A preliminary investigation of the macroinvertebrate communities of open-water habitats in two contrasting peatlands

Edel Hannigan and Mary Kelly-Quinn

Freshwater Ecology and Research Group, School of Biology and Environmental Sciences, Science Centre West, University College Dublin, Belfield, Dublin 4, Ireland
Phone: +353 (0)1 716 2339, e-mail edel.hannigan@ucd.ie, mary.kelly-quinn@ucd.ie

Summary

The present study is part of a national project developing a protocol for sustainable peatland management. Hydrochemical and biological characteristics of open-water habitats in Irish peatlands are being examined. This paper presents preliminary findings for two study sites, Scragh Bog (Co. Westmeath) and Owenirragh Bog (Co. Mayo), from samples collected during spring 2006. The hydrochemical results showed Scragh Bog to be more minerotrophic than Owenirragh Bog with higher pH, alkalinity and calcium concentrations. However, Owenirragh Bog had elevated levels of sodium, chloride and sulphate which indicate a marine influence. These differences are also reflected in the macroinvertebrate communities, with Scragh Bog hosting a higher diversity and abundance of macroinvertebrate taxa.

Key index words: hydrochemistry, bogs, fens, macroinvertebrate communities

Introduction

The BOGLAND project, funded by the Environmental Protection Agency under the ERTDI programme, is being undertaken to allow the development of a protocol for the sustainable management of Irish peatlands (see Renou-Wilson, this volume; Bullock *et al.,* this volume). Under the environmental brief, research is being undertaken on the little known aspects of peatland ecology such as the open-water bodies, where it is aimed to characterise them in terms of hydrochemistry and invertebrate communities. The work is being carried out on eight sites, two from each peatland category (according to the Irish classification): fens, Atlantic blanket bogs, mountain blanket bogs and raised bogs. All the sites are considered to be intact or minimally impacted by human activity. The present paper presents preliminary results from two contrasting peatlands: Owenirragh Bog and Scragh Bog.

Despite the importance of peatlands in Ireland, there is a paucity of research on their aquatic biota. A number of studies have attempted to use floral composition and water chemistry to classify the different mire (wetland with at least some peat) types (Bellamy, 1966;Wells, 1996). In the 1960s Boatman (1960) studied the plant communities of blanket bogs in Galway. Proctor (1992) investigated regional and local variation in the chemical composition of bog water in 39 ombrogenous bogs in Britain and Ireland. The aquatic macroinvertebrates have received less attention apart from the production of checklists for some groups in a limited number of sites (Dowling and Murray, 1981; Higgins, 1984; Reynolds, 1984; Good, 1985; Reynolds *et al.,* 1998).

Internationally, a greater volume of data exists and some studies have attempted to relate community composition to environmental factors such as pool features (Downie *et al.,* 1998), land-use effects (Standen, 1999) and restoration approaches (Van Duinen *et al.,* 2003). Indeed the successful protection of intact peatland habitats or assessment of the effectiveness of restoration efforts requires linkages to be made between community composition and environmental factors (Van Duinen *et al.,* 2004). This is one of the challenges for the BOGLAND project.

Materials and methods

Study sites

Owenirragh (54° 16'N, 9° 37'W) is an Atlantic blanket bog located on the western seaboard in County Mayo. Owenirragh Bog receives an average precipitation of approximately 1400 mm per year. In contrast, Scragh Bog (53°34'N, 7° 21'W) is a minerotrophic fen located in County Westmeath, in the Irish midlands. It receives a lower average precipitation of 934 mm.

Habitat classification

The open-water habitats in each site were initially defined by the characterisation set out by Lindsay (1988, 1995). These pools were then further divided into categories based on their surface area (Larson and House, 1990). Owenirragh Bog had small (10m² - 100m², referred to as the B-class), and large (> 100m², referred to as the A-class) pools and *Sphagnum* hollows. Scragh Bog only had small pools (10m² - 100m²) and *Sphagnum* hollows.

