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Status and management of noble crayfish *Astacus astacus* in Estonia

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ABSTRACT

Key-words: *noble crayfish,* Astacus astacus*, test fishing, stock management, Estonia*

Noble crayfish *Astacus astacus* (L.) is an indigenous and the only crayfish species in Estonia. It is potentially endangered by invasion of alien species, diseases and habitat deterioration but does not have legal protected status and is fished only for recreational purpose. Crayfish Working Group of Ministry of Environment and Department of Aquaculture of the Estonian University of Life Sciences have developed crayfish conservation and management plan. Since 1994 standardized test fishing with traps (which catch only crayfish over 7 cm TL) has been carried out and database of these fishings shows, that crayfish is dwelling in more than 255 sites in the lakes, rivers, streams, artificial reservoirs. In 52% of monitored sites populations are weak, catch per trap night is below 1 specimen. Exceptionally rich is the stock on the island Saaremaa, where in 59% of populations catch per trap night is over 4 and can reach 50. Licensed recreational catch is allowed in regions, where monitoring data show good status of crayfish stock. It is not allowed to sell the crayfish caught on recreational license. Crayfishing season is limited with August, size limit in recreational fishery is 11 cm TL. There are 10 operating crayfish farms and 15 are under construction. The farms produce yearly around 1000 kg of commercial size crayfish for export to Finland. Over 200 000 juveniles are produced for restocking yearly. Restocking projects *e.g.* restoration of populations, which have been lost because of plague have been successful. The main threat factor is crayfish plague. In 2006–2007 it destroyed the stock of crayfish farms of companies Veteko, Pähkla, Astacus and wild population of Põduste river on the island Saaremaa.

RÉSUMÉ

État et gestion de l'écrevisse à pieds rouges *Astacus astacus* en Estonie

Mots-clés : *écrevisse à pieds rouges,* Astacus astacus*, pêche expérimentale, gestion d'espèce, Estonie*

L'écrevisse à pieds rouges *Astacus astacus* (L.) est une espèce indigène et la seule espèce d'écrevisse en Estonie. Elle est potentiellement mise en danger par l'invasion d'espèces allochtones, des maladies et la détérioration de l'habitat, mais elle n'a aucun statut de protection légale et est pêchée seulement dans le cadre des loisirs. Le Groupe de travail sur l'écrevisse du Ministère de l'Environnement et le Département de l'Aquaculture de l'Université estonienne des sciences de la vie ont élaboré un plan de conservation et de gestion de l'écrevisse. Depuis 1994, des pêches d'échantillonnage standardisées avec des nasses (qui n'attrapent que les écrevisses de plus de 7 cm TL) sont conduites. La base de données de ces pêches montre que l'écrevisse est présente dans plus de 255 sites en lacs, rivières, fleuves

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et retenues. Dans 52 % des sites inventoriés, les populations sont faibles, les captures par nasse et par nuit sont en dessous d'un individu. Le stock de l'île de Saaremaa est exceptionnellement riche avec dans 59 % des populations des captures par nasse et par nuit au-dessus de 4 et pouvant atteindre 50. La pêche récréative avec permis est autorisée dans les régions où les données de suivi montrent un bon état du stock d'écrevisses. La vente est interdite pour la pêche récréative. La saison de pêche récréative est limitée au mois d'août et la taille limite est de 11 cm TL. Il existe 10 pisciculture à écrevisse et 15 sont en construction. Les pisciculture produisent annuellement 1000 kg d'écrevisse de consommation pour l'exportation en Finlande. Plus de 200 000 juvéniles sont produits pour le repeuplement chaque année. Des projets de repeuplement pour la restauration de populations détruites par la peste ont été des succès. Le principal facteur de menace est la peste de l'écrevisse. En 2006–2007, elle a détruit le stock des pisciculture des compagnies Veteko, Pähkla, Astacus et les populations de la rivière Põduste de l'île de Saaremaa.

