This publication includes the extended abstracts of oral presentations and posters delivered at the 12th European Weed Research Society (EWRS) Symposium on Aquatic Weeds, held in Jyväskylä (Finland), during the period 24-28 August 2009. The symposium was organised by the EWRS in cooperation with the International Society of Limnology (SIL), the Finnish Environment Institute (SYKE), the University of Jyväskylä and the Waterpraxis project.

The main theme of the symposium was ‘Aquatic invasions and their relation to environmental changes’. The various sessions were primarily concerned with distribution, indicator value, ecological effects and management of aquatic plants. The symposium was attended by more than one hundred participants from thirty countries.
Aquatic Weeds 2009
Proceedings of the
12th European Weed Research Society Symposium
August 24–28 2009, Jyväskylä, Finland

Arnold Pieterse, Anne-Mari Rytkönen and Seppo Hellsten (eds)
Finland is called ‘the country of a thousand lakes’. However, officially this number is much higher, i.e. 187,888, whereby only lakes with an area of more than 0.5 hectares are taken into account. The area of 47 lakes even exceeds one hundred square kilometres. In the lakes there are 98,050 islands, implying that the total length of the shoreline is more than 215,000 km. In addition, there are plenty of rivers in Finland and the total length of their banks is approximately 53,000 km.

These fresh water lakes and rivers form habitats for various species of aquatic macrophytes. Moreover, the brackish Baltic Sea and Gulf of Finland are also unique ecosystems for fresh water macrophytes, as well as for marine macro-algae. The total length of the Finnish coastline is about 46,000 km and in an area near the coast where the sea is relatively shallow, another 80,000 islands can be found. We can easily claim, therefore, that Finland is a country where conditions for aquatic plant growth are quite ideal.

The first attempts to study our flourishing aquatic flora were carried out before the Second World War, leading to one of the first lake macrophyte classifications by Lauri Maristo (1941). Unfortunately, despite the relatively good status of our surface waters, several water bodies are nowadays suffering from eutrophication and water level alterations. Moreover, climate change has promoted an expansion of invasive species, which forms a new threat to our freshwater ecosystems.

The city of Jyväskylä is situated in the middle of the Finnish lake district and offers good facilities for the 12th Aquatic Weeds symposium, which is held during the period August 24-28 2009. It is the first aquatic plant oriented symposium held in Finland. The main theme of the symposium is ‘Aquatic invasions and their relation to environmental changes’, with the following specific sessions:

- Biology, ecology and distribution of aquatic plants
- Indicator value of aquatic plants
- Management of aquatic vegetation and side effects
- Invasive plants and their ecological effects
- Environmental management in relation to aquatic plant development
- Aquatic vegetation and environmental relationships
- Practical uses

More than one hundred participants, representing all continents and almost thirty nationalities, are expected to participate. Hopefully this ‘Finnish experience’, by means of the extensive programme consisting of oral and poster presentations, an excursion to nearby lakes around Jyväskylä and the opportunity of meeting colleagues with similar interests and scientific backgrounds, will be worthwhile. The University of Jyväskylä is providing the venue: the magnificent Agora building, situated at a beautiful site along Lake Jyväsjärvi.

The Symposium is organised by the European Weed Research Society (EWRS), through its Working Group on Invasive Plants, in collaboration with the Working Groups on Macrophytes and Wetlands of the International Society of Limnology (SIL), as well as the Finnish Environment Institute (SYKE).
Organising an international symposium is a demanding task. The local organising committee includes the following members:

Seppo Hellsten (SYKE), Chairman
Timo Huttula (SYKE)
Raimo Ihme (SYKE)
Arnold Pieterse
Jukka Salonen (MTT)
Juha Karjalainen (University of Jyväskylä)
Pirjo-Leena Pitkänen (Jyväskylä Events - Congreszon Ltd)
Kati Martinmäki (SYKE)
Anne-Mari Rytkönen (SYKE)

The composition of the International scientific committee is:

Christian Bohren (Chairman), ACW, Switzerland
Arnold Pieterse (Conference secretary), The Netherlands
Joe Caffrey, Central Fisheries Board, Ireland
Frauke Ecke, Luleå University of Technology, Sweden
Teresa Ferreira, Technical University of Lisbon, Portugal
Brij Gopal, Jawaharlal Nehru University, India
Jacques Haury, University of Rennes, France
Kaisa Heikkinen, SYKE, Finland
Seppo Hellsten, SYKE, Finland
Georg Janauer, University of Vienna, Austria
Timo Kairesalo, University of Helsinki, Helsinki, Finland
Antti Kanninen, North Savo Regional Environment Centre, Finland
Jukka Salonen, MTT Agrifood Research, Finland
Jouko Sarvala, University of Turku, Finland
Krzysztof Szoszkiewicz, Agricultural University of Poznan, Poland
Heikki Toivonen, SYKE, Finland
Ludwig Triest, Vrije Universiteit Brussel, Belgium
Pertti Uotila, University of Helsinki, Finland
Nigel Willby, University of Stirling, UK

The symposium is sponsored by SYKE, the EWRS and the Federation of Finnish Learned Societies. Technical arrangements are realised by a team led by Pirjo-Leena Pitkänen from Jyväskylä Events - Congreszon Ltd. The SYKE-team consisting of Kati Martinmäki and Anne-Mari Rytkönen, is in various ways assisting and helping.

Realisation of Aquatic Weeds 2009 would have never been possible without the unselfish, voluntary work by Dr Arnold Pieterse. From September 2007, when the first ideas of revitalising this symposium series were put forward, he has worked restlessly for our common goal and earns our thanks.

On behalf of the local organising committee I wish you all a successful and pleasant symposium, which will lead to an enhanced common understanding of aquatic plants and their role in our freshwater ecosystems.

Seppo Hellsten
Finnish Environment Institute, Research Programme for Integrated River Basin Management, Oulu, Finland
Organisation

The 12th European Weed Research Society Symposium on Aquatic Weeds was organised by

The European Weed Research Society (EWRS) is an international organization which promotes and co-ordinates scientific research into all aspects of weed science. The EWRS was formed in 1975. It is open to everyone who has an interest in weed research and related topics.

The International Society of Limnology (SIL) promotes and communicates new and emerging knowledge among limnologists to advance the understanding of inland aquatic ecosystems and their management. The aim of SIL, which was founded in 1922, is to further the study and understanding of all aspects of limnology.

The Finnish Environment Institute (SYKE) is both a research institute, and a centre for environmental expertise. SYKE’s research focuses on changes in the environment, and seeks ways to control these changes.

University of Jyväskylä, founded in 1934, is one of the biggest universities in Finland. It has 7 faculties and 15 000 degree students. The core fields of research and education include natural sciences and mathematics, human-centered sciences, sport and health sciences and teacher education.

Waterpraxis – From theory and plans to eco-efficient and sustainable practices to improve the status of the Baltic Sea (2009–2012) is a project aiming at contributing to the practical implementation of the Water Framework Directive. Waterpraxis belongs to the Baltic Sea Region Programme and is part-financed by the European Union.
Content

Preface......................................................................................................................................................3

Introduction

1 The EWRS International Aquatic Weed Symposia in the past and prospects for their future .............................................................15
2 The EWRS Invasive Plants Working Group.................................................................17

