DEPARTMENT OF ZOOLOGY

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CHARACTERISING THE ZEBRA MUSSEL (*DREISSENA POLYMORPHA*, PALLAS) POPULATION IN LOUGH DOON, CO. CLARE

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Introduction

Since arriving in Ireland in c.1994 (McCarthy et al. 1997), the zebra mussel *Deissena polymorpha* has quickly extended its range in Irish waters. A native to the Black and Caspian Seas, the enormous ecological impacts of the zebra mussel in lakes throughout Europe and North America are well documented: reduced plankton levels, increased water clarity, accelerated nutrient recycling, increased growth of nuisance or noxious cyanobacteria, direct and indirect effects on the composition and distribution of native macrophytes, macroinvertebrates, unionid mussels and fishes. Together with their nuisance biofouling of pipes and boats, these characteristics have made the zebra mussel perhaps the most notorious of aquatic invasive species.

Fig. 1 Zebra mussels colonising the shell of a native freshwater musssel *Anodonta*

Research on zebra mussels in Ireland has to date focused on large lakes on the Shannon and the Erne river systems while North American models of zebra mussel-induced changes have focused on the Great Lakes. As part of the EPA-funded BioChange project examining key threats to biodiversity in Ireland, this study (2006–2009) aims to elucidate, for the first time, the effects of recent *Dreissena* invasion on water chemistry and phytoplankton production in a small, well-mixed western Irish lake. Data from this study will ultimately help forecast changes in ecological processes and ecosystem structure in Irish lakes arising from zebra mussel invasion.

Study Site

Lough Doon is a dual basin lake situated on the middle reaches of the Owenogarney river system in Co. Clare (Fig. 1). Zebra mussels (*Dreissena polymorpha*) have been reported in the lower basin of the lake since 1998 and a well-established population now exists there while numbers are currently negligible in the upper basin. Both basins are physico-chemically and morphometrically similar (Table 1), meeting the optimal conditions for zebra mussel colonisation.

Fig. 1 Aerial view of Lough Doon

Table 1. Morphometric & chemical characteristics of Upper and Lower Lough Doon. Values are mean for January–July 2007 (n=12) ± standard errors.

	Doon Upper	Doon Lower
Surface area (ha)	48.4	64.9
Volume (m^3)	2.44×10^6	3.25×10^6
Mean depth (m)	5.04	5.0
Max. depth (m)	15.2	12.1
Residence time (mth)	1.88	1.67
pH	7.69 ±0.08	7.83 ±0.06
Conductivity (mS cm^{-1})	167 ±4.8	200 ±6.1
Temperature (°C)	12.4 ±1.3	13.0 ±1.3
DO (mg L^{-1})	10.5 ±0.3	10.5 ±0.3
Alkalinity (mg $CaCO_3$ L^{-1})	72.4 ±4.4	89.7 ±4.5

Methods

To estimate zebra mussel population density in Lower Lough Doon, mussels were collected by a SCUBA diver from 25 cm^2 quadrats at depths of 1 m, 2 m, 3 m and 4 m along a transect. Sampling along 19 transects (n=76) was conducted in the Lower Lough Doon in July 2007 (Fig. 2). To investigate the presence of zebra mussels in the Upper basin, 25–70 m long dredges were carried out using a 50 cm wide dredge (n=12). Dredge lengths were measured using a Trimble GeoXT differential GPS. Dredges were also carried out at depths of greater than 4 m in the Lower basin (n=16) where zebra mussel densities were very low and patchy (Fig. 2).

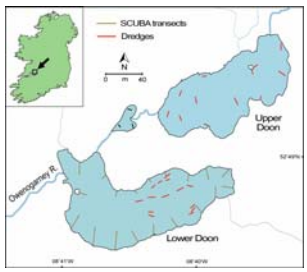

Fig. 2 Map of Lough Doon illustrating the location of the SCUBA transects and dredges conducted during the zebra mussel population survey in July 2007.

Zebra mussels >1 mm were counted and measured for shell length, then the entire sample was weighed for total wet weight (soft tissue plus shell) after opening mussels, removing excess water from the mantle and blotting them dry with absorbent paper. Data on mussel densities, biomass and lengths at different depths were combined with information obtained from digital bathymetric maps on the percentage areas of the basins at different depths to provide estimates of the total zebra mussel populations in the Upper and Lower basins of Lough Doon. Relationships between depth and the density, biomass and shell length of zebra mussels were tested using the Spearman correlation coefficient (rs) and significance levels determined using a two-tailed t-test.

Results

Results of the zebra mussel population survey (Table 2) emphasise the different levels of *Dreissena* infestation in the Upper and Lower basins of Lough Doon. The Lower basin had an estimated population of 5,5 × 108 zebra mussels (4,9 × 105 kg), equating to a filtration capacity of 5,22 × 105 m3 d-1. By comparison, the Upper basin of Lough Doon was very mildly infested. Zebra mussels were recorded in only 3 of the 12 dredges (n=5 zebra mussels) in the Upper basin, equating to a population of 2.2 × 104 (17 kg) and a filtration capacity of 18.1 m3 d-1.