INTRODUCTION

Noble crayfish *Astacus astacus* (L.) is the only freshwater decapod species in Estonia. No alien species have been introduced and the wild stock is still large enough for recreational fishery. Till the end of 19th century, crayfish consumption was common in Europe, people fished and ate them and trade with crayfish was widespread (Pöckl, 1999). Estonian rivers and lakes contained exploitable stocks of crayfish until the mid 1990s, but population density decreased significantly because of several destructive factors – aphanomycosis (crayfish plague), habitat deterioration, mink and eel predation and fishing (Järvekülg, 1958; Tuusti *et al.*, 1993). The only region which was not affected by plague until 2006 and still retains viable stock is the island Saaremaa, which besides Swedish island Gotland is a unique reserve at the all-European scale. There is rising interest in crayfish farming in Estonia. Ten crayfish farms are already operating and 15 are under design or construction. Catching, farming, trade and restocking increased the threats (spread of diseases, overfishing, introduction of alien species) to the noble crayfish. National crayfish conservation and management strategy was needed. It should include the list of crayfish populations and waters, which have to be restocked, potential donor stocks for restocking or creating broodstocks for crayfish farms and the description of pattern of spread of diseases, which may prevent transfer or restocking activities. The strategy was created by department of aquaculture of Estonian University of Life Sciences.

Earlier estimations of size of the crayfish stock of Estonia have been based on rough and variable methods of test fishing – picking by hand or dipnetting (Järvekülg, 1958; Tuusti, 1994). Standard methods of trapnetting were introduced in the beginning of 1990s and the dynamics of the status of crayfish could be followed in many populations since that time. The first results of test fishing covering Southern Estonia were published by Hurt *et al.* (1999). An attempt to create the national inventory of Estonian crayfish stocks was made within the framework of the Estonian-Norwegian project in 1996–1997 (Tuusti *et al.*, 1998). A database of results of standardized test fishing and crayfish stockings is hold since in 2003 in the department of aquaculture of Estonian University of Life Sciences. Recording of diseases was poor for long period. Until 2007 aphanomycosis could be diagnosed only from alive crayfish. But often only dead and decayed crayfish were found after mass mortality. Nowadays the molecular methods (Oidtmann *et al.*, 2004; Vrålstad *et al*., 2009) provide fast and reliable way of diagnostics. The plague outbreak in 2006–2007 was identified by real-time PCR method of DNA analysis.

The aim of this publication is to describe the status of noble crayfish populations and measures of exploiting, protection and enhancing of the stock of it in Estonia. It provides unique experience, because Estonia is one of the few countries in Europe, where no non-indigenous

crayfish have been introduced and wild native crayfish resource is exploitable for recreational purposes, while the commercial production comes from crayfish farms.

MATERIALS AND METHODS

Test fishing with standard trap nets was carried out by department of aquaculture of EMU in 127 lakes and 162 streams of Estonia in the period 1994–2009. Only the water bodies that were known to have been habited by crayfish or were considered to be suitable for crayfish were studied. Test fishing was carried out according to the standard Swedish protocol (Edsman and Söderbäck, 1999). Cylindrical traps with two conical entrances and 15 mm mesh size (knot to knot) were used. A test area, which was expected to be a suitable habitat for crayfish, was selected in each lake or river after screening of longer stretches of the shoreline. Fresh fish (mainly roach *Rutilus rutilus* and bream *Abramis brama*) was used as bait. The traps were applied as lines consisting of ten traps with an interval of 10 m and kept in the water overnight. One to three lines were used depending on the size of the water body. The abundance of crayfish was estimated as relative fishing efficiency (catch per unit effort, CPUE) *i.e.* number of crayfish caught per trap per night. The minimal size of crayfish caught by test traps was 75 mm TL. The legal minimum size of crayfish in recreational fishery was 10 cm TL until 2004, when it was raised to 11 cm. Proportion of legal size crayfish in trap catches was below 50%. The classification of Tulonen *et al.* (1998) was applied to describe the crayfish population density on the basis of the results of the test fishing CPUE. CPUE over 4 was estimated as high density, between 1 and 4 as moderate, below 1 as low – indicating only presence of crayfish population.

The data about stocking and production of crayfish for consumption or for export were obtained from official sources (Ministry of Environment and Statistical Office) and *via* personal contacts with crayfish farmers and county administration. The effect of restocking was estimated on the basis of test fishing carried out by above mentioned methodology. Data about the limnological types of Estonian lakes were provided by Limnology Center of EMU (Ott and Kõiv, 1999).

