

The riparian spider fauna (Araneae) of the river Gaula, Central Norway: implications for conservation efforts

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Abstract

The riparian spider fauna of the river Gaula near Trondheim, Central Norway, has been investigated in spring/summer 1994 by means of pitfall traps, limited sieving and hand picking. Sites varied from sand and gravel banks completely devoid of vegetation, to sand/silt deposits with or without vegetation and *Salix triandra/Alnus incana* forests on sandy soil. These special habitats turned out to harbour a very special and remarkable spider fauna. Two species were recorded for the first time in Fennoscandia: *Arctosa stigmosa* and *Caviphantes saxetorum*, both being the northernmost records in Europe. Two species were new to Norway: *Singa nitidula* and *Myrmarachne formicaria*, and 10 species were new regional records.

The spider fauna of the river banks consists of the following ecological groups based on their known ecology in Norway: (1) riparian species, both psammophilous and lithophilous, (2) hygrophilous species, (3) pioneer species, (4) ubiquitous species, and (5) accidental guests from nearby habitats. Group (1) represents about 29% of the total number of species. The isolated occurrence of rare riparian species is paralleled by riparian beetles (Coleoptera). Central Norway harbours one of the richest and most diverse riparian faunas of Northern Europe.

The river Gaula is protected by law against hydroelectric exploitation but about 65 km of the river banks have been destroyed by the construction of flood preventing walls and both riparian beetles and spiders have disappeared from many sites. Most of the riparian species are vulnerable to human disturbance and changes in the flooding pattern of the river and four are included in the Norwegian Red List with the status 'Declining, care demanding'. Protection measures include reduction of silt/sand removal, adaptation of flood preventing walls to suit the riparian fauna, reduction of leisure activities on particularly vulnerable localities and the designation of certain particularly valuable sites as Nature Reserves or Protected Sites. Clear-cutting and management of vegetation in order to maintain the open areas should also be considered.

Key words: Riparian spiders, central Norway, biological conservation

INTRODUCTION

Undisturbed river bank ecosystems are rare and threatened in Europe today (e.g. Plachter 1986), including Norway (DN 1999a), and it has become increasingly urgent to document the fauna and flora restricted to and dependent upon this habitat type. The flora is in general well-known, while the study of the riparian

invertebrate fauna is still in its infancy (Tischler 1993). With regard to spiders, some of the first ecological studies on the riparian spider fauna were the works by Schenkel (1932), Knülle (1953) and Casimir (1962). Most of the recent research has been carried out in central parts of continental Europe (e.g. Beyer 1995; Beyer & Grube 1997; Framenau 1995; Hügenschütt 1996;