Biology, ecology and distribution

3 Patterns in aquatic macrophyte diversity in North American freshwaters ....................................................................................21
4 Changes of dominant aquatic macrophytes in 52 small boreal lakes in 60 years ...........................................................................23
5 Aquatic plants of running waters in the North-East of Italy (Trentino and Veneto) ...........................................................................24
6 Macrophytic vegetation in small rivers of the Republic of Karelia (Northwestern Russia) .................................................................25
7 Diversity and ecological role of pondweeds (Potamogeton, Potamogetonaceae) in rivers in the north of European Russia ..........26
8 Aquatic macrophytes in a large river: ecological status, trophic level indication, habitat preference and species migration in the Danube ........................................................................................................27
9 Deriving an index to quantify long term changes in aquatic vegetation in lowland lakes using historical records ...............................28
10 Association of hydrophyte assemblages and zooplankton abundance in five lakes of Greece ..........................................................29
11 Utility of the submerged leaves of Nuphar lutea (L.) Smith: a positive feedback on organic matter capture ...........................................30
12 Genotypic diversity of waterplant populations: are there barriers to long-distance gene flow? ...............................................................32
13 Genetic population structure of an invasive aquatic weed, Elodea canadensis, in Finland .................................................................34
14 Stable isotope composition of Chara rudis incrustation in a lake with extensive underwater charophyte meadows ............................35
15 Azolla filiculoides, a floating aquatic fern response to elevated [CO₂] with high temperature and P nutrient ..................................................37
16 Ecological differentiation within the Glyceria fluitans-group: what affects differences in abundance or rarity? ...............................38
17 Uncertainty in Finnish lake macrophyte ecological classification metrics .........................................................................................39
18 Nutrient competition between the duckweeds Lemna minor and L. trisulca .......................................................................................40
19 Changes in macrophyte composition in channels of the Bosut river basin (Eastern Croatia) between 1980–2006 .................................................. 41
20 Nutrient concentration in macrophytes of Mediterranean ponds: variation among species and ways of growth .................................................. 42
21 Using of hemispherical and lidar photos in investigation of structure of river bank riparian scubs ........................................................................... 43
22 The influence of Ceratophyllum demersum L. and Stratiotes aloides L. on richness and diversity of aquatic vegetation in the lakes of mid-eastern Poland .................................................................................................................. 45
23 The interactive effects of eutrophication, species identity and influence of species initial abundance on competition between an invasive and native Lemna: an investigation using RGRD analysis ........................................ 46
24 Composition, abundance and distribution of macrophyte communities in the lowland River Väike Emajõgi .................................................................. 48
25 Plant cover of water bodies of the Vychegda river basin: composition, structure and conditions of formation .............................................. 50
26 Biology and species diversity of macro-algae in the Transition Zone (TZ) of the Eastern Gulf of Finland (EGoF) ........................................... 51
27 Molecular phylogeny of an aquatic plant, Ruppia (Ruppiaceae) based on chloroplast and nuclear DNA sequences ........................................ 53
28 Population structures of Stratiotes aloides in Finland .................................................. 54
29 Rare Potamogeton species in Hungary .............................................................................. 55
30 New synthesis of the Hungarian freshwater aquatic vegetation: semi-natural and invaded stands ................................................................. 56
31 Decomposition and nutrient dynamics of Phragmites australis litter in Lake Burullus, Egypt .............................................................................. 57

Indicator value of aquatic plants

32 Evaluation of the ecological quality of Cyprus rivers using aquatic macrophytes as biological quality elements ........................................ 61
33 Harmonisation and viewpoints in the Mediterranean WFD inter-calibration exercise for river macrophytes .................................................. 62
34 The current status of protected lakes in England derived from macrophyte surveys ......................................................................................... 63
35 RVI: a vegetation-based index for the assessment of the ecological quality in Iberian rivers .............................................................................. 64
36 Does macrophyte-based lake status assessment according to the EU Water Framework Directive conflict with the EU Habitat Directive in Fennoscandia? .................................................................................................................. 65
37 The effect of anthropogenic pressure and water quality on the aquatic vegetation in Polish lowland lakes ............................................................. 66
38 Macrophytes as indicators of stream condition in the Wet Tropics region, Northern Queensland, Australia ......................................................... 68
39 Assessing the condition of lake habitats – a comparison of methods for surveying aquatic macrophyte communities ................................................................. 69
40 First attempts to assess lake status by aquatic macrophytes in Finland – validation of the proposed classification system ................................................ 71
41 A new genus level macrophyte index for assessing the trophic state of Spanish rivers under the Water Framework Directive .................................................. 73

42 The Dutch water quality assessment metric for aquatic macrophytes .............................................................................................. 74

43 The ‘Macrophyte Method’ for river assessment implementation in the classification of running waters in lowland Poland ................................................................. 76

44 The use of aquatic mosses in assessment of metal pollution: appraisal of type-specific background concentrations and establishment of environmental quality standards in boreal river ecosystems ............................................................................... 77

45 Can two submersed macrophytes be used to assess spatial gradient of lake trace element contamination? .................................................. 79

46 In which way are macrophyte communities suitable tools to assess the ecological status of Spanish lakes? .................................................. 81

47 Defining reference condition for nutrient-rich boreal lakes using historical data of aquatic macrophytes .......................................................... 82

48 Trophic level distribution of aquatic plants in the Western Greek rivers – comparison of ranking scores given by European Trophic Indices .................................................................................. 84

49 Habitat conditions and indicator value of mosses in lake-side mires of North-Eastern Poland ............................................................................. 86

Management of aquatic vegetation and side effects

50 Aquatic weed management in the tropics – a review ................................................................................................................. 91

51 Major aquatic weeds in tropical and sub-tropical countries and their management .................................................................................. 93

52 Lagarosiphon major control in a large Irish lake through light exclusion .................................................................................... 95

53 Aquatic plant invasions: Nipping invasions in the bud – weed risk assessment and the trade ........................................................................... 96

54 Experimental study of competition between Ludwigia grandiflora and Egeria densa ........................................................................ 97

55 Optimising diquat use for submerged aquatic weed management 99

56 An ecological approach to aquatic plant management: role of native plant restoration .............................................................. 100

57 Natural enemies from South Africa improve the prospects for biological control of Lagarosiphon major (Ridl.) Moss ex Wager (Hydrocharitaceae) in Europe ............................................................................. 101

58 Monitoring the effects of repeated herbicide application on Lygodium microphyllum and native vegetation at A.R.M. Loxahatchee national wildlife refuge ...................................................................... 103

59 An ecological approach to aquatic plant management: role of insect biocontrol .................................................................................. 104

60 Relationships between characteristics of the biomass production of Ludwigia species and features of colonised biotopes in France. Proposition of a simple model to improve their management .......... 105
61 Monitoring invasive *Ludwigia grandiflora* in the Vilaine Basin using multitspectral remote sensing ................................................................. 106

62 Hyperspectral remote sensing of the aquatic invasive plant, *Ludwigia grandiflora*, in North-West France ........................................................... 107

63 *Mayaca fluviatilis* Aubl.: An ornamental aquatic with invasive potential in Sri Lanka ....................................................................................... 108

64 Spreading of emergent weed species and occurrence of invasive species in hydromeliorative facilities in the northern part of the Republic of Serbia ........................................................................................................... 109

65 Water pest (*Elodea canadensis* - Michx.) as an important ecological and economical problem for the hydro-power plant – Varaždin-North in Croatia .................................................................................................................. 110

**Invasive plants and their ecological effects**

66 Impact of invasive species on ecosystem goods and services of wetlands ............................................................................................................. 115

67 Growth behaviour of the invasive species *Ipomoea carnea* Jacq. in the Nile Delta, Egypt .................................................................................... 116

68 Changes in littoral invertebrate communities in Lough Corrib in response to an invasion by *Lagarosiphon major* ............................................................................................................................. 117

69 Are phenotypic differences in invasive aquatic plant species caused by phenotypic plasticity or locally adapted ecotypes? ........................................... 119

70 Impact of aquatic invasive species on native plant and benthic invertebrate assemblages in Belgian ponds .............................................................. 120

71 Comparative performance between invasive alien *Eichhornia crassipes* and native *Ludwigia stolonifera* under nutrient non-limiting conditions: Lake Naivasha, Kenya .................................................................................... 122

72 Relationships between alien or invasive water plants and native or rare water plants at multiple spatial scales ........................................................................... 124

73 Habitat characteristics of the alien species *Elodea canadensis* .............................................................................................................................. 125

74 Aquatic Plant Invasions – Predicting success .............................................................................................................................. 126

75 The spread of common watermilfoil, *Myriophyllum sibiricum*, in shallow lakes in Åland, (SW Finland) ........................................................................... 127

76 Increasing number and abundance of non-indigenous aquatic macrophyte species in Germany – an underestimated threat? ........................................ 128

77 The submerged American waterweed *Elodea canadensis* dominates ecosystem structure and nutrient cycling in a small lake ......................................... 129

78 Changes in the aquatic macrophyte vegetation in a neophyte dominated river (River Erft, North Rhine-Westphalia, Germany) .................................... 131

79 Assessment of the long term impacts of alien aquatic macrophytes on native plant communities ...................................................................................... 132

