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RANGE EXTENSION IN THE PERIOD 1985-1986 OF THE ALIEN AMPHIPODS, *GAMMARUS TIGRINUS*,
1939, AND *CRANGONYX PSEUDOGRACILIS* BOUSFIELD, 1958, IN THE NETHERLANDS
(CRUSTACEA, AMPHIPODA)

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SUMMARY

Since its first discovery in the Netherlands in 1964, the dispersal of *Gammarus tigrinus* over inland waters is followed closely. In a survey carried out in 1985 and 1986 it appeared that *G. tigrinus* has extended its range in the southwestern and southeastern parts of our country. In the rest of the country the spreading has come to an apparent standstill. Apart from the mainland, *G. tigrinus* has been found for the first time on some Frisian isles: Texel, Terschelling and Ameland.

During the present study the position of another alien amphipod, *Crangonyx pseudogracilis*, was investigated as well. For the first time some range extensions were found, since its initial discovery in 1979, in a limited area in the province of Groningen. Some remarks are made on the position of the indigenous *Gammarus* species.

INTRODUCTION

Gammarus tigrinus Sexton, 1939, is a euryhaline species, originally endemic to the east coast of North America (Bousfield, 1958). Introductions into Europe were first recorded from England, where the species inhabits brackish coastal waters and inland waters with raised ion contents through pollution (Hynes et al., 1960).

Since the first discovery of this alien amphipod in the Netherlands in 1964 (Nijssen & Stock, 1966), it showed rapid range extension. *G. tigrinus* invaded nearly all oligohaline waters in the western and northern parts of the country. In this area the local gammarid fauna almost disappeared. Pinkster et al.

(1977) explained the success of the invasion by the fact that *G. tigrinus* has a much greater reproductive capacity in oligohaline waters than the indigenous species, *G. p. pulex* (Linnaeus, 1758), *G. d. due-beni* Liljeborg, 1851, and *G. zaddachi* Sexton, 1912. Other important factors are the ability of *G. tigrinus* to thrive in (heavily) polluted waters (Schmitz, 1960) and to occupy habitats not suitable for local gammarids (Chambers, 1973; Nijssen & Stock, 1966).

However, there are limits to the spreading of *G. tigrinus* over inland waters: in fresh waters *G. tigrinus* does not reproduce; in oligohaline waters with a well developed flora and fauna *G. p. pulex*

can successfully compete with *G. tigrinus*; in waters with a high salinity, or extremely variable salinities, *G. zaddachi* and/or *G. d. duebeni* can maintain their position (Dieleman & Pinkster, 1977; Pinkster et al., 1977).

Another important factor contributing to the distribution appears to be temperature (Pinkster et al., 1980). In surveys carried out in 1978 and 1979, *G. tigrinus* had disappeared from a great number of formerly inhabited waters, especially in the north-eastern parts of the Netherlands. *G. d. duebeni* and *G. p. pulex* reappeared after an absence of many years. The long and cold winter of 1978/1979 is considered to be the cause of this decline, as *G. tigrinus* cannot reproduce when temperatures are too low. In the following years with mild winters, *G. tigrinus* quickly recovered from this decline. Moreover, in the 1984 survey it has been found for the first time in some major running waters and in a canal in the southeastern part of the Netherlands (Platvoet & Pinkster, 1985). Pinkster et al., 1977 considered this unlikely because of its poor reproductive potential under freshwater conditions. This fact was the principal reason for a new survey over most parts of the Netherlands carried out during the years of 1985 and 1986. During this survey, the present position of *Crangonyx pseudogracilis* was investigated as well. This originally North American species was recently introduced into England, and is now widely distributed in Great Britain (Gledhill et al., 1976). In the Netherlands *C. pseudogracilis* was found for the first time in 1979, in a limited area in the province of Groningen (Pinkster et al., 1980). In 1982 only a minor range extension was observed (Pinkster & Platvoet, 1983).