RESULTS AND DISCUSSION

> *NUMBER AND DISTRIBUTION OF CRAYFISH POPULATIONS IN ESTONIA*

Over 255 sites (lakes and river stretches) where crayfish live were registered in Estonia. Some regions *e.g.* South-Eastern Estonia and the island Saaremaa are quite densely populated with crayfish, while in some other areas only single sites have been detected (Figure 1). Density of most of the populations is low – catch per trap per night is usually below 1. High density, CPUE over 4 was found in 15% of 255 studied sites, in 33% it was 1–4, in 52% it was below 1. In the best condition is the crayfish stock on the Island Saaremaa, which was free of crayfish plague until 2006 and where CPUE was over 4 in 59% of populations (in the best case 50).

The distribution of crayfish in lakes depends on type of lake (Table I). It is evident that crayfish is missing from halotrophic lakes of the sea coast and dystrophic lakes with soft bottom and low pH. Trophic level does not influence abundance of crayfish so much. Crayfish can be found in oligotrophic, eutrophic and even hypertrophic lakes. In Central Europe the noble crayfish dwells also in various habitats (Maguire and Gottstein-Matocec, 2004) including lakes and rivers of different type at different altitudes. However, in many Central European countries the same pattern as in Estonia can be followed. Most of the populations are weak, indicating only presence of crayfish (Pöckl, 1999; Füreder, 2009). The status of noble crayfish stock in some neighbouring to Estonia countries (Russia, Latvia) is less known. Wild stock of Latvia has been estimated to be in good status and program of enhancement of wild stock and crayfish farming has been established (Arens and Taugbøl, 2005).

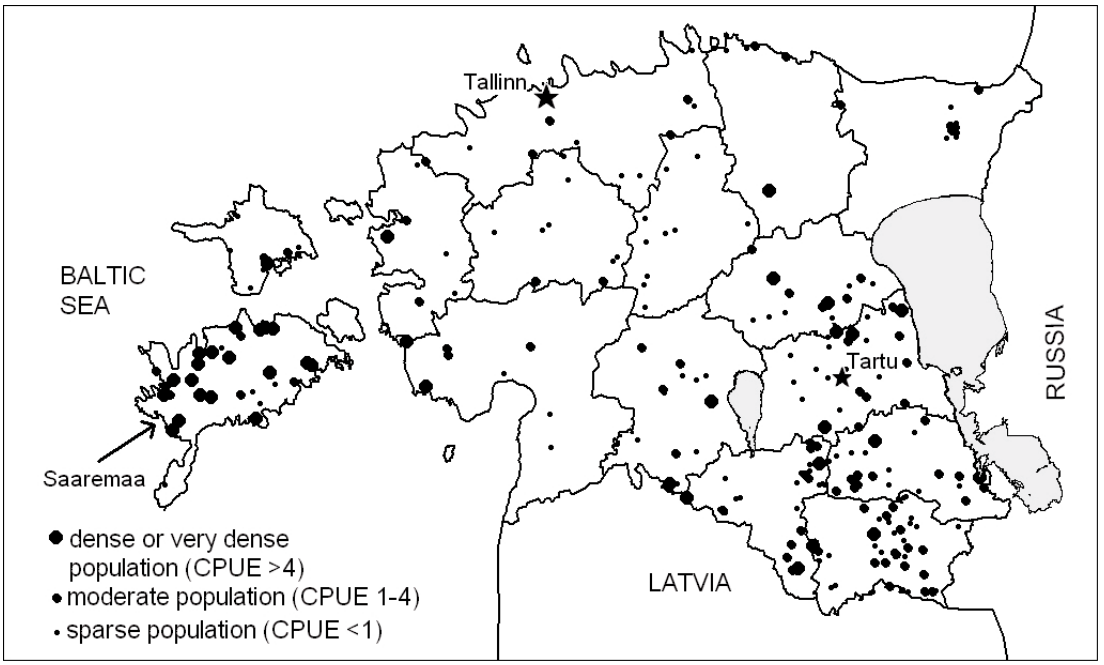

Figure 1
Distribution of noble crayfish populations of different density in Estonia.