80 Actual report on spread of invasive macrophytes in Hungary ................................................................................................................................. 133

81 Alien taxa in European aquatic vascular plant families ................................................................................................................................. 135
Environmental management in relation to aquatic plant development

82 Biomanipulation of hypereutrophic ponds: the role of submerged macrophytes ................................................................. 139

83 Interactions between water-level fluctuation and vertical extension of helophyte zones ...................................................... 141

84 Hydraulic versus hydrologic drivers of macrophyte assemblage structure ................................................................................ 142

85 Recolonisation of submerged macrophytes in the shallow lake Loenderveen after restoration measures; the success of different life-traits .................................................................................................................. 143

86 Species richness on differently managed shore stretches of Lake Peipsi, Estonia ..................................................................... 145

87 The influence of local and catchment scale variables on the distribution of Salvinia natans and Trapa natans in channels in Eastern Croatia ........................................................................................................................................ 146

88 What conditions enable expansion of weedy Bolboschoenus taxa on arable land? ................................................................... 147

89 Reaction of macrophyte production to hydrological changes in reference to the nutrient cycle in a shallow lake ......................... 148

Aquatic vegetation and environmental relationships

90 Sediment and water interactions with macrophyte element concentrations and community structure ........................................... 151

91 Retention rate of fine sediments due to the annual shoot collapse; Sparganium erectum as an ecosystem engineer in a lowland stream 152

92 Environmental factors influencing the distribution of macrophytes in middle-sized streams of Latvia ........................................... 153

94 Velocity patterns in, around and through a sequence of vegetation distribution patterns .............................................................. 157

95 The impact of environmental and anthropogenic factors on the distribution pattern of aquatic plants along the Louros River, Western Greece–‘Adoption’ of a reference pattern of aquatic assemblages .... 158

96 Macrophyte surveys in assessment of land use impact on the ecological status of rivers .......................................................... 160

97 Assessing riparian vegetation structure and the influence of land use using landscape metrics and geostatistical tools .................. 161

98 Macrophyte successions in watercress beds .......................................................................................................................... 162

99 Assessment of eutrophication effect on charophytes in Mediterranean ponds (Northwest Spain) .................................................. 163

100 The influence of connectivity and fertility on aquatic plant communities of riverine backwaters ........................................... 164

101 Influence of willow bushes elasticity on roughness coefficients .... 165

102 Aquatic vegetation as an indicator of littoral habitats and various stages of lake overgrowth in north-eastern Poland .................. 166
Practical uses

103 Water soldier (Stratiotes aloides L.) as a new potential source of active compounds with anti-inflammatory, anti-gout and antioxidant effects ................................................................. 171

104 Evaluation of water purification of an artificial agricultural drainage in a dairy farming watershed .................................................................................................................. 172

105 Addition to Invasive plants and their ecological effects: Increased growth of submerged aquatic vegetation (SAV) in Finnish lakes at the beginning of the 2000’s – is excessive SAV growth still ongoing? 173

Documentation page .................................................................................................................................................. 175

Kuvailulehti ................................................................................................................................................................. 176

Presentationsblad ..................................................................................................................................................... 177
Introduction
1 The EWRS International Aquatic Weed Symposia in the past and prospects for their future

Arnold H. Pieterse
Wilsonstraat 83, Hoofddorp 2131 PM, The Netherlands

The past

In 1958 an international group of European weed scientists organised a meeting in the Belgian city of Ghent and set up a working group to “accelerate progress in solving the problems caused by weeds”. In 1960 this led to the establishment of the EWRC, the European Weed Research Council, which in 1975 was transformed into the EWRS, the European Weed Research Society.

Already during the first years of its existence the EWRC stimulated the formation of Working Groups. The first one was the Working Group (WG) on Aquatic Weeds, which would exist for more than 40 years. A main activity of the Aquatic Weed WG during this period was the organisation of eleven international symposia in respectively: La Rochelle, France (1964), Oldenburg, Germany (1967), Oxford, UK (1971), Vienna, Austria (1974), Amsterdam, The Netherlands (1978), Novi Sad, Yugoslavia (1982), Loughborough, UK (1986), Uppsala, Sweden (1990), Dublin, Ireland (1994), Lisbon, Portugal (1998) and Moliets et Maâ, France (2002). Moreover, the WG took the initiative to publish a textbook on aquatic weeds (Pieterse & Murphy 1990).

The basis for the initial success of the WG on Aquatic Weeds was laid by Dale Robson of the former Weed Research Organisation in Oxford (UK), who chaired the Group in the period from the Oxford symposium, in 1972, up to the Novi Sad symposium, in 1982. At that time the WG on Aquatic Weeds had become one of the most successful WG’s within the EWRS. Subsequently, I took over the chairmanship, and after an eight year period, which included the symposia in Loughborough and Uppsala, Max Wade of the Loughborough University (UK) succeeded me in 1991 and was in charge of the symposia in Dublin, Lisbon and Moliets et Maâ.

Unfortunately, not long after the 11th International symposium on Aquatic Weeds in Moliets et Maâ, in 2002, the WG on Aquatic Weeds was dissolved. The official reason for this discontinuation was that in the eyes of the Scientific Committee of the EWRS, it was not anymore sufficiently active. In fact, there had been a steady decrease in the number of EWRS members dealing with aquatic weeds. Management of aquatic vegetation became more and more a job for ecologists, who do not really consider themselves as being weed scientists. After the first four symposia this trend had already started as a result of a decrease in papers on chemical control. The environmental risks of using herbicides in an aquatic ecosystem increasingly became a focus of attention, which led to more studies on mechanical control, as well as to ecological approaches, including biological control. The symposium in Novi Sad was even combined with the 2nd international symposium on herbivorous fish.
Although aquatic weeds increasingly became a matter of secondary importance within the EWRS, the aquatic weed symposia remained a popular platform for scientists working on aquatic plants all over the world and attracted many participants. In fact it had become the most prestigious series of international symposia on aquatic macrophytes. Although topics like biology, ecology, distribution, invasiveness and indicator values of aquatic plants became more numerous, papers on management remained an important contribution. The symposia also attracted many scientists from other continents, especially from North America, Australia and New Zealand, as well as from developing countries, where management of aquatic weeds in many cases is a more wide-ranging issue than in Europe.

Consequently, possibilities to continue the series after the symposium in Moliets et Maâ in 2002, have been looked for. Eventually, Seppo Hellsten of the Finnish Environment Institute (SYKE), was willing to take the lead in organising the present 12th International symposium on Aquatic Weeds in Jyväskylä.

The EWRS gave the green light for also connecting its name to the present symposium and the WG on Invasive Plants, under the direction of Christian Bohren, one of the nowadays 13 EWRS WG’s, became the official link between the EWRS and the symposium organisers. In line with the WG on Invasive Plants the main theme of our present symposium became “Aquatic invasions and their relation to environmental changes”. The International Society of Limnology (SIL), by means of their Working Groups on Macrophytes and Wetlands, as well as the University of Jyväskylä, also take part in the organisation of this symposium, which will cover all aspects of freshwater macrophytes.

**Prospects for the future**

I have attended all symposia from Vienna, in 1974, to the present one in Jyväskylä. These are 9 out of the total of 12, which prompts me to put forward some wishes and ideas about the future.

Hopefully the tradition of organising international symposia on aquatic weeds/plants will be continued. The EWRS WG on Invasive Plants could also after the present symposium, remain the most appropriate umbrella for this activity, as it seems that, at least at the present, there are not sufficient EWRS members for establishing a new WG on Aquatic Weeds. The scientific committee of the present symposium will discuss this issue, which would imply that the EWRS will keep its name connected with the series in future, in spite of the fact that it considers it less a priority. In this context a mail from Paolo Barberi, the secretary of the Scientific Committee of the EWRS, which I received on February 23 2009, has been very promising. In connection with our preliminary programme he wrote to me “I am happy that the EWRS name is linked to such an event”.

Moreover, I hope that a possible venue for the next symposium can be tentatively decided upon. Usually the period between the aquatic weed symposia has been four years, but after the previous symposium in Moliets et Maâ, this period has, from sheer necessity, been extended to seven years. Hopefully the next symposium can be held again after four years, i.e. in 2013.