THE PRESENT POSITION OF *GAMMARUS TIGRINUS*

During the present survey *G. tigrinus* was found for the first time in the inland waters of some Frisian isles: Texel, Terschelling and Ameland. In the northern part of our country, *G. tigrinus* consolidated its position. It is still the dominant species in

oligohaline waters in Friesland and Groningen although population densities seem to be less high than in former years (see also Chambers, 1987). In the western lakes of the Frisian lake district it is the only species found. In the province of Groningen it showed up in the Paterswolde Meer and Zuidlaarder Meer.

G. tigrinus has disappeared from the Noordoost Polder in the central part of the Netherlands, province of Flevoland. It is, however, still present in the polders Oostelijk and Zuidelijk Flevoland.

The province of Zuid-Holland is now almost completely invaded by *G. tigrinus*. This invasion took place gradually during the last few years, both from the north and the south. In this area *G. tigrinus* disappeared from one major lake, the Nieuwkoopse Plassen and Loosdrechtse Plassen. Some minor range extensions took place on the islands of Hoekse Waard and Goeree Overflakkee in the Deltaic region.

Since *G. tigrinus* has been found in 1984 in some major running waters and a canal in the southeast of the country, in the present survey special attention has been paid to rivers and canals. *G. tigrinus* occurs presently in the rivers IJssel, Rhine, Waal and Meuse. In the Meuse it is found up to Nijmegen (more exactly the Meuse-Waal canal). In the northern part of our country, all canals with *G. tigrinus* are within the already known distribution area. In the province of Zuid-Holland the situation is different, the canals with *G. tigrinus* forming a network extending far beyond the known distribution area. Minor range extensions, involving canals, occurred in the Meppelediep (province of Overijssel), and Zuid-Willemsvaart (province of Limburg).

During the fieldwork a strong correlation between the occurrence of *G. tigrinus* and the presence of zebra mussel, *Dreissena polymorpha* (Pallas), became apparent.

THE PRESENT POSITION OF *CRANGONYX PSEUDOGRACILIS*

Since its first discovery in 1979, in the province of Groningen, only in 1982 some slight expansion could be observed. During our last survey, however, for

