OCCURRENCE OF NATIVE AND INTRODUCED CRAYFISH IN NORTHEASTERN GERMANY AND NORTHWESTERN POLAND.

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ABSTRACT

On the basis of monitoring undertaken in 300 lakes since 1994, the recent stocking situation for freshwater crayfish in northeastern Germany (Uckermark) and northwestern Poland (Szczecin area) is described. The two native species *Astacus astacus* (L.) and *Astacus leptodactylus* (Esch.) were found in five and two sites, respectively, while the introduced species *Orconectes limosus* (Raf.) and *Pacifastacus leniusculus* (Dana) were found in 214 and two sites. No crayfish were present in 77 sites.

Historical stocking data from 1959 for 92 sites in the area of Szczecin and Koszalin, northwestern Poland taken from the litterature were compared with the recent stocking situation according to our own investigations. In 1959, a total of 22 sites contained *A. astacus* and 13 sites contained *A. leptodactylus*. Both species were absent after 1994. In contrast, the number of stocks for *O. limosus* has increased from 57 in 1959 to about 90 after 1994.

Differences in juvenile growth and female fecundity studied in two lakes are suggested as a potential mechanism for extinction of native crayfish by introduced species, apart from infection by crayfish plague. Juvenile (1 year old) *O. limosus* showed a higher weight (8.03 ± 0.12 g) and length (64.7 ± 0.9 mm) than juvenile *A. leptodactylus* (2.11 ± 0.05 g and 44.8 ± 6.9 mm, respectively). The correlation between number of ovules and female total body length indicates a significantly ($p = 0.004$) higher number of eggs at the same length for *O. limosus* (regression coefficient : + 89.5) than for *A. leptodactylus* (regression coefficient : + 36.4).

Key-words : *Astacus astacus, Astacus leptodactylus*, distribution, extinction, freshwater decapod, *Orconectes limosus, Pacifastacus leniusculus*.

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PRÉSENCE D'ÉCREVISSES AUTOCHTONES ET INTRODUITES EN ALLEMAGNE DU NORD-EST ET POLOGNE DU NORD-OUEST.

RÉSUMÉ

Sur la base des relevés effectués dans 300 lacs depuis 1994, la situation récente des stocks d'écrevisse de l'Allemagne du Nord-Est (Uckermark) et de la région de Pologne du Nord-Ouest (Szczecin) est décrite. Les deux espèces autochtones *Astacus astacus* (L.) et *Astacus leptodactylus* (Esch.) ont été trouvées dans cinq et deux sites, respectivement, alors que les espèces introduites *Orconectes limosus* (Raf.) et *Pacifastacus leniusculus* (Dana) ont été trouvées dans 214 et deux sites, respectivement. Les écrevisses étaient absentes sur 77 sites.

Les données historiques de l'état des stocks de 1959 pour 92 sites dans les régions de Szczecin et Koszalin, en Pologne du Nord-Ouest relevées dans la littérature ont été comparées avec les données récentes selon notre propre étude. En 1959, *A. astacus* était présente sur un total de 22 sites et *A. leptodactylus* sur 13 sites. Par contre, le nombre de stocks de *O. limosus* a augmenté de 57 en 1959 à environ 90 après 1994.

Mise à part l'épidémie infectieuse de peste de l'écrevisse, les différences de croissance juvénile et de fécondité des femelles entre les écrevisses natives et les espèces introduites, étudiées dans 2 lacs sont proposées comme mécanisme potentiel d'extinction de l'écrevisse native. Les *O. limosus* juvéniles (âgés d´un an) ont un poids (8,03 ± 0,12 g) et une longueur (64,7 ± 0,9 mm) plus élevés que les juvéniles de l'espèce *A. leptodactylus* (2,11 ± 0,05 g et 44,8 ± 6,9 mm, respectivement). La corrélation entre le nombre d'œufs et la longueur du corps de la femelle indique que pour une même longueur, le nombre d'œufs est significativement ($p = 0,004$) plus élevé pour *O. limosus* (coefficient de régression : + 89,5) que pour *A. leptodactylus* (coefficient de régression : + 36,4).