**Reference**

2 The EWRS Invasive Plants Working Group

Christian Bohren
Research Station Agroscope Changins-Wädenswil ACW, CH-1260 Nyon, Switzerland

We are a working group of the European Weed Research Society (EWRS) with presently 121 members from 29 countries. This working group actually focuses on invasive alien plant species and environmental weeds in Europe. We are open to integrate other activities.

We aim at bringing together scientists as well as practitioners concerned and affected by those plants. It is one of our main objectives to promote discussion and joint experimentation on possibilities to control invasive alien plant species and environmental weeds.

Main topics of the working group are:
- Identifying key research and control technology needs and encouraging their execution, including collaborative programmes;
- Organising meetings, symposia and conferences, and including the topic in existing meetings;
- Supporting communication and information exchange between agricultural and environmental researchers, between scientists and professionals, between individuals and organisations, between national and international organisations;
- Encouraging and assisting education and training on invasive plants (control, horticultural and environmental aspects) for institutions, students, professionals (interdisciplinary) and general public.

There is no formal membership of this working group. Rather it is an informal grouping of people interested in invasive plants and environmental weeds. Everyone is welcome to contribute to practical concerted research and to attend the working group meetings and other conferences. Apart from the website http://www.ewrs.org/IW/membership.asp, communication between members is via e-mail. This has been largely used to solicit opinion on the direction of the group, where and when meetings should be held, and to give in advance details of meetings.

You do not have to be a member of the EWRS to participate in the working group, although EWRS members receive discounts to attend the working group meetings and in the past, post-graduate members have been able to apply for travel subsidies to these meetings. When you join the WG, you will eventually be encouraged to become a member of the EWRS. If you would like to join the Working Group please contact the coordinator Christian Bohren, e-mail: christian.bohren@acw.admin.ch.
Biology, ecology and distribution
3 Patterns in aquatic macrophyte diversity in North American freshwaters

P.A. Chambers1, P Lacoul2, K.J. Murphy3 and S.M Thomaz4
1Environment Canada, Burlington, Ontario, Canada; 2Dalhousie University, Halifax, Nova Scotia, Canada; 3University of Glasgow, Glasgow, United Kingdom; 4Universidade Estadual de Maringá, Maringá, Brazil

Introduction

Aquatic macrophytes include macroscopic plants and bacteria of the divisions Cyanobacteria, Chlorophyta, Xanthophyta, Rhodophyta, Bryophyta, Pteridophyta and Spermatophyta, the vegetative parts of which actively grow either permanently or periodically submerged below, floating on, or growing up through the water surface. As part of a global project to identify diversity of freshwater organisms, we compiled a database of plant species fitting the definition of aquatic macrophyte and their distribution world-wide (Chambers et al. 2008). Our subsequent goal was to use the North American portion of this database to identify: (1) whether species composition differs significantly over a large spatial scale, and (2) what parameters influence the distribution of submerged macrophyte assemblages.

Results

Our compilation identified that species composition and distribution of aquatic macrophytes in the more primitive divisions are less well known than for the vascular macrophytes. The latter are represented globally by 33 orders, 88 families and c. 412 genera with ~2614 species (or ~1% of the total number of vascular plants). For North America, the numbers are 27 orders, 63 families and c. 193 genera with ~639 species. Hierarchical cluster analysis identified seven geographic assemblages within North America at ≥45% dissimilarity: Southwest USA (AZ, CA, CO, ID, MT, NE, NV, NM, ND, OR, SD, UT, WA, WY); Southeast USA (AL, AR, FL, GA, KS, KY, LA, MS, MO, NC, OK, SC, TN, TX); Eastern Canada (NB, NS, PEI, NFLD); Northeast USA and south-central Canada (CT, DE, IL, IN, IA, ME, MD, MA, MI, MN, NH, NJ, NY, OH, PA, RI, VT, VA, WV, WI, ON, southern QC); Northeast Canada (northern QC, Labrador); Northwest (AK, BC, AB, SK, MB, YT, NWT); Mexico. In Southwest USA and Southeast USA, 8% of the observed species were unique to those regions of North America compared to 2.5% of species being unique in northeast USA and south-central Canada, and <1% of species being unique in northerly regions. For Mexico, 29% of the observed species were unique to North America (although many of these species also occur in South America). Preliminary results indicate that observed changes in species composition across North America are related to physiogeographic factors such as temperature and length of growing season.
Conclusions

Our results showed large-scale patterns in species composition of vascular macrophytes across North America. Knowledge of the distribution and diversity of aquatic macrophytes is necessary for developing management strategies to control established invasives or prevent new introductions, assessing potential distribution of endangered plants, and predicting consequences of many of the threats to fresh waters (e.g., climate change, eutrophication).

Reference

4 Changes of dominant aquatic macrophytes in 52 small boreal lakes in 60 years

H. Toivonen
Finnish Environment Institute, P.O. Box 140, FIN-00251 Helsinki, Finland.

Long-term changes of dominating vascular macrophytes in 52 small lakes near the city of Tampere (southern Finland) during 60 years were studied, using data from four separate surveys (1947-51, 1975-78, 1991-93, 2005-08). The lakes represent a wide range of variation in the water chemistry, aquatic vegetation and anthropogenic influence. On an average the three most abundant species per lake were taken into account in each survey.

*Phragmites australis, Scirpus lacustris* and *Equisetum fluviatile* were the most frequent dominating helophytes in the study lakes in the 1940s. *Phragmites australis* maintained its dominance, having more dominating occurrences in later surveys. *Scirpus lacustris* and *Equisetum fluviatile* lost about half of their abundant occurrences up to the 1970s, and have recently only some. On the contrary, dominant occurrences of *Typha latifolia* have increased markedly during the study period, and became recently, after *Phragmites*, the most frequent dominating helophyte. In two lakes vigorous *Typha angustifolia x latifolia* stands developed after a few years with a low water table. *Typha* has increased most in eutrophic and hypertrophic lakes.

Due to decline of *Schoenoplectus* and *Equisetum*, floating-leaved plants have increased as dominants, and in a few cases also submerged plants. *Nuphar lutea* was the most frequent dominating floating-leaved plant in all surveys, having even more abundant occurrences in two last surveys. Dominating occurrences of *Nymphaea candida* decreased up to the 1990s, but they are recently recovering. Floating-leaved *Sparganium* (mostly *S. emersum*) showed an opposite trend. Abundant occurrences of elodeids were in two latter surveys slightly more frequent than earlier. They include a few mass occurrences of *Elodea canadensis* and *Potamogeton crispus* (newcomers in the study lakes). Abundant *Utricularia* occurrences have decreased during the study period. Mass occurrences of lemnids, floating-leaved hepatic *Ricciocarpus natans* (newcomer), and Characeae were found in a few lakes in various surveys, but these occurrences seem to be temporary.

Changes in dominant macrophytes can mostly be explained by eutrophication, grazing and housing impacts of the invasive muskrat (*Ondatra zibethica*), lowering of the water table, and small-scale building and dredging activities.

References

5 Aquatic plants of running waters in the North-East of Italy (Trentino and Veneto)

M. Fabris1, P.E. Ghetti2, A. Melzer3 and M. Siligardi1
1Regional Environmental Protection Agency of Trento, Italy; 2Department of Environmental Sciences, Ca’ Foscari University of Venice, Italy; 3Technische Universität München, Germany

This study aims to find a correlation between aquatic plants and abiotic features of river sites on one hand, and nutrients concentration in water on the other hand. Such theme has been already developed in many European Countries. Thanks to the WFD, the research about macrophytes of running waters has started to become more and more important also in Italy. To get a real knowledge of river aquatic plants many data from all over Italy are required.

Our data were collected on 54 sampling sites, belonging to different river types. 44 sites are located within the Trentino region, while 10 sites are located in the Veneto region. At every site macrophytes were mapped, concentrations of nutrients were measured and flow velocity and shading were recorded together with other site characteristics.

Aquatic vegetation was surveyed during Summer 2007 and 2008. All helophytic and hydrophytic plants, including bryophytes, charophytes and filamentous algae were recorded. Vascular plants, mosses and stoneworts were determined down to species level, while for filamentous algae only the genus was identified, in order to find a compromise between ecological information, time and experience required for the determination.

