BioInvasions Records (2015) Volume 4, Issue 1: 43–46
doi: http://dx.doi.org/10.3391/bir.2015.4.1.07

Open Access

Rapid Communication

Hemimysis anomala G.O. Sars, 1907 expands its invasive range to Northern Ireland

Kevin Gallagher[1]*, Robert Rosell[1], Louise Vaughan[1], Yvonne R. McElarney[1], Warren Campbell[1], Eugene O'Kane[1] and Chris Harrod[2,3]

[1]*Agri – Food and Biosciences Institute, Newforge Lane, Belfast, BT9 5PX, UK*
[2]*School of Biological and Chemical Sciences, Queen Mary University of London, Mile End Road, London, E1 4NS, UK*
[3]*Instituto de Ciencias Naturales Alexander Von Humboldt, Universidad de Antofagasta, Avenida Angamos 601, Antofagasta, Chile*

**Corresponding author*
E-mail: Kevin.Gallagher@afbini.gov.uk

Received: 9 June 2014 / Accepted: 5 September 2014 / Published online: 2 October 2014

Handling editor: Vadim Panov

Abstract

The invasive crustacean *Hemimysis anomala* was first discovered in the Republic of Ireland in April 2008. By 2009 it had extended its range to lakes throughout the navigated River Shannon waterway, occasionally occurring in large swarms in shallow waters and in lower densities at deep sites. In this study, a standardised stratified fish survey of Upper Lough Erne in 2013 found *H. anomala* in the stomach contents of four perch (*Perca fluviatilis*). These fish were captured at sites located at the northern and southern extremes of the lake, suggesting that invasive *H. anomala* are distributed throughout this waterbody. This catchment is directly linked to the River Shannon through the Shannon–Erne canal and our data indicates that, as previously predicted, the distribution of *H. anomala* now includes Northern Irish freshwaters.

Key words: mysid, crustacean, Ireland, invasive, zooplankton, ecology

Introduction

Non native invasive species are one of the greatest threats to biodiversity worldwide (Scalera and Zaghi 2004; Caffrey et al. 2008) and are of particular concern on islands (O'Neill and Stokes 2004; Stokes et al. 2006). Invasive species may often outcompete or consume native species (Dick et al. 2013) resulting in the domination and sometimes bioengineering of the environment (Jones et al. 1994; Holsman et al. 2010).

The numbers of freshwater invasive species in Ireland have increased dramatically during the last 30 years (Kelly et al. 2014), including the recent discovery of the Asian clam *Corbicula fluminea* (O.F. Müller, 1774) in 2009 (Sweeney 2009). The rates of inoculations are accelerating, primarily due to increased travel and trade (Caffrey et al. 2008; Maguire et al. 2011).

Hemimysis anomala G.O. Sars, 1907, a crustacean originating in the Ponto-Caspian region, has spread across continental Europe (Ketelaars et al. 1999; Ricciardi et al. 2012; Penk and Minchin 2014), arriving in Great Britain in 2006 (Holdich et al. 2006). It has also been found in the North American Great Lakes (Ricciardi et al. 2012). It was first described in the Republic of Ireland from a single lake, Lough Derg, on the River Shannon system in 2008 (Minchin and Holmes 2008), and subsequently lakes Ree and Key in the same system (Gallagher et al. 2010; Minchin and Boelens 2010) (Figure 1).

This study describes the most up-to-date range for *H. anomala* on the island of Ireland and its first occurrence in Northern Ireland.

Materials and methods

Upper Lough Erne was surveyed for fish during three consecutive nights from the 15th to the 18th October 2013 using 19 benthic and 2 pelagic mono-filament, multi-mesh (CEN 2005) gill nets (12 panel, 5–55mm mesh). The netting effort was supplemented with four benthic braided gill nets (62.5mm mesh). Netting locations were selected randomly in pre-determined depth strata (0–3m, 6–12m, 12–20m). A handheld GPS was used to record the precise location of each study site.