Mots-clés : *Astacus astacus, Astacus leptodactylus*, distribution, extinction, décapode d'eau douce, *Orconectes limosus, Pacifastacus leniusculus.*

INTRODUCTION

Freshwater crayfish have the potential to influence the community structure and food webs of their environments (HART, 1992 ; NYSTRÖM *et al.*, 1996 ; NYSTRÖM and STRAND, 1996). They thus play an important role in aquatic ecosystem function (RABENI *et al.*, 1995). The central European area represented by northeastern Germany and northwestern Poland (Figure 1) was originally inhabited by two autochthonous freshwater crayfish species : the noble crayfish *Astacus astacus* (L.) and the narrow-clawed crayfish *Astacus leptodactylus* (Esch.) (ALBRECHT, 1983). The noble crayfish is found in nearly all parts of Germany and Poland, while the narrow-clawed crayfish is restricted to some areas in southwestern and northeastern Germany and most of Poland. For both species, the number of stocks is very low and the recent populations are small compared with those before the introduction of the crayfish plague (TROSCHEL and DEHUS, 1993 ; SCHULZ, 2000 ; STRUZYNSKI and SMIETANA, 1999).

The spiny-cheek crayfish *Orconectes limosus* (Raf.) was first introduced to Europe by the German ichthyologist Max von dem Borne in December 1890, who put 100 specimens into a 0.1 ha fish pond situated near the Mysla river close to Szczecin (SMOLIAN, 1926). The specimens introduced in 1890 are presumably the only ancestors of all *O. limosus* individuals nowadays occurring in Europe (KULMATYCKI, 1935) and the

place of their introduction is at the center of the geographical area investigated in this study. In 1935, KULMATYCKI (1935) reported 13 sites of occurrence of *O. limosus* in Western Poland ; at least four of them were sites with a co-ocurrence of *O. limosus* and *A. astacus.* KULMATYCKI (1935) also noticed the effect of slow eradication of *A. astacus* by *O. limosus* and proposed a higher fecundity of *O. limosus* as a reason for this process.

