

Contribution to the understanding of the Fennoscandian *Baetis vernus* group: *B. liebenauae* [Ephemeroptera]

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This paper is an attempt to explain how and when *Baetis liebenauae* Keffermüller, 1974 arrived in Fennoscandia. The unusual and apparently two-parts northern European distribution of this species might have more to say about the absence of ephemeropterists than about the presence of the species.

Contribution à la compréhension du groupe Finno-Scandinave *Baetis vernus* : *B. liebenauae* [Ephemeroptera]

Mots clés: Ephemeroptera, migration, distribution, écologie, *Baetis liebenauae*, Finno-Scandinavie

La présente publication est un essai pour expliquer comment et quand *Baetis liebenauae* Keffermüller, 1974 est parvenue en Finno-Scandinavie. La connaissance de la distribution nord-européenne de cette espèce, apparemment inhabituelle et en deux aires, pourrait mettre en cause plutôt l'absence d'éphéméroptérologues que la présence de l'espèce en elle-même.

1. Introduction

Baetis liebenauae was described from Poland by KEFFERMÜLLER in 1974, and has since been reported from a number of countries all over Europe as well as in Fennoscandia. In Sweden, the species was identified during the Mörrum River project in 1982-1986 (Limnodata HB); in Finland, it was collected in 1977 and identified 10 years later (SAVOLAINEN & PULKKINEN 1987); and it has been known in Denmark since 1991 (JENSEN 1998) and at Kola Peninsula since 1997 (BERGENGREN et al. 2004).

The classification of *B. liebenauae* as an invasive alien species in the *Handbook of Alien Species in Europe* has led to concerned questions about its dangers. However, the true situation is the opposite; this mayfly can be regarded as a gift from heaven to salmonids and other river inhabitants, providing a well-appreciated food supply. In Sweden, the species has been red-listed as near-threatened since 2010, while in Finland and Denmark it is listed as vulnerable.

2. *Baetis liebenauae* in Sweden

The arrival of *B. liebenauae* in Sweden was first revealed by eleven brown trout (*Salmo trutta*) electro fished at Björka River in Skåne (station 1 in figure 1) at 55.39°N, 13.38°E on 19 September

1979; together, these fish had consumed twenty-four larvae. It is possible that *B. liebenauae* tried to expand northwards from here, but in the 1980s the rivers at the west coast of Sweden were severely damaged by acidification, and so any attempt at colonisation would have failed.

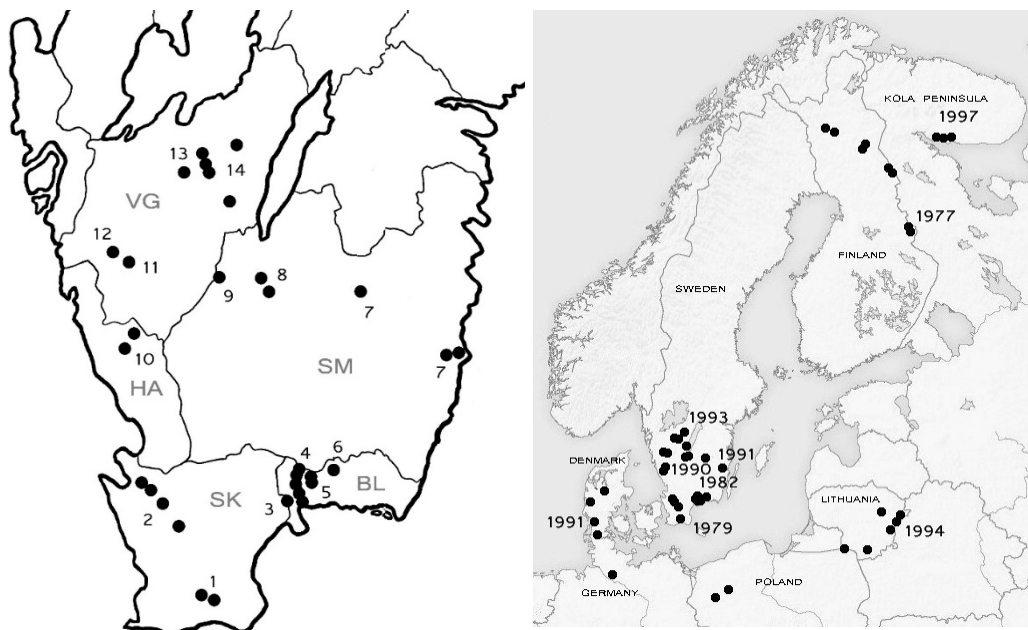


Figure 1 (on left). Distribution of *B. liebenauae* in Sweden. Station numbers are explained under “Swedish material”.