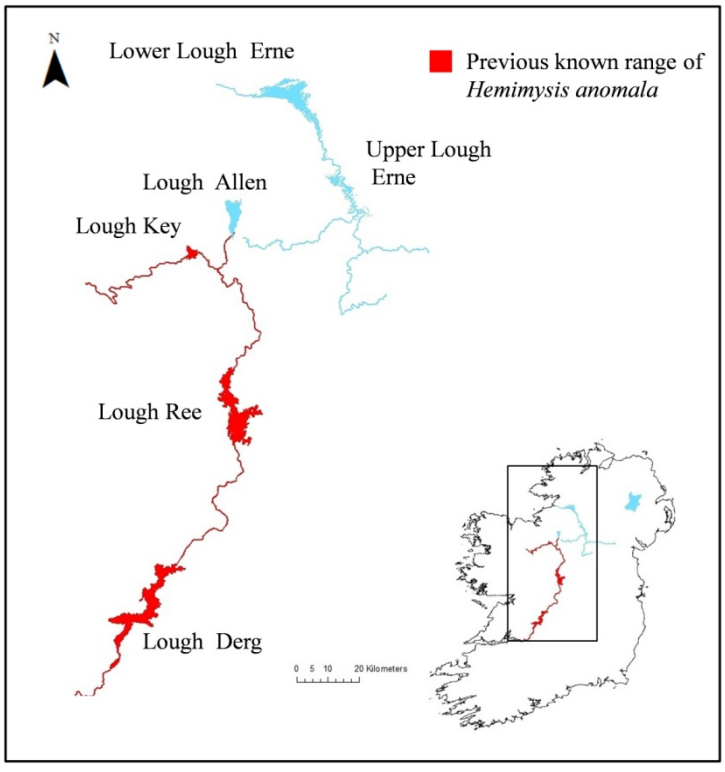

Figure 1. Map detailing previous range of *Hemimysis anomala* in Ireland.

Nets were returned to the shore for processing. Once removed from nets, fish were identified to species and measured (fork length ± 1 mm). In all fish a longitudinal ventral incision from the vent to a line level with the pectoral fin was made and stomach contents were removed and examined under a dissection microscope (20× magnification) and individual prey items were recorded.

Results and discussion

In total 751 fish specimens of four species and one hybrid were captured in the gill net survey (Table 1). Multiple individuals (circa 20 per fish) of *H. anomala* were recovered from the preserved stomach contents of four perch (*Perca fluviatilis* Linnaeus, 1758). These perch were all captured in monofilament benthic gill nets set at depths ranging from 8–16 m at three different sites in Upper Lough Erne (Table 2; Figure 2). One site was at the southern, upstream section of the lake, near to where the Woodford River is linked to the Shannon-Erne Waterway. The two other sites were at the northern end of the lake where the River Erne leaves Upper Lough Erne

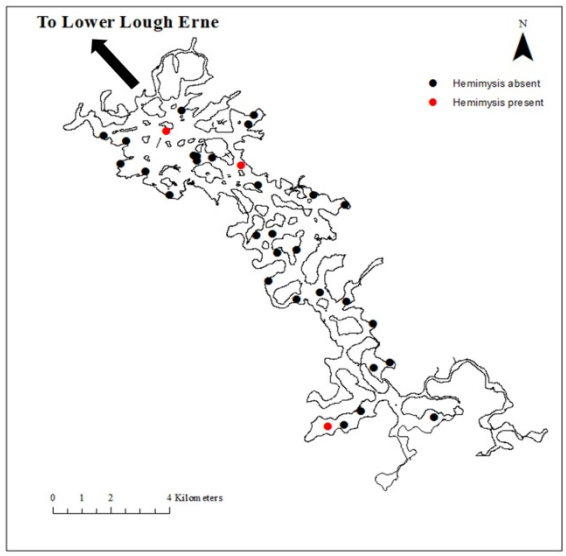

Figure 2. Map of Upper Lough Erne detailing sampling sites.

before discharging into Lower Lough Erne. The individual specimens of perch ranged in length from 95–187 mm. Individual specimens of *H. anomala* could not be measured or precisely enumerated due to the extent of chymification.