Macroinvertebrate sampling protocol

Sweep samples and activity traps, both horizontal and modified horizontal traps (Becerra Jurado *et al.,* 2008) were employed in spring (April/May) 2006. Ten, metre long sweep samples were taken with a standard pond net from pools within the B-size class, while 15 sweeps were taken from pools in the A-size class. Three sweeps were taken from the *Sphagnum* hollows. The sweep sampling points were spread around the perimeter of the pool. In the B-size class ten activity traps were spaced equally around the pool perimeter, while 15-20 traps were placed in the larger pools depending on the mesohabitats present. In densely vegetated *Sphagnum* hollows only modified horizontal activity traps were used to reduce the risk of the traps popping up.

Hydrochemistry

Water samples were collected in April 2006 and analysed for pH, conductivity, alkalinity, nutrients (NO_2^-, NO_3^- and NH_4^+), major anions (Cl^- and SO_4^{2-}) and major cations (Na^+, K^+, Mg^{2+} and Ca^{2+}).

Results

Hydrochemical Results

No significant differences in the various hydrochemical variables were found between habitats within sites, all further analyses were based on pooled data (Table 1).

Scragh Bog recorded a near-neutral pH and low levels of macronutrients. The alkalinity values indicate good buffering capacity. Calcium concentrations were high in comparison to the other ions and suggest inputs of calcium-rich groundwater. In contrast Owenirragh Bog was more acidic and had no acid-neutralising capacity as indicated by negative alkalinity values. The macronutrient values were all low. Owenirragh Bog had significantly higher ($t= 3.1, 4.4$, $df = 4$, $p<0.05$) concentrations of chloride and sulphate than Scragh Bog. However, Scragh Bog had significantly higher ($t = -8.0$, $df = 4$, $p<0.05$) concentrations of calcium. In Owenirragh Bog most of the ions were of marine origin (e.g. SO_4^{2-} =23.8%, Na^+ =100%, Mg^{2+} = 22.7% and Ca^{2+} = 100%). In contrast Scragh Bog had higher catchment influence on the hydrochemistry (e.g. marine derived ions SO_4^{2-} =15.7%, Na^+ =86.2%, Mg^{2+} = 16.5% and Ca^{2+} = 0.3%)

Macroinvertebrate results

A total of 91 taxa were recorded in Scragh Bog, which was significantly higher than the 39 taxa found in Owenirragh Bog (Wilcoxon, $Z= -5.363$, $p<0.01$). Sweep netting captured significantly ($t= 4.8$, $df = 14$, $p<0.001$) more taxa than the activity traps in all the habitats sampled (Fig. 1). In Owenirragh Bog 12 taxa were common to the two sampling methods, compared to 17 taxa in Scragh Bog. However, the activity traps recovered 5 unique taxa in Owenirragh Bog, namely *Notonecta obliqua* (Gallen), *Notonecta glauca* (Linnaeus), *Sigara scotti* (Douglas and Scott), *Aeshna juncea* (Linnaeus), and *Libellula quadrimaculata* (Linnaeus) and 7 unique taxa in Scragh Bog, five of which were beetle species *Agabus affinis* (Paykull), *Dytiscus circumcinctus* (Ahern), *Dytiscus marginalis* (Linnaeus), *Dytiscus semisulcatus* (Müller) and *Acilius canaliculatus* (Nicolai).

The dominant groups in Owenirragh Bog were dipteran larvae (17.9%), Odonata (15%), Trichoptera (21%), Coleoptera, including larvae (25.6%), Corixidae (18%) and Ephemeroptera (2.6%). Scragh Bog contained all these groups accounting for 87.9% of the total fauna together with other macroinvertebrate groups, not found in Owenirragh Bog, such as Hirudinea (5.5%), Gastropoda (5.5%) and Bivalvia (1.1%). In terms of macroinvertebrate abundance, Scragh Bog supported higher invertebrate numbers than Owenirragh Bog**.**