Figure 2 (on right). Distribution of *B. liebenauae* in Northern Europe. Years indicate the first time that the species was collected in that country or region.

Figure 1 (à gauche). Distribution de *B. liebenauae* en Suède. Se reporter au paragraphe “Swedish material” pour la numérotation des stations. Skåne (SK), Blekinge (BL), Halland (HA), Småland (SM), Västergötland (VG).

Figure 2 (à droite). Distribution de *B. liebenauae* en Europe du Nord. Les années mentionnent la première citation de présence dans chaque pays ou région.

The first time *B. liebenauae* was identified from bottom fauna samples was in the autumn of 1982. Mörrum River at Blekinge (4 in Figure 1) was sampled in 1982-1985 by Arne Johlander (ENGBLOM & LINGDELL 1986a), and in 1986 by Limnodata HB (ENGBLOM & LINGDELL 1986b). During 1989-1994, the Institute for Water and Air (IVL) inventoried the whole of the Mörrum river basin for bottom fauna, mainly in Småland (SM). My analysis of the samples showed that *B. liebenauae* appeared only in the material from the Blekinge part of the river.

B. liebenauae was not present in the Mörrum River bottom fauna samples from May 1980 (Limnodata HB), or in any of the plentiful older material from assorted collections that could be accessed. Still, before 1986 this species had completely occupied the Mörrum River from 5 m a.s.l.

at 56.10°N, 14.45°E up to 90 m a.s.l. at 56.19°N, 14.42°E, covering a range of around 20 km. In 1990, Björn Svensson suggested *B. liebenauae* for the red list, calling it a “characteristic species” for this river. It is very likely that *B. liebenauae* first arrived at the Mörrum River in 1980 or 1981.

In 1980, *B. liebenauae* was not found in the three rivers parallel to the Mörrum River that it later colonised; the distance between the outflows in the Baltic Sea for these rivers is 22 km, from Skräbe (3) via Mörrum (4) and Mie (5) to Bräkne (6). Rivers further east are either too polluted or risk drying out in summertime, and are therefore more suitable for *Siphonurus armatus*. The first possible river up the east coast is Emå River (7), where *B. liebenauae* was collected in September 1991 at 57.07°N, 16.15°E (identified 2019), the species was not present in the river in 1989.

The second river that *B. liebenauae* larvae were collected from was Högvad River (10:1), at the west coast, at 57.11°N, 12.47°E in September 1990; this was a small dense population, seemingly the result of oviposition by a single female. The river basin was sampled by Limnodata HB at a number of places in 1983-1985 before liming and in 1989-1991 after liming. There were no larvae at 10:1 in September 1989; in September 1991 the population was found over a wider area than it was in 1990 and the species was found at yet another place downstream. It is likely that *B. liebenauae* arrived at this river in the spring of 1990.

In October 1993 *B. liebenauae* was found in the Hornborga River (13:1) at 58.17°N, 13.35°E; the species was not present here in May 1984. From the Hornborga River, *B. liebenauae* should have continued northwards for another 700 km in the same way as *B. buceratus*, a species with similar preferences. However, this did not happen; the question is why?

3. Larvae morphology

B. liebenauae is generally considered to be easily recognized from its unique mandibles, and it might be for this reason that the literature has little to say about the general appearance of these larvae. KEFFERMÜLLER (1974) notes that it has a “Combination of colours typical for the group vernus Curtis, but dorsal parts dark caused by lack of pale oval spots at abdominal tergites”, while ADAM (1991) only says that there is “little contrast”.

When the newly collected bottom fauna samples arrived from Mörrum River in 1982, we suspected a practical joke at first; shining forth from the rest of the material were white *Baetis* larvae that looked as if they had spent fifty years in ethanol. When visiting the river in the spring of 1986 we could see for ourselves that these pale larvae were not only real but even most vigorous. Conversely, at Högvad River in 1990, the large grey and subdued mottled larvae were mistaken at the sampling site for a new kind of *Rhodobaetis*, similar to the tundra species *Baetis (Rhodobaetis) wallengreni* Bengtsson, 1912, but with a different swimming behaviour.

