BULLETIN DE L'INSTITUT ROYAL DES SCIENCES NATURELLES DE BELGIQUE, BIOLOGIE, 72: 119-129, 2002
BULLETIN VAN HET KONINKLIJK BELGISCH INSTITUUT VOOR NATUURWETENSCHAPPEN, BIOLOGIE, 72: 119-129, 2002

On the distribution of alien non-marine and estuarine macro-crustaceans in Belgium

by Karel WOUTERS

Abstract

The distributions of fifteen species of macroscopic crustaceans living in non-marine and estuarine environments in Belgium are discussed. The species in question are: the conchostracan *Leptestheria dahalacensis*, the amphipods *Gammarus tigrinus, Echinogammarus berilloni, Dikerogammarus villosus, Corophium curvispinum, Crangonyx pseudogracilis* and *Orchestia cavimana*, the atyid shrimp *Atyaephyra desmaresti*, the crayfish *Astacus leptodactylus, Pacifastacus leniusculus* and *Orconectes limosus* and the crabs *Callinectes sapidus, Eriocheir sinensis* and *Rhithropanopeus harrisii.*

Key-words: alien species, Belgium, cartography, faunistics, Crustacea.

Résumé

Les distributions de quinze espèces de macro-crustacés exotiques vivant dans des milieus non-marins et estuariens en Belgique sont discutées. Les epèces en question sont: le conchostracé *Leptestheria dahalacensis*, les amphipodes *Gammarus tigrinus, Echinogammarus berilloni, Dikerogammarus villosus, Corophium curvispinum, Crangonyx pseudogracilis* et *Orchestia cavimana*, la crevette d'eau douce *Atyaephyra desmaresti*, les écrevisses *Astacus leptodactylus, Pacifastacus leniusculus* et *Orconectes limosus*, et les crabes *Callinectes sapidus, Eriocheir sinensis* et *Rhithropanopeus harrisii.*

Mots-clés: espèces exotiques, Belgique, cartographie, faunistique, Crustacea.

Introduction

There is growing concern about the introduction of alien (neozoan) species, because of their presumed impact on ecologically equivalent native species and on other species, or because of the possible change in ecosystem structure and process. Many alien species, belonging to different zoological groups, have already been observed in Belgian inland waters. This paper aims at inventorying the non-marine and estuarine alien macrocopic crustaceans, which up to now have been observed in Belgium. The results are based on published distributional data, on specimens preserved in the collections of the Royal Belgian Institute of Natural Sciences (KBIN-IRSNB), and on observations by colleague zoologists (personal communications). The present paper was proposed as a poster during the Symposium "Status and trends of the Belgian fauna with particular emphasis on exotic species", held in the Royal Belgian Institute of Natural Sciences, Brussels, on 14 December 2001 (WOUTERS, 2002).

Species accounts

SUBPHYLUM Crustacea PENNANT, 1777
CLASS Branchiopoda LATREILLE, 1817
ORDER Conchostraca SARS, 1867
FAMILY Leptestheriidae DADAY, 1923

Leptestheria dahalacensis (RÜPPEL, 1837)
(Fig. 1)

The species was collected on 26 October and 8 November 1988 (BRENDONCK *et al.*, 1989) in a fishpond in Heverlee (Park Abbey). This Belgian locality should not be considered a natural range extension, because *L. dahalacensis* was most likely introduced in the fishpond when carp, originating from a place near Lake Balaton (Hungary) was brought there. Since then, however, the species adapted to this artificial en-

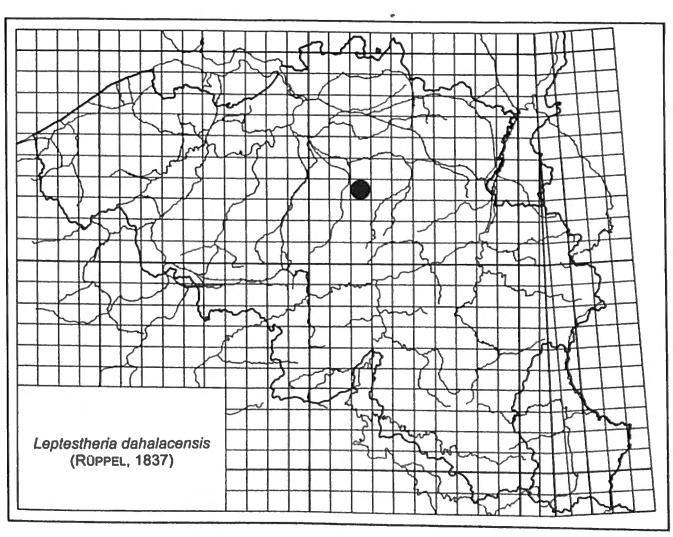

Fig. 1

vironment and established a viable population (BRENDONCK *et al.*, 1989). On 28 and 29 October and on 3 and 7 November 2001 the pond was resampled, and although this was in the same period of the year as the first record, neither living specimens, nor valves, nor resting eggs were found (K. MOREAU & L. BRENDONCK pers. comm.). It is therefore very likely that the species is no longer present in the pond.

CLASS Malacostraca LATREILLE, 1803
SUCLASS Eumalacostraca GROBBEN, 1892
SUPERORDER Peracarida CALMAN, 1904
ORDER Mysidacea BOAS, 1883
FAMILY Mysidae DANA, 1850

Hemimysis anomala (SARS, 1907)
(Fig. 2)

This species was collected for the first time in Belgium on 12 October 1999, in the Galgeweel, a brackish water pond on the left bank of the River Schelde, near the harbour of Antwerp (VERSLYCKE *et al.*, 2000). In 2000 it was collected upstream Namur (Heer and Lustin) and between Namur and Liège (Gives), and in 2001 in Lanaye, in the gravel pit of the old Meuse (VANDEN BOSSCHE, 2002). It is a Ponto-Caspian