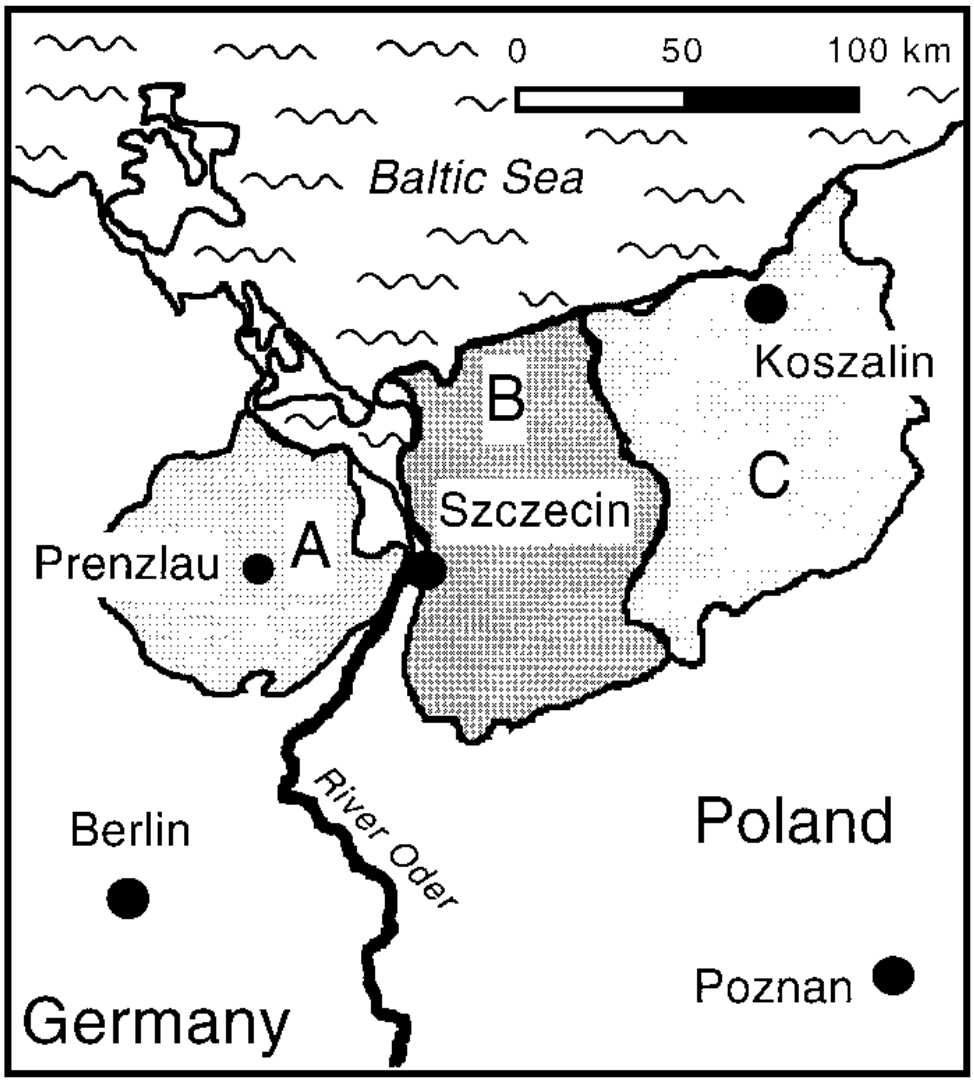

Figure 1

Map of the study area. The data from 300 lakes presented in the general survey section refer to the regions named Uckermark in northeastern Germany (A) and Szczecin area in northwestern Poland (B). The comparison of historical and recent stocking situation refers to the Szczecin (B) and Koszalin area (C).

Figure 1

Carte de la région d'étude. Les données de 300 lacs présentées dans la section de surveillance générale se rapportent aux régions nommées Uckermark en Allemagne du Nord-Est (A) et Szczecin en Pologne du Nord-Ouest (B). La comparaison des données historiques et récentes de l'état des stocks se rapportent aux régions de Szczecin (B) et Koszalin (C).

The first importation of the signal crayfish *Pacifastacus leniusculus* (Dana) was done by the Polish astacologist Józef Kossakowski. Within the period between 1972 and 1979 about 40 000 juvenile signal crayfish were taken from Simnostorp, Sweden for the purpose of introduction in Poland (KOSSAKOWSKI *et al*., 1983). However, this attempt failed (GONDKO and GIRSZTOFFT, 1987 ; KRZYWOSZ, 1994). Between 1991 and 1992 another 11 200 juvenile *P. leniusculus* were imported to Poland. This stocking attempt resulted in two areas of initial occurrence of *P. leniusculus* in northwestern Poland and the establishment of one pond farm for the aquaculture of this species in Western Pomerania (ULIKOWSKI *et al*., 2000). Nowadays, *P. leniusculus* seems to be a very important species for aquaculture in Poland.

The spread of crayfish plague (caused by the fungus *Aphanomyces astaci* Schikora), for which allochthonous crayfish species such as *O. limosus* and *P. leniusculus* serve as a vector, is considered the most serious threat to native crayfish stocks in Europe (LAURENT, 1997). Other factors with a strong negative impact on populations of native crayfish in Europe include the deterioration of water quality (WESTMAN, 1985), habitat destruction (BLANKE, 1998), competition from allochthonous crayfish species (LENKOWA, 1962 ; SÖDERBÄCK, 1995 ; WESTMAN, 1995) and predation by large stocks of predatory fishes, such as eel and perch (DEHUS, 1997).

The objective of this study is to demonstrate the recent stocking situation with special reference to introduced and native crayfish species, to compare historical and recent data on the distribution of crayfish and to suggest potential mechanisms of extinction exemplified by comparing life-cycle parameters in *A. leptodactylus* and *O. limosus*.

MATERIAL AND METHODS

General survey

A total of 300 lakes of the Szczecin and Uckermark area (Fig.1) were monitored between 1994 and 1999 in terms of recent occurrence of crayfish species according to a methodology described by SCHULZ (2000). The shallow littoral area of each lake was inspected during the night period. Simultaneously, several baited trap-nets (5 to 20 traps) were put into the littoral zone. If these investigations did not indicate any crayfish presence, the night inspections of deeper parts of the littoral zones were monitored by scuba diving. Whenever any *Astacus* species was detected, structural and water quality parameters of the site were described in detail (Table I). Occurrence of riparian and submerged macrophytes and dominating bottom type in the littoral zone were described and dominant fish species were evaluated according to information given by local fishermen.

