

Short Communication

A bomb set to drop: parthenogenetic Marmorkrebs for sale in Ireland, a European location without non-indigenous crayfish

Zen Faulkes

Department of Biology, The University of Texas-Pan American, 1201 W. University Drive, Edinburg, Texas, 78539, USA

E-mail: zfaulkes@utpa.edu

*Corresponding author

Received: 29 April 2014 / Accepted: 1 August 2014 / Published online: 3 September 2014

Handling editor: Vadim Panov

Abstract

Ireland is one of the few locations in Europe where non-indigenous North American crayfish species have not been introduced, and is a refuge for endangered white-clawed crayfish, *Austropotamobius pallipes* (Lereboullet, 1858). The parthenogenetic crayfish species Marmorkrebs, *Procambarus fallax* f. *virginalis* (Hagen, 1870), is sold in the pet trade in Ireland within the recorded range of *A. pallipes*. Marmorkrebs risk being introduced into Irish waters, where they could threaten *A. pallipes* populations, particularly as a vector for crayfish plague.

Key words: Marmorkrebs, *Procambarus fallax* f. *virginalis*, *Austropotamobius pallipes*, pet trade, Ireland, non-indigenous crayfish species

Introduction

Non-indigenous crayfish threaten native European crayfish (Holdich et al. 2009; Kouba et al. 2014) through competition and acting as vectors for crayfish plague *Aphanomyces astaci* Schikora, 1906 (Unestam 1965; Unestam 1966; Unestam 1969), a disease for which European crayfish have no resistance (Unestam 1972; Alderman et al. 1984; Reynolds 1988; Matthews and Reynolds 1992; Diéguez-Urbeondo 2009; Grandjean et al. 2014). Ireland is unusual in Europe because it has no non-indigenous crayfish in its waters (Reynolds 1997; Kouba et al. 2014). Consequently, the white-clawed crayfish, *Austropotamobius pallipes* (Lereboullet, 1858), is more abundant in Ireland than mainland Europe (Lucey and McGarrigle 1987; Holdich and Rogers 1997; Reynolds et al. 2002; Demers et al. 2005; Füreder et al. 2010). Ireland could provide *A. pallipes* stock to repopulate other regions in Europe if North American crayfish species can be controlled. Import of crayfish into Ireland is banned (Holdich and Rogers 1997; Peay 2009), and the Irish National Parks and Wildlife Service has produced a pamphlet to promote public awareness of crayfish conservation, and

the threat posed by introduced crayfish (Reynolds and O’Keeffe 2010).

Marmorkrebs, *Procambarus fallax* f. *virginalis* (Hagen, 1870), create grave concerns as a non-indigenous crayfish. First, a single individual can establish a population because they are parthenogenetic (Scholtz et al. 2003). Second, they have high propagule pressure because they are widely distributed in the pet trade (Faulkes 2010; Chucholl 2013; Faulkes 2013), resulting in releases in multiple European countries (reviewed in Chucholl et al. 2012; Kouba et al. 2014). Monitoring the online pet trade can provide insights into the risk of release of non-indigenous species (Duggan et al. 2006; Kikillus et al. 2012; Martin et al. 2012; Chucholl 2013; Papavlasopoulou et al. 2014). Here, I report on recent advertisements confirming that Marmorkrebs are being kept and sold in Ireland within the range of *A. pallipes*.