Taxon richness in the pool class ($10m^2$ - $100m^2$) was higher than the *Sphagnum* hollows ($t= 3.8$, $df = 4$, $p<0.05$) in Scragh Bog. Nearly 32% of the taxa found were common to both habitats, with only 14.3% unique taxa inhabiting the hollows, such as *Limnephilus binotatus* (Curtis), *Limnephilus decipien* (Kolenati), *Limnephilus fuscinervis* (Zetterstedt), *Coelostoma arbiculare* (Fabricius), *Cercyon tristis* (Illiger), *Cercyon convexiusculus* (Stephens), *Hydrobius fuscipes* (Linnaeus) and *Helochares punctatus* (Sharp). There was no significant difference between the habitats found in Owenirragh Bog (ANOVA, $p>0.05$). However six taxa were found to be unique to each habitat, including *Aeshna juncea* (Linnaeus), *Notonecta obliqua* (Gallen), *Sigara scotti* (Douglas and Scott) and *Holocentropus dubius* (Rambur) in the large pools and *Agabus bipustulatus* (Linnaeus), *Hydraena* sp. and *Plectrocnemia conspersa* (Curtis) in the

Table 1. Hydrochemical results for sites (mean plus standard error)

	Scragh Bog	Owenirragh Bog
pH	7.35 (+/- 0.02)	4.75 (+/- 0.02)
Alkalinity (mg $CaCO_3$/L)	127.5 (+/- 14.5)	-0.12 (+/- 0.01)
Nitrite (NO_2^-) (mg N/L)	<0.001	<0.001
Nitrate (NO_3^-) (mg N/L)	<0.1	1.57 (+/- 0.1)
Ammonia (NO_3^+) (mg N/L)	<0.01	0.09 (+/- 0.02)
Phosphate (PO_4^{3-}) (mg P/L)	<0.01	<0.01
Chloride (mg/L)	7.59 (+/- 0.89)	21.65 (+/- 2.32)
Sulphate (mg/L)	1.54 (+/- 0.42)	4.22 (+/- 0.31)
Sodium (mg/L)	5.03 (+/-0.08)	5.05 (+/- 1.11)
Potassium (mg/L)	0.28 (+/- 0.03)	0.53 (+/- 0.13)
Magnesium (mg/L)	6.29 (+/- 0.1)	6.32 (+/- 1.39)
Calcium (mg/L)	54.28 (+/- 5.05)	0.40 (+/- 0.03)
Organic Carbon	9.92 (+/- 0.74)	7.68 (+/- 1.46)

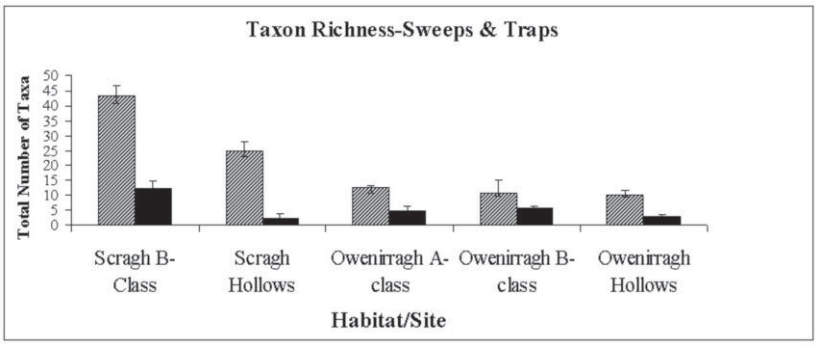

Figure 1. Mean taxon richness for habitats within both sites showing counts for both sweep and trap sampling.

smaller pools. The hollows recorded 6 unique taxa including *Nepa cinerea* (Linnaeus) and *Enochrus affinis* (Thunberg).

In terms of taxa abundance the larger pools in Owenirragh Bog had significantly higher numbers of invertebrates than the other habitats (ANOVA, $p<0.05$). The pools in Scragh Bog also had significantly higher numbers of invertebrates than the hollows ($t=4.5$, $df= 4$, $p<0.05$) (Fig 3). There was no significant correlation between water body size and taxa abundance (Pearson correlation, $p>0.05$).