Table I

Occurrence and distribution of crayfish in 300 lakes in northeastern Germany (Uckermark) and northwestern Poland (Szczecin area) with characteristics of those sites in which native crayfish species (*Astacus astacus* or *Astacus leptodactylus*) were found. For a description of the area covered, see Figure 1. The data refer to monitoring conducted between 1994 and 1999.

Tableau I

Présence et distribution de l'écrevisse dans 300 lacs de l'Allemagne du Nord-Est (Uckermark) et de la Pologne du Nord-Ouest (région de Szczecin), avec les caractéristiques des sites où les espèces autochtones d'écrevisses (*Astacus astacus* ou *Astacus leptodactylus*) ont été trouvées. Pour une description de la région couverte, voir la Figure 1. Les données se rapportent aux relevés effectués entre 1994 et 1999.

Crayfish species	Total no. of sites	Region		Dominant type of bottom structure[1]	Macrophytes in litoral area		Dominant fish fauna[2]
		Uckermark	Szczecin		emergent	submerged	
Astacus astacus	5	3	2[3]	sand	*Phragmites*	No plants, *Elodea, Myriophyllum*	perch, roach
Astacus leptodactylus	2	0	2	mud	*Phragmites*	*Myriophyllum*	bream, pike
Orconectes limosus	214	24	190	sand, clay, mud	*Phragmites, Carex* or no vegetation	*Myriophyllum, Elodea* or no vegetation	perch, roach
Pacifastacus leniusculus	2	0	2[3]	sand, clay	*Carex*	*Elodea*	perch, burbot
Without crayfish	77	75	2	sand, clay, mud	*Phragmites, Carex* or no vegetation	*Myriophyllum, Elodea* or no vegetation	perch, roach

[1] Covering more than 70 % of the nearshore bottom.
[2] According to local fishermen : perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), bream (*Abramis brama*), pike (*Esox lucius*), burbot (*Lota lota*).
[3] One stock is present in a river connected to a lake.

Historical and recent situation

In the Szczecin and Koszalin area (Figure 1), a verification of data reported by LENKOWA (1962) was performed. A total of 92 sites described in 1959 by LENKOWA (1962) were checked again between 1994 and 1998 using the methodology described above. Thirteen of these sites contained *A. leptodactylus* in 1959, while 22 contained *A. astacus* and 57 contained *O. limosus* (Table II). Since LENKOWA (1962) used only the local and not the official names of the lakes, it was impossible for us to identify with certainty 22 further sites that had been reported to contain an *Astacus* species in 1959.

Table II

Historic and recent stocking situation with native (*A. astacus* and *A. leptodactylus*) and introduced (*O. limosus*) crayfish in 92 lakes in the Szczecin and Koszalin area. Data for 1959 taken from LENKOWA (1962).

Tableau II

Données historiques et récentes de l'état des stocks de l'écrevisse native (*A. astacus* et *A. leptodactylus*) et introduite (*O. limosus)* dans 92 lacs des régions de Szczecin et Koszalin. Les données de 1959 sont de LENKOWA (1962).

Species	1959	1994 - 1998
Astacus astacus	22	0
Astacus leptodactylus	13	0
Orconectes limosus	57	33 (+ 57)[1]
No crayfish	0	2

[1] The 57 lakes identified in 1959 as *O. limosus* habitats were not thoroughly re-evaluated after 1994 ; see text for details.

Potential mechanisms of extinction

In order to determine potential mechanisms of extinction of native crayfish by introduced crayfish species, juvenile length and weight as well as the female fecundity were compared for *A. leptodactylus* and *O. limosus*. Growth and weight were compared for 326 1-year-old *O. limosus* from Dabie lake, eastern edge of Sczcecin, and 251 1-year-old *A. leptodactylus* from Bylice Lake, 65 km southeast of Sczcecin (SMIETANA, 1998). Juvenile *O. limosus* were collected between August and September and juvenile *A. leptodactylus* between October and November. At time of catch, the juveniles of the latter species were more than 4 months old, while the juveniles of *O. limosus* were about 3 months old and thus younger.