The survey was carried out on 50 m uniform sections, on the basis of morphological and shading conditions, substrate characteristics, flowing velocity and vegetation patterns. The abundance of each species was estimated through a five degree scale (1 = very rare, 2 = infrequent, 3 = common, 4 = frequent, 5 = abundant, predominant), according to the Kohler’s method. The relationship between the five-degree scale and the plant quantity is described by the function $y = x^3$, where $y$ is the quantity and $x$ is the value of abundance according to the five-degree scale.

Every reach was surveyed using a field data sheet, which includes the assessment of some morphological and hydrological parameters, especially of those that strongly influence the macrophyte community, i.e. flow velocity, shading, water depth, substrate composition, as well as all aspects which could be useful in the data interpretation.

The surveyed sites have been divided into groups, through clustering, according to their abiotic features. We did the same with macrophytes, working both on presence/absence data and on the abundance/coverage matrix, to find some characteristic assemblages, which could be associated to different river types. The PCA was run on the species matrix in order to understand which are the main factors that influence macrophyte assemblage patterns. The correlation between aquatic plant species and nutrients concentration was analysed using the Spearman’s rank order test.
6 Macrophytic vegetation in small rivers of the Republic of Karelia (Northwestern Russia)

S. Komulaynen
Institute of Biology, Karelian Research Center, Russian Academy of Sciences, 185910 Petrozavodsk Pushkinskaya 11, Karelia, Russia

Introduction

Macrophytes are a characteristic constituent of lotic systems. Aquatic vegetation has a greater effect on the hydrobiological regime in small rivers than in other types of water bodies, although the dominance of rocky bottoms and the shading by riverine vegetation markedly decrease the species diversity and biomass of aquatic flora in these ecosystems.

The aim of the present study was to determine the species composition and distribution of communities of macrophytes in small rivers in the Republic of Karelia and to assess their effect on periphyton, plankton and benthos formation.

Results and discussion

Fifty-four macrophyte species have been observed in the rivers studied, 48 being higher aquatic plants, of which 39 were hydrophytes. Furthermore, wetland plants, hygrophytes and mesophytes have been encountered. The diversity of the aquatic vegetation was markedly lower in the more northern parts of the region.

The main factor, which is responsible for the aquatic vegetation structure of these rivulets, is the current. The macrophytic vegetation in the upper and riffle zones consisted almost entirely of bryophytes, the most abundant of which was Fontinalis antipyretica, with an average biomass of about 155 g/m² AFDW (Ash-Free Dry Weight). Some of these plants had a maximum biomass of not more than 60 g/m². Submerged angiosperms belonging to the genera Batrachium and Myriophyllum were sporadically found in this zone, but the macrophytic alga Lemanea fluviatile was widespread. In pools angiosperms were the predominant group of macrophytes and it was estimated that Carex spp. were there the most common, - 450 g/m². The biomass of Phragmites australis, the most widespread species in all types of basins in the studied area, was only 180 g/m².

Macrophytes bring about a large effect on the formation of plankton, benthos and periphyton. Zooplankton in the studied macrophyte-covered river stretches was more diverse and had a larger biomass than in open areas. The abundance of zooplankton increased to 4.5 x 10³ individuals/m³, and a biomass of 262.5 mg/m³ in an Equisetum fluviatile vegetation and to 36.3 x 10³ individuals/m³ and a biomass of 5.7 g/m³ in Nuphar luteum stands, respectively. It was ascertained that overgrowing of the boulder-pebble bottom with aquatic moss leads to a marked increase in the abundance (up to 85 x 10³ ind. /m²) and biomass (up to 85 g/m²) of zoobenthos. Macrophytes are a suitable substrate for periphyton formation. The maximum periphyton biomass was observed on Fontinalis antipyretica and Equisetum fluviatile.
Diversity and ecological role of pondweeds (*Potamogeton*, Potamogetonaceae) in rivers in the north of European Russia

A.A. Bobrov and E.V. Chemeris
I. D. Papanin Institute for Biology of Inland waters of the RAS, Borok, Russia

A study of pondweeds (*Potamogeton*, Potamogetonaceae) was carried out for the first time in streams and rivers in the north of European Russia (Murmansk, Arkhangelsk, Vologda regions, Karelia and Komi Republics, Yaroslavl, Kostroma, Kirov and Perm regions). Taxonomic composition, distribution, ecology, role in river ecosystem functioning, as well as hybridisation processes, were investigated by traditional and modern methods. According to field, literature and herbarium data, it was ascertained that 15 species (*P. alpinus*, *P. berchtoldii*, *P. crispus*, *P. filiformis*, *P. friesii*, *P. gramineus*, *P. lucens*, *P. natans*, *P. obtusifolius*, *P. pectinatus*, *P. perfoliatus*, *P. praelongus*, *P. pusillus*, *P. subretusus*, *P. trichoides*) and 13 hybrids (*P. ×angustifolius*, *P. ×botnicus*, *P. ×cognatus*, *P. ×cooperi*, *P. ×fennicus*, *P. ×fluitans*, *P. ×nitens*, *P. ×olivaceus*, *P. ×prussicus*, *P. ×salicifolius*, *P. ×sparganiifolius*, *P. ×suecicus*, *P. ×vepsicus*) occur at the present in the region’s watercourses. The greatest diversity of river *Potamogeton* has been found within the taiga zone, especially in regions with a flat relief and significant differences in the landscape. Most pondweeds occur in small and medium rivers. The species and hybrids are characteristic for a given type of watercourse, i.e. of a larger and smaller order, and for other types of water bodies (bogs, lakes, oxbows, etc.). Pondweeds grow in a wide range of river habitats. Their distribution in river ecotopes largely depends on the current. *Potamogeton* species are represented by specific morphotypes in flowing water, e.g. with relatively narrow and long leaves. Most taxa successfully develop on various stony bottoms, which provide a stable underground, and prefer clean water with medium mineralisation, hardness and trophic level. In many rivers pondweeds are active primary producers under favourable conditions. Their stands may considerably affect hydrological and hydrochemical parameters. They create the environment, serve as a substrate, provide food and shelter for various organisms, and play an important role in self-purification of the river ecosystems. Hybrids are most diverse and abundant in rivers of plains and hills of the forest areas, also in karst watercourses. Hybridisation is initiated by instability and dynamism of river ecosystems, and is further enhanced by active disturbances and extreme conditions for pondweed survival. Thus, it may be concluded that the genus *Potamogeton* in rivers in the north of European Russia is characterised by a high taxonomic diversity and that they play a significant role in these watercourses. Rare taxa, which need protection, have been listed.

The research was supported by the Russian Foundation for Basic Research (projects 04-04-49814, 07-04-00351) and the Russian Science Support Foundation.
Aquatic macrophytes in a large river: ecological status, trophic level indication, habitat preference and species migration in the Danube

G.A. Janauer, B. Schmidt, E. Lanz and U. Schmidt-Mumm
University of Vienna, Department of Limnology and Hydrobotany, Vienna, Austria

Introduction

The Danube is the second largest river in Europe and the only one crossing Central Europe from West to East (length: 2850 km). It originates in the Schwarzwald Mountains, but alpine tributaries and those from the Carpathians dominate the discharge regime. Strong gradients of climate (atlantic/continental), elevation (from c. 3900 to zero metres), and catchment features characterise its basin. The implementation of the European Water Framework Directive (WFD) is coordinated by the International Commission for the Protection of the Danube River (ICPDR), representing the 19 countries in the Danube River Basin.

Data basis and results

Based on Joint Danube Survey 2 data (Liska et al. 2007, 96 sites) a provisional assessment of the ecological quality of the Danube was carried out. Indicator values of individual macrophyte species were adapted to reference conditions in different Danube reaches, as those of tributaries were not fully applicable (e.g. moss species, ‘ubiquistic’ species). A shift in habitat preference was detected for some species along the Danube. Negative impact of hydro-power reservoirs and pollution sources were reflected in macrophyte composition. Macrophyte indicator species composition was significantly different for all 10 geo-morphological river sections.

Trophic level was assessed with UK (MTR), French (IBMR) and German (TIM) methods for JDS 2 sites (Lanz 2008). MTR and IBMR results indicated often in parallel, whereas TIM often indicated differently, caused by number and type of indicator species. When regarding the fact that none of these methods was developed for rivers the length and catchment size of the Danube, and taking the River Continuum Concept as a scientific background, the mainly meso- to eutrophic results are reflecting the reality quite well.

