

Distribution and habitats of *Berosus* in The Netherlands (Coleoptera: Hydrophilidae)

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Abstract: A key to the identification, and the distribution of the six species of the genus *Berosus* (Coleoptera: Hydrophilidae) in The Netherlands is presented. *Berosus fulvus* is reported for the first time from The Netherlands. However, this species may be extinct now, because the last record dates from 1942. Some characteristics of the habitats of the most common species in The Netherlands, *B. luridus* and *B. signaticollis*, are given. Both species are typical for waters with a low pH, low conductivity and low chlorinity as heathland pools and peat-pits. *Berosus fulvus* and *B. spinosus* can be considered halobiont species, while *B. affinis* and *B. hispanicus* are halotolerant.

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Introduction

The genus *Berosus* (Coleoptera: Hydrophilidae) is represented in all major biogeographic regions with a total of more than 200 species (Hansen, 1991). In the last check list of water beetles in The Netherlands (Drost et al., 1992) four species of the genus *Berosus* are mentioned: *B. affinis* Brullé, *B. luridus* (Linnaeus), *B. signaticollis* (Charpentier) and *B. spinosus* (Steven in Schönherr). Recent revisions of North-African (Aouad & Aguesse, 1991) and European material (Schödl, 1991, 1993) resulted in some dramatic changes in the European check list. As a result of these revisions *Berosus hispanicus* Küster could be added to the Dutch list (Schödl, 1993). A revision of the Dutch material of *Berosus* seemed necessary, because the distribution areas of other "new" species might also include The Netherlands. The main museum and private collections, and material from Water Authority Boards were investigated for this reason.

Material and methods

The distribution maps of the Dutch *Berosus*-species are based on the collections of the

National Museum of Natural History, Leiden (RMNH), the Zoological Museum, Amsterdam (ZMA), the Noord-Brabants Natuurmuseum (Tilburg), the Departments of Entomology and Water Quality Management of the Wageningen Agricultural University (LUW), Gemeenschappelijke Technologische Dienst Oost-Brabant, Hoogheemraadschap Uitwaterende Sluizen, Hoogheemraadschap West-Brabant, Provincie Noord-Holland, Provincie Overijssel, Waterschap Friesland, Waterschap Groot Salland, Waterschap Regge en Dinkel, Waterschap Rijn en IJssel, Zuiveringschap Limburg, Zuiveringschap Drenthe, and the private collections of H. Cuppen (Apeldoorn), B. Drost (Wadenhoijen), G. van Ee (Haarlem), Th. Heijerman (Wageningen), J. Huijbregts (Leidschendam), T. Joosten (Groningen), F. van Nunen (Vianen), C. van de Sande (Amsterdam), B. Storm (Groningen), G. van der Velde (Nijmegen), O. Vorst (Utrecht), P. van Wielink (Berkel-Enschot), J. Wieringa (Nijmegen) and the authors. The maps are primarily based on specimens identified by the authors, but include also Dutch material examined by Schödl (1991, 1993; mainly from the Museum, Den Haag), and by Burmeister (1982; only *B. luridus*) from Walcheren. The

distribution of the *Berosus*-species in The Netherlands is plotted in the 10 km-squares of the U.T.M.-grid (fig. 13-17) in which small dots refer to records prior to 1975 and large dots to records since 1975; the single record of *B. hispanicus* (fig. 15) is indicated by an asterisk.

For phenology of the *Berosus*-species all available data were used, while for habitat and physical-chemical variables mainly the first author's records were available. Owing to the paucity of records for some species and insufficient labelling of specimens in the past for all species, statistical treatment of ecological data was not possible.

Identification

Identification of the Dutch *Berosus* material revealed that, in addition to the five species mentioned above, one more species occurs in The Netherlands: *Berosus fulvus* Kuwert. For the identification of Dutch *Berosus* the following key, based on Schödl (1991, 1993), can be used:

1. Elytra with two spines near the apex (fig. 1) 2
Elytra without spines near the apex (fig. 2) 3
2. Labrum black (teneral specimens can have a yellow labrum). Pronotum without dark marks. Aedeagus: fig. 3. *B. fulvus*
Labrum yellow. Pronotum with dark marks (marks can be weak in teneral specimens). Aedeagus: fig. 4. *B. spinosus*
3. First abdominal sternite only in the basal half with a keel. Mesosternum with a very large, dentated keel (fig. 5). Aedeagus: fig. 9. *B. signaticollis*