To determine the absolute fecundity, 32 females of *O. limosus* from Dabie lake, and 28 females of *A. leptodactylus* from Bylice Lake (SMIETANA, 1998) were collected. The ovaries of the fully matured females were removed, preserved in 4 % formalin, and the number of ripe yellow ovules was counted. The correlation between total body length and number of ovules was estimated and presented according to methods described by STYPINSKA (1972a, 1972b, 1978). Weight and length data from juvenile crayfish were compared with the t-test. The difference between regression coefficients was estimated using the test for parallelism (ZAR, 1984).

RESULTS

General survey

The results obtained during the general survey of 300 lakes in the Uckermark and Sczcecin area are summarized in Table I. *A. astacus* was found in five sites, of which three

were situated in the Uckermark area in northeastern Germany. *A. leptodactylus* was detected only in two sites of the Sczcecin area in northwestern Poland and was not present in northeastern Germany. A total of 192 sites (approx. 95 %) in the Sczcecin area contained one of the introduced crayfish species *O. limosus* or *P. leniusculus*, while only 2 sites were free of crayfish. In contrast, a large number of lakes in the Uckermark area (approx. 75 %) did not contain any crayfish species, indicating the availability of many sites that potentially can be used for future restocking programmes.

Historical and recent situation

The historical and recent stocking situation with crayfish in 92 lakes in the Szczecin and Koszalin area (Figure 1) is summarized in Table II. According to LENKOWA (1962), *A. astacus* was present in 22 lakes and *A. leptodactylus* in 13 lakes in 1959. A recent survey undertaken between 1994 and 1998 has shown that both native species vanished from all these sites (Table II). The introduced crayfish species *O. limosus* was present in 33 of the 35 sites fomerly containing native species and two sites were free of crayfish species. The 57 lakes that contained *O. limosus* in 1959 were not thoroughly re-evaluated. However, all of these sites that were checked (23 of the 57 sites) still contained *O. limosus*.

Potential mechanisms of extinction

The length and weight of juvenile (1-year-old) *A. leptodactylus* and *O. limosus* are compared in Figure 2. Juvenile *O. limosus* showed a significantly higher total body length (64.7 ± 0.9 mm ; p = 0.004) and body weight (8.03 ± 0.12 g ; p = 0.004) than juvenile *A. leptodactylus* (44.8 ± 6.9 mm and 2.11 ± 0.05 g), although the juveniles of the latter species were even older.

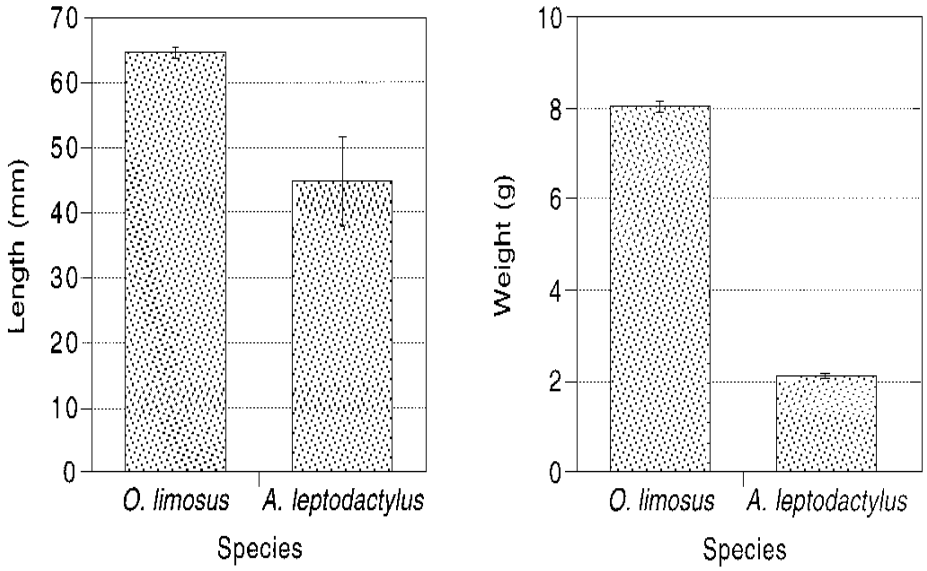

Figure 2
Average (± SE) weight and length of 1-year-old male crayfish *Astacus leptodactylus* (n = 251) and *Orconectes limosus* (n = 326) caught from two lakes in the Szczecin area.