Figure 1
Distribution des populations de l'écrevisse à pieds rouges en Estonie.

Table I
Distribution of crayfish in different types of lakes of Estonia.

Tableau I
Distribution de l'écrevisse à pieds rouges dans différents types de lacs d'Estonie.

Limnological type of lakes by database of Center of Limnology	Number of limnologically typified lakes	Number of known crayfish populations*	Number of populations of different density by CPUE		
			High or very high	Moderate	Low
Alkalitrophic	20	2	1	0	1
Acidotrophic	19	1	0	1	0
Dystrophic	186	0	0	0	0
Halotrophic	38	0	0	0	0
Hypertrophic	30	10	2	3	5
Hard-water eutrophic	154	46	6	11	29
Hard-water mixotrophic	93	12	0	5	7
Macrophytic	68	2	0	1	1
Oligotrophic	28	7	0	5	2
Soft-water eutrophic	26	3	0	2	1
Soft-water mixotrophic	58	6	0	1	5
Semidystrophic	34	11	0	7	4
Total	**754**	**100**	**9**	**36**	**55**

* Test fishing has not been carried out in all limnologically typified lakes.

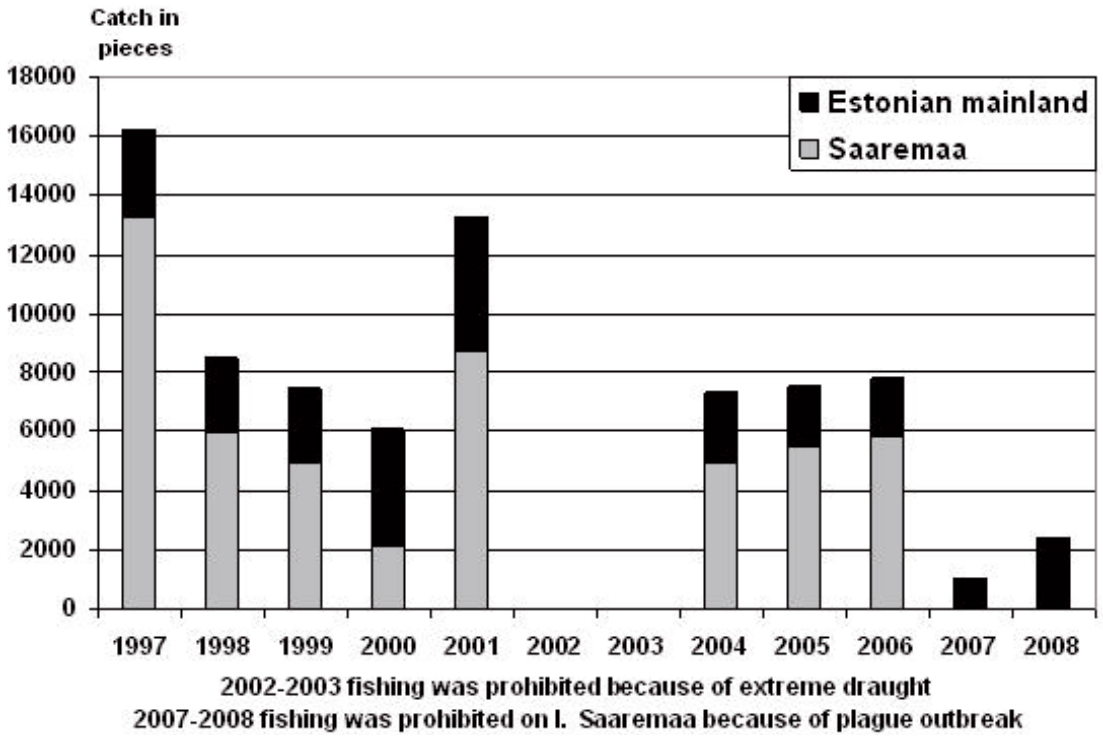

Figure 2
Recreational licensed catch of crayfish from Estonian lakes and rivers by years.

Figure 2
Captures annuelles par pêche récréative d'écrevisse dans les rivières et lacs d'Estonie.