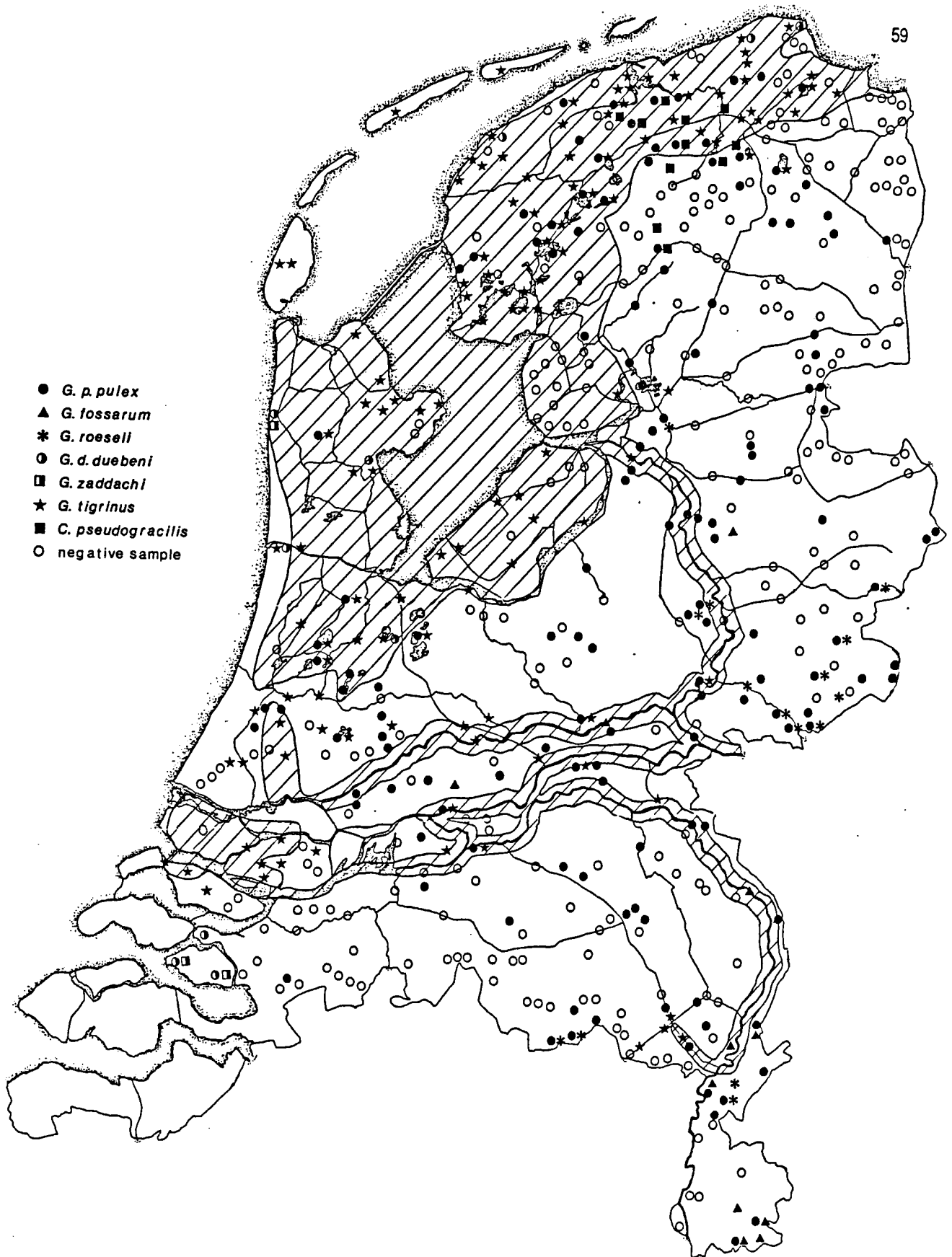


Fig. 1. Distribution of indigenous *Gammarus* species (*G. p. pulex*, *G. fossarum*, *G. roeseli*, *G. d. duebeni* and *G. zaddachi*) and alien amphipods (*G. tigrinus* and *C. pseudogracilis*) in the Netherlands at the end of 1986. The minimal area occupied by *G. tigrinus* at the end of 1984 is hatched.

the first time sizeable range extensions were found. Newly invaded waters were the Stroobosser Trekvaart up to Westergeest, in the western direction, and the Opsterlandse Compagnonsvaart and Tjongerkanaal in the southern direction. These last localities are 20 km away from the formerly known distribution area. Also some minor range extension occurred in waters already occupied by *C. pseudogracilis*, mostly in southern direction.

THE PRESENT POSITION OF INDIGENOUS GAMMARUS SPECIES

In the investigated area the following indigenous gammarids were found: *G. p. pulex* (Linnaeus, 1758), *G. d. duebeni* Liljeborg, 1852, *G. zaddachi* Sexton, 1912, *G. fossarum* Koch, 1836, and *G. roeseli* Gervais, 1835.

Gammarus p. pulex

G. p. pulex is the most common freshwater gammarid, which inhabits natural and man-made waters, usually on sandy bottoms, in the eastern and southern parts of the Netherlands. Many areas are however devoid of any gammarid fauna due to severe pollution of these water systems, especially in the Brabantian rivers. In the province of Zuid-Holland a spatial separation is found between *G. p. pulex* and *G. tigrinus*: *G. p. pulex* inhabits the relatively unpolluted ditches and lakes with a well developed and diverse flora and *G. tigrinus* is the dominant (often only) species in the surrounding canals.

In the provinces of Friesland and Groningen *G. p. pulex* maintains its position in fresh and oligohaline waters on sandy bottoms. It is found in nearly all Frisian lakes except those in the westernmost part of the province. Although the species prefers fresh and oligohaline waters it is sometimes found at chlorinities up to 1200 mg/l (see also Pinkster, 1972, and Karaman & Pinkster, 1977 a).