Discussion

Hydrochemistry is one of the factors used to draw a distinction between different peatland types. Blanket bogs generally have a low pH and low levels of nutrients (Larson and House, 1990; O' Connell, 1998). The results obtained for Owenirragh blanket bog in this study complement those expected for this bog type. The chloride ions, sodium ions and 23% of the magnesium ions present can be attributed to the influence of the sea (Sparling, 1967). In fact the composition of the water in this bog is quite similar to that of rainwater (Jordan, 1997). The hydrochemical character of Scragh Bog is in line with that expected of a minerotrophic fen (Heinselman, 1970), near neutral pH with a rich supply of ions. The significantly higher calcium value is probably derived from the underlying limestone geology introduced from the groundwater source feeding the fen.

There was a significant difference in taxon richness and abundances between the two sites, with Scragh Bog having nearly twice the number of taxa. The difference is attributed to the Mollusca, which have a high demand for calcium (Macan, 1977) and Hirudinea, most of which need an alkalinity greater than 60mg $CaCO_3$/L (Elliott and Mann, 1979). The higher ion concentrations found in Scragh bog probably accounts for the higher productivity of the system. Productivity of a peatland ecosystem is said to be controlled by water level, water flow and nutrient level (Rydin and Jeglum, 2006). Previous studies also found that species assemblages varied between ombrotrophic waterbodies and more nutrient enriched water bodies (Smits *et al.,* 2002).

There was a significant difference in macroinvertebrate abundance between the habitats in each site, with the larger pools having higher abundance, a trend also noticed by Downie *et al.* (1998).There was a significant difference in the taxon richness between the habitats present in Scragh Bog, with the pools being responsible for a considerable number of the taxa recorded. However no such difference occurred between the habitats in Owenirragh Bog. The differences in Scragh Bog may be due to the larger difference in size between habitat types compared to the range of habitats in Owenirragh Bog which represent a more gentle size gradient.

In conclusion, the present study, albeit limited to two sites, has contributed significantly to the check list of macroinvertebrates in peatland water bodies. Furthermore, it has suggested some influence of hydrochemistry on both taxon richness and abundance, which will be more fully explored when data from an additional six sites becomes available.

Acknowledgments

EH would like to thank the BOGLAND project manager Dr Florence Renou-Wilson, my field work partners Rachel Wisdom and Louise Deering and colleagues in the Freshwater Ecology Research Group for their help with species identifications.

References

Becerra Jurado, G., Masterson, M., Harrington, R. and Kelly-Quinn, M. (2008). Evaluation of sampling methods for biodiversity estimation in heavily vegetated ponds. *Hydrobiologia* **597**, 97-107.

Bellamy, D.B. (1966). An ecological approach to the classification of the lowland mires of Ireland. *Proceedings of the Royal Irish Academy* **65B** (6).

Boatman, D.J. (1960). The relationships of some bog communities in Western Galway. *Proceedings of the Royal Irish Academy,* **61B** (8).

Dowling, C. and Murray, D.A. (1981). The distribution of the Chironomidae (Diptera) in two Irish blanket bogs. *Proceedings of the Royal Irish Academy, Section B-Biological, Geological and Chemical Science* **81B**(6.).

Downie, I.S., Coulson, J.C., Foster, G.N. and Whitfield, D.P. (1998). Distribution of aquatic macroinvertebrates within the peatland pool complexes in the Flow Country, Scotland. *Hydrobiologia* **377**, 95-105.

Elliott, J.M. and Mann, K.H. (1979). *A key to the British freshwater Leeches.* Freshwater Biological Association.

Good, J.A. (1985). Invertebrates of Irish midlands raised bogs: part IV notes on terrestrial insects. *Bulletin of the Irish Biogeographical Society* **9**, 2-9.

Heinselman, M.L. (1970). Landscape evolution, peatland types, and the environment in the Lake Agassiz Peatlands Natural Area, Minnesota. *Ecological Monograph* **40**, 235-261.