Methods

Custom searches in Google Alerts (<http://www.google.com/alerts>) scan the Internet for the terms “Marmorkrebs” and “marbled crayfish” on English language websites. Results of these searches are

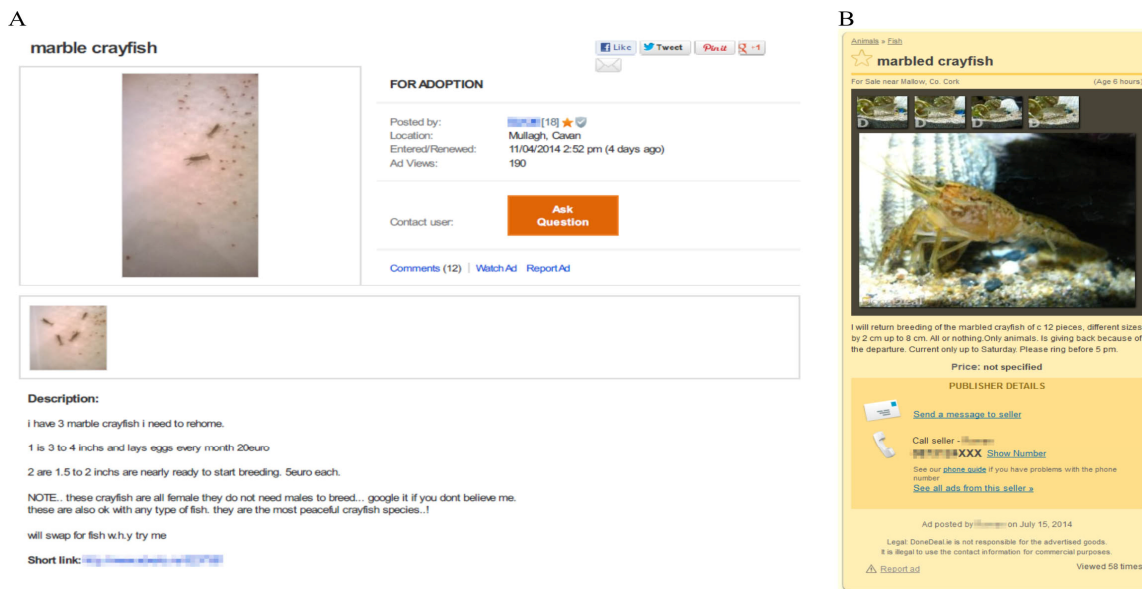


Figure 1. Screen shots of advertisements for marble crayfish on Irish advertising websites from (A) April and (B) July 2014. Names and contact information of users have been concealed by pixelation.

emailed daily. The location of the sellers were determined using Google Earth 7.1.2 (<http://earth.google.com>), and the distribution of *A. pallipes* in Ireland was taken from Figure 2 from Demers et al. (2005).

Results

Advertisements for “marble crayfish” were placed on sales websites on 11 April 2014 (<http://www.adverts.ie>, which advertises itself as, “Ireland’s trusted marketplace”; Figure 1) and 15 July 2014 (<http://www.donedeal.ie>, which describes itself as, “Ireland’s biggest classifieds site”). The sellers were located in Mullagh, Cavan, and Mallow, Co. Cork, Ireland, both of which are within the recorded distribution of *A. pallipes* (Figure 2). The April seller wrote, “these crayfish are all female they do not need males to breed”, which, combined with the commonly used name for *P. fallax* f. *virginalis*, “marble crayfish”, suggests the buyer believed these were Marmorkrebs. A large individual was priced at 20€ (about US\$27) and smaller ones at 5€ (about US\$6.9); the latter is the typical price for Marmorkrebs in Europe (Churchill 2013) and close to the North American mode price of US\$5 (Faulkes 2013). Comments on the ad indicated that there was at least one potential buyer. The July ad indicated the seller had about a dozen crayfish, but gave no price details.