Figure 2
Poids et longueur moyenne (± SE) des écrevisses mâles de 1 an *Astacus leptodactylus* (n = 251) et *Orconectes limosus* (n = 326) attrapées dans deux lacs de la région Szczecin.

Fully-matured female *O. limosus* had a considerably higher number of eggs than female *A. leptodactylus* of the same body length (Figure 3). This difference amounted to approx. 200 eggs for females of 9 cm length and 300 eggs for females of 11 cm length. The regression coefficient for the linear correlation of number of eggs and female body length was + 89.5 for *O. limosus* and thus significanlty higher (p = 0.004) than the regression coefficient for *A. leptodactylus* (+ 36.4).

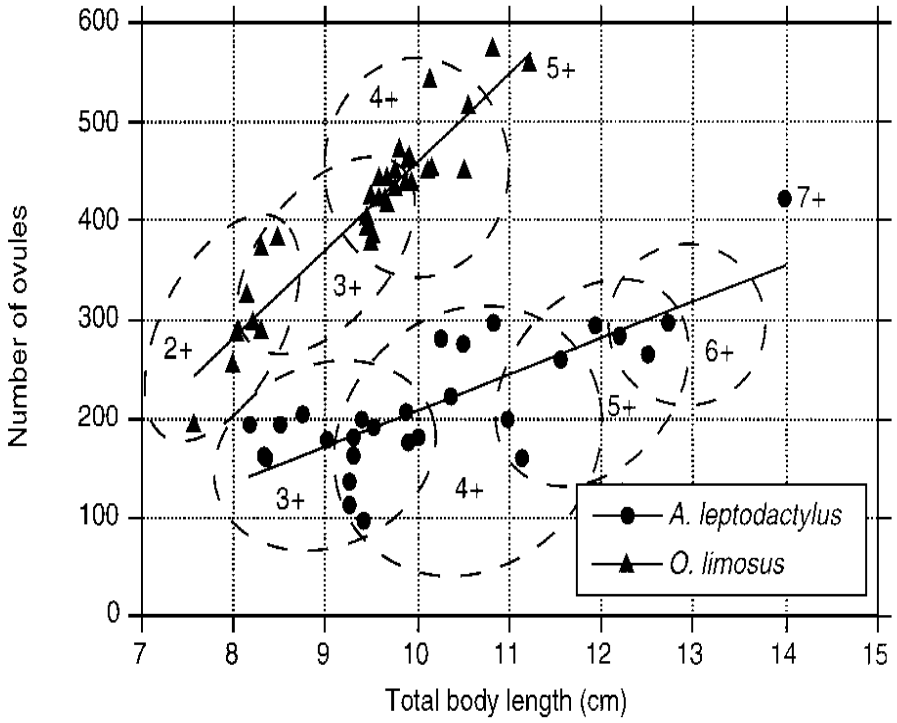

Figure 3
Fecundity of female crayfish *Astacus leptodactylus* (n = 28) and *Orconectes limosus* (n = 32) caught from two lakes in the Szczecin area, expressed as linear regression between number of ovules and total body length.

Figure 3
Fécondité de l'écrevisse femelle *Astacus leptodactylus* (n = 28) et *Orconectes limosus* (n = 32) attrapées dans deux lacs de la région de Szczecin, exprimée par une régression linéaire entre le nombre d'ovules et la longueur totale du corps.

DISCUSSION

General survey

The general survey of 300 sites in the Uckermark and Szcecin area clearly indicated the dominance of introduced crayfish species such as *O. limosus* and the low number of *Astacus* stocks. This result confirmed a situation that is representative for other regions of Poland (MASTYNSKI and ANDRZEJEWSKI, 2000 ; KRZYWOSZ *et al.*, 1995a ; DURIS, 1999). Recently, an expansion of *O. limosus* was reported in the Elba and Veltava river in the Czech Republic (DURIS, 2000). An expansion of *O. limosus* from the territory of Poland to Lithuanian waters has been reported by BURBA (1994, 1996). In 1998, an

expansion of *O. limosus* was confirmed by the first record of this species in Belarus (KULESH, ALEKHNOVICH, personal communication). TROSCHEL and DEHUS (1993) reported a general distribution of *O. limosus* in Germany and estimated this species as widespread.

