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Opinion paper

Invasive non-indigenous crayfish species in Europe: Recommendations on managing them

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ABSTRACT

Key-words: *Europe, crayfish, non-indigenous, management, regulation*

The expansion of non-indigenous crayfish in Europe and the damage caused by them on indigenous species and habitats is a cause for increasing concern. Yet there is a great deal of variation in the measures put in place to control introductions of crayfish in different countries in Europe and indeed within countries. Recommendations from a conference on the future of native crayfish in Europe were that there is a need for much tighter regulation on the sale of non-indigenous crayfish within Europe, including a need to prevent the introduction of more species *via* the aquarium trade. There is a clear need to identify the threats to remaining populations of indigenous crayfish regionally and nationally and to provide well-enforced biosecurity measures to help protect these populations. It was recognised that this can only be done with concerted efforts on education and information sharing, because without public cooperation, the on-going trend of decline in indigenous crayfish will continue.

RÉSUMÉ

Écrevisses non indigènes et invasives en Europe : recommandations pour leur gestion

Mots-clés : *Europe, écrevisses, non-indigène, gestion, réglementation*

L'extension des écrevisses non indigènes en Europe et les dégâts qu'elles causent à l'encontre des écrevisses indigènes est une préoccupation croissante. Il y a encore une très grande variété de mesures mises en place pour contrôler les introductions d'écrevisses dans les différents pays européens et même à l'intérieur de ces pays. Des recommandations, faites au cours d'une conférence sur l'avenir des écrevisses natives d'Europe, mettent en avant le besoin d'une législation plus sévère au sujet de la vente des écrevisses non indigènes au sein de l'Europe, incluant un besoin de prévenir l'introduction de ces espèces *via* l'aquariophilie. Il y a une grande nécessité d'identifier les menaces pesant sur les populations indigènes tant au point de vue régional que national et de fournir des mesures bien renforcées en termes de biosécurité pour aider à protéger ces populations. Il a été admis que cela ne peut être réalisé sans à la fois des efforts concertés sur l'éducation et une information partagée parce que sans la coopération du public, le déclin des écrevisses indigènes se poursuivra inéluctablement.

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INTRODUCTION

The spread of non-indigenous crayfish species (NICS) through river systems in Europe is a cause for concern because of the severe adverse impacts on indigenous crayfish species (ICS). This is due to transmission of crayfish plague *Aphanomyces astaci* and where infection has not occurred, by competition. NICS have been highly successful in establishing in Europe and whilst some of them have had a commercial value, the established species have had significant adverse impacts (Holdich, 1999). In addition to the impacts on ICS, there is the issue of the ecological impacts of NICS on other aquatic species (reviewed by Nyström, 1999). Burrowing species of crayfish, such as signal crayfish *Pacifastacus leniusculus* and red swamp crayfish *Procambarus clarkii*, are able to modify habitat structure by the consumption of aquatic plants, undermining of banks and increasing the mobility of substrates. The species selected for introduction because of their value for aquaculture tend to have high tolerance of varied environmental conditions, an ability to feed at a range of trophic levels and to utilise whatever food sources are abundant locally, combined with characteristics of high fecundity, rapid growth rate and aggression. These characteristics in combination give the NICS currently established in Europe high potential to successfully invade a wide range of waterbodies across Europe and bring about significant impacts on aquatic ecosystems.

The issue of invasive NICS was raised in many of the presentations at a Regional European Crayfish Workshop held in Pisek, Czech Republic, 7–10th September 2009. Whilst the conference theme was “The Future of Native Crayfish in Europe”, that future is being heavily influenced by the expansion of NICS, with the European indigenous crayfish species (ICS) increasing threatened and declining due to NICS and crayfish plague. Three roundtable discussions were held at the Workshop, to address (1) the issues of conservation of ICS, (2) crayfish plague and (3) invading NICS and how to manage them. This opinion paper presents the discussion from the third session and offers recommendations on action, based on the experience of the participants in this roundtable session and others, from the informal discussion during the conference.