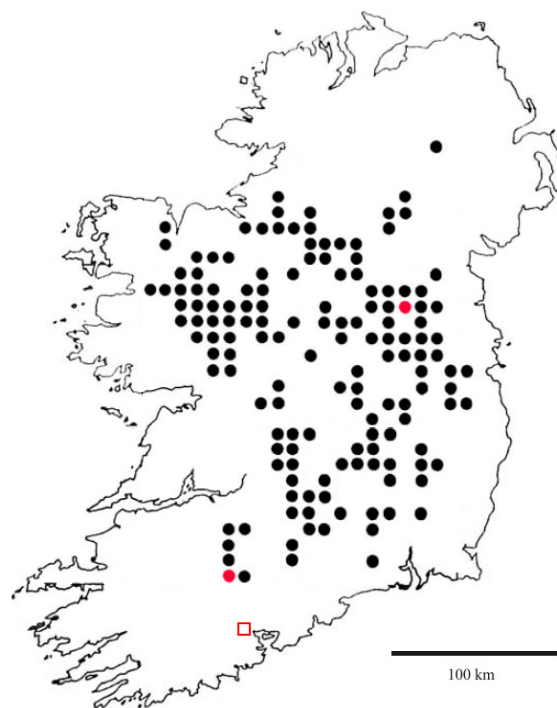


Figure 2. Distribution of *Austropotamobius pallipes* in 10 km grid, redrawn from Demers et al. (2005). Location of sellers in this paper shown with red circles. Location of seller in Reynolds (2014) shown by red square.

I informed the National Parks and Wildlife Service (Ireland) of both advertisements by email. A representative of that agency replied on 14 April 2014 that a local conservation ranger had been informed of the ad. The April ad was withdrawn from the website on 17 April 2014. The July ad was removed 17 July 2014.

While this paper was initially being reviewed, Reynolds (2014) reported Marmorkrebs were available for sale online in Cork, Ireland. This is not within the known range of *A. pallipes*, however (Figure 2).

Discussion

The sale of Marmorkrebs in the Irish pet trade (this report; Reynolds 2014) is of great concern for the conservation of white-clawed crayfish, *A. pallipes*. Some quantitative species distribution models suggest that Ireland contains suitable habitat for Marmorkrebs (Figure 3D in Feria and Faulkes 2011). Marmorkrebs can carry crayfish plague (Steyskall et al. 2013), which wiped out one *A. pallipes* population in Ireland, even in the absence of any North American crayfish species (Reynolds 1988; Matthews and Reynolds 1992). *Aphanomyces astaci* can be spread from dead crayfish or fish feces (Oidtmann et al. 2002), so even if Marmorkrebs are contained in aquaria while alive, their presence increases the risk of crayfish plague if their cadavers come into contact with natural waters. Further, Marmorkrebs could affect *A. pallipes* populations by direct competition. *A. pallipes* can be outcompeted by other decapod crustaceans (Barbaresi and Gherardi 1997), and Marmorkrebs can compete with *Procambarus clarkii* (Girard, 1852) in fights (Jimenez and Faulkes 2011). This risk may be mitigated if Marmorkrebs and *A. pallipes* use different habitats: Marmorkrebs populations commonly occur in lentic ponds and lakes (Chucholl et al. 2012), while *A. pallipes* populations occur in lotic riparian streams and rivers (Smith et al. 1996; Naura and Robinson 1998; Broquet et al. 2002; Demers et al. 2003).

Even in the unlikely event that the crayfish for sale were not Marmorkrebs, the sale of any crayfish species in the Irish pet trade is a concern. The online sale of illegal crayfish as ostensibly benign pets suggests that the Irish pet trade be more closely scrutinized for compliance with laws prohibiting import of crayfish into Ireland, and that the laws be more highly visible to the general public. While there is considerable discussion among the crayfish research community concerning

expanding and strengthening laws on the import and sale of crayfish (Peay 2009), the sale of Marmorkrebs in Ireland, where import of crayfish is already illegal, highlights the difficulty of enforcing even existing laws concerning crayfish. Vendors (DiStefano et al. 2009) and pet owners (Faulkes 2013) are often non-compliant with local laws, often through simple ignorance. Enforcement of existing laws is also typically low in many jurisdictions (Peay 2009), and aimed at end users rather than vendors (Stebbing et al. 2014), which may reduce the effectiveness of such laws. Education is often mentioned as an important component in controlling introductions of non-indigenous crayfish (Peay 2009; Stebbing et al. 2014). Systematic studies on the effectiveness of educational campaigns aimed at the general public (such as Reynolds and O'Keeffe 2010) or changes in enforcement would be valuable.