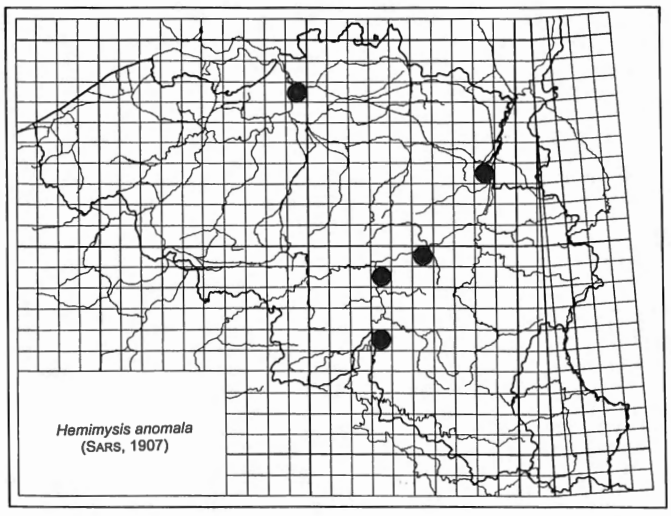

Fig. 2

invader which had previously already been discovered in Germany, in the rivers Rhine and Neckar (SCHLUETER *et al.*, 1998) and in the Netherlands, in the Noorder IJ-plas, near Amsterdam (FAASSE, 1998). As VERSLYCKE *et al.* (2001) point out, the species may be more widely distributed, but the hidden life-style makes it difficult to assess its geographic distribution.

ORDER Amphipoda LATREILLE, 1816
FAMILY Gammaridae LEACH, 1813

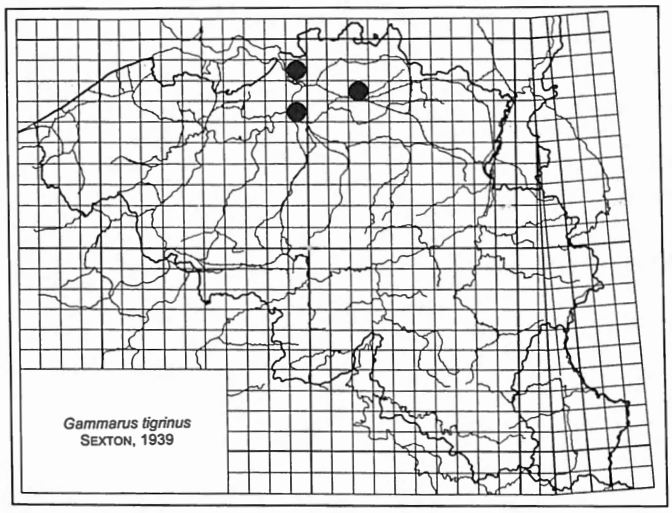

Fig. 3

Gammarus tigrinus SEXTON, 1939
(Fig. 3)

G. tigrinus was collected for the first time in Belgium in April 1996, in the "Grote Put" in Antwerpen-Ekeren (VERCAUTEREN *et al.*, 1999). In 1997 and 1998 the species was found in two other localities, namely the Bloso sports centre "Netepark" in Herentals, and in a ditch in Bornem Hingene (VERCAUTEREN & WOUTERS, 1999). Although *G. tigrinus* is a North American species, it is reasonable to assume that is was imported in Belgium by human activities (probably fish stocking), from the Netherlands, where it has become a very common species since its introduction (PINKSTER *et al.*, 1992).

Echinogammarus berilloni CATTA, 1878
(Fig.4)

There are only very few published records available of the distribution of this southern European species in Belgium,

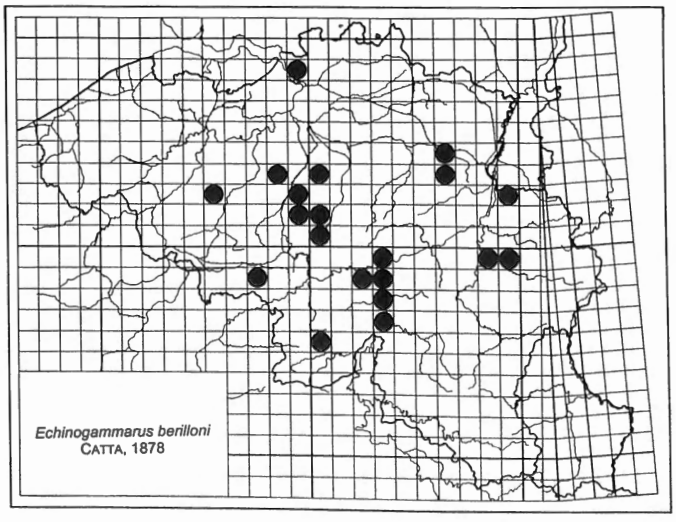

Fig. 4

namely: Ohain in the river Smohain in 1943-1946 (MARLIER, 1951), in a pond in Lombise in 1955 (LELOUP & VAN MEEL, 1958), Jambes, in the Meuse in 1983 (WOUTERS, 1985) and in the river Meuse in Agimont, Hastière, Waulsort, Anseremme, Dinant, Houx, Rivière, Lustin, Bas-Oha, Amay, during the period 1980-1984 (MEURISSE-GÉNIN *et al.*, 1987).