It could therefore be asked whether *B. liebenauae* immigrated twice, with the Mörrum population arriving from Poland and the Högvad population coming via Denmark.

4. Distribution in Northern Europe

Poland. On 25 May 1971, *B. liebenauae* was collected in the upper part of the River Odra (Oder) near Skwierzyzna in Zielona Góra province (KEFFERMÜLLER 1974). The species was later found in the lower part of the same river basin at Gwda and Drawa in Western Pomerania (GLAZA-CZOW 1994, JAZDZEWSKA 2001). The River Odra has its outflow in the Bay of Pomerania in the

Baltic Sea at 54.08°N, 13.45°E. From here it is 250 km to Mörrum River (4) and 190 km to the electro fished brown trout at Björkaån (1); this might be too long a flight, but as an alternative way of travelling, imagoes might have crossed the wide sea on one of the many ferries between Poland and Sweden.

Germany. *B. liebenauae* have been collected from the Seeve at Horst, Lower Saxony (Hörsten Niedersachsen) at 53.24°N, 10.03°E (HAYBACH 1998); and the Elbe river basin has its outflow at 53.51°N, 8.59°E in the North Sea. Assuming flight along the coastline in search of rivers to explore, Denmark is not far from here.

Denmark. *B. liebenauae* is not found on the islands between the mainland and Sweden, only at Jutland (Jylland) (GRØN 1999) where the rivers have their outflows in the North Sea:

1. Ribe river basin with outflow at 55.20°N, 8.39°E; found at Ribe in 1991, Hjortvad Å in 1998, and Gelså in 1998.

2. Vidå river basin with outflow at 55.20°N, 8.39°E; found at Grønå in 1998.

3. Skjaern river basin with outflow at 55.59°N, 8.07°E; found at Skjaern in 1993.

4. Storå river basin with outflow at 56.22°N, 8.06°E; found at Sunds Nørreå in 1998.

5. Karup river basin with outflow in Limfjord at 56.33°N, 9.03°E and further outflow in the Sound (Kattegat) at 56.58°N, 10.21°E; known from the Karup River since 1991 and found at the Haderup River (JENSEN 1998). It is 130 km from the Limfjord outflow in the Sound to the Högved River (10).

Lithuania. The Nemunas (Njemen) river basin has its outflow in the Baltic Sea at 55.19°N, 21.14°E. *B. liebenauae* was collected on 18 September 1994 by Björn Oledal in the Neris River upstream of Vilnius at 54.43°N, 25.18°E (Limnodata HB). In eastern Poland, it was found in Suwałki near Rutka at 54.20°N, 22.58°E (HAYBACH 1998). It was later collected again in the same river basin: Nemunas at 54.01°N, 23.59°E on 12 July 2007, Merkys at 54.06°N, 24.16°E on 3 July 2008, Neris at 54.50°N, 25.28°E on 12 July 2007, Lakaja at 55.08°N, 25.46°E on 14 July 2007, Žeimena at 55.04°N, 25.55°E on 4 July 2008, and Virinta at 55.24°N, 25.06°E on 5 July 2008 (KOVÁCS et al. 2008).

Finland. *B. liebenauae* was first collected in 1977 (SAVOLAINEN & PULKKINEN 1987). SAVOLAINEN (2009) gives a distribution map and the finds below:

1. Oulu River basin with outflow in the Gulf of Bothnia at 65.20°N, 25.16°E; found in Niemisjoki at 64.06°N, 30.05°E on 6 August 1977 and on 7 August 1998, Kytökoski at 64.07°N, 30.12°E in 1997, and Suomussalmi Kuivajoki at 64.40°N, 30.01°E in 1993.

2. Kemi River basin with outflow in the Gulf of Bothnia at 65.46°N, 24.25°E; found in Vuotosjoki at 67.04°N, 27.47°E in 1994, Serrijoki in 1994, Jeesiöjoki at 67.39°N, 25.32°E in 1996–1997, Nunarajoki at 67.40°N, 25.29°E in 1994, Myllyjoki at 67.48°N, 24.47°E in 1998 (10 August), 2004, and 2006 (25 July). Also found in three tributaries to River Seurujoki at 67.50°N, 25.16°E: Konikoski and Lintula in 2009 and Rossinmukka in 2014 (Agnico Eagle Finland Oy, Report 17.5.2017, available on the Internet).