MONITORING DISTRIBUTION OF CRAYFISH

CRAYNET was instigated in 2002, a European Thematic Network. The programme involved a series of themed workshop meetings on crayfish, which helped to link researchers and aquatic resource managers across Europe. The programme stimulated interest in the current distribution of crayfish species, culminating in the production of the Atlas of Crayfish in Europe (Souty-Grosset *et al.*, 2006) and other educational aids. The distribution has been updated this year in a detailed review of the current status of crayfish in all the countries and regions in Europe and the overall status of the various ICS and NICS (Holdich *et al.*, 2009). Nonetheless, the on-going invasion by various NICS and the additional human-assisted introductions occurring in most countries means that the distribution of crayfish species is changing every year. There is a need for a coordinated approach to surveillance and monitoring at a range of scales. With many thousands of isolated and interconnected waterbodies in each country, it is unlikely that government agencies in the various countries will have the resources to carry out large scale, comprehensive surveys at regular intervals. Agencies, of necessity, tend to focus on statutory requirements. These include the requirements of the EU Species and Habitats Directive to monitor whether Natura 2000 sites are in favourable condition, but this only covers a small proportion of the distribution of crayfish.

Another major driver in future will be monitoring required under the EU Water Framework Directive (European Parliament, 2000), which requires Member States “to protect, enhance and restore all bodies of surface water with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of the Directive, subject to certain exceptions” (Article 4(1)(a)(ii)). The business of inter-calibration to achieve common standards across the European Union is a complex process, which has involved lengthy consultation and development and is going through further refinement in its second phase in 2008–2011.

Nonetheless, all Member States are required to have their rivers achieve "good ecological status" by 2015. The presence of certain invasive non-indigenous species, including signal crayfish, may be a contributing factor in a waterbody failing to meet the target.

Once the requirements of the Water Framework Directive are in place, major investments will be required to enhance and restore waterbodies that fail to meet good ecological status and there are large financial penalties for states that fail to meet the environmental objectives of the Water Framework Directive. This may give Member States an incentive to improve measures to prevent further introductions of non-indigenous crayfish. For example, it is difficult to see how any waterbody could be classed as being in good ecological status if subjected to the scale of ecological impact by red swamp crayfish *Procambarus clarkii* in the Iberian peninsula (Gutierrez-Yurrita *et al.*, 1998; Ilheu *et al.*, 2002; Rodriguez *et al.*, 2005; Cruz *et al.*, 2006).

Environmental objectives are being set for river basin districts *i.e.* for whole river catchments or groups of catchments or sub-catchments, depending on the geography. This is a useful approach because once non-indigenous crayfish (or indeed other invasive aquatic species) become established in one part of a catchment, watercourses provide routes for invasion to extensive areas. This is further exacerbated by canal networks, which provide links between many catchments.

Production of distribution maps of crayfish species will always lag behind the actual distribution of the species. However, participants in the roundtable discussion reported that there is a lot of variation in the availability of species distribution data, both within and between countries. Records of crayfish come from:

- large scale targeted surveys for crayfish,
- student and other academic projects of various kinds,
- *ad hoc* records from routine monitoring of biological water quality, from fisheries surveys, or surveys for aquatic mammals such as otter *Lutra lutra*,
- ecological surveys for other purposes, such as environmental impact assessments of new developments,
- anglers or fishermen, who either harvest crayfish or find them as bycatch, and
- reports by members of the public, such children finding crayfish in a stream, or finding large numbers of dead crayfish, or live crayfish stranded after a flood, or from water bailiffs finding unauthorised crayfish traps in use and suspecting that crayfish have been introduced.

There is a need for a validation process for records, especially as members of the public may not be sure of species and this checking is generally best done locally. The compilation of records locally and nationally requires a well-publicised system, so it is clear where records should be sent. Some countries have a history of biological recording by amateur naturalists and relatively well-developed schemes for compiling biological records from a wide range of sources. In some other countries recording schemes are less well developed and more dependent on the knowledge of a few individuals. In some areas web-based recording systems have been set up to encourage members of the public to inform authorities about new locations of invasive non-native species. For example, there is an "alien watch" scheme in Ireland (Invasive Species Ireland, 2009), where sightings anywhere in Ireland can be reported, both from the Republic of Ireland and Northern Ireland (UK). This is a good example of transboundary cooperation on the issue of non-native species, but more work is needed, especially given the observed transboundary spread of NICS in mainland Europe.

DAISIE (Delivering Alien Invasive Species Inventories for Europe) was a response at European scale to the need for distribution data on non-indigenous species (DAISIE, 2009) and the journal *Aquatic Invasions* was set up to encourage rapid publication of information on newly arrived aquatic species in Europe, as an early warning of new potentially invasive species (Panov and Gollasch, 2006). The roundtable discussion group agreed that countries with connections by water ought to share information on invading crayfish populations on a regular basis, including information on distribution and rates of spread, so that better forecasting of invasions can be carried out.