The collections of the KBIN-IRSNB contain a large number of specimens from different localities, and therefore are an important source of information on the distribution of *E. berilloni.*

Neerijse, Langerode, 19 June 1925, first record for Belgium
Vossem, river Voer, 1930, 1931
Remouchamps, in the cave, 1931
Ternat, without further indication, 1932
Berneau, river Berwinne, 1932
Malonne, river Sambre, 1932
Dave, river Meuse, 1933
Namur, Saint Servais, river Houyoux, 1933
Between Cerfontaine and Falemprise, in the Eau d'Heure,1934
Comblain-au-Pont, river Ourthe, 1935
Hasselt, river Demer, 1937
Hasselt, rivulet in connetion with river Demer, 1937
Between Comblain-la-Tour and Comblain-au-Pont, river Ourthe, 1937
Berendrecht, in the Dorpsbeek, 1939
Hastière, river Meuse, 1941
Heverlee, river Dijle, 1942
Le Cala, river Bousval, 1942
La Hulpe, river Argentine, 1943
Waulsort, river Meuse, 1943
Hastière, river Meuse, 1943
Between Hastière and Hermeton, river Meuse, 1943
Between Waulsort and Hastière, river Meuse, 1943
Hastière, river Meuse, 1945
Hermeton, river Meuse, 1945
Leuven, river Dijle, 1945
Leuven, Leibeek, 1945
Destelheide, rivulet, near the mill, 1945
Petite Spienne, river Trouille, 1945
Wimmertingen, in the Mombeek, 1945
Everbeek, near Geraardsbergen, Terkleppebeek, 1982

Dikerogammarus villosus (SOWINSKY, 1874).
(Fig. 5)

In a recent paper on the first record of *Hypania invalida* (GRUBE, 1860), a pontocaspian polychaete, in the River Meuse, VANDEN BOSSCHE *et al.* (2001) also mention the presence of *Dikerogammarus villosus*, in 1998, in four stations in the river Meuse (Heer, Lustin Gives, Chokier). In a second paper VANDEN BOSSCHE (2002) emphasizes that since the first record in 1998, *D. villosus* represents now 100 % of the population of Gammaridae and Crangonyctidae in the river Meuse between Namur and Liège, and that the species is spreading rapidly. In 2000 it was already found upstream Namur. *D. villosus* was also collected in Northern

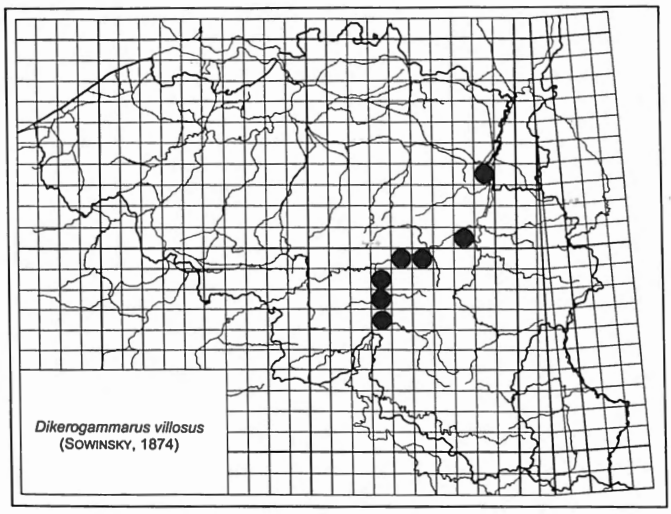

Fig. 5

France in 1999 and 2000, not far from the Belgian border (DEVIN *et al.*, 2001).

FAMILY Corophiidae DANA, 1813

Corophium curvispinum SARS, 1895
(Fig. 6)

The first (but not the oldest) record of the species was published by WOUTERS (1985), who found the species in 1983 in the river Meuse in Jambes. In later papers, D'UDEKEM D'ACOZ & STROOT (1988) report the presence of this species in the river Meuse in Huy, in 1981 (oldest record), and MEURISSE-GÉNIN *et al.* (1987) from Lustin, Bas-Oha and Amay. VANDEN BOSSCHE *et al.* (2002) collected the species in 2000 in four more localities in the river Meuse between the French border and Liège, and in 2001 in Lanaye, in the two blind arms facing the Dutch border. *C. curvispinum* is a tube-building species, originating from the Ponto-Caspian area.

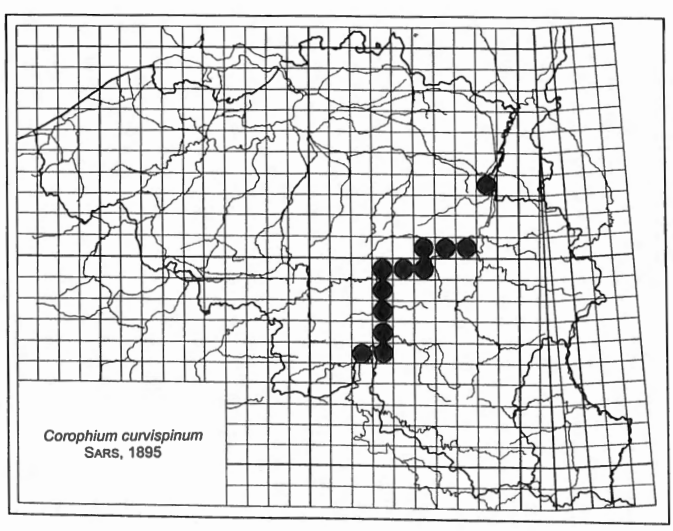

Fig. 6

Since the beginning of the 20th century, it has been extending its range in western direction. It is a highly successful invader. It is a very common species now in the rivers Rhine (DEN HARTOG *et al.*, 1992, VAN DER VELDE *et al.*, 2000), Moselle (BACHMANN *et al.*, 2001) and Meuse (D'UDEKEM D'ACOZ & STROOT, 1988), at least between the French border and Liège. Whether the species occurs also in the more northern (Belgian) part of the Meuse, and in the canals that are in direct connection with the river, remains unknown. Sampling in November 2001 in the river Meuse near Dilsen Stokkem yielded no specimens.