3. Kounda River basin with outflow in the White Sea (Beloje More) at 66.41°N, 32.52°E; found in Oulankajoki Mataraniemi at 66.22°N, 29.20°E in 1980 and Kuusinkijoki Käpykoski at 66.13°N, 29.47°E in 2007.

Kola Peninsula. *B. liebenauae* was identified from three rivers all with outflow in the White Sea; the collection at Pana River was by Håkan Söderberg (BERGENGREN et al. 2004), while those at Ruma and Kuzreka were by Jan Åslund and Anders Dahlen (Limnodata HB):

1. Pana River at 66.53°N, 35.55°E, 80 m a.s.l., 70 m wide, 19.3°C, 7 August 1997.
2. Ruma river at 66.41°N, 34.20°E, 20 m a.s.l., 5 m wide, 10°C, 18 August 1998.
3. Kuzreka river at 66.36°N, 34.48°E, 5 m a.s.l., 12 m wide, 12°C, 16 August 1998.

5. Life cycle and ecology

In the southern part of Europe, *B. liebenauae* is bivoltine and there can be overwintering larvae. A third generation has been observed in a spring in northern Italy with water temperatures ranging between 9°C and 17°C (BUFFAGNI & GOMBA 1996). In Poland, there are two generations and overwintering eggs (GLAZACZOW et al. 2016). Swedish larvae have consequently been found in climate zones 1-4 from late April to mid-October, with the first generation flying in July and the second in October.

Several of the Swedish rivers where *B. liebenauae* later occurred were sampled in the early 1980s, but probably at the wrong time to find larvae; that is, the third week of April and last week of July.

GLAZACZOW et al. (2016) describe a developmental trap caused by increasing water temperature in the Polish River Gwda, resulting in lost generations for *B. liebenauae*. The higher water temperature in the regulated river prolongs the summer diapause; if autumn temperatures remain in the interval 10-12°C there can still be a successful hatching but in temperatures below 5°C the subimagos do not rise from the water surface.

Another possible example of a lost generation - but for a different reason - comes from Gnyltå River (8) at 57.32°N, 14.08°E and 198 m a.s.l. Larvae were collected on 26 September 1998 with a water temperature of 9.3°C, but were not found on 14 September 1999 at 8.6°C, despite a whole day's searching. It is possible that the water was too cold for hatching in October 1998 in this river situated on the southern Swedish highlands in climate zone 5. In Sweden, *B. liebenauae* is seemingly a bivoltine southern summer species. Climate zone 4 might be the limit for a second generation for this species, and stepping down from two generations to only one might not be an option. However, this hypothesis is contradicted by the fact that in the taiga in northern Finland and Kola Peninsula, *B. liebenauae* is univoltine in climate zone 7-8.

B. liebenauae is generally regarded as a lowland taxon, in Poland occurring only up to 150 m a.s.l. (GLAZACZOW 1994). However, in the Alps it is found in Switzerland (SARTORI et al. 1996) and in Austria (BAUERNFEIND 1990) at altitudes of 315-350 m a.s.l., and it was once found in Italy as high as 500 m a.s.l. (BUFFAGNI & GOMBA 1996). In Sweden the altitudes range between 5 and 198 m, in Finland between 175 and 225 m, and at Kola Peninsula between 5 and 80 m a.s.l.

In Switzerland, *B. liebenauae* has been reported from a stream less than 2 m wide (SARTORI et al. 1996), and the rivers where it has been found in northern Italy are usually not more than 3-4 m wide. Conversely, in Poland the species is mainly found in rivers over 12 m and only sparsely in small rivers; in Sweden it is found in rivers of all widths from 5 to 50 m but primarily in rivers 7-20 m wide; and the three rivers in which it has been seen at Kola Peninsula are between 5 and 70 m wide.

B. liebenauae inhabits slow water in Italy and rather fast water in Poland (BUFFAGNI & GOMBA 1996). A speed of 1 m/s has been mentioned for Austria (BAUERNFEIND 1990). In Sweden and at Kola Peninsula, *B. liebenauae* seems to favour rivers with currents of 0.5-1 m/s.