Azolla filiculoides, Eichhornia crassipes and Lemna turionifera were recorded new in 2007. Other than Elodea canadensis (rarely found today) and E. nuttallii these are competitive invaders, less for the main river channel, but for the floodplain waters of the Danube. Yet, in Germany 23 neophytic macrophytes are listed – and the Rhine-Main-Danube canal connects both catchments. Therefore, migration of species can be expected to continue.

Future adaptations of the WFD should consider all the aspects mentioned above.

References


9 Deriving an index to quantify long term changes in aquatic vegetation in lowland lakes using historical records

G. Madgwick$^{1,2}$, N.J. Willby$^2$ and C.D. Sayer$^{2}$

$^1$Environmental Change Research Centre, Department of Geography, University College London, Gower Street, London WC1E 6BT, UK; $^2$School of Biological and Environmental Sciences, University of Stirling, Stirling FK9 4LA, Scotland, UK.

The Water Framework Directive (WFD), adopted by European Union Member States in 2003, requires ecological status to be assessed using biological elements, including macrophytes. Ecological status is evaluated by assessing the level of deviation from the communities expected under ‘undisturbed conditions’ (European Union, 2000). Information on historic distributions of species in particular lakes prior to the major impacts of the 20th century may provide the most robust description of ‘undisturbed conditions’, especially in the case of lowland, naturally eutrophic, shallow lakes, where ‘un-impacted’ analogues are very scarce or lacking. This paper uses historical macrophyte data from two sets of UK lowland lakes (the Norfolk Broads and the West Midland Meres), to develop a change index based on species persistence over the last 200 years, within individual lakes. Species persistence, measured as the proportion of lakes still containing a historically present species, was found to have a linear relationship with current day levels of occupancy across all lakes. This relationship was used to derive change index scores for species with limited historical data. Index scores were found to relate to functional groupings based on morphological characteristics. Species with low index scores, which showed several periods of steep decline in the broads and meres, were not confined to those intolerant of high nutrient concentrations per se, though species with high index scores were generally those tolerant of high nutrient concentrations. The use of a change index enabled the robust interpretation of datasets based on a large variety of historic sources and incorporating a number of known and unknown biases. Further to this, it offers a tool for the ecological assessment of lakes linked directly to the amount of change in macrophyte communities since the 19th century, prior to modern impacts, and thus closely approximates the definition of status given in the WFD.
Association of hydrophyte assemblages and zooplankton abundance in five lakes of Greece

K. Stefanidis and E. Papastergiadou
Department of Biology, University of Patras, GR 26500 Patras, Greece

Introduction

Submerged hydrophyte vegetation consists of a highly important biotic component of maintaining lake ecosystems towards a ‘clear water’ ecological status. Aquatic macrophytes are well known to play a significant multidimensional role in lakes by competing with phytoplankton growth, stabilising sediment and offering refuge to fish, macroinvertebrates and littoral zooplankton among others (Burks et al. 2006). The objective of the current research was to assess the ecological status of five Greek lakes by evaluating hydrophyte assemblages and examining its possible effect on zooplankton functional groups. During the current study seasonal field samplings were carried out from 2006 to 2008. Water quality parameters such as transparency, pH, conductivity and D.O. were measured at each sampling site and water samples were collected for quantitative determination of nutrients of nitrogen and phosphorus, and chlorophyll-a. Hydrophyte abundance and composition was recorded according to a 5 point scale. Moreover zooplankton samples were collected from dominant hydrophyte beds of each lake, in order to estimate abundance, dominant species and functional groups ratios (Kuczyńska-Kippen & Nagengast 2006).

Relationships between hydrophytes abundance and zooplankton functional groups

In order to investigate the possible existence of associations among the hydrophyte, zooplankton and physicochemical data, correspondence analysis and Pearson’s correlations were performed. Ordination techniques and analysis of variance were also used to distinguish significant spatial distribution of biotic variables among lakes and groups of sites sharing similar morphological and abiotic characteristics and in relation with trophy gradient. Hydrophyte vegetation among the five studied lakes is consisted of a variety of submerged and floating leaved species, where Ceratophyllum demersum, Myriophyllum spicatum, Potamogeton pectinatus, P. perfoliatus, Valisneria spiralis, P. lucens, Najas marina, Trapa natans, Nuphar lutea, Nymphaea alba etc. are found in higher abundance and frequency. According to the preliminary results, most common and abundant species of zooplankton were Bosmina longirostris, Keratella cohlearis, K. quadrata, Diaphanosoma brachyurum, Trichocerca weberi, T. similis. Correlations between environmental and biotic variables and statistically significant differences among the studied lakes were found regarding the biotic and environmental variables. Further research is conducted in order to reveal the possible association functions between different hydrophyte groups and biotic data.

References

Utility of the submerged leaves of *Nuphar lutea* (L.) Smith: a positive feedback on organic matter capture

**J. Schoelynck**\(^1\), **K. Bal**\(^1\), **T. Okruzsko**\(^2\) and **P. Meire**\(^1\)

\(^1\)University of Antwerp, Department of Biology, Ecosystem Management Research Group, Universiteitsplein 1C, B-2610 Wilrijk, Belgium; \(^2\)Warsaw Agricultural University, Department of Hydraulic Engineering and Environmental Reclamation, ul. Nowoursynowska 166, 02-787 Warszawa, Poland.

**Introduction**

It is assumed that the submerged leaves of *Nuphar lutea* serve as their earliest photosynthetic organs at the beginning of the growth season. Secondary floating leaves develop later and largely take over the photosynthetic function. However, a lot of submerged leaves are present in summer despite a large floating biomass. This study examines a possible second utility of *Nuphar* submerged leaves.

**Results**

Summer observations and sampling in the Biebrza river (N-E Poland) revealed a significantly different (p<0.0001) amount of submerged leaves between river-standing individuals (8±0.4) and individuals standing in adjacent oxbow lakes (4±0.3). Moreover, river submerged leaves are 25% larger than lake submerged leaves bringing the total submerged leaf surface area in the river on 4560±233cm\(^2\) versus a significant lower (p<0.0001) 1458±207cm\(^2\) in the lakes. Total surface area of the floating leaves (1578±132cm\(^2\)) and amount of flowers (2±0.2) per individual were the same, implying equal photosynthetic and reproductive success.

The slowing down of the current could be one of the possible reasons for these differences. Likewise, large submerged leaves enhance sedimentation of smaller particles and more organic matter (OM): 6.8±0.9% in *Nuphar* patches versus 1.4±0.3% in unvegetated locations in the river (p<0.05). In the adjacent lakes, no such differences were found (OM: 7.71.1% versus 8.2±0.6% in unvegetated locations). Moreover, the C/N ratio of the organic matter in river *Nuphar* patches is smaller (p<0.05) which indicates the debris to be more reactive. Eventually, this leads to a rapid turnover of nutrients.

To withstand hydrodynamic forces, which are function of leaf surface area, the river standing individuals might need to invest more in structural rigidity. This investment could overcompensate the benefit of the additional nutrient gathering. However, we have found no extra stem tissue in river standing individuals (mean stem diameter: 0.73±0.01cm), nor did concentrations of structural molecules such as cellulose (309.6±8.1mg.g\(^{-1}\)) or lignin (31.6±1.5mg.g\(^{-1}\)) differ between river and lake standing individuals.
Discussion and conclusions

Light penetration is deeper in the Biebrza River than in its adjacent lakes, which allows submerged leaves to continue their primary photosynthetic function. However, from our results it is clear that heaving more and large submerged leaves, proceeds a positive feedback on available organic matter and hence nutrients. Extra structural investments do not seem necessary to accomplish this and seed exchange between river and lakes is easy during winter flooding. Therefore we think it is a useful tool in a stressful hydrodynamic environment, but not an evolutionary adaptation.
12 Genotypic diversity of waterplant populations: are there barriers to long-distance gene flow?

L. Triest

No line on the horizon?