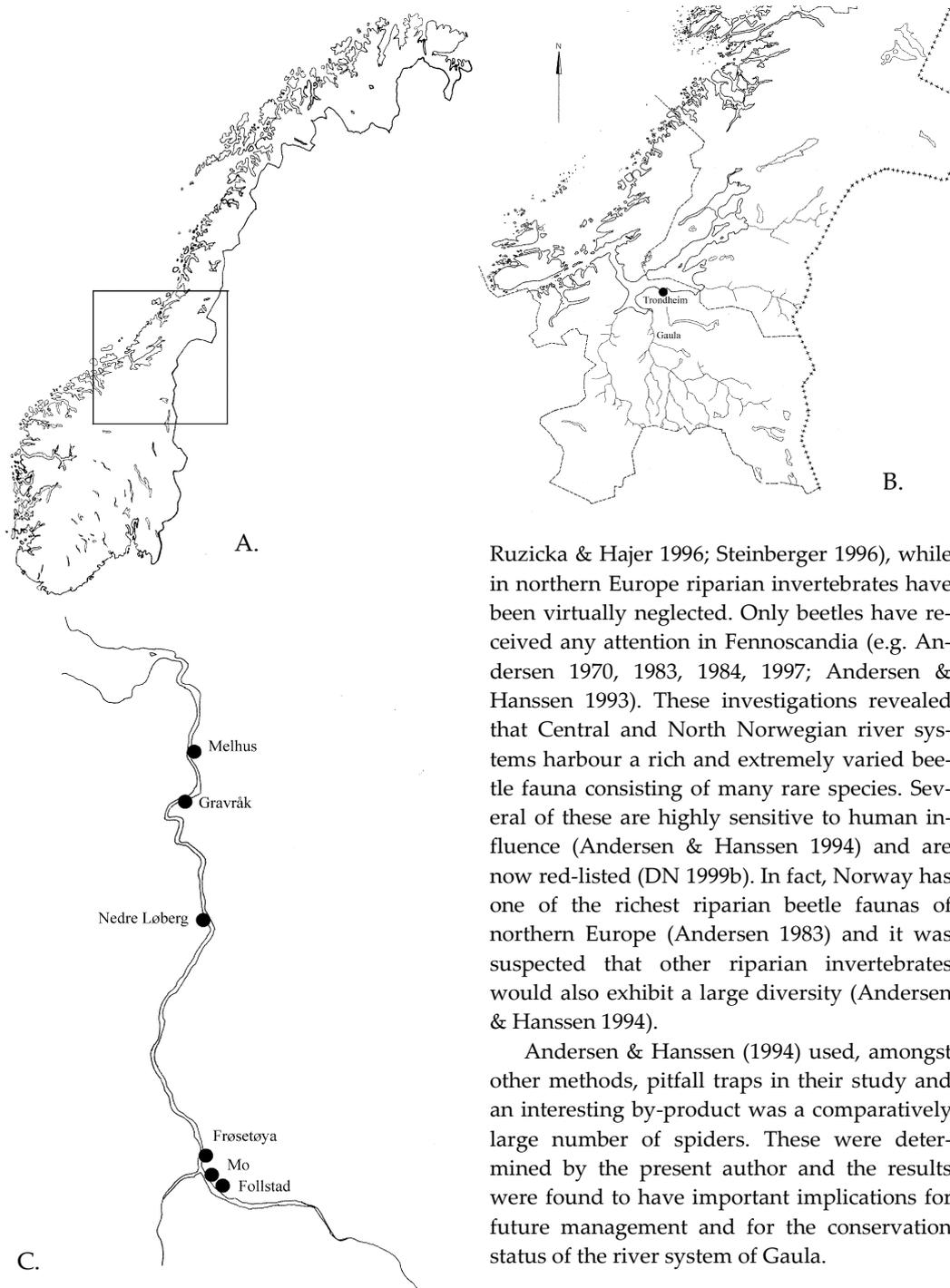


Fig. 1. (A) The study area in Central Norway. (B) Major rivers in the Trøndelag counties. (C) Study sites along the river Gaula.

Ruzicka & Hajer 1996; Steinberger 1996), while in northern Europe riparian invertebrates have been virtually neglected. Only beetles have received any attention in Fennoscandia (e.g. Andersen 1970, 1983, 1984, 1997; Andersen & Hanssen 1993). These investigations revealed that Central and North Norwegian river systems harbour a rich and extremely varied beetle fauna consisting of many rare species. Several of these are highly sensitive to human influence (Andersen & Hanssen 1994) and are now red-listed (DN 1999b). In fact, Norway has one of the richest riparian beetle faunas of northern Europe (Andersen 1983) and it was suspected that other riparian invertebrates would also exhibit a large diversity (Andersen & Hanssen 1994).

Andersen & Hanssen (1994) used, amongst other methods, pitfall traps in their study and an interesting by-product was a comparatively large number of spiders. These were determined by the present author and the results were found to have important implications for future management and for the conservation status of the river system of Gaula.

MATERIALS AND METHODS

Most of the material presented here originated from pitfall traps consisting of plastic cups, 66

mm wide and 95 mm deep, dug into the substrate. The catching period started on 13 May 1994 and lasted to 21 August, although the traps were not operated for exactly the same period on all localities. No attempt will therefore be made to compare the catches from the different sites. The traps were emptied on 24 May, 20 June and 24 July.

Limited hand collecting and sieving were also carried out on a few other localities. These methods were not standardised and information on sampling intensity is not available. The resulting material is presented in Table 2.