Apart from crayfish plague and environmental pollution (especially with pesticides), the presence of *O. limosus* is regarded as the main threat to native crayfish stocks and their restitution in Poland (STRUZYNSKI and SMIETANA, 1999). In addition to the obvious fact of disappearance of native crayfish species if crayfish plague is transmitted by alien species such as *O. limosus* or *P. leniusculus,* other mechanisms of ousting should be taken into consideration. There are observations of co-occurrence of *A. astacus* or *A. leptodactylus* and *O. limosus* in the same body of water over a span of a few years (KRZYWOSZ *et al.,* 1995b ; STRUZYNSKI and NIEMIEC, 2000 ; DEHUS, 1990).

The common opinion that the presence of crayfish indicates and causes clean water conditions has resulted in an extensive, uncontrolled transfer of *O. limosus* into many lakes by anglers, fishermen, and owners of water bodies, who were trying to use it to test the water quality (STRUZYNSKI and SMIETANA, 1999). *O. limosus* is also distributed to new lakes by anglers who use it as bait. This phenomenon has also been described for Germany (TROSCHEL and DEHUS, 1993). Due to the general distribution of *O. limosus* in almost all surface waters in northwestern Poland, the restitution is very difficult.

In contrast, our study indicated a large number of crayfish-free lakes in the Uckermark in northeastern Germany. About 75 % of the lakes investigated in this area were not inhabited by either native or introduced species. As stated by SCHULZ (2000), there is a potential to find further stocks of native crayfish as well as to identify even more potential habitats for restocking programmes in this part of Germany. In Brandenburg alone, which comprises about 8.2 % of the area of Germany, there exist more than 1 600 small lakes with an area between 1 and 5 ha (MIETZ, 1996), most of them not investigated in detail.

Results of trial introductions of *Pacifastacus leniusculus* in Poland conducted by Kossakowski (GONDKO and GIRSZTOFTT 1987) showed that this species seems less likely to expand than *O. limosus*. Eutrophication of polish lakes is probably the main argument for the lack of expansion of *P. leniusculus* (ULIKOWSKI *et al*., 2000). However if this species is introduced to only slightly eutrophicated waters, it can be dangerous for the last *A. astacus* stocks in northwestern Poland.

It can be concluded from these results that cross-border species conservation activities should focus on the establishment of native crayfish stocks in crayfish-free lakes in northeastern Germany. In parallel, measures to reduce the distribution of alien crayfish species are strongly recommended for the area of northwestern Poland.

Historical and recent situation

In 1962, LENKOWA (1962) reported 57 sites of occurrence of *O. limosus* in the Szczecin and Koszalin area as well 18 stocks of *A. leptodactylus* and 39 stocks of *A. astacus*, three of them as coexisting stocks together with *O. limosus*. The results of this study comparing the recent stocking situation with the historical data reported by LENKOWA (1962) show that the former habitats of native crayfish species have now been taken over by introduced species, namely *O. limosus*. Similar results are reported by MASTYNSKI and ANDRZEJEWSKI (2000) for the Wielkopolska region, where all former known sites of *A. astacus* and *A. leptodactylus* are now inhabited by *O. limosus*. The same phenomenon was reported by BIALKOZ *et al*. (1996) for the Suwalki area and GIELO (1975) for the Gorzów Wielkopolski area.

Many authors have reported a still ongoing invasion of *O. limosus* from northwestern Poland to the remaining parts of the country (LENKOWA, 1962 ; JAZDZEWSKI and KONOPACKA, 1993 ; STRUZYNSKI and SMIETANA, 1999). At this stage, only the southeastern part of Poland is not inhabited by *O. limosus* (STRUZYNSKI and SMIETANA, 1999). The status of native crayfish species is still declining. After 1918, Poland was the second on the list of important crayfish-exporting countries in Europe, just behind the USSR. In 1927, the annual yield was approximately 610 tonnes (STRUZYNSKI, 2000). In 1959, the total annual catch was 59.8 tonnes (PYKA and KRASNIEWSKI, 1997). Nowadays, the commercial exploitation of native crayfish is centred in the southeastern part of Poland and amounts to no more than 2 tonnes per year (STRUZYNSKI, 2000) ; it is confined mostly to the area of Poland that is not inhabited by *O. limosus.*

It can be concluded that one of the main reasons for the disappearance of native crayfish species in Poland, apart from crayfish plague and environmental pollution, is the presence of *O. limosus*. This suggests the importance of investigations on the autecology of introduced and native species, as presented in the following section.