Aquatic plants on average are considered to show broad distributional ranges. High rates of long distance dispersal through seeds or local dispersal through vegetative propagules are considered as explanatory factors of limited taxonomic (i.e. genetic) differentiation over broad geographic, continental ranges. The potential of bird-mediated seed transport is relatively well documented through experimental observations. The transport potential of clonal plant fragments and propagules remains poorly documented but is hypothesised to occur at short distances. The concept of broad distribution ranges should however be approached through a genetic diversity perspective rather than on basis of morphology alone. (Sub)cosmopolitan species could represent cryptic species or ESUs (Evolutionary Significant Units), each with a different history of their dispersal and origin.

The objective of this study is to compile evidence on the extent of ESUs of selected submerged water plant groups and to infer the imprint of long distance dispersal using highly variable chloroplast DNA and nuclear microsatellite DNA. We used the following water plants as model: European Ruppia and Zannichellia taxa from discrete coastal lagoons and few inland lakes, also temporary habitats; Potamogeton pectinatus populations from shallow lakes and river system at a local scale.

Magnificent!

Chloroplast DNA fragments revealed distinguishable maternal lines in Zannichellia and Ruppia. On basis of herbarium DNA, Zannichellia pedunculata appeared to be more restricted to lowlands of Western Europe whereas Z. palustris should be considered as cryptic (Baltic versus Western Europe versus Camargue, S. France). The ‘continental seagrass’ Ruppia has the widest salinity tolerance among the submerged macrophytes and occurs in a wide variety of saline saltmarsh pond and lagoon systems. Although two cosmopolitan species R. maritima and R. cirrhosa are recognised in Europe and R. drepanensis in the western Mediterranean, their diversity and approximate distribution are not well-known. Therefore the Ruppia chloroplast DNA diversity was investigated along a European transect (North to South; in the Mediterranean from West to East). We studied over 2200 individuals from more than 50 wetland areas. The various haplotypes represented at least four distinct groups or taxa, which is higher than commonly accepted. The dispersal of Ruppia taxa across the European continent is discussed in a phylogeographical context and documented with aspects of long distance dispersal and isolation by distance. At a much more local scale, nuclear microsatellite markers in water plants (e.g. managed or disturbed populations of Potamogeton pectinatus in rivers and standing waters) demonstrated clonal diversity and isolation by distance.
**U2 ?**

The conclusion is that restriction to gene flow and limits to dispersal should be evidenced further as it appears to be more common than generally accepted. A better knowledge of the ESU’s will shed light on ecological factors that limit their distribution. A European (or worldwide) network for DNA *barcoding* of native water plant species should be activated.
13 Genetic population structure of an invasive aquatic weed, *Elodea canadensis*, in Finland

*T. Huotari*<sup>1)</sup>, *H. Korpelainen*<sup>1)</sup> and *K. Kostamo*<sup>1,2)</sup>

<sup>1)</sup>University of Helsinki, Department of Applied Biology, Helsinki, Finland; <sup>2}</sup>Finnish Environment Institute, Finnish Inventory Program for the Underwater Marine Environment, Helsinki, Finland

Canadian water weed (*Elodea canadensis*; Hydrocharitaceae) is a submerged aquatic angiosperm native to North America. This strongly invasive species was introduced to Europe in 1836 and to Finland, to the Botanical Garden of the University of Helsinki, in 1884. At present, it is common in the whole Southern and Central Finland. Its aggressive growth and mass occurrences may change the balance of lake and river ecosystems and make the recreational use of lakes more difficult. Only female plants have been reported from Europe since 1903, thus reproduction is thought to be only vegetative.

To better understand the mechanism and evolutionary consequences of the invasion process, it is necessary to study the population structure of invasive species. Since *E. canadensis* has spread to Finland recently and may originate from a few, clonally reproducing founder individuals, the Finnish populations were expected to contain only small amounts of genetic variation. To determine the genetic characteristics of Finnish populations, we developed and used eight polymorphic microsatellite markers. In all, 20–30 samples from each of eight Finnish populations were collected and genotyped. Multiple clones were detected in all studied populations. Allele numbers varied between two and five per locus. The expected heterozygosity calculated over all loci per population varied between 0.158 and 0.469 and the observed heterozygosity between 0.187 and 0.401. Based on the analysis of molecular variance (AMOVA), 74.8% of the genetic variation was found within populations compared to 25.2% found among populations. The values of pairwise population differentiation (*F<sub>st</sub>*) ranged from 0.079 to 0.577. Most (21/28) of these values were significant (*p*<0.05). The overall *F<sub>st</sub>* value equalled 0.328, which indicates restricted gene flow among populations. In the assignment test, 61.4% of the individuals were correctly assigned to their original populations. These preliminary results of the population genetic analysis of the Finnish populations indicate that there is genetic variation both within and among the *E. canadensis* populations. The amount and distribution of the genetic variation also suggest that there have been multiple invasions of *E. canadensis* to Finland.

In addition, we have sampled six native, North American populations to compare the level, structure and distribution of genetic variation of *E. canadensis* in native and introduced regions. Population genetic characteristics of these populations are being analysed. Also, we have recently developed four novel microsatellite markers for *E. canadensis*. The results obtained with these markers will be combined with the present data.
Stable isotope composition of *Chara rudis* incrustation in a lake with extensive underwater charophyte meadows

M. Pełechaty¹, K. Apolinarska², A. Pukacz³, M. Siepak², P. Boszke¹,³, J. Krupska¹ and M. Sinkowski³

Adam Mickiewicz University, Poznań-Słubice, Poland: ¹Department of Hydrobiology, Faculty of Biology; ²Institute of Geology, Faculty of Geographical and Geological Sciences; ³Collegium Polonicum.

**Study aims**

Stable isotope composition (δ¹³C and δ¹⁸O) was analysed in mineral incrustation of *Chara rudis* and surrounding waters. This species forms dense and extensive charophyte meadows. Since then, it may contribute to the calcium carbonate precipitation and deposition of marl lake sediments.

The study aim was to answer the following questions:

I. Was calcium carbonate precipitated in an isotopic equilibrium with lake’s waters?

II. Was the precipitation site-specific?

**Material and analyses**

The study was performed in a small (15.1 ha) and shallow (mean depth: 4.3 m) mid-forest lake with charophyte meadows composed mainly of *Chara rudis*, covering > 50% of the surface area. Samples of *C. rudis* (apical 2 internodia of 10 ind./site) and water from above the plants were collected monthly between June and late October 2008 at three permanent study sites (1.0 m, 1.5 m and 2.0 m deep), located in the middle of extensive stands of *Chara rudis* (100% coverage at each site). Additional water samples were collected at three sites in the macrophyte-free pelagial. Data concerning species composition and cover, PVI and *C. rudis* morphology were gathered along with physical-chemical properties of water.

**Results**

The difference in δ¹³C between incrustation and water from above *C. rudis* exceeded 2‰ at each site. It suggests that calcium carbonate was not precipitated in an isotopic equilibrium with DIC in lake’s waters. Incrustation was enriched in heavier carbon isotope, ¹³C. By contrast, water was enriched in ¹⁸O. The difference between δ¹⁸O of incrustation and water exceeded 2‰ between July and September. δ¹³C compositions of incrustation and DIC were positively correlated, whereas negative relation was found in case of δ¹⁸O of incrustation and water. Negative dependence appeared between the composition of δ¹³C in incrustation and Ca²⁺ and carbonates concentration in water. δ¹⁸O composition was negatively correlated with the content of mineral incrustation in *Chara* dry weight, Mg²⁺ concentration and conductivity, and positively with oxygen content and pH in water. Community depth, structure and PVI had
no effect. No significant differences appeared between isotope composition in the pelagial and Chara stands.

The study was financed by the Polish Ministry of Science and Higher Education as project No. N N305 337534.
**Azolla filiculoides**, a floating aquatic fern response to elevated $[\text{CO}_2]$ with high temperature and P nutrient

W. Cheng, H. Sakai, K. Yagi and T. Hasegawa
National Institute for Agro-Environmental Sciences, 3-1-3 Kannondai, Tsukuba, Ibaraki, 305-8604 Japan.