Acknowledgements

I thank three anonymous reviewers for their comments.

References

- Alderman DJ, Polglase JL, Frayling M, Hogger J (1984) Crayfish plague in Britain. *Journal of Fish Diseases* 7: 401–405, <http://dx.doi.org/10.1111/j.1365-2761.1984.tb01205.x>
- Barbaresi S, Gherardi F (1997) Italian freshwater decapods: Exclusion between the crayfish *Austropotamobius pallipes* (Faxon) and the crab *Potamon fluviatile* (Herbst). *Bulletin Francais de la Pêche et de la Pisciculture* 347: 731–747, <http://dx.doi.org/10.1051/kmae/1997047>
- Broquet T, Thibault M, Neveu A (2002) Distribution and habitat requirements of the white-clawed crayfish, *Austropotamobius pallipes*, in a stream from the Pays de Loire region, France: an experimental and descriptive study. *Bulletin Francais de la Pêche et de la Pisciculture* 367: 717–728, <http://dx.doi.org/10.1051/kmae:2002061>
- Chucholl C (2013) Invaders for sale: trade and determinants of introduction of ornamental freshwater crayfish. *Biological Invasions* 15: 125–141, <http://dx.doi.org/10.1007/s10530-012-0273-2>
- Chucholl C, Morawetz K, Groß H (2012) The clones are coming – strong increase in Marmorkrebs [*Procambarus fallax* (Hagen, 1870) f. *virginalis*] records from Europe. *Aquatic Invasions* 7: 511–519, <http://dx.doi.org/10.3391/ai.2012.7.4.008>
- Chucholl C, Pfeiffer M (2010) First evidence for an established Marmorkrebs (Decapoda, Astacida, Cambaridae) population in Southwestern Germany, in syntopic occurrence with *Orconectes limosus* (Rafinesque, 1817). *Aquatic Invasions* 5: 405–412, <http://dx.doi.org/10.3391/ai.2010.5.4.10>
- Demers A, Reynolds JD, Cioni A (2003) Habitat preference of different size classes of *Austropotamobius pallipes* in an Irish river. *Bulletin Francais de la Pêche et de la Pisciculture* 370–371: 127–137, <http://dx.doi.org/10.1051/kmae:2003008>
- Demers A, Lucey J, McGarrigle M, Reynolds J (2005) The distribution of the white-clawed crayfish, *Austropotamobius pallipes*, in Ireland. *Biology & Environment: Proceedings of the Royal Irish Academy* 105: 65–69, <http://dx.doi.org/10.3318/BIOE.2005.105.2.65>