- First abdominal sternite with a median keel extending over the basal half. Mesosternum with a smaller or strongly reduced keel (fig. 6-8) 4
- 4. Elytral striae deep; interstriae clearly convex. Mesosternum with a short strong keel (fig. 6). Aedeagus: fig. 10. *B. luridus*
- Elytral striae shallow; interstriae flat. Mesosternum with a dentated or smaller keel (fig. 7-8) 5
- 5. Pronotum with a single, though anteriorly often deeply incised, dark spot; punctures evenly distributed. Keel on mesosternum very low, at most very fine dentated (fig. 7). Aedeagus: fig. 11. *B. affinis*
- Pronotum with a pair of dark spots; spots divided by a line without punctures. Keel on mesosternum higher near the middle, finely dentated (fig. 8). Aedeagus: fig. 12.
..... *B. hispanicus*

Data

Some numerical results with respect to the data are presented in table 1. All specimens collected (by one or more collectors) from the same locality and the same date (or overlapping periods) are considered as a single record. The number of specimens is the number of collected specimens, which are either preserved in a dry collection (musea and most private collections) or on ethanol (most material from Water Authority Boards). Occasionally, high densities of *Berosus* were observed in the field; in these cases the actual number of collected specimens are counted. The number of specimens from literature (Schödl, 1991, 1993; Burmeister, 1982) without indication of numbers is always counted as

Table 1. Number of records, total number of specimens, sexes and number of specimens for pre- and post-1975 records of *Berosus* in The Netherlands.

	Records	Specimens	♂	♀	Pre-1975	Post-1975
<i>B. hispanicus</i>	1	1				1
<i>B. affinis</i>	10	31	14	14	27	4
<i>B. fulvus</i>	6	16	8	8	16	
<i>B. spinosus</i>	18	100	54	43	99	1
<i>B. luridus</i>	331	909	389	338	499	410
<i>B. signaticollis</i>	238	639	260	223	126	513