FAMILY Crangonyctidae BOUSFIELD, 1973

Crangonyx pseudogracilis BOUSFIELD, 1958
(Fig. 7)

Crangonyx pseudogracilis was collected for the first time in Belgium on 28 October 1992, in the Gebuistloop in Puurs. In 1998 the species was found in two other localities, namely in a ditch in "Hof ter Zielbeek" in Puurs and in a ditch in Ruisbroek (VERCAUTEREN & WOUTERS, 1999 and VERCAUTEREN *et al.*, 2000). How this Northern American species was introduced remains uncertain. Perhaps it was introduced by human activities from the Netherlands, where it is a common species in some areas of the country. VANDEN

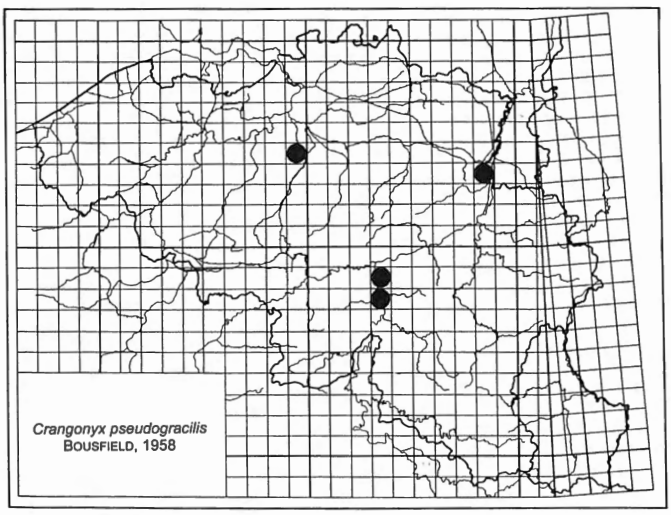

Fig. 7

BOSSCHE (2002) reports the species from the river Meuse in Yvoir and in Lanaye, Vielle Meuse (1998). In 1998, 2000 and 2001, *C. pseudogracilis* disappeared from the catches in Lustin. In 2001 the remaining populations were found in Lanaye, Vieille Meuse. According to VANDEN BOSSCHE (2002), "*C. pseudogracilis* is likely to vanish completely from the river Meuse, under the increasing pressure of *Dikerogammarus villosus*".

FAMILY Talitridae BULYCHEVA, 1957

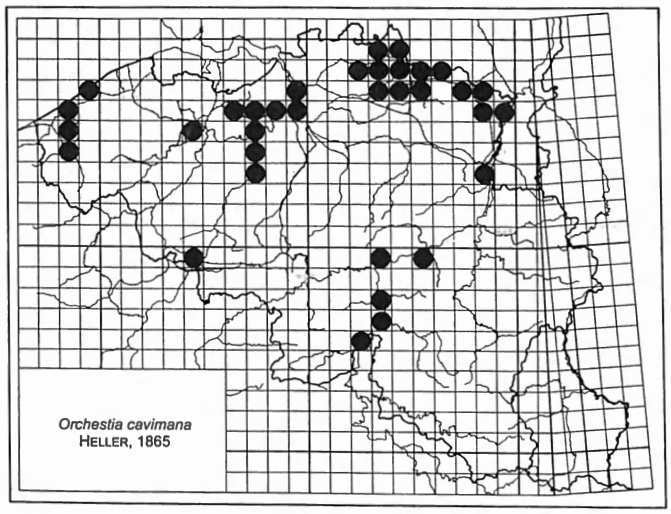

Fig. 8

Orchestia cavimana HELLER, 1865
(Fig. 8)

There are only very few published records of this species available: several localities in NW. Belgium, namely Kallo, Bazel, Tielrode, Lokeren, Appels near Dendermonde (DEN HARTOG, 1963), Alveringem, Lovaart (IHE, 1979, p. 58), Jambes, river Meuse (WOUTERS, 1985) and two publications with distribution maps of *O. cavimana*, with points situated in Belgium (KINZELBACH, 1972; CONRATH *et al.*, 1977). VANDEN BOSSCHE (2002) reports the species from the river Meuse in Yvoir (1991), and from Petit-Lanaye (1995 and 1998). He collected numerous specimens in Gives and Lanaye, Nouvelle Gravière, in 2001. *O. cavimana* is a Mediterranean-Ponto-Caspian amphipod. It was collected for the first time in Western Europe, in the River Waal in Zaltbommel (HOEK, 1879). According to KINZELBACH (1972) and VAN DER VELDE *et al.* (2000) it spread in southern direction, via the river Schelde, and was already observed in Northern France, near Cambrai, in the canal of Saint-Quentin in 1906. The arrival of this species in Belgium should therefore be dated somewhat before or around 1900.

The collections of the KBIN-IRSNB contain a large number of specimens from different localities, and therefore are the main source of information on the distribution of *O. cavimana* in Belgium.

Antwerpen, left bank of river Schelde, 26 March 1927, oldest specimen in the collections
Deinze, banks of the River Leie, 1939
Hingene Wintham, confluence of the rivers Schelde and Rupel, 1944
Ninove, banks of the river Dender, 1945
Aalst, banks of the river Dender, 1945
Oostende, Slijkens sluice, 1945
Nieuwpoort, evacuation channel, 1945
Harchies, 1977, 1978
Kaaskerke, banks of the river IJzer, 1981

In 1980 and 1981 the present author collected numerous specimens in the canals in northeastern Belgium.
a) Canal from Herentals to Bocholt (1980):
Geel sluice 9, Geel Ten Aart, Geel sluice 7, Mol sluice 6, Dessel sluice 5, Mol Sluis, Mol Maat, Lommel, Neerpelt, Sint-Huibrechts-Lille, Kaulille, Bocholt.
b) Zuid-Willemsvaart (1980):
Bocholt, Bocholt 200 m from the Dutch border, Bree, Bree-Tongerlo, Neeroeteren
c) Canal Schoten-Turnhout-Dessel (1981):
Beerse, Rijkevorsel Sint-Jozef, Turnhout Stockt, Dessel Witgoor, Retie, Arendonk, Ravels.

O. cavimana, which orginated from the Ponto-Caspion region, has become a common species in Western Europe and is probably more widespread in Belgium than it may appear from the distributional data here presented.

