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Spider distribution patterns along the tidal River Scheldt (Belgium)

Frederik Hendrickx[1], Jean-Pierre Maelfait[2], Wouter Muylaert[2] and **Maurice Hoffmann[2]**

[1]Laboratory of Ecology, Biogeography and
Nature Conservation, University of Ghent,
K. L. Ledeganckstraat 35, 9000 Ghent, Belgium

[2]Institute of Nature Conservation,
Kliniekstraat 25, 1070 Brussels, Belgium

Summary

The spider fauna of the tidal part of the River Scheldt has been investigated. Although quite low numbers of species were encountered, some very rare spiders, such as *Tmeticus affinis*, *Baryphyma duffeyi*, *Donacochara speciosa* and *Hypomma fulvum*, were found in very high numbers. In correlation with the salinity gradient, two spider communities can be distinguished. The freshwater part of the river is characterized by the high abundance of *Tmeticus affinis*, *Diplocephalus permixtus* and, to a lesser extent, *Donacochara speciosa*. Typical species of the brackish part are *Baryphyma duffeyi*, *Pardosa purbeckensis* and, although not a halophilous spider, *Clubiona juvenis*. *Hypomma fulvum* was very abundant along the total length of the estuary. The degree to which the high level of pollution may have affected these spider communities is difficult to judge, owing to the lack of data collection in the past. It is possible that some species are lacking, or are only represented in low densities, in the freshwater part, owing to the low habitat quality caused by pollution.

Introduction

The River Scheldt (Fig. 1) is a typical lowland river with a fall of about 120 m over a total length of about 350 km. It rises in St Quentin in France, runs for some 300 km through Belgium, and flows into the North Sea in The Netherlands. Because of its low fall, sea water enters and leaves the lower part of the river twice a day with the tides. This tidal variation extends about 160 km upstream and is stopped at the sluice gates near Ghent, where the difference between low and high water level is still some 2 m. This tidal influence leads to two special aspects of the river. First, a long gradient, going from fully saline sea water through brackish to fresh water is present; generally speaking, sea water does not reach much further than the city centre of Antwerp. Second, the river banks are flooded twice a day, giving rise to tidal marshes. These tidal marshes, situated in the freshwater part of the river, are unique in Europe.

The vegetation of the tidal marshes in the freshwater part of the estuary consists mainly of reed (*Phragmites australis*) and willow scrub (*Salix* sp.). Along the brackish part of the river, the vegetation consists mainly of salt grasslands with some patches of reed on the higher parts.

The water and underwater soils of the river have a very high pollution level caused, amongst other things, by accumulation of trace metals such as Cd, Zn and Cu. There is a strong tendency towards a higher Zn, Pb, Ni, Cu and Cd content as the percentage of marine mud declines. The same is true for the soils of the intertidal flats: as the percentage of marine silt declines, higher levels of these heavy metals are found (Zwolsman & Van Eck, 1993). Pollution levels on the banks of the river have received much less attention, although there are heavy concentrations in the spiders living on the tidal marshes (Maelfait & Hendrickx, 1998).

Whilst many investigations have been carried out, mostly on birds and plants, terrestrial invertebrates have received only little attention. Our main aim was to answer the following two questions: (1) are there some spider species typical of this unique habitat despite its heavy pollution? and (2) what are the main factors