Table 1. Species and sample size encountered in Upper Lough Erne gill net survey.

Species	Common name	Sample size (n)
Salmo trutta Linnaeus, 1758	Brown Trout	1
Perca fluviatilis Linnaeus, 1758	Perch	321
Esox lucius Linnaeus, 1758	Pike	5
Rutilus rutilus Linnaeus, 1758	Roach	326
Rutilus rutilus × *Abramis brama* Linnaeus, 1758	Roach × Bream Hybrid	98

Table 2. Positive sample site locations.

Date	Site	Lat	Long	Depth (m)	No. fish with HA in gut
18/10/2013	1	N54°14'14.2"	W7°31'35.6"	14.5	1
15/10/2013	2	N54°14'55.3"	W7°33'57.7"	13	1
18/10/2013	3	N54°09'06.9"	W7°28'55.2"	8.8	2

H. anomala were identified by examining telson morphology as per Ketelaars et al. (1999). This is a first record for *H. anomala* in Northern Ireland.

The presence of this species at the two extreme ends of Upper Lough Erne indicates that *H. anomala* is now established throughout this lake. Given the riverine character and low turnover time of 0.04 years (NIEA 2009) of Upper Lough Erne (U.L.E.), it is probable that the species is also present in Lower Lough Erne. Its mode of transmission to U.L.E. is likely to have been anthropogenically assisted through the discharge of bilge/domestic water from water craft or discharge of water from anglers' bait boxes (Minchin and Boelens 2010). The path of spread of *Hemimysis* has followed that of the zebra mussel (*Dreissena polymorpha* (Pallas, 1771)) (Rosell et al. 1998).

H. anomala is a lipid rich organism providing perch with similar nutritional value as to that provided by juvenile fish (Borcherding et al. 2007). Borcherding et al. (2007) also found that in the River Rhine *H. anomala* contributes from 20 to 100% of the diet of 0+ perch. Growth rates of juvenile perch also accelerated in the presence of *H. anomala*.

In the Netherlands, an invasion by *H. anomala* caused a decline in phytoplankton and zooplankton biomass (Ketelaars et al. 1999). Two months after the discovery, a sharp reduction in anomopod densities, compared to the three previous years, was observed. The invertebrate predators *Bythotrephes longimanus* (Leydig, 1860) and *Leptodora kindti* (Focke, 1844) soon vanished as did the anomopod *Chydorus sphaericus* (Muller, 1785). However, copepod densities remained unaffected. Ketelaars et al. (1999) also found that densities of *Daphnia* spp., *Bosmina* spp., Ostracods, and Rotifera declined significantly in the period directly after initial detection of *H. anomala*. Uncertainties regarding the top down effects of *H. anomala* on zooplankton exist when algal production is low and therefore limits zooplankton production (Ketelaars et al. 1999).

The introduction of this species to the River Erne catchment is worrying as this species is known to be a voracious predator capable of consuming zooplankton prey at three times the rate of its closest native ecological equivalent *Mysis salemaai* (Audzijoynte and Vanola 2005), formerly *Mysis relicta* Lovén, 1862 (Dick et al. 2013). Lough Erne has also experienced an ecological shift (Rosell 2012) since the introduction of *Dreissena polymorpha* in the period between 1996 and 1998 (Rosell et al. 1998). The presence of *H. anomala* may in the short-term aid the population expansion and growth of some fishes (Borcherding et al. 2007), however in the long term it may adversely affect zooplankton composition that is crucial for the success of 0+ fish, including the endangered pollan (*Coregonus pollan* Thompson, 1835) (Harrod et al. 2002). The co-occurrence of these two high impact invaders (Maguire and Grey 2006; Gallardo and Aldridge 2013) is likely to compound the current changes in ecological state that this water body is already experiencing (Rosell 2014).