STUDY AREA

The study sites were situated along the lower part of the river Gaula in Central Norway (Fig. 1). This is the least disturbed major river in the region. Total length of the riverbanks is 114.5 km, catchment area is 3651 km², and about 70% of the total area lies between 300–900 m. above sea level (Stølen 1992). Below the Gaulfossen waterfall the river is heavily influenced by agriculture and construction activities. Some 65 km of river bank has been destroyed by the construction of flood-preventing walls, including as much as 50% below Gaulfossen (Stølen 1992). A highway and railroad track follow the river for most of its length, exerting a considerable influence on the river's topography. The river is protected against hydroelectric development (Stølen 1992).

The lower portion of the river was chosen for study because it contains the highest number of substrate types and habitats. The following localities along the river were studied (Fig. 1C), the first four using pitfall traps and the other three using manual collection methods (habitat descriptions and quality assessment with regard to beetles from Andersen & Hanssen 1994):

Mo (south)

Heterogeneous river banks consisting of gravel and stone deposits near the river and sand/silt deposits close to a former tributary. The heterogeneous state of the deposits is caused by previous disturbance through digging activities. There are numerous temporary ponds and

open sand banks separated by small stands of *Alnus* spp., *Salix triandra* and *Myricaria germanica*. Ten pitfall traps were used.

Mo (north)

Open stone and gravel deposits. Higher elevations covered partly with *Rhacomitrium* spp. and *Astragalus* spp. tufts on sand and gravel. Sand/silt deposits mostly overgrown by *Salix triandra*. Seven pitfall traps were used.

Frøsetøya

Large deposit containing open stone and gravel in the lower part of the 'island', partly grown with *Myricaria germanica*. Smaller occurrences of sand/silt deposits with a little vegetation. Vegetation-free sand banks are currently small and possibly not large enough to sustain many riparian beetle species (Andersen & Hanssen 1994). Eight pitfall traps were used.

Follstad

Large, open and sparsely grown sand deposit situated next to a forested deposit at higher elevation. Several grain sizes of sand present and patches with some silt. Frequently flooded. Number of pitfall traps was not recorded.

Gravråk

Old deposit with sand banks at higher elevations surrounded by deciduous forests (*Alnus* and *Salix triandra*). The upper part contains a small pond created by previous extraction of material. The open sand banks are old, at least 40–50 years.

Melhus

Relatively large sand/silt deposits situated between the river and a tributary. A well-grown *Salix* forest to one side. One of the best investigated sites along the river with regard to beetles and one of the most important localities for riparian species. Extraction of material in the 1970s and –80s did not destroy the locality, but the reduced elevation of the river itself has led to the sand banks becoming overgrown. It is therefore likely that many riparian species are close to extinction here.

Table 1. Spiders collected by pitfall traps at river Gaula, Norway. Underlined: riparian species.