> CONSERVATION AND MANAGEMENT OF WILD STOCK

Wild crayfish stock is nowadays not large enough for the commercial fishery. In the beginning of 1900s 13 (maximum 30) tons of crayfish were exported from Estonia. Noble crayfish is enlisted as vulnerable in IUCN Red List but in Estonia it is not protected by Nature Conservation Act. The threat factors are similar to other East European countries, where in some cases noble crayfish is classified as endangered (Pöckl, 1999). However, there are differences between countries. Influence of overfishing is not so significant in Estonia, as it is in Serbia and Montenegro (Simic *et al*., 2008). At the same time alien species are still only potential threat in Estonia and the preventive measures against introduction of them have to be taken. The main measure of protection of noble crayfish is regulation of fishing – catch licensing, limited minimal size, closed season. Wild stock is not commercially exploited, only recreational fishery is carried out on the basis of licenses issued by Environmental Board of Ministry of Environment. Sale of the crayfish caught on basis of license is prohibited. Crayfish may be caught by traps or dipnets in regions, where stock is abundant enough by the monitoring data of scientists. The annual legal recreational catch has been less than 10 000 crayfish during last years (Figure 2), but total catch might be higher because of not recorded illegal fishing. On the average (excluding the years, when catching was prohibited) 65–68% of the crayfish were caught on the island Saaremaa. Reasons of temporary ban of recreational catch of crayfish were: (1) extreme draught in 2002, when many small streams dried and the population was considered to be endangered; (2) outbreak of crayfish plague on Saaremaa in 2006–2007, when all fishing on this island was prohibited to prevent spread of disease. Minimal legal size (TL) is 11 cm. Crayfishing season is August.

Conservation and management policy of the crayfish stock is coordinated by a Crayfish Working Group of the Ministry of Environment consisting of scientists and officials. The database

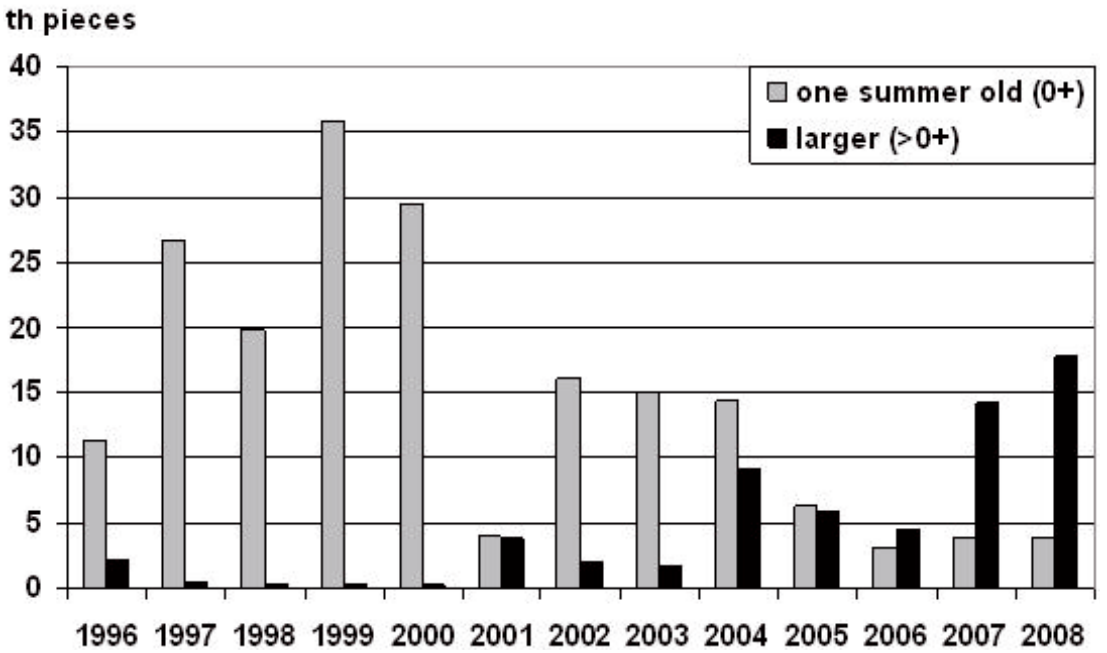

Figure 3
Restocking of crayfish into Estonian lakes and rivers by years.