Higgins, D.G. (1984). Invertebrates of Irish midlands raised bogs: part 1. Araneae, Opiliones, Chilopoda. *Bulletin of the Irish Biogeographical Society* **8**, 91-97.

Jordan, C. (1997). Mapping of rainfall chemistry in Ireland 1972-94. *Biology and Environment: Proceedings of the Royal Irish Academy* **97B**(1), 53-73.

Larson, D.L. and House, N.L. (1990). Insect communities of Newfoundland bog pools with emphasis on the Odonata. *The Canadian Entomologist* **122**, 469-501.

Lindsay, R. (1995). *Bogs: The Ecology, Classification and Conservation of Ombrotrophic Mires*. Scottish Natural Heritage.

Lindsay, R., Charman, D.J., Everingham, F., O'Reilly, R.M., Palmer, M.A., Rowell, T.A. and Stroud, D.A. (1988). *The Flow Country: The Peatlands of Caithness and Sutherland*. Nature Conservancy Council, Peterborough.

Macan, T.T. (1977). *A key to the British Fresh- and Brackish-water Gastropods*. Freshwater Biological Association.

O' Connell, C. (1998). *Part 1 – Irish peatlands, their ecology and conservation. A Day in the bog field studies guide.* Irish Peatland Conservation Council.

Proctor, M.C.F. (1992). Regional and local variation in the chemical composition of ombrogenous mire waters in Britain and Ireland. *Journal of Ecology* **80**, 719-736.

Reynolds, J.D. (1984). Invertebrates of Irish midlands raised bogs: part 2. Odonata, Aquatic Hemiptera, Trichoptera. *Bulletin of the Irish Biogeographical Society* **8**, 98-102.

Reynolds, J.D., Duigan, C., Marnell, F. and O'Connor, A. (1998). Chapter 4: Extreme and ephemeral water bodies in Ireland. In P. S. Giller (ed.), *Studies in Irish Limnology,* 67-99. The Marine Institute, Dublin, Cork.

Rydin, H. and Jeglum, J.K. (2006). *The Biology of Peatlands*. Oxford University Press.

Smits, M.J.A., Van Duinen, G.A., Bosman, J.G., Brock, A.M.T., Javois, J., Kuper, J.T., Peeters, T.M.J. and Esselink, H. (2002). Species richness in a species poor system: Aquatic macroinvertebrates of Nigula Raba, an intact raised bog system in Estonia. In G. Schmilewski and L. Rochefort (eds.), *Peat in Horticulture – Quality and Environmental Changes, Proceedings of the International Peat Symposium*, *Parnu, Estonia, 3-6 September, 2002*, 283-291. International Peat Society.

Sparling, J.H. (1967). The Occurrence of *Schoenus nigricans* L. in Blanket Bogs: I. Environmental Conditions Affecting the Growth of *S. nigricans* in Blanket Bog. *The Journal of Ecology* **55**(1), 1-13.

Standen, V. (1999). Quantifying macroinvertebrate taxon richness & abundance in open and forested pool complexes in the Sutherland Flows. *Aquatic Conservation: marine and Freshwater Ecosystems* **9**, 209-217.

Van Duinen, G.A., Brock, A., Kuper, J., Leuven, R.S.E.W., Peeters, T.M.J., Roelofs, J.G.M., Van der Velde, G., Verberk, W.C.E.P. and Esselink, H. (2003). Do restoration measures rehabilitate fauna diversity in raised bogs? A comparative study on aquatic macroinvertebrates. *Wetlands Ecology and Management* **11**, 447-459.

Van Duinen, G.J., Brock, A., Kuper, J., Peeters, T. and Esselink, H. (2004). Do raised bog restoration measures rehabilitate aquatic fauna diversity?A comparative study between pristine, degraded, and rewetted bogs. In J. Päivänen (ed.), *12th International Peat Congress*, *Tampere, Finland, 6-11 June 2004*, 399-405.

Wells, E.D. (1996). Classification of Peatland Vegetation in Atlantic Canada. *Journal of Vegetation Science* **7**(6), 847-878.