- Diéguez-Urbeondo J (2009) Current techniques, approaches and knowledge in diagnosis of crayfish plague and other crayfish diseases. *Knowledge and Management of Aquatic Ecosystems* 394–395: 02, <http://dx.doi.org/10.1051/kmae/2010004>
- DiStefano RJ, Litvan ME, Horner PT (2009) The bait industry as a potential vector for alien crayfish introductions: problem recognition by fisheries agencies and a Missouri evaluation. *Fisheries* 34:586–597, <http://dx.doi.org/10.1577/1548-8446-34.12.586>
- Duggan I, Rixon C, MacIsaac H (2006) Popularity and propagule pressure: determinants of introduction and establishment of aquarium fish. *Biological Invasions* 8: 377–382, <http://dx.doi.org/10.1007/s10530-004-2310-2>
- Faulkes Z (2010) The spread of the parthenogenetic marbled crayfish, *Marmorkrebs* (*Procambarus* sp.), in the North American pet trade. *Aquatic Invasions* 5: 447–450, <http://dx.doi.org/10.3391/ai.2010.5.4.16>
- Faulkes Z (2013) How much is that crayfish in the window? Online monitoring of Marmorkrebs, *Procambarus fallax* f. *virginalis* (Hagen, 1870) in the North American pet trade. *Freshwater Crayfish* 19: 39–44, <http://dx.doi.org/10.5869/fc.2013.v19.039>
- Feria TP, Faulkes Z (2011) Forecasting the distribution of Marmorkrebs, a parthenogenetic crayfish with high invasive potential, in Madagascar, Europe, and North America. *Aquatic Invasions* 6: 55–67, <http://dx.doi.org/10.3391/ai.2011.6.1.07>
- Füreder L, Gherardi F, Holdich D, Reynolds J, Sibley P, Souty-Grosset C (2010) *Austropotamobius pallipes*. <http://www.iucnredlist.org/details/summary/2430/0> (Accessed 22 April 2014)
- Grandjean F, Vrástád T, Diéguez-Urbeondo J, Jelić M, Mangombi J, Delaunay C, Filipová L, Rezinciuc S, Kozubíková-Balcarová E, Guyonnet D, Viljamaa-Dirks S, Petrušek A (2014) Microsatellite markers for direct genotyping of the crayfish plague pathogen *Aphanomyces astaci* (Oomycetes) from infected host tissues. *Veterinary Microbiology* 170: 317–324, <http://dx.doi.org/10.1016/j.vetmic.2014.02.020>
- Holdich DM, Reynolds JD, Souty-Grosset C, Sibley PJ (2009) A review of the ever increasing threat to European crayfish from non-indigenous crayfish species. *Knowledge and Management of Aquatic Ecosystems* 394–395: 11, <http://dx.doi.org/10.1051/kmae/2009025>
- Holdich DM, Rogers WD (1997) The white-clawed crayfish, *Austropotamobius pallipes*, in Great Britain and Ireland with particular reference to its conservation in Great Britain. *Bulletin Francais de la Pêche et de la Pisciculture* 347: 597–616, <http://dx.doi.org/10.1051/kmae/1997050>
- Jimenez SA, Faulkes Z (2011) Can the parthenogenetic marbled crayfish Marmorkrebs compete with other crayfish species in fights? *Journal of Ethology* 29: 115–120, <http://dx.doi.org/10.1007/s10164-010-0232-2>
- Kikillus KH, Hare K, Hartley S (2012) Online trading tools as a method of estimating propagule pressure via the pet-release pathway. *Biological Invasions* 14: 2657–2664, <http://dx.doi.org/10.1007/s10530-012-0262-5>
- Kouba A, Petrušek A, Kozák P (2014) Continental-wide distribution of crayfish species in Europe: update and maps. *Knowledge and Management of Aquatic Ecosystems* 413: 05, <http://dx.doi.org/10.1051/kmae/2014007>
- Lucey J, McGarrigle ML (1987) The distribution of the crayfish *Austropotamobius pallipes* (Lereboullet) in Ireland. Department of Agriculture and Fisheries, Irish Fisheries Investigations Series A, 29
- Martin DR, Pracheil BM, DeBoer JA, Wilde GR, Pope KL (2012) Using the Internet to understand angler behavior in the information age. *Fisheries* 37: 458–463, <http://dx.doi.org/10.1080/03632415.2012.722875>
- Matthews M, Reynolds J (1992) Ecological impact of crayfish plague in Ireland. *Hydrobiologia* 234: 1–6, <http://dx.doi.org/10.1007/BF00010773>