ASSESSING THE RISKS OF INVASIVE CRAYFISH

Estimating the current distribution of crayfish species, both indigenous and non-indigenous is important, but it is a tool for targeted action in countries throughout Europe, or should be, panellists agreed. Assessing the risks of invasive species before they become widely established is recommended by IUCN (2000). Some European countries have started this, for example risk assessments carried out for several NICS already present in Great Britain, predicting their impacts and potential for expansion of range (Non Native Species Secretariat, 2008; Peay *et al.*, to appear). Even so, several contributors to the roundtable discussion felt there was not enough action by authorities on the issue of NICS, either because there was not enough appreciation of the risks, or because authorities had a general feeling that there was nothing that could be done. Even where there was high concern about indigenous crayfish and the losses of populations to crayfish plague or invading NICS, it was thought there was not enough effort on measures to prevent further introductions. In some cases, it was suggested that although effort was being put into studying populations of indigenous crayfish, this was being threatened by insufficient management action to protect the populations. Again, forecasting future distribution may help to identify risks to existing indigenous crayfish populations and barriers to the spread of NICS.

PREVENTING FURTHER INTRODUCTIONS – LEGAL INSTRUMENTS

There was unanimous agreement that the aquarium trade is now the most likely source of new crayfish species entering Europe. Whilst some of these are tropical species, it is very likely that some could survive in Europe and become invasive. All agreed that there should be a Europe-wide ban on the supply or keeping of crayfish in aquaria, with the exception of keeping for scientific purposes, under strict regulation. In Ireland and Scotland there is a total ban on aquarium trade in crayfish and it is illegal to keep any species. In England and Wales only one species is permitted, the red claw crayfish *Cherax quadricarinatus*. By contrast many crayfish species are available for sale in the Czech Republic and at least twenty Cambarid species are sold in Germany, some of which are advertised as pond species.

At least three new populations of marbled crayfish *Procambarus* sp. have been found in the wild in Germany in the past two years, all aquarium discards (Chucholl, pers. comm.). It has been confirmed that several Cambarid species can carry crayfish plague and it is probable that marbled crayfish is also a potential carrier. Nonetheless, there appears to a strong lobby group in the aquarium trade, which is likely to resist any attempts to restrict the sale of exotic specimens. The roundtable discussion group felt strongly that a total ban was required. If that could not be achieved, the burden of proof should be placed on the aquarium trade, *i.e.* would-be importers should be required to pay for thorough risk assessments of any species proposed for import in future.

The recent EU Environmental Liability Directive, 2004/35/EC (European Parliament, 2004), has the objectives of preventing or remedying environmental damage. It is intended to implement the “polluter pays” principle of the Convention on Biodiversity, 1973. Whilst part of the Directive deals with activities that have inherently high risks of pollution, such as chemical factories, another section deals with any professional activities where, through fault or negligence, an operator has caused damage to species or natural habitats protected at EU level under the Habitats Directive 1992 or Birds Directives 1979. The problem is that whilst the aquarium trade profits from the sale of NICS, the environmental damage is caused by the purchasers who release aquarium stock they no longer want. It would be difficult to prove liability on the part of the trader, although it might be possible to bring a case against a member state that failed to restrict trade in NICS, if this led subsequently to cases of impact on protected species or habitats and especially if it led to transboundary impacts.

As a minimum, there needs to be regulation of exports to the rules of receiving countries. At present, an aquarium wholesaler in a country in Europe where sale of NICS is legal can sell a new species of NICS to anyone in Sweden, Ireland or other countries where the species

is banned. The recipient may be carrying out an illegal act in his own country by keeping the crayfish, but the seller is not, even though he may know (as the recipient may not) that the keeping is illegal in the country to which he is exporting the crayfish. The increasing number of aquarium trade fairs and internet sales make it all the more likely that hobbyists will bring in crayfish species. It has been difficult for European countries to put in place any restrictions on imports and there have been strong legal challenges from commercial interests, for example when Sweden banned the import of crayfish in order to protect its own stocks (Edsman, 2004).