Attention must now be concentrated on monitoring this species and inhibiting its expansion into other catchments. The migrational habits of this species make it difficult to sample and monitor using conventional methods of netting and trapping. A novel technique gleaned from this study could be to use stomach content analysis of established predatory fish such as the perch, coupled with night time sampling as per Minchin and Boelens (2010) to provide accurate results of the early spread of this invasive species.

Acknowledgements

We are grateful to staff members working on the INTERREG IVa funded DOLMANT project. We would also like to thank the Northern Ireland Environment Agency for co- funding the Water Framework Directive fish status assessment of Upper Lough Erne leading to this discovery. We would also like to acknowledge assistance from staff of the Department of Culture Arts and Leisure Inland Fisheries and Waterways Branch (DCAL IWIF) and staff and students based at the Agri – Food and Biosciences Institute (AFBI) who provided invaluable assistance in our field and laboratory work.

References

Borcherding J, Hermasch B, Murawski P (2007) Field observations and laboratory experiments on growth and lipid content of young-of-the-year perch. *Ecology of Freshwater Fish* 16: 198–209, http://dx.doi.org/10.1111/j.1600-0633.2006.00212.x

Caffrey JM, Acevedo S, Gallagher K, Britton R (2008) Chub (*Leuciscus cephalus*): a new potentially invasive fish species in Ireland. *Aquatic Invasions* 3: 197–205, http://dx.doi.org/10.3391/ai.2008.3.2.11

CEN (2005) Water Quality - Sampling of Fish with Multi-Mesh Gillnets. European Committee for Standardization. Brussels and Belgium, 27 pp

Dick JTA, Gallagher K, Avlijas S, Clarke HC, Lewis SE, Leung S, Minchin D, Caffrey J, Alexander ME, Maguire C, Harrod C, Reid N, Haddaway NR, Farnsworth KD, Penk M, Ricciardi A (2013) Ecological impacts of an invasive predator explained and predicted by comparative functional responses. *Biological Invasions* 15: 837–846, http://dx.doi.org/10.1007/s10530-012-0332-8

Gallagher K, Reid N, Maguire CM, Harrod C, Caffrey J, Dick JTA (2010) Potential impact of a new freshwater invader: the bloody-red shrimp (*Hemimysis anomala*). Report prepared by the Natural Heritage Research Partnership, Quercus, Queen's University Belfast for the Northern Ireland Environment Agency and Inland Fisheries Ireland. Northern Ireland Environment Agency Research and Development Series, 12, 18 pp

Gallardo B, Aldridge DC (2013) The 'dirty dozen': socio-economic factors amplify the invasion potential of 12 high-risk aquatic invasive species in Great Britain and Ireland. *Journal of Applied Ecology* 50: 757–766, http://dx.doi.org/10.1111/1365-2664.12079

Harrod C, Griffiths D, Rosell R, McCarthy TK (2002) Current status of the pollan (*Coregonus autumnalis* Pallas 1776) in Ireland. *Archiv für Hydrobiologie Beiheft: Ergebnisse der Limnologie* 57: 627–638

Holdich D, Gallagher S, Rippon L, Harding P, Stubbington R (2006) The invasive Ponto-Caspian mysid, *Hemimysis anomala*, reaches the UK. *Aquatic Invasions* 1: 4–6, http://dx.doi.org/10.3391/ai.2006.1.1.2

Holsmann KK, McDonald PS, Barreyro PA, Armstrong DA (2010) Restoration through eradication? Removal of an invasive bioengineer restores some habitat function for a native predator. *Ecological Applications* 20: 2249–2262, http://dx.doi.org/10.1890/09-1168.1

Jones CG, Lawton JH, Shachak M (1994) Organisms as ecosystem engineers. *Oikos* 69: 373–386, http://dx.doi.org/10.2307/3545850