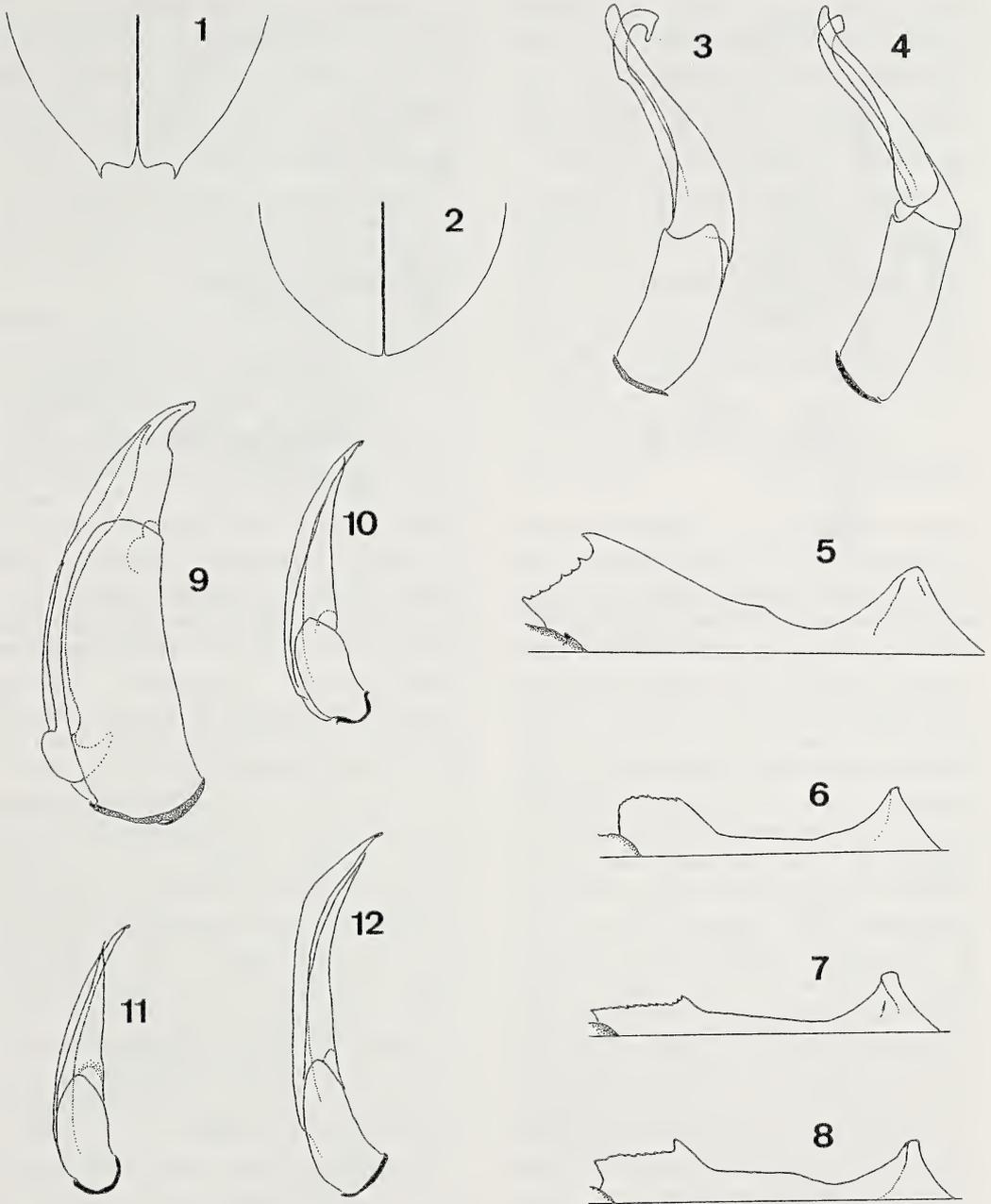


Fig. 1-12. *Berosus*: 1, 3, *B. fulvus*; 2, 5, 9, *B. signaticollis*; 4, *B. spinosus*; 6, 10, *B. luridus*; 7, 11, *B. affinis*; 8, 12, *B. hispanicus*; 1-2, apex of elytra; 3-4, 9-12, aedeagus; 5-8, mesosternum.

one. Most specimens were sexed; specimens with missing fore legs or fore legs covered by glue were not sexed in case of a certain species identification.

The first four *Berosus*-species in table 1 can be considered very rare in The Netherlands.

Although the number of records for *B. luridus* and *B. signaticollis* is relatively high, they can not be considered very common species. The use of a data-set from Water Authority Boards, existing of more than 5.000 samples of macro-invertebrates (a low estimate), cer-

tainly has enlarged the number of records for these two species, but less than 1% of these samples contained *Berosus*-species.

The sex-ratio for all *Berosus*-species (table 1) is close to 1 with a slight, but not statistically significant, overrepresentation of males.

Compared with each other on the basis of number of specimens, the relative abundance of *B. luridus* has distinctly decreased since 1975, while the relative abundance of *B. signaticollis* has increased (table 1). The same applies to the number of records of both species over the same time periods.

Distribution

Berosus luridus (fig. 13) is known from 69 grid-squares since 1975 and additionally from 49 grid-squares before that period. In 26 grid-squares the species occurred in both periods. The distribution pattern shows that *B. luridus* is mainly confined to the southern, middle and eastern part of the country. Outside this area there are old records from Den Haag, Leiden, Wassenaar and Noord-Oost-Polder (single specimens) and larger series from Amsterdam, Zeeburg and the Wadden-islands Texel and Terschelling. Recent records outside the main distribution area are from Hulst, Middelburg (Burmeister, 1982), Vlijmen, Zeewolde and the Wadden-islands Texel and Terschelling (single specimens from each locality, except Hulst: three specimens). The distribution pattern coincides with the presence of sand and peat soils. The species is absent on clay soils. Within its distribution area in The Netherlands (squares with sand and peat soils) *B. luridus* is rather rare; the species is recorded from about 35% of the possible grid-squares. The present day absence from the dune area (except for the Texel and Terschelling records) is striking, and is possibly the result of a diminishing amount of wet dune valleys or infiltration of these valleys with eutrophic river water. Brakman (1966) reported *B. luridus* from six provinces, while the present study includes records from all (12) provinces.

The distribution of *B. luridus* comprises the

western Palaearctis. In the mediterranean area the species is rare. The species is known from Norway, Sweden, Finland, Denmark, The Netherlands, Belgium, Germany, England, Scotland, France, Italy, Switzerland, Austria, Poland, Czechia, Slovakia, Hungary, Slovenia, Serbia, Bosnia, Albania, Roumania, Estonia, Latvia, Lithuania, Belarus, Ukraine, Russia, the Caucasus and Turkey (Foster, 1987; Hansen, 1987; Schödl, 1993).