Mörrum River (4:6) on 1 June 1986 home for *Baetis liebenauae*.
La rivière Mörrum (4:6) le 1^{er} juin 1986: site de *Baetis liebenauae*.

In the southern and central parts of Europe, *B. liebenauae* is exclusively found on submerged macrophytes but seemingly without any preference for specific water plants (BUFFAGNI & GOMBA 1996). In Sweden, the vegetation is often rich, as for the Mörrum River, but can also be sparse or there can be only mosses and algae. At Kola Peninsula, Ruma River had the moss *Fontinalis*, green algae, and the red alga *Nostoc*; Kuzreka River was rich in mosses; and the sparser vegetation in the Pana River comprised *Fontinalis*, some green algae, *Nostoc*, and *Carex* and *Sparganium*.

B. liebenauae is a tolerant species, as long as there is a hard bottom, some sort of vegetation, constantly-running water, and not too much pollution. However, it is rather sensitive to acidification; pH measured at sampling occasions in Sweden ranged from 6.28 to 7.43 (an interval similar to *B. buceratus*), and for the Pana River at Kola Peninsula, pH was as high as 8.00.

In Switzerland *B. liebenauae* was preferably collected with *Rhodobaetis* (SARTORI et. al.1996), and in Italy with *Rhodobaetis* and *Alainites muticus* (BUFFAGNI & GOMBA 1996).

In the 37 Swedish samples (Limnodata HB), including the 11 brown trout treated as one sample, *B. liebenauae* was collected with up to 14 mayfly species at the same location and with 19 mayfly species in total. Most frequent was *Rhodobaetis* in 30 of the samples, *Heptagenia sulphu-*

rea in 29, *Caenis luctuosa* in 24, *Nigrobaetis digitatus* in 21, *Alainites muticus* in 20, and *Serratella ignita* in 18. It is notable that the hemipteran *Aphelocheirus aestivalis*, a signal species that guarantees an interesting and diverse bottom fauna, was present in 21 of the samples. External Swedish taxa lists confirm this picture.

In the rivers at Kola Peninsula, *B. liebenauae* was recorded with 12 other mayfly species, of which *Heptagenia dalecarlica* was the most dominant.

6. Conclusion

Why has *B. liebenauae* not moved further north in Sweden? *B. buceratus*, which is not found in Norway or Finland and was first discovered in Sweden (SK) in 1906, has reached up to Husån (ÅN) at 63.33°N, 19.02°E in climate zone 4; a journey that might have taken some hundred years. It is possible that more than four decades are needed to take the drastic step from two generations a year to only one generation. If so, *B. liebenauae* must have reached Finland long before it reached Sweden, thus taking two different migration routes to northern Europe. Alternatively, *B. liebenauae* may have started its European odyssey from somewhere in the far east of Russia.

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The climate zones 1-9 (9 is tundra) are listed at: www.tradgard.org/svensk_tradgard/zonkarta/zonkarta_stor.html

Latitudes and longitudes are taken from Google Earth: <http://earth.google.com/>

Swedish material

The Swedish *Baetis liebenauae* material at Limnodata HB originates from 9 river basins (in SK, BL, HA, VG, SM) and comprises 36 bottom fauna samples in addition to stomach contents from 11 brown trout. External data from another 5 river basins from Ekologgruppen (SK, BL, SM), Medins Biologi AB, and Cal-luna (VG, SM) are included below in italics and within square brackets. Several of the taxa lists can be found on the Internet.