During the present survey, *G. p. pulex* was found

in the rivers IJssel, Rhine, Waal and Meuse often accompanied by *G. tigrinus* and sometimes by *G. fossarum* (in the Meuse). In canals in the northern and western parts of the country it is absent. In the south, it is only found in the canal Wessem-Nederweert and in the Zuid-Willemsvaart in the province of Limburg. In the canal Wessem-Nederweert *G. p. pulex* coexists with *G. tigrinus*.

Gammarus d. duebeni

G. d. duebeni is a brackish water species which can stand extremely fluctuating salinities. In the province of Friesland and Groningen it maintained its position in the mesohaline waters behind the dikes. In Noord-Holland it is found at a former dike burst near the IJsselmeer, and near the Noordzeekanaal. As to the lakes of Noord- and Zuid-Holland, *G. d. duebeni* is found only in the Vinkeveense Plassen. In all localities mentioned *G. duebeni* is found together with *G. tigrinus*.

In the Deltaic region of the province of Zeeland *G. d. duebeni* is still common. In many places it is found together with *G. zaddachi*.

Gammarus zaddachi

G. zaddachi is a true brackish water species, living in estuaries and mesohaline waters. During the present survey, it was only found in the Deltaic region, and in a ditch behind the Hondsbossche Zee-wering. It has disappeared from the meso- and polyhaline waters behind the dikes in Friesland and Groningen, where it was still the dominant species in 1981 (Pinkster & Platvoet, 1983).

Gammarus fossarum

G. fossarum is a freshwater gammarid, inhabiting the upper regions of relatively unpolluted streams. In

the province of Limburg it is found in some small rivers with a rather high stream velocity, Gulp, Geul, Zinzelbeek, and Swalm. However, it is also found in some larger rivers, the Meuse and the Lower Rhine.

Gammarus roeseli

G. roeseli is a freshwater gammarid which inhabits relatively slowly flowing rivers. It can stand a high amount of organic pollution (Karaman & Pinkster, 1977 b). It is rarely found in the province of Gelderland and in a small part of the provinces of Noord-Brabant and Limburg (see fig. 1). It nearly always coexists with *G. p. pulex*.

DISCUSSION

Since 1964, probably the year of its introduction, *G. tigrinus* has invaded nearly all oligohaline waters in the northern and western parts of the Netherlands. Recently it became clear that this euryhaline species did not remain confined to these areas, as it was found in the major rivers of our country, and in a canal in the province of Limburg. This situation is comparable to that in Western Germany, where *G. tigrinus* was found in some canals connecting to the river Ems, and in the river Weser (Tesch & Fries, 1963; Herhaus, 1978).

As previously described (Pinkster et al., 1977), the range extension of this alien amphipod has a disastrous effect on the indigenous amphipod fauna. However, after some longlasting winters with severe colds, the local gammarids showed a remarkable recovery (Pinkster & Platvoet, 1983). In the provinces of Friesland and Groningen *G. tigrinus* reached its greatest extension in 1976 (Dieleman & Pinkster, 1977). This area is bordered in the south by freshwaters where *G. p. pulex* is the only gammarid, and more to the east, at the German border, by water system with severe pollution. Although *G. d. duebeni* regained some ground *G. tigrinus* is still the most common gammarid in the

north of the country often accompanied by *G. p. pulex* (in most of the Frisian lakes). As the ultimate borders of *G. tigrinus* are set by fresh waters, or heavily polluted waters, future range extension in the northern part of the Netherlands is unlikely.

In the central part of the Netherlands (the province of Flevoland), *G. tigrinus* has disappeared from the Noordoost Polder. Possibly this is due to progressive pollution in this agricultural region, as a result of over-fertilisation. Apart from the river IJssel and the canal Meppelerdiep, *G. tigrinus* is not found in the adjacent areas of the provinces Overijssel, Gelderland and Utrecht. As in the north, the distribution area is strictly determined by fresh waters, where *G. tigrinus* cannot reproduce and where *G. p. pulex* is the dominant gammarid.