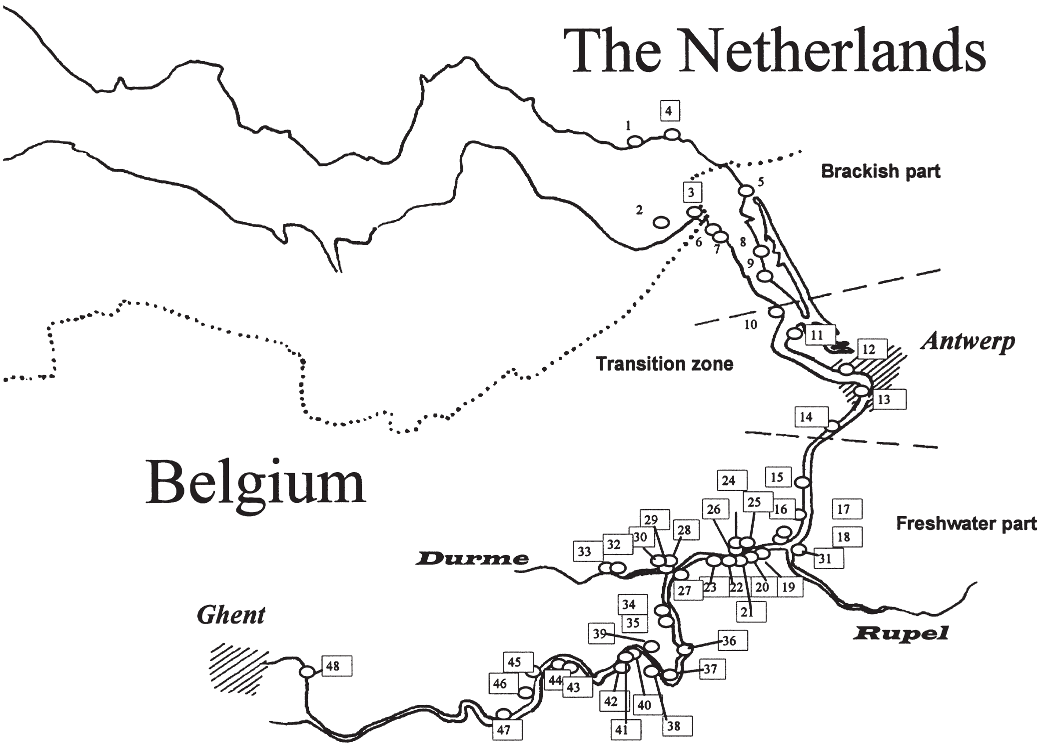

Fig. 1: Map of the River Scheldt showing the locations of the 48 permanent quadrats.

affecting the distribution of the different spider species along this river?

Material and methods

Most studies on spider communities make use of pitfall trapping for standardized collecting of spiders. Because of the regular flooding of these tidal marshes, pitfall trapping was impossible. Instead, we conducted 30 minutes of pooter collecting per site as a sampling unit. Preliminary sampling of the spiders occurring on the banks of the river took place at the end of May and the beginning of June, 1992, the main collections took place during July 1995, August 1995 and May 1996. In this second sampling campaign, 48 permanent quadrats, all restricted to reed belts, were sampled once during each sampling period mentioned above. Of the 48 permanent quadrats, 10 were situated in the brackish zone, 4 in the transition zone and 34 in the freshwater zone. During the two sampling campaigns, a total of 194 collections were carried out: 140 in the freshwater part of the estuary, 17 in the transition zone, and 37 in the brackish part. Owing to the lower number of brackish marshes than freshwater marshes, catching effort could not be evenly distributed over the different types of marsh.

On the 48 permanent sampling sites of the second sampling campaign, salt content of the soil water (mg Cl^{-}/l), percentage litter cover of the soil (%), inundation frequency (number of inundations/month), and reed density (number

Table 1: Number of individuals caught in the three types of marshes occurring along the River Scheldt. Numbers of individuals caught in the brackish and the transition zone were transformed to the (rounded) numbers that would have been caught in 140 sampling units (catches) to make the catches more comparable (see text). Species of special faunistic interest are in bold type.