Species	♂/♀	New to	Locality
Araneidae			
<u>Singa nitidula</u> L. Koch, 1844	1/0	Norway	Mo (south)
Clubionidae			
<i>Clubiona lutescens</i> Westring, 1851	1/1	Central Norway	Frøsetøya, Melhus, Mo (south)
Gnaphosidae			
<u>Micaria nivosa</u> L. Koch, 1866	5/8		Follstad, Frøsetøya, Mo
Hahniidae			
<i>Cryphoeca silvicola</i> (C. L. Koch, 1834)	1/0		Mo (north)
Linyphiidae			
<i>Allomengea scopigera</i> (Grube, 1859)	3/1		Mo
<i>Bathyphantes gracilis</i> Blackwall, 1841	1/0		Mo (north)
<i>B. nigrinus</i> (Westring, 1851)	1/2		Mo (north)
<u>Caviphantes saxetorum</u> (Hull, 1916)	0/1	Fennoscandia	Mo (south)
<i>Dicymbium nigrum</i> (Blackwall, 1834)	0/1		Mo (north)
<i>D. tibiale</i> (Blackwall, 1836)	6/0		Mo
<i>Diplocephalus cristatus</i> Blackwall, 1833	4/0		Mo
<i>Diplostyla concolor</i> (Wider, 1834)	0/1		Mo (north)
<i>Dismodicus bifrons</i> (Blackwall, 1841)	2/1		Follstad, Mo (south)
<i>Erigone atra</i> Blackwall, 1833	11/2		Follstad, Mo
<i>E. dentipalpis</i> (Wider, 1834)	3/0		Follstad, Frøsetøya, Mo (south)
<i>Erigonella hiemalis</i> (Blackwall, 1841)	1/0	Central Norway	Follstad
<i>Gongylidium rufipes</i> (Linnaeus, 1758)	2/1		Follstad, Mo
<i>Hypomma bituberculatum</i> (Wider, 1834)	4/1		Follstad
<i>Kaestneria pullata</i> (O.P.-Cambridge, 1863)	2/2	Central Norway	Follstad, Mo (south)
<i>Leptohoptrum robustum</i> (Westring, 1851)	2/2		Mo (nord), Mo (south)
<i>Neriere clathrata</i> (Sundevall, 1830)	0/1		Frøsetøya
<u>Oedothorax agrestis</u> (Blackwall, 1853)	1/0	Central Norway	Mo (nord)
<i>O. apicatus</i> (Blackwall, 1850)	3/0	Central Norway	Mo
<u>O. retusus</u> (Westring, 1851)	192/158		Follstad, Frøsetøya, Mo
<i>Pocadicnemis pumila</i> (Blackwall, 1841)	2/0		Follstad, Mo (north)
<u>Porrhomma pygmaeum</u> (Blackwall, 1834)	1/4	Central Norway	Mo
<i>Savignia frontata</i> Blackwall, 1833	4/7		Mo
<u>Silometopus reussi</u> (Thorell, 1871)	3/0	Central Norway	Mo (north)
<u>Tapinocyba insecta</u> (L. Koch, 1869)	0/1	Central Norway	Mo (south)
<i>Tenuiphantes alacris</i> (Blackwall, 1853)	1/0		Follstad
<u>Troxochrus scabriculus</u> (Westring, 1851)	8/13	Central Norway	Frøsetøya, Mo
<i>Walckenaeria cuspidata</i> (Blackwall, 1833)	2/0		Mo (north)
<i>W. nudipalpis</i> (Westring, 1851)	0/1		Mo (north)
<u>W. vigilax</u> (Blackwall, 1853)	2/0	Central Norway	Follstad
Lycosidae			
<u>Arctosa cinerea</u> (Fabricius, 1777)	4/0		Mo
<u>A. stigmosa</u> (Thorell, 1875) X	31/12	Fennoscandia	Follstad, Frøsetøya, Mo
<u>Pardosa agricola</u> (Thorell, 1856)	73/24		Follstad, Frøsetøya, Mo
<i>P. amentata</i> (Clerck, 1757)	75/35		Follstad, Frøsetøya, Mo
<i>P. lugubris</i> (Walckenaer, 1802)	1/0		Mo
<i>P. riparia</i> (C. L. Koch, 1833)	1/1		Frøsetøya
<i>Trochosa terricola</i> Thorell, 1856	4/4		Follstad, Mo (syd)
Salticidae			
<i>Myrmarachne formicaria</i> (De Geer, 1778)	1/0	Norway	Mo (north)
Thomisidae			
<i>Xysticus audax</i> (Schrank, 1803)	1/0		Mo (south)
<i>X. cristatus</i> (Clerck, 1757)	1/0		Follstad
<i>X. ulmi</i> (Hahn, 1832)	1/0		Mo (south)
TOTAL	460/285		

Table 2. Spider collected by sieving and hand picking at river Gaula, Norway. Underlined: riparian species.

