded at that time.
6. Therefore it must be concluded that the species arrived after 1870 (the publication date of the local flora).
7. One possibility is that the species was introduced to zinc works from overseas with ore already longer time ago and covered large areas of slag around the plant. These were primary habitats, a source for fragments, which were dispersed to potential secondary habitats, for example abandoned mining areas or slagheaps.
8. It could be that the introduction and later dispersal of the species happened before the mines were closed down, that means before 1953-1967, and that the species was additionally dispersed not only by fragments through the air but also by man from one mine to the other with mining activities, for example with machinery.

One argument corroborates the argumentation:

9. The observations in the Middle-Rhine valley show that *Scopelophila* is not growing on heavy metal enriched substrates such as slag like around zinc works but also occurs on schist walls and even solid rock (fig. 16, 18), which could indicate a status as native species.

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Figs. 1: *Scopelophila cataractae* growing on a wall along the stream in the Gründelbach valley near St. Goar, Middle Rhine. The tufts are up to 8 cm high. Behind the wall was an area where deposits of the zinc works were dumped. Inhabitants of St. Goar told that there was “red and blue soil”, where the children were not allowed to play. Later the area was simply covered with soil. Ground water is leaching the deposits with the result that the leaking water has a pH of 2 (!). The place is known to the authorities, which regard it as unproblematical, since the water is diluted in the stream. This is a nice example how bryophytes indicate heavy metal pollution.



Fig. 2: Slagheap of mine Leopoldine Luise in the Gelbach valley, Westerwald.



Fig. 3: *Scopelophila* grows here in barren ground but not on heavy metal enriched substrate.



Fig. 4: Entrance of a mine from the 19. century.



Fig. 5: The ceiling is covered by *Scopelophila*.



Fig. 6: Closed entrance of a mine from the 19. century. The walls consists of schist.



Fig. 7: The dark spot in the right part consist of *Scopelophila*.



Fig. 8: Wall made from schist in the Gründelbach valley, presumably of a loading ramp.



Fig. 9: *Scopelophila catarractae* on the wall of fig.



Figs.10-11: Slagheap of 19. century mining activities in the Sieg valley E of Bonn. Scopelophila grows in open places amongst grasses on top. The material consists of schist but not from enriched heavy metals.



Fig. 12: Old entrance of mine Rosenberg near Braubach, Middle Rhine



Fig. 13: Scopelophila grows below Dryopteris beside the mine.



Fig. 14: Ruines of mining buildings in Braubach, Middle Rhine.



Fig.15: Scopelophila growing in fissures of walls in the ruins.



Fig. 16: Scopelophila on native rock in Braubach.



Fig. 17: Scopelophila on barren ground in Braubach.



Fig. 18: Scopelophila on solid rock behind the former zinc works at Fellen near St. Goar.