BRACKISH MARSHES

***Hypomma fulvum* Bösenberg, 1902**	1922
***Baryphyma duffeyi* (Millidge, 1954)**	1676
Clubiona phragmitis C. L. Koch, 1843	870
Pirata piraticus (Clerck, 1757)	219
Lepthyphantes tenuis (Blackwall, 1852)	114
Bathyphantes gracilis (Blackwall, 1841)	95
***Clubiona juvenis* Simon, 1871**	95
Hypomma bituberculatum (Wider, 1834)	91
***Pardosa purbeckensis* (F. O. P.-Cambridge, l895)**	76
Pachygnatha clercki Sundevall, 1823	64
Diplocephalus permixtus (O. P.-Cambridge, 1871)	61
Erigone atra (Blackwall, 1841)	49
Bathyphantes approximatus (O. P.-Cambridge, 1871)	45
Oedothorax retusus (Westring, 1851)	45
Erigone sp. juv.	42
Oedothorax sp. juv.	42
***Donacochara speciosa* (Thorell, 1875)**	30
Oedothorax fuscus (Blackwall, 1834)	23
Pardosa prativaga (L. Koch, 1870)	15
***Microlinyphia impigra* (O. P.-Cambridge, 1871)**	11
Trochosa ruricola (Degeer, 1778)	11
Clubiona stagnatilis Kulczyński, 1897	8
Diplostyla concolor (Wider, 1834)	8
***Erigone longipalpis* (Sundevall, l830)**	8
Gnathonarium dentatum (Wider, 1834)	8
Porrhomma pygmaeum (Blackwall, 1834)	8
Sitticus sp. juv.	8
Troxochrus scabriculus (Westring, 1851)	8
***Aphileta misera* (O. P.-Cambridge, 1879)**	4
Clubiona subtilis L. Koch, 1867	4
Erigone dentipalpis (Wider, 1834)	4
Gongylidiellum vivum (O. P.-Cambridge, 1875)	4
***Halorates reprobus* (O. P.-Cambridge, 1879)**	4
Lathys humilis (Blackwall, 1855)	4
Milleriana inerrans (O. P.-Cambridge, 1884)	4
Oedothorax apicatus (Blackwall, 1850)	4
Ozyptila sp. juv.	4
Pardosa palustris (Linnaeus, 1758)	4
Porrhomma microphthalmum (O. P.-Cambridge, 1871)	4
***Porrhomma oblitum* (O. P.-Cambridge, l870)**	4
Tiso vagans (Blackwall, 1834)	4
***Tmeticus affinis* (Blackwall, l855)**	4

TRANSITION ZONE

Clubiona phragmitis C. L. Koch, 1843	1474
Gnathonarium dentatum (Wider, 1834)	733
***Hypomma fulvum* Bösenberg, l902**	445
Pirata piraticus (Clerck, 1757)	272
Bathyphantes gracilis (Blackwall, 1841)	222
***Donacochara speciosa* (Thorell, l875)**	198
Erigone atra (Blackwall, 1841)	82
Diplocephalus permixtus (O. P.-Cambridge, 1871)	66
Bathyphantes approximatus (O. P.-Cambridge, 1871)	49
Erigone sp. juv.	41
Lepthyphantes tenuis (Blackwall, 1852)	25
Pachygnatha clercki Sundevall, 1823	16
Pardosa prativaga (L. Koch, 1870)	16
Theridion sp. juv.	16
Arctosa leopardus (Sundevall, 1833)	8
***Clubiona juvenis* Simon, 1871**	8
Diplostyla concolor (Wider, 1834)	8
Erigone vagans Audouin, 1826	8
***Microlinyphia impigra* (O. P.-Cambridge, 1871)**	8
Robertus lividus (Blackwall, 1836)	8
***Tmeticus affinis* (Blackwall, 1855)**	8