In the southwestern parts of our country, *G. tigrinus* is still extending its range. As *G. tigrinus* was found in all canals of the province of Zuid-Holland, this area is now totally occupied. However, there are many water bodies in which *G. p. pulex* is still the dominant gammarid. These waters are characterized by a relatively low Cl-content, relatively low pollution and a well developed and diverse flora and fauna. In this type of habitat *G. p. pulex* can build up dense populations (Dieleman & Pinkster, 1977). In most oligohaline lakes *G. p. pulex* is found together with *G. tigrinus*. These areas are surrounded by canals in which *G. tigrinus* is the only gammarid. These canals in which the zebra mussel (*Dreissena polymorpha*) is always present, proved to be an excellent habitat for *G. tigrinus*. Future developments will be a consolidation of the positions taken by *G. tigrinus* and *G. p. pulex*, in canals and lakes, respectively. In the Deltaic region invasion of the islands Hoeksche Waard and Goeree-Overflakkee is now almost completed. Range extension in eastern direction is not likely, the Brabantian rivers being fresh and strongly polluted. *G. p. pulex* is here the only gammarid. Future range extensions are however possible in southern direction, after crossing the waters in between the islands. It will be interesting to follow the future developments in the province of Zeeland.

In the year of 1982 Berndt (1984) found *G. tigrinus* in the lower Rhine between Emmerich and Rees, in Western Germany. It was not until 1984 (Platvoet & Pinkster, 1985), that *G. tigrinus* was also demonstrated in the Dutch part of that river. Furthermore in the province of Limburg it was found in all major running waters, and in a canal on sandy bottom.

Moderately polluted canals and rivers offer a special kind of habitat, to which *G. tigrinus* proves to be excellently adapted (Schmitz, 1960; Ruoff, 1965). This in contrast to indigenous species, like *G. p. pulex*, which reach their greatest competitive power in relatively unpolluted habitats with a well developed and diverse flora and fauna. Both good adaptation to canals and rivers without submerse vegetation, and relaxed competition with indigenous species, will be largely in favor of *G. tigrinus*. The effect of the combination of these factors was likewise demonstrated in the past by the role canals play in the invasion of large parts of our country by other organisms, e.g. *Athyaephyra desmarestii* (Millet, 1831).

In our large rivers, the Meuse and the Rhine, the high ion content, caused by various industries and mining, may also contribute to the successful spreading of *G. tigrinus*. Although these major running waters branch out far from the previously known distribution area, *G. tigrinus* will stay strictly confined to these waters due to the unsuitable surrounding habitats.

C. pseudogracilis was first discovered in the Netherlands in 1979, in a limited area in the province of Groningen (Pinkster et al., 1980). Although this originally North American amphipod has rapidly spread over Great Britain and Ireland (Gledhill et al., 1976), only minor range extensions were being observed in the Netherlands up to the year of 1984. During the present survey, however, *C. pseudogracilis* substantially extended its range in the western and southern direction.

Invaded in western direction was the Stroobosser Trekvaart, an oligohaline water where *C. pseudogracilis* coexists with *G. tigrinus*. So far no data are available about the salinity tolerance and

preference of this amphipod, so future range extensions in oligohaline waters are unpredictable. Also the outcome of competition between *C. pseudogracilis* and *G. tigrinus*, if any, is yet unknown. However, it is unlikely that *G. tigrinus* will easily be outnumbered by *C. pseudogracilis* (see Pinkster & Platvoet, 1983) and further range extensions in western direction will be limited. In southern direction the Opsterlandse Compagnonsvaart and Tjongerkanaal were invaded, about 20 km remote from the formerly known distribution area. This newly invaded area is characterized by fresh waters or sandy bottoms where *G. p. pulex* was the only amphipod present. This range extension was already predicted by Pinkster & Platvoet (1983), as the reproductive capacity of *C. pseudogracilis* is much greater than that of *G. p. pulex*. Invasion of these two canals may be the first step towards a rapid dispersal over fresh inland waters.