SUPERORDER Eucaridea CALMAN, 1904
ORDER Decapoda, LATREILLE, 1803
INFRAORDER Caridea DANA, 1852
FAMILY Atyidae DE HAAN, 1895

Atyaephyra desmaresti (MILLET, 1831)
(Fig. 9)

The first (but not oldest) record of this species was published by PELSENEER (1886), who presumably collected it in Hastière, in the River Meuse, in 1886. This specimen is still preserved in the collections of the KBIN-IRSNB. The locality mentioned on the label is "Hastière ?", indicating that there is some doubt about the origin of the specimen. In 1931 LESTAGE published a review article, covering all previously published records, and adding some new ones. He also questioned the validity of the locality Hastière, following herein an earlier publication of ROUSSEAU (1919). According to LESTAGE the oldest, and therefore first record for Belgium, is probably 1895, in the Canal of Charleroi, Brussels.
Later records of the species were published by ADAM & LELOUP (1940), THIENEMANN (1950, p. 685), MEURISSE-GÉNIN *et al.* (1985), and WOUTERS (1985). This freshwater shrimp originates from southern Europe. Since the half of the 19th century, this species has been spreading in northern direction through canals and rivers. It was recorded in Paris in 1843, in Belgium in 1895 and in the Netherlands in 1915 (REDEKE, 1936)

Not earlier reported records:

Sin Job in 't Goor, canal Schoten-Dessel, 1978
(coll. KBIN-IRSNB)
Sint Lenaerts, canal Schoten-Dessel, 1978 and 1981
(coll. KBIN-IRSNB)
Lier, Netekanaal, 1978 (coll. KBIN-IRSNB)
Mol, canal Schoten-Dessel, 1980 (coll. KBIN-IRSNB)
Ravels, canal Schoten-Dessel, 1981, (coll. KBIN-IRSNB)
Edegem, ditch of the fort, 2001
(TH. VERCAUTEREN, pers. comm.)

INFRAORDER Astacidea LATREILLE, 1803
FAMILY Astacidae LATREILLE, 1803

Astacus leptodactylus (ESCHSCHOLTZ, 1823)
(Fig. 10)

The distribution of this species, the "turkish crayfish", is discussed in the following papers: DARVILLE (1982), GÉRARD (1986a,b, 1989), ARRIGNON, GÉRARD, KRIER & LAURENT (1999). In 1996, the species was observed in southern Belgium (Wallonia) in 109 ponds and in 17 river localities (ARRIGNON, GÉRARD, KRIER & LAURENT, 1999). There are no specimens of this species deposited in the collections of the KBIN-IRSNB. The distribution map (Fig. 10) presented in this paper is based on data published by GÉRARD (1986a). Details on the distribution of this species in southern Belgium can be found in ARRIGNON, GÉRARD, KRIER & LAURENT (1999).