1. SK. Kävlinge river basin, outflow in the Sound (Lommabukten) at 55.43°N, 12.59°E.
 - 1:1. Björkaån (SK) 55.39°N, 13.38°E, 24 m a.s.l., 12 m wide, 19 September 1979, brown trout electro fished by Brodde Almér, Sweetwater Laboratory at Drottningholm Stockholm / [1 October 2003].
 - 1:2. [Björkaån (SK) 55.38°N, 13.48°E, 58 m a.s.l., 12 m wide, 1 October 2003].
2. SK. Rönne river basin, outflow in the Sound (Skälderviken) at 56.16°N, 12.50°E.
 - 2:1. Rönneån (SK) 56.01°N, 13.23°E, 42 m a.s.l., 12 m wide, 13 July 1993.
 - 2:2. [Bäljaneån (SK) 56.08°N, 13.06°E, 10 m a.s.l., 9 October 1996].
 - 2:3. [Pinnån (SK) 56.12°N, 13.01°E, 24 m a.s.l., 16 m wide, 4 October 2000 / 14 October 2015 / 17 October 2017].
 - 2:4. [Rösjöholmsån (SK) 56.15°N, 12.56°E, 10 m a.s.l., 8 m wide, 4 October 2000].
3. BL. Skräbeån river basin, outflow in the Baltic Sea (Nordsjön) at 56.01°N, 14.28°E.
 - 3:1. [Höljeån (SK) 56.13°N, 14.31°E, 35 m a.s.l. 5 m wide, 1996?]. *B. liebenauae* was not present on 16 May 1980.
4. BL. Mörrum river basin, outflow in the Baltic Sea at 56.09°N, 14.44°E. 24 samples 1982–1993 [and 6 external samples 2007–2015].
 - 4:1. Mörrumsån (BL) 56.10.49°N, 14.45.00°E, 5 m a.s.l., 50 m wide, 27 May 1986 / 3 June 1986.
 - 4:2. Mörrumsån (BL) 56.11.28°N, 14.45.05°E, 50 m wide, 3 June 1986.
 - 4:3. Mörrumsån (BL) 56.11.56°N, 14.44.53°E, 10 m a.s.l., 15 September 1982 / 15 September 1983 / 16 September 1990 / [2 October 2015].
 - 4:4. [Mörrumsån (BL) 2 October 2015].
 - 4:5. Mörrumsån (BL) 56.12.12°N, 14.45.03°E, 27 April 1990.
 - 4:6. Mörrumsån (BL) 56.12.45°N, 14.45.14°E, 50 m wide, 1 June 1986.
 - 4:7. Mörrumsån (BL) 56.12.43°N, 14.45.18°E, 20 m a.s.l., 50 m wide, 1 June 1986 / 5 June 1986 / [2 October 2015].
 - 4:8. Mörrumsån (BL) 56.13.27°N, 14.45.42°E, 26 m a.s.l., 14 September 1984 / 10 September 1985.