Species	♂/♀	Locality
Clubionidae		
<i>Clubiona lutescens</i> Westring, 1851	1/1	Melhu
Linyphiidae		
<i>Bathypantes nigrinus</i> (Westring, 1851)	1/0	Gravråk
<i>Erigone atra</i> Blackwall, 1833	0/1	Nedre Løberg
<i>E. dentipalpis</i> (Wider, 1834)	6/3	Gravråk, Melhus, Nedre Løberg
<i>Hypomma bituberculatum</i> (Wider, 1834)	3/2	Melhus, Nedre Løberg
<i>Leptorhoptrum robustum</i> (Westring, 1851)	0/1	Melhus
<i>Neriene peltata</i> (Wider, 1834)	1/0	Gravråk
<u><i>Oedothorax agrestis</i> (Blackwall, 1853)</u>		Gravråk, Melhus
<u><i>O. retusus</i> (Westring, 1851)</u>	14/39	Gravråk, Melhus, Nedre Løberg
<u><i>Porrhomma pygmaeum</i> (Blackwall, 1834)</u>	1/0	Nedre Løberg
<u><i>Troxochrus scabriculus</i> (Westring, 1851)</u>	0/6	Gravråk, Nedre Løberg
Lycosidae		
<u><i>Arctosa cinerea</i> (Fabricius, 1777)</u>	1/1	Gravråk
<u><i>A. stigmosa</i> (Thorell, 1875)</u>	1/1	Melhus
<u><i>Pardosa agricola</i> (Thorell, 1856)</u>	3/2	Gravråk, Melhus
<i>P. amentata</i> (Clerck, 1757)	4/2	Gravråk
Tetragnathidae		
<i>Pachygnatha clercki</i> Sundevall, 1823	0/1	Gravråk
TOTAL	34/61	

Nedre Løberg

Large open sand deposits surrounded by *Myricaria germanica*. Mostly coarse sand but with some finer deposits along the vegetation belt. Beyond the *Salix* stands there are stone and gravel deposits. A few flats of silt close to an artificial gravel formation. Previous extraction of material is evident but a few riparian beetles have managed to re-establish populations here.

RESULTS

Altogether 745 specimens belonging to 45 species from 8 families were collected by pitfall traps (Table 1), and 98 specimens belonging to 16 species from 4 families (Table 2) were taken by manual methods. The latter method yielded only two species not taken by the pitfall traps. Linyphiids dominated the material, being represented by 30 species, followed by lycosids with 7 species and thomisids with 3 species. All other families were represented by a single species. In terms of individuals the linyphiids made up some 62% of the pitfall material and the lycosids some 36%. The dominance of the linyphiids was largely due to the preponderance of one species, *Oedothorax retusus*, which made up 47% of the total pitfall material. The species was also the most numerous in the manually collected mate-

rial. Apart from *Pardosa amentata*, *P. agricola* and *Arctosa stigmosa*, the other species were taken in relatively small numbers.

A great number of faunistic and ecologically interesting species were discovered, including two new to Fennoscandia, two new to Norway and 10 not previously recorded from the central parts of Norway. All but one of the species new to Norway/Fennoscandia (*Myrmarachne formicaria*) are riparian. As many as 13 species may be classified as riparian species (following the definition of Andersen 1983). The most important new records are presented in Aakra (2000).

The following ecological groups of species may be recognised (based on published and unpublished Norwegian material), although it should be noted that the habitat preferences of some species may differ from that recorded in other regions of Europe:

- Riparian species, both psammophilous (sand preferents) and lithophilous (gravel preferents). They include *Arctosa cinerea*, *A. stigmosa*, *Pardosa agricola*, *Singa nitidula*, *Micaria nivosa*, *Caviphantes saxetorum*, *Oedothorax agrestis*, *O. retusus*, *Silometopus reussi*, *Tapinocyba insecta*, *Troxochrus scabriculus* and *Walckenaeria vigilax*. With the exception of *A. stigmosa*, *C. saxetorum*

and *S. nitidula* these species have also been found in other habitat types (mainly sandy beaches) in southern parts of Norway, but in Central Norway comparable habitats are scarce or absent and the species are therefore considered riparian within the region.

- Hygrophilous species, which may be found in a variety of moist habitats, including *Clubiona lutescens*, *Allomengea scopigera*, *Bathypantes gracilis*, *B. nigrinus*, *Gongylidium rufipes*, *Hypomma bituberculatum*, *Savignia frontata*, *Pardosa amentata* and *Trochosa terricola*.

- Pioneer species, *Erigone atra* and *E. dentipalpis*.

- Ubiquitous species, which are found in a wide variety of habitats in Norway, such as *Xysticus cristatus*, *Walckenaeria cuspidata* and *W. nudipalpis*.

- Accidental guests from nearby habitats, mainly forest species like *Pardosa lugubris s. str.*, *Cryphoeca silvicola*, *Dicymbium tibiale* and *Tenuiphantes alacris*.