Berosus signaticollis (fig. 14) is known from 91 grid-squares since 1975 and additionally from 24 grid-squares before that period. In 17 grid-squares the species is recorded in both periods. Like the previous species *B. signaticollis* is mainly confined to the southern, middle and eastern part of the country. Outside this area there are old records from Den Haag, Amsterdam, Zeeburg and the Wadden-island Terschelling (single specimens, except Zeeburg). Recent records outside the main range are from Hulst, Terneuzen, Westerschouwen, Goedereede, Vlijmen, Vianen, Dreumel, Egmond, Schoorl, Zuidelijk Flevoland and the Wadden-islands Terschelling, Ameland and Schiermonnikoog (one or two specimens on each locality, but numerous on one locality on Ameland). This distribution pattern coincides with the presence of sand and peat soils, but the species is occasionally also taken in waters with a clay soil. Within its main distribution area in The Netherlands (squares with sand and peat soils) *B. signaticollis* is rather rare; the species is recorded from about 35% of the possible grid-squares. Brakman (1966) reported *B. signaticollis* from 10 provinces, while the present study includes records from all provinces.

The distribution of *B. signaticollis* comprises the western Palaearctis. The species is known from Sweden, Ireland, England, The Netherlands, Belgium, France, Spain, Germany, Switzerland, Austria, Italy, Poland, Czechia, Slovakia, Hungary, Roumania, Slovenia, Croatia, Serbia, Bosnia, Macedonia, Albania, Greece, Turkey, Ukraine, Russia, Georgia, Kazakhstan, Turkmenistan, Tadschikistan, Usbekistan, Morocco and Algeria (Foster, 1987; Hansen, 1987; Schödl, 1993).

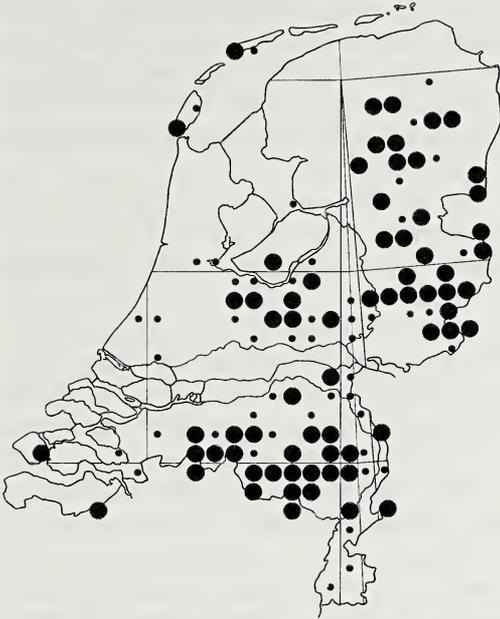


Fig. 13. Distribution of *Berosus luridus* in The Netherlands (small dots: pre-1975 records; large dots: (also) post-1975 records).

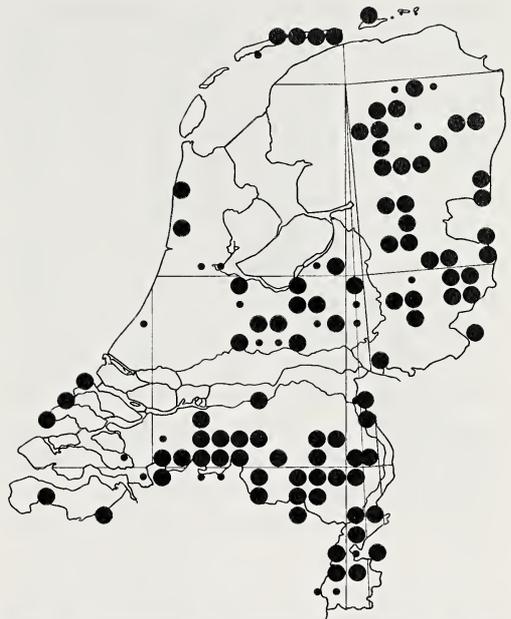


Fig. 14. Distribution of *Berosus signaticollis* in The Netherlands (small dots: pre-1975 records; large dots: (also) post-1975 records).



Fig. 15. Distribution of *Berosus affinis* (small dots: pre-1975 records; large dot: post-1975 record) and *B. hispanicus* (asterisk: post-1975 record) in The Netherlands.



Fig. 16. Distribution of *Berosus spinosus* in The Netherlands (small dots: pre-1975 records; large dot: post-1975 record).



Fig. 17. Distribution of *Berosus fulvus* in The Netherlands (small dots: pre-1975 records).