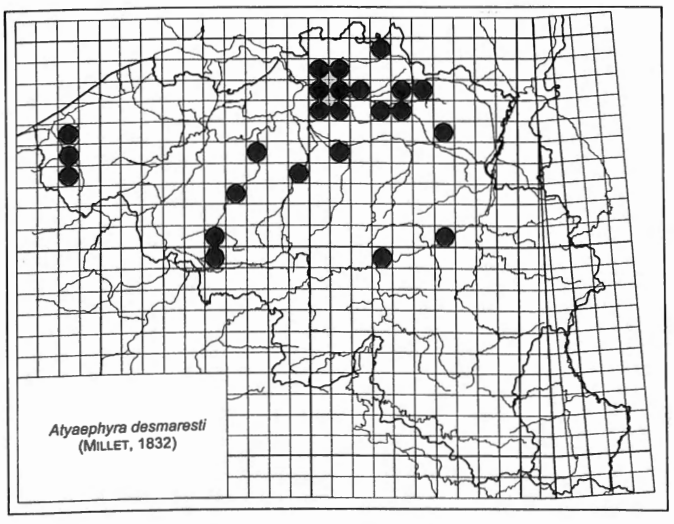

Fig. 9

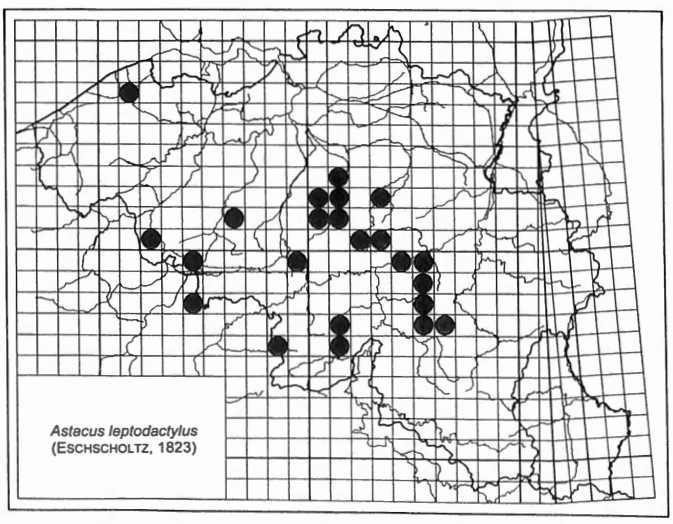

Fig. 10

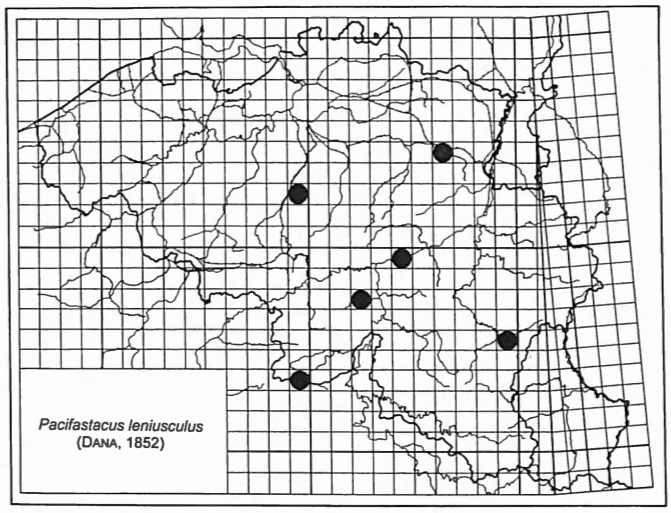

Fig. 11

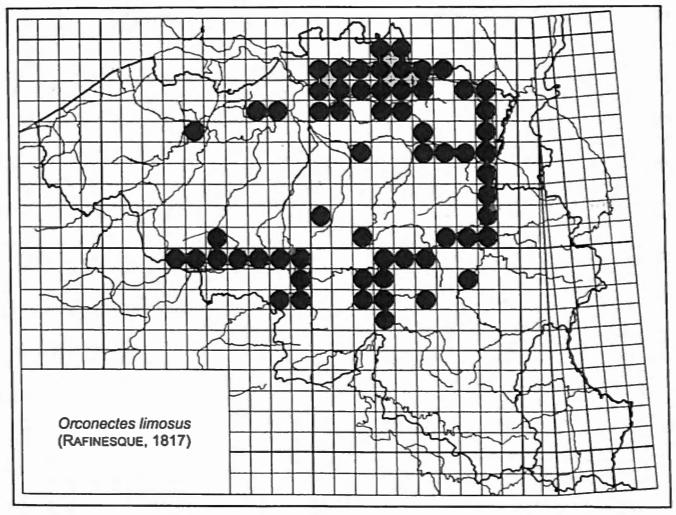

Fig. 12

Pacifastacus leniusculus (DANA, 1852)
(Fig. 11)

The distribution of this species, the "signal crayfish", is discussed in the following papers: DARVILLE (1982), GÉRARD (1986a,b, 1989), ARRIGNON, GÉRARD, KRIER & LAURENT (1999). In Southern Belgium (Wallonia) the species was found in 39 ponds and in 27 river localities (ARRIGNON, GÉRARD, KRIER & LAURENT, 1999). There are no specimens of this species deposited in the collections of the KBIN-IRSNB. The distribution map (Fig. 11) presented in this paper is based on data published by GÉRARD (1986a). Details on the distribution of this species in southern Belgium can be found in ARRIGNON, GÉRARD, KRIER & LAURENT (1999).

FAMILY Cambaridae HOBBS, 1942

Orconectes (Faxonius) limosus (RAFINESQUE, 1817)
(Fig. 12)

The distribution of this species, the "spiny-cheek crayfish", is amply discussed in a number of papers: DARVILLE (1982), JELLASICS (1985), GÉRARD (1986a,b, 1989), ADEMA (1989), ARRIGNON, GÉRARD, KRIER & LAURENT, 1999).
According to GÉRARD (1986a), *O. limosus* arrived in Belgium, from France, via the river Meuse, in the late fifties or the early sixties. A more specific date is not available. The date of the oldest specimen available in the collections of the KBIN-IRSNB is 1971. This is probably more than ten years after the installation of the species in the river Meuse. Since its first introduction it has become a common species in large rivers and canals. In Southern Belgium (Wallonia), the species was found in 30 river localities, and in 103 ponds (ARRIGNON, GÉRARD, KRIER & LAURENT, 1999).

Only a few specimens are deposited in the collections of the KBIN-IRSNB.

Waulsort, river Meuse, 21 July 1971 (oldest known record, but certainly not date of arrival in Belgium)
Jambes, La Plante, river Meuse, 1977 and 1983
Mol, sluice 6, canal Herentals-Bocholt, 1977
Freyr, moat of the castle, 1979
Sint-Niklaas, pond "De Ster", 1991.

In 2001, the species was also observed in:
Edegem, ditch of the fort
(TH. VERCAUTEREN, pers. comm.),
Rotselaar, Lake "Toren ter Heide"
(H. VERREYCKEN, pers. comm.),
Brugge, canal Gent-Oostende (AQUAFIN, 2001).

INFRAORDER Brachyura LATREILLE, 1803
FAMILY Portunidae RAFINESQUE, 1918

Callinectes sapidus RATHBUN, 1896
(Fig. 13)

The North American blue crab was collected for the first time in november 1981, in the water cooling system of Bayer

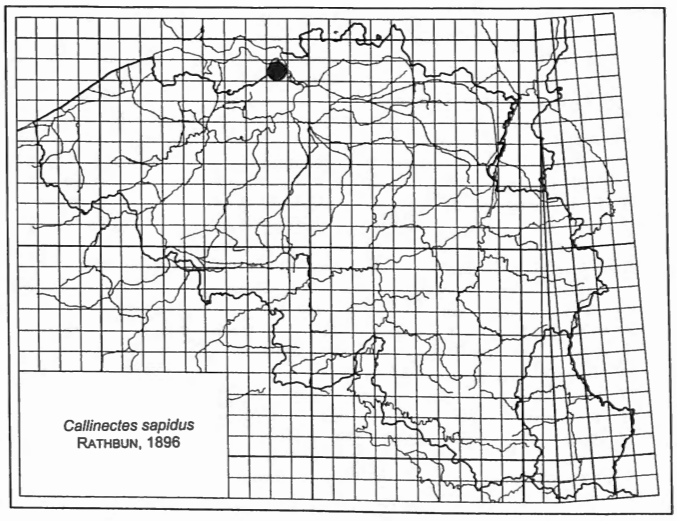

Fig. 13

Antwerpen NV, which draws its water from the river Schelde (ANONYMOUS, 1981). The presence of *C. sapidus* in the river Schelde was later confirmed by VAN DAMME & MAES (1993) and by MAES *et al.* (1998), who found a male specimen in the cooling circuit of the nuclear power plant in Doel, in October 1993.

FAMILY Grapsidae MACLEAY, 1838

Eriocheir sinensis H. MILNE EDWARDS, 1854
(Figs 14 & 15)

The mitten crab was observed for the first time in Belgium in 1933 by a fisherman who caught a specimen in Kruisschans (N. of Antwerpen) (LESTAGE, 1935). Since this species was considered a "public ennemy", its distribution was closely monitored. This led to a large number of scientific publications and articles in the press. It is not our goal to review the entire bibliography here. The most important, and synoptic papers are those of LESTAGE (1935), LELOUP (1937, 1938, 1939, 1943), HUET (1941), CAPART (1956) and ADEMA (1991). These data, covering the period 1933-1956 are represented in Fig. 14.