Group (1) represents about 29% of the total number of species. In other words, the riparian fauna of Gaula consists of a comparatively large number of species which are unlikely to be found in other habitats in the region. It is also obvious that the river banks, including the *Alnus* and *Salix triandra* forests, are important for a wide range of hygrophilous species.

DISCUSSION

Studies suggest that riparian spiders have behavioural adaptations to cope with frequent inundations in what is a very variable and harsh environment (Cooke & Merrett 1967; Siepe 1985). The continental studies also show that river banks harbour a very rich and diverse spider fauna with a large number of extremely rare species, many of which are not or only occasionally encountered in other habitats (Steinberger 1996).

The results presented here fully corroborate this notion. From a comparatively modest spider material, 29% were classified as riparian and at least five of them are rare or uncommon in Norway with no, or only very few, previous records. The vulnerability of these species is best highlighted by examining the species' habitat requirements, distribution and general

conservation status in some detail. The noteworthy species may be divided into two groups: species rare and uncommon throughout their known range; and more frequently recorded species which are, however, rarely found in central Norway where comparatively few appropriate habitats are available.

Arctosa cinerea

The known distribution of this species in Norway has been described by the author (Aakra 2000). Distribution in central Norway, including older records, is rather extensive. There is also one older, unverified record from coastal sand dunes in south-eastern Norway (Strand 1898). Unfortunately, the species has disappeared from at least one known locality along Gaula, a serious indication of the species' vulnerability to habitat changes (see Framenau 1995). In Sweden, the species occurs on sandy lake and sea shores north of Norrbotten (Holm 1947). It is only known from coastal parts of southern and central Finland and sandy inland habitats of northern Finland (Krogerus 1932; Palmgren 1939). The species is widely distributed in Europe at least as far south as Italy, but it has clearly been declining in numbers in at least Switzerland and Germany (see Framenau 1995).

A. cinerea is strongly psammophilous, preferring sites with a mixture of sand and shingle (Framenau 1995) in both coastal sand dunes as well as along rivers and by estuaries. It was given the Red List category 'Declining, care demanding' by Aakra & Hauge (2000).

Arctosa stigmosa

This is perhaps the most surprising arachnological discovery in recent times in Norway, being the first record from Fennoscandia and the northernmost in Europe. A single specimen has also been found by the river Orkla to the west of Gaula. It is likely that *A. stigmosa* can be found in the other major river systems in the Trøndelag counties, e.g. where *A. cinerea* has been found outside saline habitats.

The species was previously known from scattered localities in central parts of continen-

tal Europe, the closest known occurrences are from Baltikum (Relys 1994; Mikhailov 1997) and Poland (J. Kupryjanowicz pers. comm.). Known European records are from France, Romania, Bulgaria, Hungary, Slovakia, southern Germany, Switzerland (Denis 1937; Buchar 1968; Maurer & Hänggi 1990; Blick & Scheidler 1991; Blick et al. 2000; Framenau 1995; Steinberger 1996), and the species ranges eastwards through southern Siberia (Mikhailov 1997), China and Korea to Japan (Paik 1994 sub *A. subamylacea* (Bösenberg & Strand, 1906). In continental parts of Europe it is very rare and local (Buchar & Thaler 1995; Steinberger 1996).

Little is known of the ecology of this species which is apparently confined to sand and gravel-covered river banks. It is almost certainly not halotolerant like *A. cinerea*. It does not appear to construct a burrow in the sand, but probably spends the day in litter close to the river banks. Preliminary studies suggests that *A. stigmosa* is nocturnal (Aakra 2000). The species is probably just as vulnerable to habitat deterioration as *A. cinerea* and was given the same Red List category by Aakra & Hauge (2000).

Caviphantes saxetorum

Another first record for Fennoscandia. Based on available literature *C. saxetorum* is rare throughout its range. The closest known occurrence is Scotland (Cooke & Merrett 1967; Locket et al. 1974) and the species is otherwise known from central parts of continental Europe (Georgescu 1973; Wunderlich 1975, 1979; Maurer & Hänggi 1989; Steinberger 1996; Thaler 1993), Poland (Starega 1972), Russia (Mikhailov 1997) and North America (Crawford 1990).