Berosus affinis (fig. 15) is only known from four localities in the southwestern part of The Netherlands: Zierikzee (between 1876 and 1886), Vlissingen (1926) and Middelburg (1997) in the province of Zeeland, and Bergen op Zoom (between 1904 and 1908) in the province of Noord-Brabant. These provinces were already mentioned by Everts (1898, 1922; with localities Zierikzee and Bergen op Zoom) and Brakman (1966). The Zierikzee locality was also mentioned by Schödl (1993). *Berosus affinis* was considered very rare by Drost et al. (1992); in fact the species could have been considered extinct at that time in The Netherlands, because the last record dated from 1926 (5 ♂, 3 ♀, Vlissingen, 26.iv.1926, leg. Bernet Kempers, coll. ZMA). The recent record of four specimens of *B. affinis* from Middelburg (24.viii.1997, leg. A. van Nieuwenhuyzen & B. van Maanen) represents the first collection of this species in more than 70 years.

The distribution of *B. affinis* comprises the western Palaearctis, where the species is most common in the mediterranean area. The Dutch records are the most north-western on the European mainland. *Berosus affinis* is known

from England, The Netherlands, France, Spain, Portugal, Austria, Italy, Croatia, Bosnia, Serbia, Macedonia, Albania, Bulgaria, Greece, Cyprus, Turkey, Syria, Israel, Iran, Morocco, Algeria, Tunisia and Egypt (Foster, 1987; Schödl, 1993).

Berosus hispanicus (fig. 15; asterisk) is only known from the province of Noord-Brabant, where the species was collected on 26.vii.1981 near Goirle by A. van Berge Henegouwen (Schödl, 1993). It is the most northern record of the species in Europe, except for a doubtful record from Norway mentioned by Schödl (1993). Also the Dutch locality is far outside the range of the species.

The distribution of *B. hispanicus* comprises the western Palaearctis, where the species is most common in the mediterranean area. The species is known from The Netherlands, Austria, Czechia, France, Spain, Portugal, Italy, Croatia, Greece, Malta, Turkey, Morocco, Algeria, Tunisia, Libya and Mali (Schödl, 1993).

Berosus spinosus (fig. 16) is known from only 1 grid-square since 1975 (♀, Flevoland, Almere, Paradijvogelweg, ditch, 26.viii.1990, leg. and coll. J. G. M. Cuppen) and additionally from 8 grid-squares before that period. All pre-1975 localities (Amsterdam, Zeeburg, Marken, Wieringen (province of Noord-Holland), Urk, Schokland (province of Flevoland), Oud Vossemeer, Middelburg and Vlissingen (province of Zeeland)) are situated in the western part of The Netherlands and probably most collections were made in brackish waters. Everts (1893) recorded the species for the first time from The Netherlands from Amsterdam and Zeeburg. Brakman (1966) mentioned only the provinces Noord-Holland and Zeeland for this species, though he probably was well aware of the records from Urk and Schokland. The localities Amsterdam and Zeeburg were also reported by Schödl (1991). The records of Burmeister (1982) from Westkapelle en Zoutelande (Zeeland) are omitted from the map due to possible confusion with *B. fulvus*. On several occasions the species was taken together with *B. fulvus*.

The distribution of *B. spinosus* is Palaearc-

tic. The species is known from Norway, Sweden (Nilsson, 1994), Finland, Denmark (Hansen, 1992), The Netherlands, Germany, Italy, Austria, Estonia, Poland, Slovakia, Hungary, Bulgaria, Roumania, Croatia, Serbia, Macedonia, Albania, Greece, Russia, Ukraine, Georgia, Azerbadkhan, Turkmenistan, Turkey, Iran, Afghanistan, Kazachstan, Tadschikistan, Usbekistan, Kirgisia, Mongolia and China (Schödl, 1991).

Berosus fulvus (fig. 17) is known from only 5 grid-squares before 1975. The species can be considered as extinct in The Netherlands as the last record dates from 1942 (♀, Flevoland, Urk, vii.1942, leg. Dammerman, LUW, Entomologie). All localities (Marken, Texel, Wieringen (province of Noord-Holland), Urk (province of Flevoland) and Vlissingen (province of Zeeland)) are situated in the western part of the country and probably all collections were made in brackish waters. On most occasions the species was taken together with *B. spinosus*.

The distribution of *B. fulvus* comprises the Palaearctic area with the exception of the extreme north. The species is known from Sweden (Nilsson, 1994), Denmark (Hansen, 1992; Hansen et al., 1992), England (Foster, 1987, 1992), France, Spain, Germany, Austria, Hungary, Turkey, Russia, Turkmenistan, Kazachstan, Iran and Mongolia (Schödl, 1991).

Phenology

Berosus hispanicus has been taken once in July, *B. affinis* between April - June, and in August - September, while both *B. spinosus* and *B. fulvus* have been collected from May till September. All records of these four species are based on a limited number of observations. Hansen (1987) mentioned *B. spinosus* from May-September, with larvae and pupae at the beginning of July.