- 4:9. Mörrumsån (BL) 56.13.42°N, 14.46.03°E, 30 m a.s.l., 16 September 1982 / [1 October 2015].
- 4:10. Mörrumsån (BL) [1 October 2015].
- 4:11. Mörrumsån (BL) 56.14.25°N, 14.46.44°E, 35 m a.s.l., 20 m wide, 5 June 1986.
- 4:12. Mörrumsån (BL) 56.14.38°N, 14.46.59°E, 36 m a.s.l., 16 September 1982.
- 4:13. Mörrumsån (BL) 56.15.54°N, 14.46.01°E, 40 m a.s.l., 30 m wide, 7 June 1986.
- 4:14. Mörrumsån (BL) 56.17.36°N, 14.44.44°E, 50 m a.s.l., 40 m wide, 4 June 1986 / 10 June 1992 / 22 May 1993 / [17 May 2007]. *B. liebenauae* was not present on 16 May 1980.
- 4:15. Mörrumsån (BL) 56.18.07°N, 14.44.21°E, 52 m a.s.l., 11 September 1985.
- 4:16. Mörrum river (BL) 56.18.21°N, 14.44.12°E, 55 m a.s.l., 50 m wide, 6 June 1986.
- 4:17. Mörrumsån (BL) 56.18.41°N, 14.44.01°E, 55 m a.s.l., 17 September 1982.
- 4:18. Mörrumsån (BL) 56.19.48°N, 14.42.17°E, 90 m a.s.l., 10 m wide, 7 June 1986. *B. liebenauae* was not present on 16 May 1980.
- 4:19. Mörrumsån (BL) 56.19.49°N, 14.42.19°E, 90 m a.s.l., 25 m wide, 8 June 1986.
- 5. BL. Mie river basin, outflow in The Baltic Sea at 56.09°N, 14.51°E.**
- 5:1. Mieån (BL) 56.20°N, 14.51°E, 75 m a.s.l., 29 April 1995 / 12 June 1995.
- 5:2. [Mieån (BL) 56.19°N, 14.52°E, 73 m a.s.l., 17 October 2012].
- 6. BL. Bräkne river basin, outflow in the Baltic Sea at 56.09°N, 15.07°E.**
- 6:1. Bräkneån (BL) 56.19°N, 15.04°E, 49 m a.s.l., 9 m wide, 19 July 1994. *B. liebenauae* was not present at 65 m a.s.l. on 16 May 1980.
- 7. SM. Emån river basin with outflow in the Baltic Sea at 57.07°N, 16.30°E**
- 7:1. Emån (SM) 57.07°N, 16.29°E, 8 m a.s.l., 5 September 1992.
- 7:2. Emån (SM) 57.07°N, 16.15°E, 37 m a.s.l., 7 September 1991.
- 7:3. [Emån (SM) 57.24°N, 15.31°E, 108 m a.s.l., 20 m wide, 1 October 2008].
- B. liebenauae* was not present at 10 or 50 m a.s.l. in 1980 (May), at 95 m a.s.l. in 1980 (June), at 90 m a.s.l. in 1984 (June), or at 130 m a.s.l. in 1988 (May). In 1989 not present at 5, 30 or 85 m a.s.l. in May, at 30, 50 or 85 m a.s.l. in August, or at 5 or 10 m a.s.l. in September, and in 1991 not present at 90 m a.s.l. on 7 September.
- 8. HA. Lagan river basin, outflow in the Sound (Laholmsbukten) at 56.32°N, 12.56°E.**
- 8:1. Gnyltån (SM) 57.32°N, 14.08°E, 198 m a.s.l., 7 m wide, 26 September 1998. *B. liebenauae* was not present on 14 September 1999.
- 8:2. [Hokaån (SM) 57.25°N, 14.18°E, 176 m a.s.l., 7 October 2008].
- 9. HA. Nissan river basin, outflow in the Sound (Laholmsbukten) at 56.39°N, 12.51°E.**
- 9:1. [Svanån (SM) 57.33°N, 13.42°E, 180 m a.s.l., 20 October 2009 / 4 October 2012 / 7 October 2014 / 1 October 2017].
- 10. HA. Ätran river basin, outflow in the Sound (Kattegat) at 56.53°N, 12.28°E.**
- 10:1. Högvadsån (HA) 57.11.04°N, 12.47.11°E, 80 m a.s.l., 11 m wide, 16 September 1990 / 23 September 1991. *B. liebenauae* was not present on 23 September 1989.
- 10:2. Högvadsån (HA) 57.05.30°N, 12.39.09°E, 33 m a.s.l., 20 m wide, 23 September 1991.
- 11. HA. Viskan river basin, outflow in the Sound (Kattegat) at 57.13°N, 12.12°E.**
- 11:1. [Viskan (VG) 57.38°N, 12.52°E, 120 m a.s.l., 16 October 2017]. *B. liebenauae* was not present at 80 m a.s.l. or at 140 m a.s.l. on 29 May 1984.
- 12. HA. Rolfsån river basin, outflow in the Sound (Kattegat) at 57.27°N, 12.04°E.**

12:1. [*Sörån (HA)* 57.40°N, 12.36°E, 98 m a.s.l., 5 October 2011].

13. VG. Lidan river basin enters Lake Vänern at 58.30°N, 13.10°E, 48 m a.s.l., and has its outflow via Gota River (Götaälv) in the Sound (Kattegat) at 57.47°N, 11.49°E.

13:1. Hornborgaån (VG) 58.17.54°N, 13.35.57°E, 130 m a.s.l., 15 m wide, 5 October 1993 collected by the Natural History Museum at Stockholm / [3 October 1994 / 2 October 1996]. *B. liebenauae* was not present on 11 May 1984.

13:2. [*Slafsån (VG)* 58.15°N, 13.36°E 144 m a.s.l., 5 October 1993 / October 1996].

13:3. [*Slafsån (VG)* 58.13°N, 13.38°E 152 m a.s.l., 7 October 1993 / October 1996].

13:4. [*Lidan (VG)* 58.11.21°N, 13.13.28°E, 115 m a.s.l., 1 October 1996].

14. VG. Tidån river basin enters Lake Vänern at 58.42°N, 13.49°E, 48 m a.s.l., and has its outflow via Gota River (Götaälv) in the Sound (Kattegat) at 57.47°N, 11.49°E.

14:1. [*Ösan (VG)* 58.21°N, 13.57°E, 123 m a.s.l., 5 October 1993].

14:2. [*Tidån (VG)* 58.03°N, 13.52°E, 192 m a.s.l., 10 October 2016].