Kelly R, Lundy MG, Mineur F, Harrod C, Maggs CA, Humphries NE, Sims DW, Reid N (2014) Historical data reveal power-law dispersal patterns of invasive aquatic species. *Ecography* 37: 001–010, http://dx.doi.org/10.1111/j.1600-0587.2013.00296.x

Ketelaars HAM, Lambregts-van de Clundert FE, Carpentier CJ, Wagenvoort AJ, Hoogenboezem W (1999) Ecological effects of the mass occurrence of the Ponto-Caspian invader, *Hemimysis anomala* GO Sars, 1907 (Crustacea: Mysidacea), in a freshwater storage reservoir in the Netherlands, with notes on its autecology and new records. *Hydrobiologia* 394: 233–248, http://dx.doi.org/10.1023/A:1003619631920

Maguire C, Gallagher K, Maggs C, Dick JTA, Caffrey J, O'Flynn C, Fitzpatrick U, Kelly J, Harrod C (2011) Alien invasive species in Irish water bodies. STRIVE. Dublin, Ireland: Environmental Protection Agency, 125 pp

Maguire CM, Grey J (2006) Determination of zooplankton dietary shift following a zebra mussel invasion, as indicated by stable isotope analysis. *Freshwater Biology* 51: 1310–1319, http://dx.doi.org/10.1111/j.1365-2427.2006.01568.x

Minchin D, Boelens R (2010) *Hemimysis anomala* is established in the Shannon River Basin District in Ireland. *Aquatic Invasions* 5: S71–S78, http://dx.doi.org/10.3391/ai.2010.5.S1.016

Minchin D, Holmes JMC (2008) The Ponto-Caspian mysid, *Hemimysis anomala* G.O. Sars 1907 (Crustacea), arrives in Ireland. *Aquatic Invasions* 3: 257–259, http://dx.doi.org/10.3391/ai.2008.3.2.19

NIEA (2009) Heavily Modified Water Bodies–North Western River Basin District. North Western River Management Plan, 51 pp

O'Neill K, Stokes K (2004) The Impacts and Effects of Invasive Species in Ireland and the Mechanisms of their Introduction and Spread. Consultation document for a workshop on invasive alien species, 101 pp

Penk MR, Minchin D (2014) Seasonal migration of a glacial relict mysid (Crustacea) into the littoral zone and its co-occurrence with an introduced competitor in Lough Derg (Ireland). *Hydrobiologia* 726: 1–11, http://dx.doi.org/10.1007/s10750-013-1744-x

Ricciardi A, Avlijas S, Marty J (2012) Forecasting the ecological impacts of the *Hemimysis anomala* invasion in North America: lessons from other freshwater mysid introductions. *Journal Great Lakes Research* 38**:** 7–13, http://dx.doi.org/10.1016/j.jglr.2011.06.007

Rosell R (2012) Lower Lough Erne Fish Stocks, DCAL - AFBI Surveys 1991 to 2010. Agri - Food and Biosciences Institute, 12 pp

Rosell R (2014) Lower Lough Erne fish stocks, DCAL - AFBI Surveys 1991 to 2013. Report on stock status January 2014. Agri - Food and Biosciences Institute, 13 pp

Rosell RS, Maguire CM, McCarthy TK (1998) First reported settlement of zebra mussels *Dreissena polymorpha* in the Erne system, Co. Fermanagh, Northern Ireland. *Biology and Environment-Proceedings of the Royal Irish Academy* 98B: 191–193

Scalera R, Zaghi D (2004) Alien Species and Nature Conservation in the EU. The Role of the LIFE Program. LIFE Focus, European Communities, 101 pp

Stokes K, O'Neill K, MacDonald RW (2006) Invasive Species in Ireland. Report to Environment and Heritage Service and National Parks and Wildlife Service by Quercus, Queen's University. Environment and Heritage Service, Belfast and National Parks and Wildlife Service, Dublin

Sweeney P (2009) First record of Asian Clam (*Corbicula fluminea* (Müller, 1774) in Ireland. *The Irish Naturalists' Journal* 30: 147–148