Berosus luridus has been collected during the whole year with a distinct optimum from April till June, and much smaller peaks in August and October (fig. 18). Hansen (1987) mentioned this species from March-October, which is also the main abundancy period in

The Netherlands. The same phenology applies to *B. signaticollis* (fig. 19), but the late summer/autumn peak is less evident. This phenology indicates the univoltine life-cycle of both species with a mating period in spring (mating of *B. signaticollis* was observed on 23 May 1992), larval development during summer and emergence of the new generation in autumn. Larvae of the genus *Berosus* have been found mainly in May and June, and, occasionally in September and October. Teneral specimens of *Berosus luridus* were observed in September, October and December (no data for *B. signaticollis*). On 7 September 1996 numerous specimens of *B. luridus* and *B. signaticollis* were observed hidden in shallow pits under *Sphagnum* in a desiccated heathland pool. Probably most specimens leave the water soon after their emergence as observations in late autumn, winter and early spring are scarce. This winter minimum is certainly influenced by low collecting activity during this period, but most records in this season come from samples collected above the water line.

Physico-chemical variables

Analyses of physico-chemical variables from localities of the rare Dutch *Berosus*-species is not available. In literature some data for these species were found. Gallardo et al. (1997) mentioned a significant overrepresentation of *B. hispanicus* in southern Spain in fresh water streams with a chlorinity between 60 and 205 mg/l (maximum measured: 205 mg/l). For *B. affinis*, Sáinz-Cantero & Alba-Tercedor (1991) reported a pH of 7.7 and a conductivity of 65 µS/cm in the Sierra Nevada. Sánchez-Meca et al. (1992) have found a wide amplitude with respect to conductivity and chlorinity for both *B. affinis* and *B. hispanicus*, covering the range from fresh water to mesohaline conditions. Gallardo-Mayenco (1994) mentioned *B. hispanicus* as a halophilic species from mesohaline streams in southern Spain. For *B. fulvus*, they mentioned a salinity of 18 g/l. Further information is presented under habitat.

The main characteristics of water samples on localities with *Berosus luridus* and *B. sig-*

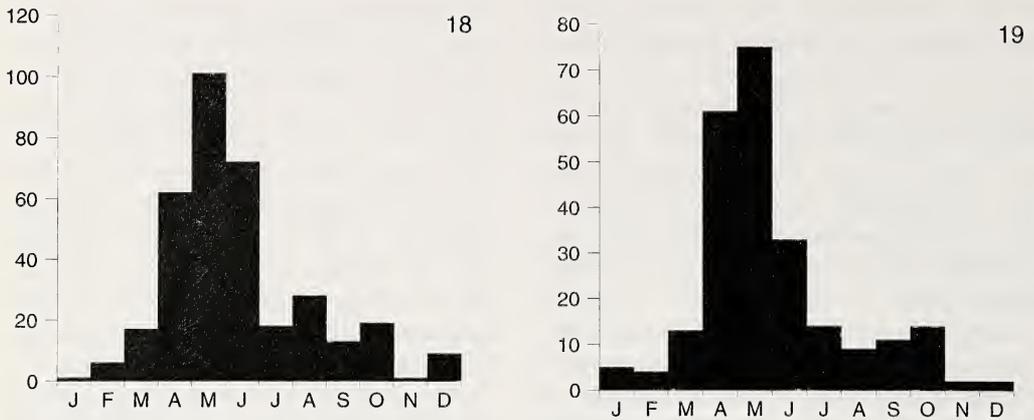


Fig. 18-19. Phenology of *Berosus* in The Netherlands on basis of the number of records; 18, *B. luridus*; 19, *B. signaticollis*.

signaticollis are given in table 2 and 3, respectively. Ranges for acidity are quite wide for both species, but the low median value of especially *B. luridus* indicates that it has a strong preference for acidic waters (acidobiont), while *B. signaticollis* can be considered an acidophilous species. Ranges with respect to electrical conductivity, chlorinity and total hardness are quite wide for both species, but the very low median values for all variables and both species indicate that they can be considered as extreme haloxenic species from soft waters. The wider tolerance for these variables of *B. signaticollis* is in accordance with its distribution pattern in The Netherlands and its occasional occurrence on clay soils. Chemical variables indicate that both species are most often encountered in pools and puddles filled with rain water (on sandy and peaty soils).

The few available data with respect to nutrients indicate that both species are occurring in oligotrophic waters with very low amounts of phosphate and nitrate.