- Naura M, Robinson M (1998) Principles of using River Habitat Survey to predict the distribution of aquatic species: an example applied to the native white-clawed crayfish *Austropotamobius pallipes*. *Aquatic Conservation: Marine and Freshwater Ecosystems* 8: 515–527, [http://dx.doi.org/10.1002/\(SICI\)1099-0755\(199807/08\)8:4<515::AID-AQC261>3.0.CO;2-J](http://dx.doi.org/10.1002/(SICI)1099-0755(199807/08)8:4<515::AID-AQC261>3.0.CO;2-J)
- Oidtmann B, Heitz E, Rogers D, Hoffmann RW (2002) Transmission of crayfish plague. *Diseases of Aquatic Organisms* 52: 259–167, <http://dx.doi.org/10.3354/dao052159>
- Papavaslopoulou I, Perdikaris C, Vardakas L, Paschos I (2014) Enemy at the gates: introduction potential of non-indigenous freshwater crayfish in Greece via the aquarium trade. *Central European Journal of Biology* 9: 11–18, <http://dx.doi.org/10.2478/s11535-013-0120-6>
- Peay S (2009) Invasive non-indigenous crayfish species in Europe: Recommendations on managing them. *Knowledge and Management of Aquatic Ecosystems* 394–395: 03, <http://dx.doi.org/10.1051/kmae/2010009>
- Reynolds JD (1988) Crayfish extinctions and crayfish plague in central Ireland. *Biological Conservation* 45: 279–285, [http://dx.doi.org/10.1016/0006-3207\(88\)90059-6](http://dx.doi.org/10.1016/0006-3207(88)90059-6)
- Reynolds JD (1997) The present status of freshwater crayfish in Ireland. *Bulletin Francais de la Pêche et de la Pisciculture*: 693–700, <http://dx.doi.org/10.1051/kmae/1997046>
- Reynolds J (2014) Crayfish in Ireland: A last European frontier. *Crayfish News* 36: 5
- Reynolds JD, Demers A, Marnell F (2002) Managing an abundant crayfish resource for conservation - *A. pallipes* in Ireland. *Bulletin Francais de la Pêche et de la Pisciculture* 367: 823–832, <http://dx.doi.org/10.1051/kmae:2002070>
- Reynolds JD, O’Keeffe C (2010) Protect Irish Crayfish. Service NPW. Dublin, Department of the Environment, Heritage and Local Government
- Scholtz G, Braband A, Tolley L, Reimann A, Mittmann B, Lukhaup C, Steuerwald F, Vogt G (2003) Parthenogenesis in an outsider crayfish. *Nature* 421: 806–806, <http://dx.doi.org/10.1038/421806a>
- Smith GRT, Learner MA, Slater FM, Foster J (1996) Habitat features important for the conservation of the native crayfish *Austropotamobius pallipes* in Britain. *Biological Conservation* 75: 239–246, [http://dx.doi.org/10.1016/0006-3207\(95\)00073-9](http://dx.doi.org/10.1016/0006-3207(95)00073-9)
- Stebbing PD, Longshaw M, Scott A (2014) Review of methods for the management of non-indigenous crayfish, with particular reference to Great Britain. *Ethology Ecology & Evolution* 26: 204–231, <http://dx.doi.org/10.1080/03949370.2014.908326>
- Steyskall C, Konar M, Wieser G, Vogl G (2013) Is the marbled crayfish *Procambarus fallax* forma *virginalis* a potential vector for the crayfish plague pathogen *Aphanomyces astaci*? 16th International Conference on Diseases of Fish and Shellfish. Tampere, Finland
- Unestam T (1965) Studies on the crayfish plague fungus *Aphanomyces astaci* I. Some factors affecting growth in vitro. *Physiologia Plantarum* 18: 483–505, <http://dx.doi.org/10.1111/j.1399-3054.1965.tb06911.x>
- Unestam T (1966) Studies on the crayfish plague fungus *Aphanomyces astaci* II. Factors affecting zoospores and zoospore production. *Physiologia Plantarum* 19: 1110–1119, <http://dx.doi.org/10.1111/j.1399-3054.1966.tb07104.x>
- Unestam T (1969) On the adaptation of *Aphanomyces astaci* as a parasite. *Physiologia Plantarum* 22: 221–235, <http://dx.doi.org/10.1111/j.1399-3054.1969.tb07371.x>
- Unestam T (1972) On the host range and origin of the crayfish plague fungus. Report. *Institute of the Freshwater Research Drottningholm* 52: 192–198