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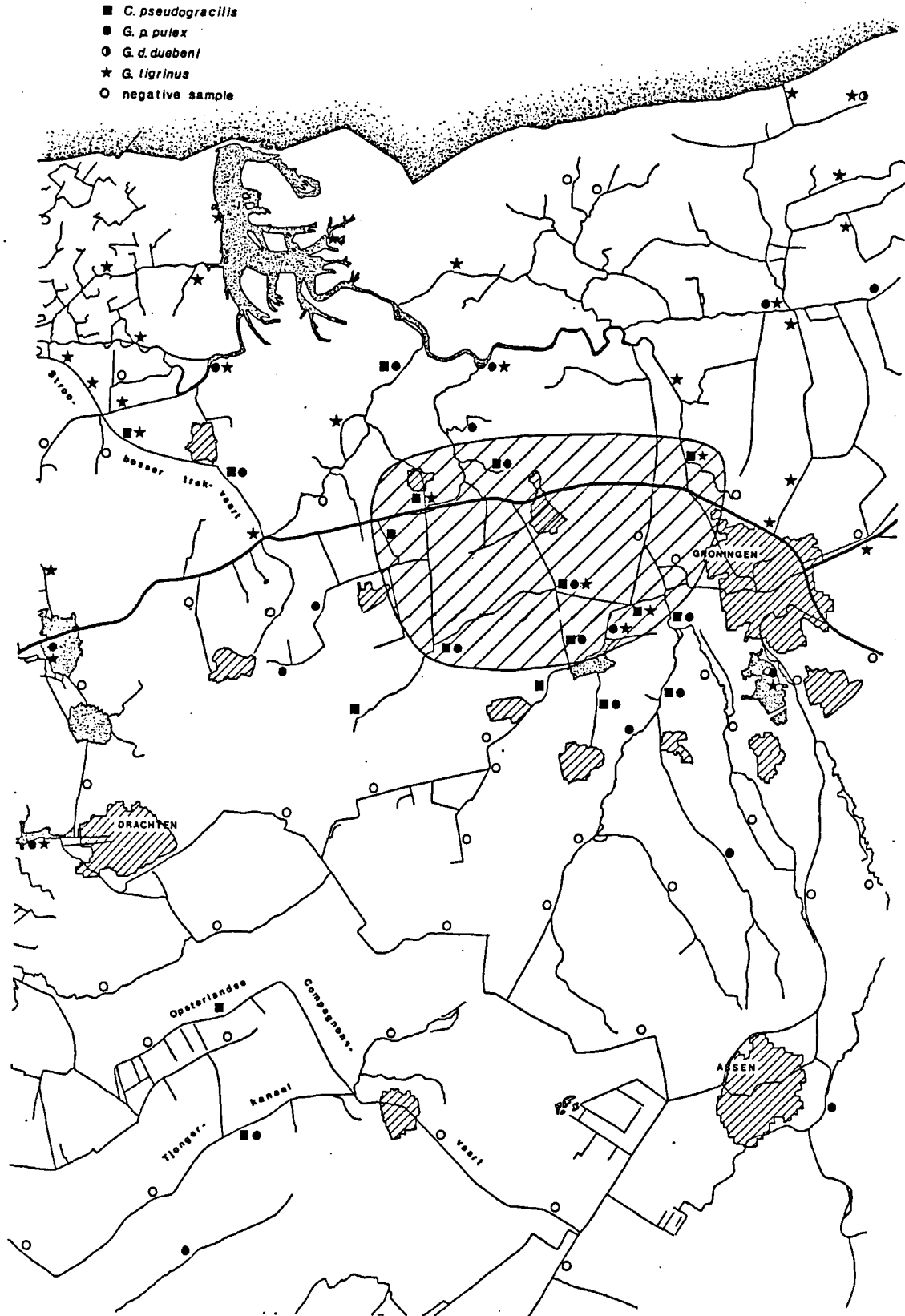


Fig. 2. Records of *C. pseudogracilis* and other aquatic amphipod species in the provinces of Groningen and Friesland at the end of 1986. The minimal area occupied by *C. pseudogracilis* at the end of 1984 is hatched.

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