Habitat

The single record of *B. hispanicus* in The Netherlands originates from a heathland pond on the Rechte Heide near Goirle. Schödl (1993) gives many localities for *B. hispanicus*, but very few indications about its habitat, only occasionally lakes and ponds are mentioned. The highest altitude mentioned is ca 2000 m in the High Atlas in Morocco. Gallardo et al. (1997) mentioned semi-permanent streams with a chlorinity of 60-200 mg/l as habitat for *B. hispanicus* in southern Spain.

The Dutch habitats of *B. affinis* can not be deduced from labels on preserved museum material. Everts (1922) mentioned the species from saltings near Bergen op Zoom and it is generally assumed (e.g. Drost et al., 1992) that the species inhabits overgrown, brackish clay-pits. The four known localities are all situated in a region where brackish waters are common and for this reason brackish pools and puddles are assumed to be its Dutch habitat. The recent record of Middelburg (1997) originates from a

Table 2. Number of observations, minimum and maximum, 90% range, and median of some physical/chemical variables on localities with *Berosus luridus*.

	N	min	max	90% range	median
pH	69	3.1	7.5	3.5- 6.8	4.4
EGV ($\mu\text{S}/\text{cm}$)	68	33	1515	53 -400	147
Cl ⁻ (mg/l)	65	6.0	70.0	7.2- 56.8	13.5
°D	41	1	35	1 - 5	2

Table 3. Number of observations, minimum and maximum, 90% range, and median of some physical/chemical variables on localities with *Berosus signaticollis*.

	N	min	max	90% range	median
pH	55	3.1	8.8	3.4- 7.6	5.8
EGV ($\mu\text{S}/\text{cm}$)	53	33	3830	36 -709	176
Cl ⁻ (mg/l)	45	6.0	1090.0	7.9- 58.0	16.2
°D	37	1	46	1 - 25	2

(probably recently excavated) cattle drinking-pool with a surface of 150 m² in a meadow. In this pool with a depth of 1.5 m the vegetation was dominated by *Myriophyllum spicatum* L. (95%) and some floating algae. The marginal vegetation consisted of very sparse *Scirpus maritimus* L. The deep hoofprints in the clay soil around the pool showed that the cattle drank the water and that salinity was not very high. The occurrence of numerous halophilic and halobiont water beetles as *Halipilus apicalis* Thomson, *Hygrotus parallelogrammus* (Ahrens), *Ochthebius marinus* (Paykull), *Enochrus halophilus* (Bedel) and *Enochrus bicolor* (Fabricius), together with halotolerant beetles as *Hygrotus confluens* (Fabricius) and *Agabus nebulosus* (Forster) indicated, however, that the salinity was not very low. In England *B. affinis* seems to be more or less restricted to brackish waters and, more inland, to clay and sand pits (Balfour-Browne, 1958). Koch (1989) refers to *B. affinis* as an eurytopic species from stagnant waters with much detritus. On a few occasions Schödl (1993) mentions lakes, ponds and streams from sea level up to 1000 m as habitat. Sáinz-Cantero & Alba-Tercedor (1991) report *B. affinis* from the Sierra Nevada (Spain) from an altitude of 1200 m. The species is certainly not restricted to brackish waters as many specimens have been collected far inland in fresh waters in France, Spain, Portugal (personal observations) and Italy (Schödl, 1993). Climatological factors could be very well responsible for the temporary establishment of populations in Dutch (brackish) waters.

Also for *B. fulvus* there are no indications on labels of museum material concerning the habitat of the species. However, Kempers (1897) mentions one specimen (as *B. spinosus*) from Texel collected in brackish water.

This specimen, a male, was recovered in the collection of RNMH and appeared to be *B. fulvus*. Later, Kempers (1928) mentioned *B. spinosus* from brackish waters in the province of Zeeland (material in RNMH, ZMA, LUW-Entomologie). Part of this material from Vlissingen belonged to *B. fulvus*. In northern and western Europe *B. fulvus* seems to be restricted to brackish coastal areas (Foster, 1992; Hansen, 1992; Nilsson, 1994), but in eastern Europe and Asia the species is found also inland and even at high altitudes (1650 m; Schödl, 1991). Probably most of these inland localities are salt lakes.