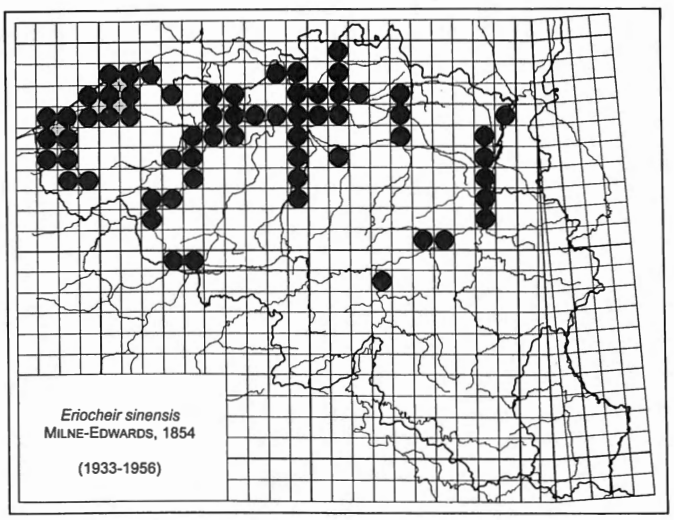

Fig. 14

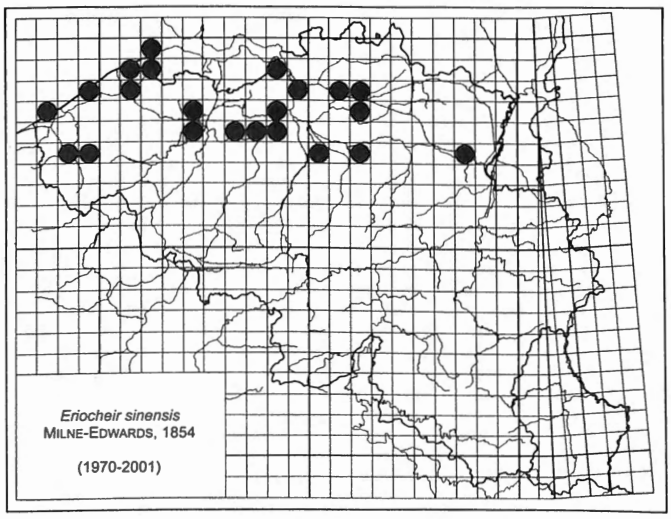

Fig. 15

Since this period, and more particularly from 1970 on (Fig. 15), new distributional data have become available, as published records, as specimens deposited in the collections of the KBIN-IRSNB, or as personal communications. Here follows the list of these data (in chronological order).

Woumen, De Blankaart, 1970 (DESENDER, 1981)
Knokke-Heist, 1970 (D'UDEKEM D'ACOZ, 1985)
De Panne and Oostende, 1981 (KERCKHOF, 1982)
Duinbergen, 1983 (D'UDEKEM D'ACOZ, 1985)
Knokke-Heist, 1983 (ENEMAN, 1984)
Oostende, 1984 (MARES, 1995)
Doel, 1985 (DUMOULIN & RAPPÉ, 1985)
Baasrode, 1985 (TH. VERCAUTEREN, pers. comm.)
Oostende, 1990 (VANDERPERREN, 1991, MARES, 1995)
Oostduinkerke, 1990 (VANHAELEN, 1995)
Zeebrugge, 1991 (VANDERPERREN, 1992, MARES, 1995)
Oostende, 1991 (VANDERPERREN, 1992, MARES, 1995)
Oostende, 1991 (coll. KBIN-IRSNB)
Oostende, 1992 (MARES, 1995)
Oostende, Sluiskreek, 1994 (MARES, 1995)
Woumen, 1994 (VERHAEGHE, 1996)
Weert, sluice of the river Schelde, 1994
(coll. KBIN-IRSNB)
Doel, cooling circuit of the nuclear power plant, 1994-1995
(MAES *et al.*, 1998)
Koksijde, 1995 (VANHAELEN, 1995)
Woumen, 1995 (VERHAEGHE, 1996)
Between Lier and Geel, in the river Grote Nete, 1995
(TH. VERCAUTEREN, pers. comm.)
Antwerpen, antitank-canal, 1995
(TH. VERCAUTEREN, pers. comm.)
Oostduinkerke, 1996 (ADELAERE, 1996)
Oostende, 1996 (ENEMAN, 1996)
Oostende, Spuikom, 1996 (MARES, 1996)
Canal Oostende-Brugge, numerous specimens, 1996
(MARES, 1996)
Oostende, Noord-Edekreek, canal Oostende-Brugge, canal Nieuwpoort-Plassendale, Keignaartkreek, 1996
(MARES, 1996)
Oostende, sluices of the Spuikom, 1996 (KERCKHOF, 1996)
Wetteren, 1996 (KERCKHOF, 1996)
Lier, Netekanaal, 1996 (TH. VERCAUTEREN, pers. comm.)
Antwerpen, Galgeweel, 1996
(TH. VERCAUTEREN, pers. comm.)
Koksijde and Oostduinkerke, 1997 (VANHAELEN, 1997)
Antwerpen, River Schijn and Galgeweel, 1997
(TH. VERCAUTEREN, pers. comm.)
Lier, Netekanaal, 1997 (TH. VERCAUTEREN, pers. comm.)
Genk, natural reserve "De Maten", 1998
(K. COTTENIE, pers. comm.)
Dendermonde, River Schelde, 1999 (coll. KBIN-IRSNB)
Brugge, Brugse Rijen, 1999 (J. TAVERNIER, pers. comm.)
Dendermonde, pond of the pumping station of St. Onolfsdijk, 1999 (J. TAVERNIER, pers. comm.)
Grobbendonk, Albert Canal, 2000

(H. VERREYCKEN, pers. comm.)
Schellebelle, Driese Sloot, 2000
(H. VERREYCKEN, pers. comm.)
Gent, Ossemeersen and Ringvaart, 2001 (AQUAFIN, 2001)
Rotselaar, lake "Toren Ter Heide", 2001
(H. VERREYCKEN, pers. comm.)