FRESHWATER MARSHES

Clubiona phragmitis C. L. Koch, 1843	1127
Diplocephalus permixtus (O. P.-Cambridge, 1871)	846
Pirata piraticus (Clerck, 1757)	745
***Tmeticus affinis* (Blackwall, 1855)**	636
Bathyphantes gracilis (Blackwall, 1841)	529
***Hypomma fulvum* Bösenberg, 1902**	477
***Donacochara speciosa* (Thorell, 1875)**	261
Erigone atra (Blackwall, 1841)	119
Pachygnatha clercki Sundevall, 1823	102
Gnathonarium dentatum (Wider, 1834)	74
Lepthyphantes tenuis (Blackwall, 1852)	49
Erigone vagans Audouin, 1826	35
Porrhomma pygmaeum (Blackwall, 1834)	19
Erigone sp. juv.	17
Oedothorax fuscus (Blackwall, 1834)	12
Oedothorax sp. juv.	12
Erigone dentipalpis (Wider, 1834)	11
Bathyphantes approximatus (O. P.-Cambridge, 1871)	8
Oedothorax agrestris (Blackwall, 1853)	8
Oedothorax retusus (Westring, 1851)	8
Clubiona reclusa O. P.-Cambridge, 1863	6
Diplostyla concolor (Wider, 1834)	5
Larinioides cornutus (Clerck, 1757)	5
Theridion pictum (Walckenaer, 1802)	5
Theridion sp. juv.	5
***Microlinyphia impigra* (O. P.-Cambridge, 1871)**	4
Savignya frontata (Blackwall, 1833)	4
Tetragnatha sp. juv.	4
Theridion bimaculatum (Linnaeus, 1767)	4
Theridion varians Hahn, 1833	3
Meioneta rurestris (C. L. Koch, 1836)	2
***Oedothorax gibbosus* (Blackwall, 1841)**	2
Pachygnatha degeeri Sundevall, 1830	2
Pardosa amentata (Clerck, 1757)	2
Pardosa prativaga (L. Koch, 1870)	2
Pirata hygrophilus Thorell, 1872	2
Antistea elegans (Blackwall, 1841)	1
Araniella sp.	1
***Baryphyma pratense* (Blackwall, 1861)**	1
Clubiona lutescens Westring, 1851	1
Dictyna arundinacea (Linnaeus, 1758)	1
Dicymbium nigrum (Blackwall, 1834)	1
Diplocephalus cristatus (Blackwall, 1833)	1
Dismodicus bifrons (Blackwall, 1841)	1
Enoplognatha ovata (Clerck, 1757)	1
***Erigone longipalpis* (Sundevall, 1830)**	1
Gongylidiellum vivum (O. P.-Cambridge, 1875)	1
Gongylidium rufipes (Sundevall, 1829)	1
***Halorates distinctus* (Simon, 1884)**	1
Metellina sp. juv.	1
Neriene montana (Clerck, 1757)	1
Oedothorax apicatus (Blackwall, 1850)	1
Pirata latitans (Blackwall, 1841)	1
Porrhomma oblitum (O. P.-Cambridge, 1870)	1
Tetragnatha extensa (Linnaeus, 1758)	1
Tetragnatha montana Simon, 1874	1
Trochosa ruricola (Degeer, 1778)	1
***Trochosa spinipalpis* (F. O. P.-Cambridge, 1895)**	1
Walckenaeria nudipalpis (Westring, 1851)	1
Zelotes pedestris (C. L. Koch, 1839)	1

of living stems/m²) were determined. Along the gradient a distinction can be made between the brackish marshes in which the soil salinity exceeds 4000 mg Cl^-/l and the freshwater marshes (< 1000 mg Cl^-/l) (Fig. 1). Because no sharp boundary could be established between those two marshes, we also defined a transition zone with soil salinity between 4000 mg Cl^-/l and 1000 mg Cl^-/l.

Ordination of the 48 permanent quadrats and their species was carried out by conducting a Canonical Correspondence Analysis (Ter Braak, 1988), in which the axes are correlated with the above mentioned environmental variables.

Results and discussion

Table 1 shows the catches of the 194 collections by species in the different parts of the estuary. Species of special faunistic interest are in bold. To make the densities in the different marshes comparable, the numbers caught in the brackish marshes and in the transition zone were recalculated as if 140 collections had been taken. In Figure 2, the scores of the samples and of the species along axes 1 and 2 resulting from a canonical correspondence analysis (CCA) of the collections made in 48 permanent quadrats in the reed-belts are plotted; also shown are the contributions of each environmental variable to each axis. Only the captures of the 8 most abundant species were taken into account.

In total, more than 7000 specimens were identified (including juveniles, if determination was possible) belonging to 74 species. This number of species is quite low compared to investigations with a similar number of individuals. One important reason for this could be the impossibility of web building in such a regularly flooded habitat. This is also obvious when we look at the families/subfamilies to which most of the captures belong: Clubionidae, Lycosidae and Erigoninae. The first two are non-web-building families; for many species of the Erigoninae webs have no or only a marginal role in prey capture. Another reason is probably the monotonous structure of the habitat, mainly consisting of reed-marshes.