Potential mechanisms of extinction

The comparision of autecological parameters in two crayfish populations revealed a larger weight and size for juvenile *O. limosus* and a higher fecundity for female *O. limosus* in comparison to juveniles and females of *A. leptodactylus*. Both the faster growth and the higher fecundity are likely make *O. limosus* more competitive with native *Astacus* species. Our data for juvenile weight and length are in the same range as other data reported for *O. limosus* (KOSSAKOWSKI, 1961) and *A. leptodactylus* (KOSSAKOWSKI, 1964 ; ARRIGNON, 1996).

Over half a century ago KULMATYCKI (1935) noticed that *O. limosus* slowly but permanently eradicates *A. astacus* from natural habitats. Higher fecundity was stated as a potential reason for this phenomenon. Our data have shown a statistically significant difference in fecundity between *O. limosus* and *A. leptodactylus*. Other data that confirm the higher fecundity of *O. limosus* in comparison with *A. leptodactylus* or *A. astacus* in Polish waters are summarized in Table III. A high reproductive rate of *O. limosus* has also been mentioned by TROSCHEL and DEHUS (1993).

Table III

Comparison of our own data and data taken from the literature on fecundity of female crayfish. Regression coefficients refer to a linear regression (y = ax + b) between number of eggs and length.

Tableau III

Comparaison de nos données et de celles de la littérature sur la fécondité de l'écrevisse femelle. Les coefficients de régression se rapportent à la régression linéaire (y = ax + b) entre le nombre d'œufs et la longueur.

Species	Lake	n	Regression coeficient a	Factor b	Squared correlation coefficient r^2	Significance	Reference
O. limosus	Dabie	32	84.93	-434.57	0.88	$p < 0.0001$	Our own data
A. leptodactylus	Bylice	28	36.42	-156.90	0.62	$p < 0.0001$	Our own data
A. leptodactylus	Rzeplino	24	37.70	-182.60	0.44	$p < 0.001$	Smietana 1998
A. astacus	Zerbun	50	60.21	-395.16	0.82	$p < 0.05$	Stypinska 1978
A. astacus	Dluzek	50	49.17	-294.28	0.75	$p < 0.05$	Stypinska 1978
O. limosus	Spychowskie	50	110.91	-543.28	0.90	$p < 0.05$	Stypinska 1978
O. limosus	Wdzydze	50	82.45	-317.09	0.85	$p < 0.05$	Stypinska 1978

It is important to note that the number of juveniles is the ultimate measure of fecundity and not the number of ovules. However, the exact estimation of juvenile density in natural habitats is very difficult and thus we decided to use the number of ovules as a variable describing differences in fecundity. Since *A. leptodactylus* carries the eggs much longer (about 6 months) than *O. limosus* (about 6 weeks), it seems likely that the probability of eggs not developing to juveniles is much higher in *A. leptodactylus*. This corroborates the assumption of higher fertility of *O. limosus* showing considerably higher number of ovules.

The observed differences in growth and fecundity may play an important role in the competitive relation between *Astacus* species and *O. limosus,* when they co-occur in the same surface water. According to observations of KRZYWOSZ *et al*. (1995b) as well as STRUZYNSKI and NIEMIEC (2000), only large adult individuals of *Astacus* species were present in sites of co-occurrence, whereas there was a range of size-classes of *O. limosus*. The observation that *O. limosus* interacts competitively with *A. astacus* was also reported by DEHUS (1990). However, competitive interactions between *Astacus* species and *O. limosus* need to be studied in greater detail.

The differences between Cambaridae species (such as *O. limosus*) and Astacidae in life span (2.5 to 4 years and up to 8 years) or age at sexual maturity (below two years and 2 to 4 years) (LODGE and HILL, 1994), indicate a possible mechanism of eradication. These mechanisms might be similar to those examined by SÖDERBÄCK (1993), who described co-occurring *Pacifastacus leniusculus* and *A. astacus* in Sweden. He stated that even if no crayfish plague is present, *P. leniusculus* can outcompete *A. astacus* due to behavioural differences such as aggressive interactions.

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