

The alteration of lake ecosystems by invasive alien species. A case study on a potential keystone species: *Orconectes limosus*

Introduction

In the context of the EU Water Framework Directive invasive alien species (IAS) represent a significant pressure that can alter the structure and functioning of aquatic ecosystems. IAS may lead to ecological degradation resulting in a lower classification of a water body and confound the interpretation of ecological assessment metrics. Habitat disturbance has been identified as a key factor contributing to IAS success in rivers (e.g. Aguiar *et al.*, 2007). We undertook a study of the crayfish populations in lake Varese (Northern Italy) with the objectives: 1) to examine the differences in densities with different habitat types in the lake, 2) to determine whether hydromorphological modification of a shoreline has led to higher densities and 3) to examine the biomass of crayfish relative to macroinvertebrates to indicate their relative importance in the lake ecosystem.

Materials and Methods

Four sites were sampled, two dominated by macrophytes, one based on natural stone substrate and one which had been changed from natural macrophyte cover to a stone substrate by the construction of a wall, stony shore and pier. Information on crayfish abundance was gathered using 3 methods: multiple mark-recapture using visible implant elastomer tags to mark the ventral somites, quadrat sampling and catch per unit effort based on two hours of night-time snorkelling. Information on each site's habitat was gathered following the Lake Habitat Survey (LHS) (Rowan *et al.*, 2004). Macroinvertebrates were collected during spring using a 152 mm² Ponar grab.

Results

Catch per unit effort (CPUE) results indicated that crayfish abundance was highest on natural stone shoreline (stone site 2) and lowest at the two sites dominated by macrophytes. Stone site 1 which had been hydromorphologically modified from macrophyte cover had crayfish abundances up to three times higher than intact macrophyte sites (Figure 1). This site also had a low value of riparian naturalness and was subject to several pressures (Table 1). CPUE data may be subject to bias, varying significantly with operator as well as other factors and does not give a quantitative estimate of density. A multiple mark-recapture exercise was conducted at stone site 2 and estimated the density as 16.7 *O. limosus* m² with a standard deviation of 7.3. A direct estimate of density was also conducted using 10 underwater quadrats (Figure 2) which estimated the density as 6.2 m² (S.D. 4.1).



Figure 1 Abundance (catch per unit effort) of *O. limosus* at four sites.

Table 1 Catch per unit effort data for crayfish (expressed per hour of night-time snorkelling) and site characterisation data. *site hydromorphologically modified.

	plant site 1	plant site 2	stone site 1*	stone site 2
Crayfish				
CPUE <i>O. limosus</i>	8	11	33	67
CPUE <i>P. clarkii</i>	0.5	0.0	1.0	0.13
Site characterisation				
Naturalness of riparian zone	0.92	0.83	0.08	0.88
Habitat pressures	0.0	1.5	4.0	2.5
Shoreline slope	0.019	0.010	0.106	0.116

In addition to the large difference found in density estimates there was also substantial difference in the population size structure as determined by the open-water snorkelling method used for mark-recapture and that of quadrat sampling (Figure 3). Snorkelling tended to capture larger individuals and grossly underestimated the smaller <1 yr individuals. Macroinvertebrate biomass varied from 97 to 210 kg ha⁻¹ at the four sites examined compared to a biomass of 112 kg ha⁻¹ of *O. limosus* found at stone site 2 (Figure 4).

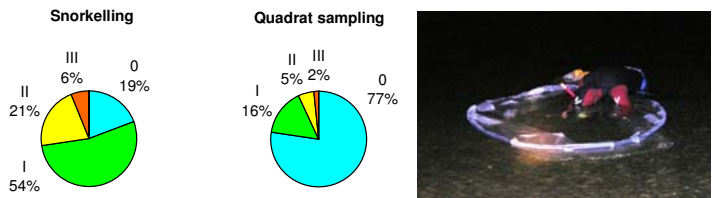


Figure 3 Age classes (after Pieplow, 1938) using two different sampling methods.

Figure 2 Quantitative sampling using an underwater quadrat.

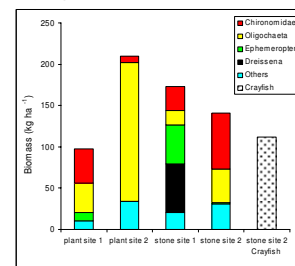


Figure 4 Wet biomass of macroinvertebrates found at four sites in lake Varese compared with the biomass of *O. limosus* from stone site 2. Biomass values for crayfish are an average from 8 quadrats.

Discussion

As expected, crayfish were more abundant on stone habitats owing to its provision of refuge (Lodge & Hill, 1994). Modification of the shoreline at one site (stone site 1) likely promoted the establishment of crayfish. *Procambarus clarkii*, a new introduction to the lake also occurred at highest abundance there (Table 1). Habitat modifications can be detected using the LHS (Table 1) and such data may be useful for incorporation into risk assessments for alien species colonisation and success.

Compared to quadrat sampling, mark-recapture data may overestimate population density owing to lake shores being open systems where unknown mortality, migration and immigration make estimates difficult. Substantial difference was also found in the population age structure as determined by snorkelling. Therefore, the use of underwater quadrats may provide a more reliable estimation of population density and structure needed for the assessment and management of crayfish.

Crayfish were present at biomasses comparable to that of macroinvertebrates indicating their importance in the structure and functioning of the lake ecosystem.

References

- Aguiar, F.C., Ferreira, M.T., Albuquerque, A., Moreira, I., 2007. Alien and endemic flora at reference and non-reference sites in Mediterranean-type streams in Portugal. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 17, 335–347.
- Lodge, D.M., Hill, A.M., 1994. Factors governing species composition, population size, and productivity of cool-water crayfishes. *Nordic J. Freshw. Res.* 69, 111–136.
- Pieplow, U., 1938. cited in Kossakowski, J., 1971. Crayfish. (Translated from Polish.) U.S. Dep. Commerce. National Technical Information Service, Springfield, Va. 183p.
- Rowan, I.S., Duck, R.W., Carwardine, J., Bragg, O.M., Black, A.R. and Cutler, M.E.I., 2004. Development of a technique for lake habitat survey (LHS): phase 1. Edinburgh, SNIFFER. [www.sniffer.org.uk]

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