As can be seen from Figure 2, salinity seemed to be the most important factor affecting spider distribution along the river, showing a high correlation (r = 0.88) with the first axis. Nevertheless, some important factors such as reed density (correlation with first axis: r = 0.70) and inundation frequency (correlation with first axis: r = –0.56) seemed to show a clear covariation with the salinity of the soil water. Reed belts in the brackish part of the river are situated on a higher level and are thus less frequently inundated.

Freshwater marshes

On the right-hand side of the graphical presentation of the CCA analysis, a quite typical spider community is present within the freshwater marshes, characterized by the high abundance of *Tmeticus affinis, Donacochara speciosa, Diplocephalus permixtus, Hypomma fulvum, Clubiona phragmites* and *Pirata piraticus*. It is the first habitat type in Belgium in which such high densities have been found for the first four species.

Tmeticus affinis, especially, is a very rare species: it is known from only three other localities in Belgium, all reed belts in very wet places. Among the 194 catches, more than 600 individuals of this species, including juveniles, were captured in a variety of situations, such as reed belts widely varying in litter accumulation and willow scrub. In the 48 reed-belt samples (Fig. 2), the absence of this species in brackish marshes is also very obvious. Along the second axis, it has an isolated position clearly correlated with the second axis and shows a slight preference towards the reed belts with a low percentage of litter cover, although this environmental variable was not significantly correlated with this axis (r = –0.44). Following other authors (e.g. Locket & Millidge, 1953; Wiehle, 1960), this species seems not to be solely bound to reed belts; it also seems to occur in other wet eutrophic grassy vegetation. Casemir (1962) made large catches on the borders of a eutrophic marsh in vegetation dominated by *Glyceria maxima*. He found that its numbers strongly declined after long inundations. Crocker & Felton (1972) and Pühringer (1975) found *T. affinis* together with *Tetragnatha striata*. Juveniles of *T. affinis* could easily be determined; they appeared from the end of May and had their highest abundance in August (65% of the individuals). They become adult before winter.