Figure 3
Repeuplements d'écrevisse dans les rivières et lacs d'Estonie annuellement.

Table II
Restocking and results of test fishing of crayfish in L. Nõuni after plague outbreak in 2002.

Tableau II
Repeuplement et résultats des pêches expérimentales dans le lac Nõuni après l'effondrement dû à la peste en 2002.

Year	Number of stocked crayfish	Average CPUE of test fishing	CPUE of test fishing in the best crayfish habitat
2003	1000		
2004	1000	0	0
2005	2000	0.1	0.1
2006	2000	0.1	0.2
2007	5000	0.1	0.1
2008		1.0	2.9
2009		1.1	3.3

of crayfish populations was created by the group in 2004 and an overview of status of noble crayfish was published (Medar *et al.*, 2006). Similar database has been earlier formed for Austria (Pöckl, 1999). Conservation and management plans of wild noble crayfish stock were developed by the Crayfish Working Group for every county and for the whole Estonia and transferred to the ministry and county administrations.

Establishing of new populations in old gravel or clay pits and rearing of crayfish in farm ponds offers a chance to create recreational crayfish catching tourism, which may be the most reasonable way of crayfish management and is encouraged by Ministry of Environment. This has to be carried out under controlled conditions and according to the laws which are prohibiting import of live alien crayfish.

> RESTOCKING OF CRAYFISH

Building of several crayfish farms in 2000s has provided good opportunities of purchasing of crayfish juveniles for stocking. For establishing of new or supporting weak crayfish populations more than 250 000 specimens of different age were stocked by state into nearly 100 natural water bodies during the period 1996–2008 (Figure 3). There was a significant shift from stocking of only one summer old crayfish (2–3 cm TL) to stocking of older year classes (mainly 2 or 3 summer old specimens, TL over 5 cm) after 2001. The effect of stocking was estimated as more or less positive in a half of studied stocking sites. Five new populations were created, increase of density or restoration of vanished populations was registered in 32 sites. Compared to other countries it can be considered as a positive result. In Austria the restockings often failed, only 15% of the restocking experiments were successful (Pöckl, 1999).

A good example of success of restoration of a crayfish population after plague is case of Lake Nõuni. This 82 ha lake contained viable crayfish population until 2002. CPUE of test fishing was around 5–7 in 1999–2001. In 2002 it suffered from suspected plague outbreak. Test fishing with 80 traps in different parts of the lake did not reveal presence of any crayfish in the lake. The lake was considered to be free of crayfish and crayfish plague. 11 000 crayfish of different age but mainly of large size (TL 6–10 cm) were released into the lake in 2003–2007 (Table II). In the first years of monitoring few crayfish (probably stocked specimens) were caught, but CPUE was rising continuously and exceeded 3 in the best biotope in 2009. Crayfish, which were caught in 2008–2009 and were under 10 cm TL should represent already new generations.

> CRAYFISH FARMING

There are 10 operating crayfish farms in Estonia and approximately 15 are under design or construction. Five farms produced and sold crayfish for consumption in 2008. Total production of market size crayfish has been below 1000 kg yearly (Figure 4), but many small crayfish are sold to other crayfish farmers or used for restocking (Figure 3). Commercial size crayfish (over 10 cm TL) are mainly exported to Finland. The production could be much higher if crayfish plague did not destroy the stock of ponds of three crayfish farms in 2006–2007.

> DISEASES

The most serious threat factor for noble crayfish is crayfish plague. Despite long history of crayfish plague studies (Söderhäll and Cerenius, 1999) some aspects of the etiology and ways of spreading of plague are still unknown. In Estonia crayfish plague has seriously damaged natural populations since the end of 19th century. Except the I. Saaremaa the crayfish stock declined after several outbreaks during 1900s. Five cases of mass mortality of crayfish (suspected plague outbreaks) were reported in natural waters on Estonian mainland after 2000. However, outbreaks of plague have caused serious economic losses in crayfish farms. By means of real-time PCR based DNA analysis it has been proved, that crayfish mortality in three crayfish farms and in one river system on I. Saaremaa in 2006–2007 was caused by crayfish plague (Hurt *et al.*, 2008). Thus, this island is not any more a plague free reserve. Accelerated development of crayfish farming and trade is a serious threat factor of spreading of diseases including plague. Newly established crayfish farms need to bring in juvenile crayfish from other farms for rearing or adults for creating broodstock, which creates danger of contamination. But plague can be transferred also *via* trade of alive fish between fish farms. Continuous exchange of rainbow trout between fish farms takes place and large amount of water is transferred with fish. If the water source of a fish farm contains wild crayfish or farm is producing both fish and crayfish the spread of plague with transport water is highly probable in case of disease outbreak.