The European Union is working "Towards an EU strategy on invasive species" and options for a legislative framework in Europe have been outlined (Genovesi and Shine, 2003), with four options ranging from "business as usual" through to a complete new European Directive, but the progress has been slow. The European Commission consulted the European Economic and Social Committee and Committee of the Regions on the draft strategy in December 2008 (Commission of the European Communities, 2008) and it was discussed at the meeting of 10th–11th June 2009 (Siecker, 2009). The committee was critical of the delay in action on a strategy. It called for specific EU legislation to deal with the problems of invasive species as a matter of urgency and a European Agency to monitor implementation. Failure to deal with invasive species was seen as an issue that could prevent the EU from achieving its agreed target of "Halting the Loss of Biodiversity by 2010 and Beyond". The committee reported:

"Rapidly growing trade and transport activities expand the opportunities for IS (invasive species) introduction, and environmental pressures. The existence of the single market means that once an IS is introduced in the territory of one Member State, it can be dispersed rapidly throughout the EU. Therefore, addressing trade-related issues can only be done effectively at the EC's external frontier. Given the way that these species become established and spread, measures taken by one Member State can be totally negated, if neighbouring countries fail to take action or respond in an uncoordinated manner" (Siecker, 2009).

PREVENTING INTRODUCTIONS – INCONSISTENCIES

The roundtable discussion group considered that the transport and sale of live crayfish for human consumption poses a significant threat of further introductions, either through discard of surplus stock, or illegal stocking to meet demand. The group highlighted some major inconsistencies in approach within several countries. For example, in some countries signal crayfish can be harvested but not released after capture, which leaves the problem of what to do with crayfish too small for market. In Poland, NICS (especially spiny-cheek crayfish *Orconectes limosus*) are frequently caught as a bycatch by fishermen using fyke nets. No NICS are allowed to be released and there is little tradition of local consumption of crayfish, but there is an increasing likelihood of them being transported for sale elsewhere. Crayfish can still be used as angling bait in Poland, despite it being illegal to release NICS. Use of angling bait is considered to be a significant risk factor for transmission of crayfish plague or accidental introductions and is banned in the other countries represented here.

In England and Wales, harvesting of NICS is permitted only in some regions, a policy intended to discourage illegal introductions of signal crayfish into catchments that still have abundant indigenous crayfish. The differences in regulation between regions are not well understood by the public. Yet live crayfish can be sold for food anywhere, even in restricted zones. Traders are supposed to take care to prevent escape of their stock, but have no control over the purchasers. Furthermore, whilst harvesting is banned in certain regions, where NICS are already present within the restricted region, angling clubs can apply to remove them for purposes of fisheries management and can reduce the cost of doing this by allowing commercial trappers to take the crayfish for sale. Harvesting for "control" of NICS is certainly well-intentioned, but experience within Europe seems to be that when harvesting is allowed, further introductions follow (*e.g.* Alonso *et al.*, 2000; Edsman, 2004).

Countries differ in the degree of regulation of harvesting. For example, the fishing regulations differ among the federal states of Germany, although in the southern federal states and some

others there are comparable regulations. All ICS are protected by closed season and a minimum size and the harvest of *Austropotamobius pallipes* is entirely prohibited. For NICS there are no regulations concerning closed season or minimum size. Licensed recreational fishermen are allowed to catch NICS (with the consent of the owner of the angling rights) without any further regulations. However, the use of traps does usually require a special permission, which is often given for harvesting NICS.

In England, trapping of NICS is only permitted by authorized persons in specific areas with individually tagged traps. Trapping consents for recreational and commercial harvesting are freely given in areas with many populations of NICS, but are limited to trapping for "control" of NICS that cause nuisance to anglers in other areas, whereas in regions where ICS are still relatively widespread trapping is generally not authorized. In Scotland, there is no trapping allowed, apart from a couple of research projects on control of NICS. In Austria, holders of fishing licences are allowed to carry out unrestricted harvesting of any size class throughout the year. Stocking of ponds with NICS is banned where there is a connection to another waterbody, but stocking of isolated garden ponds is not as strictly controlled. There was concern from Austria about people illegally stocking ponds with crayfish, unsure of which species they were introducing, plus the issue of escape of crayfish from supposedly isolated ponds that were occasionally inundated during floods. All the countries represented complained about growing incidence of illegal harvesting and illegal stocking of NICS. Enforcement was described as a major problem, with it being too difficult to prove liability for illegal stocking. Prosecutions were either never brought, or were unsuccessful. For example, if water bailiffs in Croatia find illegal crayfish traps they have the ability to issue fines for unauthorized harvesting, but do not apply them in practice.