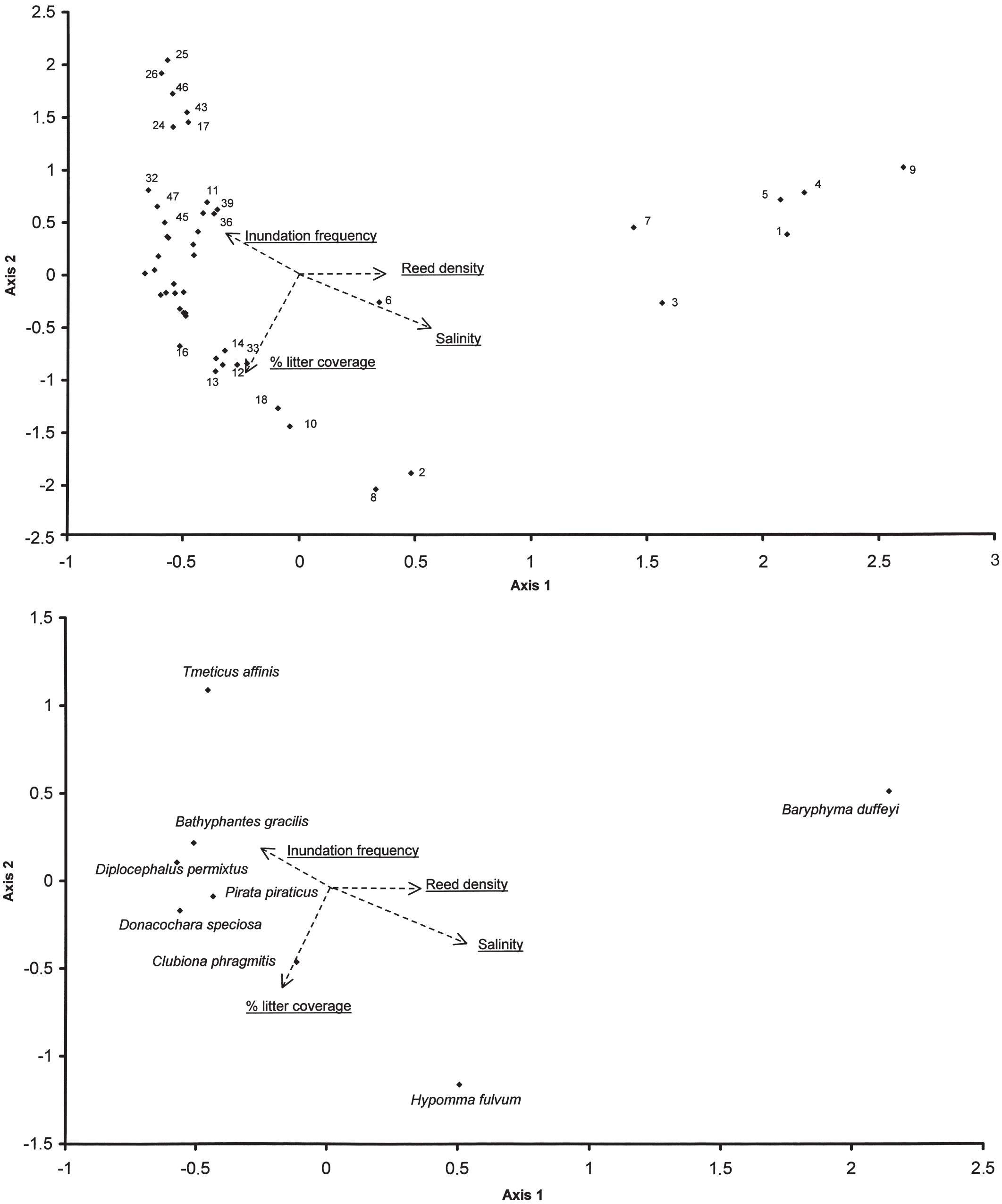

Fig. 2: Species and sample scores of the CCA analysis of the collections made in the 48 permanent quadrats, all located in reed belts. Eigenvalues: axis 1 = 0.594; axis 2 = 0.151.

Although widespread in Belgium, *Diplocephalus permixtus* has almost never been found in such great abundance as in the freshwater part of the Scheldt estuary, equally common in willow scrub as in reed belts. Only a few individuals were found in the brackish part. The highest densities were found at places that are very frequently flooded.

Donacochara speciosa was only found in reed belts.

In contrast to the above-mentioned species, *Hypomma fulvum* also reaches high densities in the brackish part of the river as well as in the freshwater part. It is a species strictly bound to reed; it lays its eggs in the heads of that plant (Duffey, 1991). In Belgium it is an uncommon species occurring almost exclusively in very wet reed belts with accumulation of litter, needed for its overwintering. It was one of the most common species in this study with a total of more than 900 individuals captured (Table 1). In our study area, the highest densities were found in places with a well developed, but not too tightly packed litter layer, which can also be seen from the results of the CCA analysis (Fig. 2). This graph also shows the slight preference of *H. fulvum* for the brackish marshes, which is probably not directly caused by the salt content of the soil, rather by the different structure of the reed belts. As could be noted from an additional sampling in April, adults appeared from the beginning of that month and died before the end of summer (in August there were only 8 adults in a total of 400 individuals of *H. fulvum*).

Brackish marshes

The brackish part of the estuary also has a typical spider community which differs not only in the absence of *Tmeticus affinis* and the higher abundance of *Hypomma fulvum*, as mentioned above, but also in the presence of some halophilous spiders such as *Baryphyma duffeyi*, *Pardosa purbeckensis* and *Halorates reprobus*. No records of these species were made on sites where the soil water salinity was below 4200 mg Cl^-/l. *B. duffeyi*, especially, could reach very high densities in the least dense reedbelts and between fields of *Elymus athericus* with no litter accumulation (up to 20 individuals/m^2). The observed life-cycle pattern was the same as described for *H. fulvum*. *P. purbeckensis* was almost absent from the reed vegetation but was very common in parts of the marshes with low vegetation, such as salty meadows grazed by cattle. One individual of *H. reprobus* was found in a brackish reed marsh highly exposed to tidal movement of the river. Between the reed stems, only some seaweed and some stones were present on the bare, clayey soil. Until our sampling, the species had only been found in the "De Yzermonding" salt marsh in Nieuwpoort. The habitat where it has been found corresponds very well with that described in Decleer & Bosmans (1989).