The principal habitat appears to be sand banks along rivers (Locket et al. 1974; Steinberger 1996) but there are also records from dry ruderal sites (Wunderlich 1975; Maurer & Hänggi 1989). Apparently the species occupies the spaces between rocks and sand which would classify it as microcavernicolous (Cooke & Merrett 1967; Wunderlich 1979). Presence of sand seems to be a requirement for this species, probably with

high moisture levels. The species was given the status 'Declining, care demanding' in the Norwegian Red List (Aakra & Hauge 2000).

Myrmarachne formicaria

New to Norway and the northernmost record in Europe. This species is probably not a riparian element. In Sweden it is known to occur as far north as Värmland (L.J. Jonsson pers. comm.), whereas in Finland it is only known from the southern coastal region (Palmgren 1943).

Heimer & Nentwig (1991) report the species to be found in a variety of habitats: The current record is in accordance with Tullgren (1944) who indicated a preference for spaces beneath flat rocks on warm beaches.

Singa nitidula

This is the first and hitherto only known record from Norway. The species is apparently rare in both Sweden (L.J. Jonsson and T. Kronstedt pers. comm.) and Finland (Palmgren 1974) where it occurs from Uppland and Dalarna and north to the end of the Botnian Bay, respectively. It was recently placed on the Swedish Red List under 'Data Deficient' (Gärdenfors 2000) and the Norwegian Red List (Aakra & Hauge 2000) as 'Declining, care demanding'. *S. nitidula* is usually found in low vegetation and litter along streaming water (Palmgren 1974) and can therefore be classified as riparian.

Species commonly found along the river

A relatively large number of species are common along the rivers of central Norway (this paper, unpublished data), but for several of them (e.g. *Silometopus reussi*, *Tapinocyba insecta*, *Troxochrus scabriculus*, *Walckenaeria vigilax*) there are no other records in this area and they may be restricted here to river banks. Other species are almost certainly found in other habitats as well, but preliminary data suggests that sand and gravel banks along rivers constitute their main habitat in central Norway (e.g. *Micaria nivosa*, *Oedothorax agrestis*, *O. retusus*, *Pardosa agricola*). It is therefore obvious that the river banks are important not only for rare and

stenotopic species, but also for more widespread and eurytopic species. Focus should therefore not be restricted to the rare and faunistically interesting species, but extended to the whole river bank community and its role in the ecosystem.

Conservation of the riparian invertebrate fauna

Although the river Gaula is protected by law against hydroelectric developments, other human activities pose a severe threat to the riparian invertebrate fauna. Specifically, the river banks are not protected against construction of flood preventing walls, leisure activities or other common human disturbance factors. New roads are planned which will be situated close to the river. Furthermore, the nearby flood-influenced forests and meadows are often chopped down or converted to agricultural land, a practice which deprives the riparian species of their winter quarters (Andersen & Hanssen 1994). In other words, the legislated protection of the river systems does not, in practice, fulfil its purpose for the riparian invertebrates. These animals are dependent upon the river's regular flooding, which is in contrast to the human interest in taming the river by the construction of flood preventing walls. The continued survival of the riparian species depends on future management decisions. Several solutions to this problem were proposed by Andersen & Hanssen (1994), including:

- cessation of sand and silt extraction,
- placement of flood reducing walls only when the effect on deposition of sand and silt will be minimal,
- creation of suitable habitats for the species by removing parts of the forests and alluvial vegetation.

In light of the rare and remarkable species recently discovered along the river, I propose a few additional conservation measures:

- designation of the largest sand bank areas as Nature Reserves,
- prohibition of extensive leisure and construction activities in these sites,
- monitoring procedures and further research

along Gaula and other major river systems in order to assess the status and range of the rare species.

Whether the rare riparian invertebrate species along Gaula can be preserved for future generations remains to be seen. Given its uniqueness in a north European context, the number of rare and vulnerable species (both beetles and spiders) found there, and the apparent decline of some species in recent years, it is obvious that such precautions cannot be implemented too soon. If no actions are taken by the local and/or national authorities, the future of species like *Arctosa cinerea*, *A. stigmosa* and *Caviphantes saxetorum* may seem bleak, indeed.

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