FAMILY Xanthidae MACLEAY, 1838

Rhithropanopeus harrisii (GOULD, 1841)
(Fig. 16)

This species was found for the first time in Belgium in Doel, Prosperpolder, river Schelde, on 26 May 1985. A cheliped of a second specimen was collected at the same locality on 27 October 1985 (DUMOULIN & RAPPÉ, 1985), and another cheliped was collected in 1987 (ADEMA, 1991). Five living specimens were found in 1991 in the cooling circuit of the nuclear power plant in Doel (VAN DAMME *et al.*, 1992 and MAES *et al.*, 1998), and six living specimens were caught on the right bank of the river Schelde in Lillo, in 1994 (D'UDEKEM D'ACOZ, 1994). Although the dwarf crab is a North american species, it reached the Belgian part of the river Schelde from the Netherlands, where it is a common species, as well in Holland and Friesland as in the delta area (ADEMA, 1991).

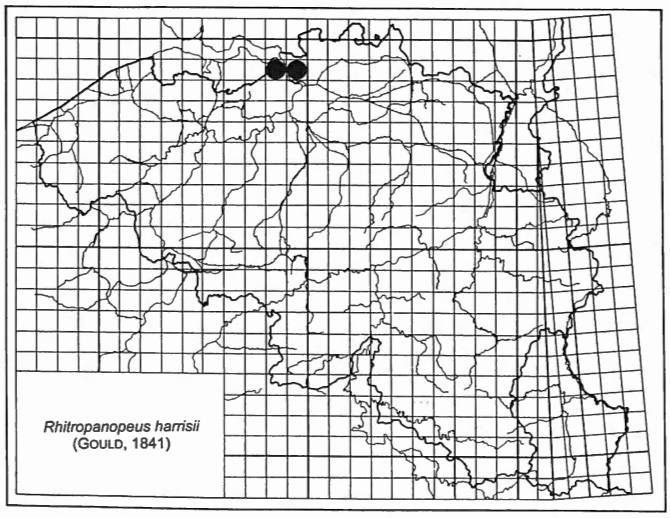

Fig. 16

Discussion

Up to now fifteen species of alien crustaceans have been recorded in Belgian non-marine and estuarine waters. The first new arrival was *Atyaephyra desmaresti* in 1895 and the latest one *Hemimysis anomala* in 1999. However, when the species are listed according to the year of their arrival, based on the available data, it can be noticed that only six species were introduced before 1980, and that nine species have been introduced since 1980.

1895 *Atyaephyra desmaresti*
1925 *Echinogammarus berilloni*
1927 *Orchestia cavimana*
1933 *Eriocheir sinensis*
1950ies *Orconectes limosus*
1970ies *Astacus leptodactylus*
1980ies *Pacifastacus leniusculus*
1981 *Callinectes sapidus*
1981 *Corophium curvispinum*
1985 *Rhithropanopeus harrisii*
1988 *Leptestheria dahalacensis*
1992 *Crangonyx pseudogracilis*
1996 *Gammarus tigrinus*
1998 *Dikerogammarus villosus*
1999 *Hemimysis anomala.*

It should be noted that the year of the first record of a species does not necessarily represent the real year of arrival. There can be a more or less substantial delay between both dates, depending on, among other things, the sampling effort. Nevertheless the accelerated rhythm of arrival of new alien species since 1980 remains a remarkable observation. This situtation is not different from what can be seen in the neighbouring countries. What is more, it can be inferred from observations in the Netherlands, Germany and France, that still other alien crustacean species can be expected to arrive soon in Belgian waters, mostly in large rivers and in canals, such as the isopod *Jaera istri* VEUILLE, 1979, the amphipods *Dikerogammarus haemobaphes* (EICHWALD, 1841) and *Echinogammarus ischnus* (STEBBING, 1898), the mysid *Limnomysis benedeni* CZERNIAVSKY, 1882, and probably still other species.

The origin of the alien crustaceans mentioned in this paper is diverse. Four species are of Ponto-Caspian origin, six from North America, one from Hungary, two from southern Europe, one from Turkey and one from China. With exception of *Leptestheria dahalacensis*, however, which was directly introduced in Belgium with fish stock originating from a place near lake Balaton, all other species were introduced from neighbouring countries. The connection of large river systems by canals, and certainly the opening of the Main-Danube canal in 1992 contributed largely to the dispersal of exotic crustaceans in Europe.

From all this, it can be deduced that the overall knowledge on the distribution of alien crustaceans in Belgian inland waters and estuarine environments is relatively limited, with exception of the distribution of crayfish in Southern Belgium, wich is well documented, thanks to the works of Pierre GÉRARD (GÉRARD, 1986a,b, 1989 and ARRIGNON, GÉRARD, KRIER & LAURENT, 1999), and of some crustaceans in the river Meuse Basin (VANDEN BOSSCHE, 2002 and VANDEN BOSSCHE *et al.*, 2001). Because of the presumed impact of alien species on the native fauna, much closer monitoring of the arrival of new exotic species and of their subsequent spreading in rivers and ponds is needed.

Acknowledgements

The author is greatly indebted to the many persons who kindly provided information on the distribution of some of the species mentioned in this paper: TH. VERCAUTEREN (Provinciaal Instituut voor Hygiëne, Antwerpen), H. VERREYCKEN (Instituut voor Bosbouw en Wildbeheer, Groenendaal-Hoeilaart), K. COTTENIE, K. MOREAU, L. BRENDONCK and J. MAES (K.U.Leuven, Laboratory of Aquatic Ecology), T. DE GRAAF (Infocenter Gazet van Antwerpen), B. GODDEERIS and J. TAVERNIER (KBIN-IRSNB, Brussels).

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