In the Czech Republic ICS are protected and the presence of crayfish is seen as evidence of good environmental quality, especially in areas that have had poor water quality historically. People appreciate wildlife and like to have ponds with crayfish present, but have often introduced NICS in the mistaken belief that they were stocking indigenous noble crayfish *Astacus astacus*. In England, there is increasingly good public understanding of the risks to indigenous white-clawed crayfish from NICS; but there has been a lot of promotion of wild harvest by celebrity chefs and others, sometimes even encouraging the public to carry out wild harvest of NICS, as an activity that supposedly benefits the indigenous species, rather than one that exacerbates the problems.

In this roundtable session none of the participants were from Scandinavia, which has by far the strongest tradition of harvesting crayfish. Where the local demand for crayfish for consumption exceeds supply, it encourages local stocking or re-stocking of crayfish, and where outbreaks of crayfish plague have already occurred this encourages the use of NICS. It also encourages an export market in countries with little or no tradition of eating crayfish, with all the associated risks of live transport and sale. This is seen as a significant problem in Baltic states such as Estonia.

CONTROLLING THE SPREAD OF NICS

A few successful eradications of populations of NICS have been carried out using non-selective biocide treatments against signal crayfish in limited areas and other biocide treatment projects have been carried out recently but the outcome is not yet confirmed. Whilst this is a potentially important tool if populations can be detected early enough, few countries so far have allowed treatments (Scotland, England, Norway, Sweden, USA). In most cases, by the time populations of NICS are detected they are too extensive, or in too large a waterbody for biocide treatment to be technically feasible, quite apart from the issues of approval of treatment. A population of the yabby *Cherax destructor* appears to have been eradicated in Spain by treatment with crayfish plague, to which Australian species are as susceptible as European ICS (Diéguez-Uribeondo and Muzquiz, 2005), although this is unlikely to be effective against invading American NICS, which can carry the disease. Various countries are attempting to control NICS by trapping. In some cases new programmes are starting (*e.g.* in Croatia

for spiny-cheek crayfish, Faller *et al.* (in preparation)), whereas some cases in England and Scotland have run for five to ten years. In one case trapping has been done almost continuously for more than ten years (Wright, 2009, pers. comm.), although other projects have been abandoned in less than five years. Although there are cases where trapping intensity in angling lakes has been reported as being sufficient to reduce the nuisance of crayfish to anglers (Holdich *et al.*, 1995), there does not appear to be *any* evidence that trapping has prevented the continued expansion of NICS in a watercourse.

PRIORITIES FOR ACTION ON NICS

The roundtable discussion group considered the priorities for action relating to NICS were as follows:

- all European countries should ban any further introductions of NICS;
- there should be better regulation of trade for human consumption, including a ban on export of live crayfish and preferably phasing out of sale of live crayfish within countries too;
- in regulation on NICS all countries need to consider the risk of transboundary spread of crayfish and crayfish plague and take measures to prevent this occurring;
- to safeguard indigenous crayfish countries need to set up priority areas for their conservation, which will include planning and implementing biosecurity measures, *e.g.* control of fish stocking and angling to minimise the risk of crayfish plague;
- exchange experience and knowledge between scientists, managers and regulators within and between individual countries, both within the EU and in neighbouring countries;
- actively promote awareness of the risk of NICS, both environmental and economic, among commercial fishermen, anglers and the general public, with measures such as guidance on disinfection of angling gear, easy guides for identification of crayfish species, sources of advice on crayfish for fishery managers, encouragement of interest and local pride in indigenous crayfish;
- encourage and fund research into methods of eradication and control of NICS, carry out field trials and report outcomes.

Within the European Union, the need for coordinated action to tackle invasive species in general has now been recognised at high political levels, stimulated by the burgeoning economic impacts of invasive species in Europe and the accelerating rate of new arrivals. Whilst prevention, eradication and control may be seen as expensive options, or having impacts on trade, the costs of inaction or insufficient action are likely to be even greater.

On 25th June 2009 the Environment Council of the European Union agreed to adopt a new EU strategy on invasive species and legislation to fill the gaps in existing regulation (Council of the European Union, 2009). In the concluding paragraph the Council states that it:

"STRESSES the importance of adequate financing for research, monitoring, prevention of introduction and spread, early detection and eradication of IAS [Invasive Alien Species] and transboundary and international cooperation, and UNDERLINES the role of Member States and the Commission in increasing public awareness, responsibility and education, and ensuring public participation and involvement as well as engaging relevant sectors that play a role in the movement of IAS, including by encouraging the application of voluntary codes of good practices."

The roundtable on NICS endorses this approach for invasive species in general and NICS in particular and calls for rapid progress at European, national and regional scales.

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