Labels on specimens of *B. spinosus* in Dutch collections give no indications about its habitat with one exception. The female specimen from Oud Vossemeer was taken in a probably brackish pond as it was surrounded by *Scirpus maritimus* L. and was taken together with the water bug *Sigara stagnalis* (Leach), generally occurring in brackish waters (Nieser, 1982). The specimen from Almere was collected in a shallow ditch with a chlorinity of nearly 700 mg/l on clay covered by a rather thick layer of black detritus. The vegetation in this unshaded ditch consisted of *Potamogeton pectinatus* L. (40%) and *P. pusillus* L. (30%) and algae, with a sparse emergent vegetation of mainly *Agrostis stolonifera* L. along the margins. Among the 41 species of water beetles collected, *Enochrus bicolor* was the only halophilic species. Kempers (1928) mentions *B. spinosus* from brackish waters in the province of Zeeland (material collected by him and S. Lako from Vlissingen en Middelburg in RNMH, ZMA, LUW-Entomologie). For *B. spinosus*, Burmeister (1982) mentions chlorinities of ca 4000 mg/l for the localities Westkapelle en Zoutelande (but records may refer to *B. fulvus*) and describes these locali-

ties extensively. *Berosus spinosus* seems to be more or less restricted to (brackish) coastal areas (Schödl, 1991; Hansen, 1987, 1992; Nilsson, 1994) in northern and western Europe, but in central, southern and eastern Europe and Asia there are many inland records (Schödl, 1991). They probably refer to inland salt lakes and ponds (Koch, 1989) in areas with an evaporation surplus. The highest altitude where the species was found is 1650 m (Schödl, 1991).

Berosus luridus is most frequently sampled in heathland pools and puddles, peat-pits, and, occasionally, in dune pools and isolated ditches. Brackish and running waters are avoided, as well as waters with a clayish soil. The waters are sun-exposed, shallow, filled with rain water and often temporary. Soils are mostly covered by only a thin detritus layer, but occasionally with a thick one. Most often the vegetation in the water is dominated by *Sphagnum*, while the bordering dominant emergent vegetation usually consists of *Juncus bulbosus* L., *Juncus effusus* L., *Molinia caerulea* (L.) Moench, *Eriophorum angustifolium* Honckeny, *Erica tetralix* L. and *Calluna vulgaris* (L.) Hull. Floating leaved plants are normally absent. Koch (1989) mentions *B. luridus* from more or less shaded stagnant waters, which is a very broad concept and not in agreement with Dutch observations (sun-exposed). The habitat description of Hansen (1987) is in agreement with the Dutch one except that the species does not occur under rather eutrophic conditions nor on clay soils. The habitat description of Balfour-Browne (1957) is much too wide in comparison with Dutch conditions. The highest altitude mentioned by Schödl (1993) for *B. luridus* is 650 m, but higher altitudes are likely on the basis of the reported sampling localities.

The usual habitat for *B. signaticollis* is the same as for *B. luridus*, but *B. signaticollis* is more frequent in the dune area. Also, but occasionally, the species has been observed on clay soils and in slightly brackish waters. Under these circumstances *B. signaticollis* is characteristic for recently excavated ditches or pools on mineral soils with clear water and a

sparse vegetation, and usually occurs then in very low numbers. In agreement with its occurrence under pioneer conditions, one flying male of *B. signaticollis* was taken at light on 6 June 1997 near Tilburg by H. Spijkers (coll. P. S. van Wielink). Koch (1989) and Hansen (1987) mention *B. signaticollis* as a typical inhabitant of moors (heathland pools) which agrees with its Dutch habitat. In addition Koch (1989) reports also clay pits which is in accordance with Dutch data. The highest altitude mentioned by Schödl (1993) for *B. signaticollis* is 700 m, but higher altitudes seem likely on the basis of the reported sampling localities.

Discussion

Four out of the six *Berosus*-species ever collected in The Netherlands are considered extinct (*B. fulvus*) or have been taken only very incidentally since 1975 (*B. affinis*, *B. hispanicus* and *B. spinosus*). Their habitats only can be described in general terms as they have never been described explicitly, and insufficient labelling in the past prohibits to do so. Localities in which populations of one of these species turn up should be protected by maintenance of the present management.

Both *Berosus luridus* and *B. signaticollis* are mainly confined to sandy and peaty pools, ponds, ditches and small lakes filled with rain water in nature reserves. Both species are, despite the large number of records, rather rare and often taken together. Their preferred habitat, oligotrophic heathland ponds, has declined in numbers since the beginning of the 20th century due to reclamation and increased use of (artificial) fertilizers. Acid precipitation has, however, increased the number of acidic pools during the second half of the century. Distribution patterns of both species have hardly changed during the last century, though *B. signaticollis* has increased in the western part of the country during the last twenty years. A decrease in the number of recorded grid-squares (fig. 13) and specimens since 1975 (table 1) is, however, clear for *B. luridus*, while the number of grid-squares (fig. 14) and

specimens since 1975 (table 1) increased in *B. signaticollis*. An obvious reason for this shift can not be deduced from the available data.

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