In addition to these halophilous spiders, there was a remarkable affinity of some non-halophilous spiders to the salt marshes. An example is *Clubiona juvenis*, which is a very rare spider known from only four localities before this study (Decleer & Bosmans, 1989). In Belgium it is only found in very wet, often flooded, reed belts. It has been characterized as a diplostenotopic species also occurring in very dry, grassy vegetation such as marram (*Ammophila arenaria*) dunes (Carter, 1972). The main reason for its preference for the brackish reed marshes is probably the denser structure and the thinner stems of the reed belts occurring there, in contrast to the reed vegetation of the freshwater part of the Scheldt. The brackish reed belts are also situated higher in the marsh and are only rarely inundated.

Transition zone

Although there was no spider species typical of the transition zone, the absence of the halophilous spider species *Pardosa purbeckensis* and *Baryphyma duffeyi*, and the absence of some typical freshwater species such as *Tmeticus affinis* indicate a spider community intermediate between the brackish and the freshwater marshes. On one marsh, unusually high numbers of *Gnathonarium dentatum* were caught in May 1996, leading to a seemingly very high preference of that species for the transition zone.

Concluding remarks

Correlated with the salinity gradient, two spider communities can be distinguished. The freshwater part of the river is characterized by the great abundance of *Tmeticus affinis*, *Diplocephalus permixtus* and, to a lesser extent, *Donacochara speciosa*. Typical species of the brackish marshes are *Baryphyma duffeyi*, *Pardosa purbeckensis* and, although not a halophilous spider, *Clubiona juvenis*. *Hypomma fulvum* was very abundant along the total length of the estuary.

Along the second axis of the CCA, reed-dependent species such as *Hypomma fulvum*, *Donacochara speciosa* and *Clubiona phragmitis* are separated from species not strictly bound to reed belts such as *Tmeticus affinis*, *Baryphyma duffeyi*, *Diplocephalus permixtus* and *Bathyphantes gracilis*. Although litter coverage is not significantly correlated with the second axis, the lesser quantities of litter could play an important role in the absence of reed-bound spider species.

The degree to which the high level of pollution and the habitat degradation of the river banks could have affected these spider communities is difficult to judge due to the lack of data collection in the past. A possible way of evaluating that influence might be the occurrence and the relative abundance of pairs of sister species in the brackish and the freshwater parts respectively. In contrast to the high abundance of *Baryphyma duffeyi*, only one individual of *B. pratense* has been captured in the freshwater part of the river. Although this last species can reach high densities in wet eutrophic marshes with *Phragmithes australis* and *Glyceria maxima* (Casemir, 1962; Decleer, 1989) and it occurs along rivers (Locket & Millidge, 1953; Wiehle, 1960), it is almost absent along the freshwater part of the Scheldt. A similar pattern is the absence of *Pardosa agrestis* in the freshwater part and the high abundance of its sister species *P. purbeckensis* in the brackish marshes. The natural habitat of the former species is indeed described as the banks of large rivers; it is replaced by *P. purbeckensis* in the more saline parts (Locket & Millidge, 1951; Roberts, 1985; Alderweireldt & Maelfait, 1990). Another example of a pair of sister species showing the same pattern is *Halorates distinctus* and *H. reprobus*. We also made the same observation for the terrestrial amphipod *Orchestia gammarellus*, present in tremendous densities in the brackish marshes, and its sister species *O. cavimana*, only found in very low abundance in the freshwater marshes. Although speculative, these patterns might indicate that the freshwater part of the Scheldt estuary was most heavily affected by the post-War pollution and by the loss of natural river banks. It is probably the part in which most biotic recovery is to be expected when the water quality of the Scheldt improves and if measures can be taken to restore more natural river bank habitats.

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