Table 2. Number, biomass and filtration capacity of zebra mussels in Upper and Lower Lough Doon, and theoretical lake water recycling rates.

	Doon Upper	Doon Lower
Mean shell length (mm)	18.18	19.71
Total population	2.2×10^4	5.5×10^8
Total biomass (kg)	17	4.9×10^5
Filtration capacity[1] (m^3 d^{-1})	18.1	5.22×10^5
Recycling rate[2] (d)	134,807	6

[1]Filtering rate calculated as 44.4 mL g^{-1} WTW h^{-1} (wet tissue mass, shell plus tissue) [2]Theoretical recycling rate = lake volume ÷ filtration capacity

The mean shell size of zebra mussels in the Lower basin was 19.71 mm (n=4,685) (Table 2) and the large majority of mussels were in the 2+ age cohort (16–23 mm) (Figure 3a). The length frequency distribution at different depths along a single transect (Figure 3b) reveals a second smaller peak at 6–9 mm, the 1+ cohort, likely representing settlement from the previous summer and autumn (Higgins et al., in press).

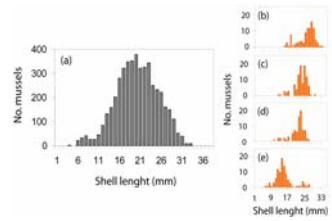

Fig. 3 (a) Length-frequency distribution of zebra mussels in Lower Lough Doon (mean shell length 19.7 mm). Data are from 17 transects at depths of 1 m, 2 m, 3 m, and 4 m (n = 4,685). Also shown are length-frequency distributions along a single transect at depths of (b) 1 m, (c) 2 m, (d) 3 m and (d) 4m (n = 382).

The highest density of zebra mussels (1,999 ind. m-2) was recorded in the Lower basin at 1 m depth (Figure 4a), while the mean density of zebra mussels lakewide was 860 ind. m-2. Shell size, population density and biomass were all decreased significantly with depth (Figure 4a–c). At 18.18 mm, the mean shell size of zebra mussels in the Upper basin was smaller than in the Lower basin (Table 2); however, the small sample size (n=5) precludes a detailed characterisation of the zebra mussel population in the Upper basin.

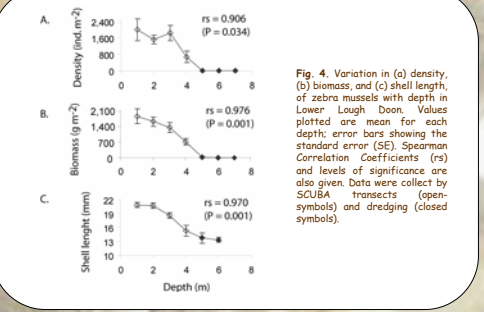

Fig. 4. Variation in (a) density, (b) biomass, and (c) shell length, of zebra mussels with depth in Lower Lough Doon. Values plotted are mean for each depth; error bars showing the standard error (SE). Spearman Correlation Coefficients (rs) and levels of significance are also given. Data were collect by SCUBA transects (open-symbols) and dredging (closed symbols).

Overview & Conclusions

While both basins of Lough Doon meet the optimum ranges of pH, hardness, temperature and dissolved oxygen required for zebra mussel colonisation, at present only the Lower basin contains a sizeable, well established zebra mussel population. Movement of boats via a public slipway at the Lower basin is the most likely route of initial infestation in the mid or late-1990s. Zebra mussels now heavily colonise rocks and stones, macrophytes, dead *Anodonta* shells and aggregations of dead *Dreissena* shells in the littoral zone of the Lower basin at depths of 1–3 m.

The mean (860 ind. m^{-2}) and maximum (1,999 ind. m^{-2}) density of zebra mussels in the Lower basin of Lough Doon is relatively low compared to mean (3,900 ind. m^{-2}) and maximum (6,800 ind. m^{-2}) densities reported in Lough Key or those reported from the Great Lakes. Thus, the zebra mussel population in Lower Lough Doon during July 2007 can be considered a modest infestation. Zebra mussel density, biomass and shell size all declined significantly in Lower Lough Doon below 3 m depth (Higgins et al., in press). Whether this trend reflects a higher proportion of young mussels or slower growth rates at greater depths is not yet known.

The large difference in zebra mussel densities in the Upper and Lower basins of Lough Doon provided a unique experimental design to investigate whether the well-documented trends from large lakes in Europe and North America following *Dreissena*-infestation are replicated in a small, well-mixed Irish lough.

References

McCarthy TK, Fitzgerald J and O'Connor W (1997) The occurrence of the zebra mussel *Dreissena Polymorpha* (Pallas 1771), an introduced biofouling freshwater bivalve in Ireland, Irish Naturalists Journal 25: 413–416

Higgins T., Grennan J. and McCarthy TK (in press) Effects of recent zebra mussel invasion on water chemistry and phytoplankton production in a small Irish lake. Aquatic Invasions.

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