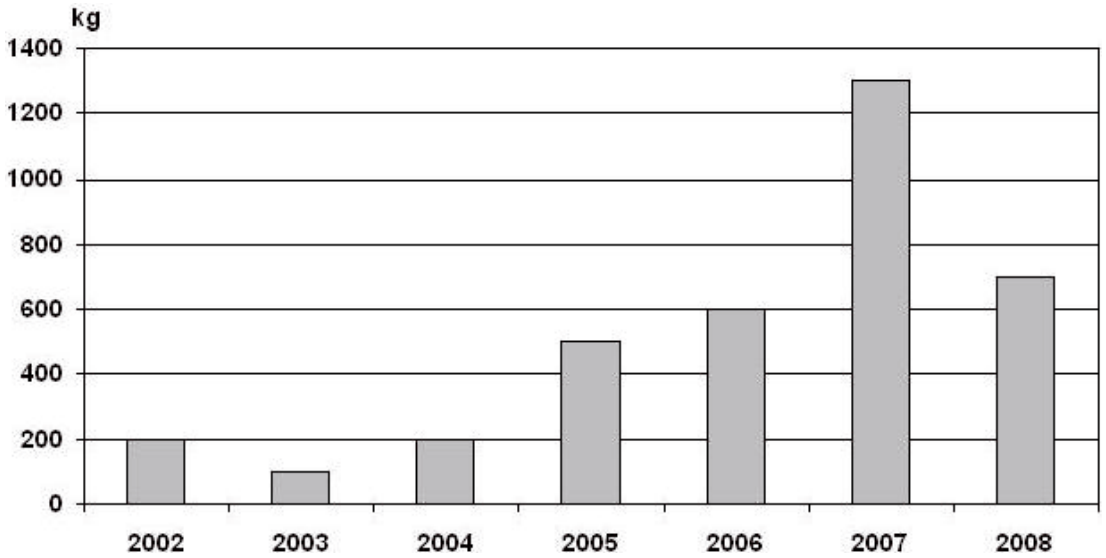

Figure 4
Sales of noble crayfish for consumption by Estonian crayfish farms (official data are corrected on basis of direct information from farmers) by years.

Figure 4
Ventes annuelles d'écrevisse à pieds rouges pour la consommation par les piscicultures estoniennes (les données officielles ont été corrigées sur la base d'informations directes des pisciculteurs).

Another serious threat is a disease, which causes brown lesions on shell of noble crayfish. It has been described as burn spot disease. After boiling of crayfish the damaged areas are black and clearly visible on the red shell. In case of heavy damage crayfish loose legs, claws or other parts of body. Thus, such crayfish cannot be marketed or at least cannot be sold with normal price. The disease probably affects also growth rate, viability, fecundity, etc. This disease seems to be rather specific problem of Estonia. It is not very wide spread, but in a few water bodies or farm ponds the frequency of diseased animals can reach 50%. In other countries very little has been done to investigate this disease and data about it are scarce. This is the reason, why the pathogen and its etiology are not known. There have been suggestions that fungi *Ramularia astaci*, *Oidium* sp., etc., may cause these symptoms (Alderman and Polglase, 1988). Study of Finnish and Estonian scientists (Makkonen *et al.*, 2008) indicated, that in seriously damaged crayfish several fungi which do not belong to the aforementioned species, *e.g.* genera *Saprolegnia* and *Mucor* were present. Although the symptoms resemble to the immune reaction of signal crayfish to aphanomycosis, molecular genetic analysis did not indicate presence of *Aphanomyces astaci*. The other diseases (porcelain disease, *Psorospermium*, *Branchiobdellidae*) have not caused problems for crayfish stocks.

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