Depending on population growth and energy use scenarios, atmospheric $\text{CO}_2$ concentration ($[\text{CO}_2]$) is expected to rise from 380 ppm currently to between 485 and 1000 ppm by 2100. Increases of $\text{CO}_2$ and other greenhouse gases ($\text{CH}_4$ and $\text{N}_2\text{O}$) in the atmosphere are predicted to cause an average global warming of 1.1 to 6.4°C by 2100. On the other hand, the stimulative effect of atmospheric $\text{CO}_2$ enrichment on plant growth and development has been predicted to increase in vegetative productivity. Since N nutrient is a major determinant of photosynthesis, the $\text{CO}_2$ fertilisation effect on plant productivity is already limited by N. Usually, it is recognised that the $\text{N}_2$-fixing plant species often show large growth response to elevated $[\text{CO}_2]$ than non-fixing species if others nutrients (P, K and etc.) were not deficient. *Azolla* is a floating aquatic fern growing in tropical and temperate freshwater ecosystems. Because *Azolla* has symbiotic N fixation cyanobacteria, *Anabaena azollae*, within its leaf cavities, it is cultivated rice paddy for improving rice N nutrient in southern China and northern Vietnam as green manure for many centuries.

To understand how C assimilation and N accumulation of *Azolla filiculoides* respond to elevated $[\text{CO}_2]$ with P nutrient and high temperature, we conducted pot experiments in 2007 and 2008 summer seasons. The interaction of elevated $[\text{CO}_2]$ and P nutrient on *A. filiculoides* growth was studied in the first season of 2007. As results, the biomass and C assimilation by *A. filiculoides* were significantly increased by elevated $[\text{CO}_2]$ and P nutrient (both $P < 0.01$) with a significant interaction ($P < 0.01$). During 2008 season, *A. filiculoides* was grown in 4 controlled-environment chambers with two levels of $[\text{CO}_2]$ (ambient, 380 ppm; and elevated, 680 ppm) and two levels of temperature (34/26 and 29/21 °C of day/night). The biomass and C assimilation by *A. filiculoides* were significantly increased by elevated $[\text{CO}_2]$ and high temperature (both $P < 0.01$). But significant interaction by elevated $[\text{CO}_2]$ and high temperature was not found. N concentration was decreased by elevated $[\text{CO}_2]$ and increased by high temperature (both $P < 0.01$). Acetylene reduction assay and $^{15}\text{N}$ natural abundance analysis also showed the N fixation activity of *A. filiculoides* was not affected by elevated $[\text{CO}_2]$, but significantly stimulated by high temperature. Therefore, we conclude that the N accumulation potential of *A. filiculoides* in the climate warming future, mainly lie in temperature and P nutrient, and C assimilation should be increased by elevated $[\text{CO}_2]$. 
16 Ecological differentiation within the Glyceria fluitans-group: what affects differences in abundance or rarity?

H. Chudáčková1, P. Zákravský2 and Z. Hroudová2

1Department of Botany, Charles University Prague, Czech Republic; 2Department of Genetical Ecology, Institute of Botany of ASCR, Průhonice, Czech Republic

Introduction

Ecological demands and ties to abiotic environmental factors belong among the basic characteristics of every species, as they can be of great help in distinguishing morphologically similar organisms. This is especially the case of closely related taxa, because their ecological differences may play a larger role than information hidden in their morphological features. The Glyceria fluitans group is a complex of closely related taxa that differ, besides ploidy level, also in their European area of distribution and frequency of occurrence. Their distribution areas overlap in the Czech Republic. Some differences in reproductive systems were also found in this group. Frequency of occurrence seems to correlate with ploidy level, tetraploids (G. fluitans and G. notata) being the more frequent while diploids (G. declinata and G. nemoralis) occur rarely. We tried to reveal which environmental conditions and characteristics of individual species may be connected to their performance and whether their morphological variation correlates with their ecological amplitude.

Ecological differentiation, frequency of occurrence and genome size in Glyceria

The species under study showed differences in habitat range (polyploids having more than one ecological optimum), soil reaction (G. fluitans preferring lower pH whereas G. notata occurring in alkaline, K+ rich soils), soil trophic levels (the occurrence of G. nemoralis seems to correlate closely with the presence of phosphorus in the soil – unlike G. declinata, which prefers soils low in nutrients), and in species composition of plant communities (this reflects the differences in preferred habitats). Among diploids G. declinata inhabits secondary habitats, contrary to G. nemoralis, while tetraploids differ in their preference of running or stagnant water. Although G. declinata is distributed sparsely in its native area of distribution, it was currently found spreading as an invasive plant in parts of California.

We have learnt that nuclear genome size differs among diploids – unlike tetraploids, which are indistinguishable. Our results are consistent with studies (Knight et al. 2005) showing that species with larger genomes tend to be limited in their distribution and range of ecological environments they can occupy (G. nemoralis, with the highest 1Cx value, is the rarest species in this group).

Reference

17 Uncertainty in Finnish lake macrophyte ecological classification metrics

A. Kanninen\textsuperscript{1)}, V-M. Vallinkoski\textsuperscript{1)}, J. Leka\textsuperscript{2)} and S. Hellsten\textsuperscript{3)}
\textsuperscript{1)}North Savo Regional Environment Centre, Kuopio, Finland; \textsuperscript{2)}South Savo Regional Environment Centre, Mikkeli, Finland; \textsuperscript{3)}Finnish Environment Institute, Oulu, Finland

Quantitative estimates of uncertainty related to bioassessment methods are required to reach accurate waterbody ecological classification decisions. Different sources of variability associated with Finnish lake macrophyte classification metrics (Proportion of Type Specific Taxa (PTST), Percent Model Affinity (PMA) and Reference Index (RI)) was analysed using data of 12 small (area < 5 km\textsuperscript{2}) humic (water colour 30-90 mg Pt/l) lakes in Eastern Central Finland. Fifteen macrophyte transects per lake were surveyed. A subset of six lakes (altogether 29 transects, 5-6 per lake) was used to estimate the variation related to different observers by repeating the survey at same sites by three different field teams. A subset of five lakes was used to quantify the between-observer variation in a whole lake survey method. The two methods were also compared with regard to the ecological status metrics. The effect of shore type (slope, fetch) on the ecological quality metrics was explored by quantifying the variation of the metrics between three shore type categories. The estimates of variance from different sources (observer, method, shore type) were used to calculate probabilities of misclassification due to different sources, following the methods described by Clarke & Hering (2006).

Misclassification probabilities of different metrics due to observer variation varied on average between 12-25% at ecological class midpoints. The areal survey method was more efficient than the transect method in producing information on number of species and showed lower variation in the metrics using species presence-absence data only (PTST and RI). The transect method produced more repeatable results of the metric using abundance data (PMA). The different field methods produced quite similar classification results, although the variation and subsequent misclassification probabilities were higher between methods than between observers within one method. Shore type was the greatest source of variation, resulting in misclassification probabilities between 20-37%. The results suggest that metrics using species presence-absence data only may be more effectively derived from survey data of larger areas than transects only. When using transects, the effect of shore type on the metric variation should be controlled for.

Reference
Nutrient competition between the duckweeds *Lemna minor* and *L. trisulca*

A. Ojala and A. Julmala-Jäntti
University of Helsinki, Department of Ecological and Environmental Sciences, Lahti, Finland

**Introduction**

The surface-floating *Lemna minor* L. and the submerged *L. trisulca* L. belong to the native flora of Finland and are found in eutrophic environments throughout the country. They thrive in water bodies ranging from small ditches to littoral zones of large lakes. Due to their mode of growth these duckweeds take their nutrients directly from the water and thus, they can show rapid responses to changes in prevailing nutrient concentrations. They are so effective in taking up nutrients that especially concentrations of inorganic nitrogen and phosphorus can drop to growth limiting levels. Since duckweeds grow fast and are easy to keep in culture, they have been widely used in physiological as well as eco-toxicological studies. However, quite surprisingly the basic ecology of these minute plants is not that well known at all.

**Methods and results**

We used *L. minor* and *L. trisulca* in growth experiments where their ability to exploit nutrient resources was studied. When these species coexist in nature, *L. minor* usually forms a thick growth on surface whereas *L. trisulca* is less abundant in the water column below. However, in Lake Vesijärvi in southern Finland the case is quite opposite and *L. trisulca* grows much more vigorously than *L. minor*. On the other hand, in Lake Kutajärvi, located 10 km apart from Lake Vesijärvi *L. minor* grows vigorously forming extended healthy looking stands, whereas *L. trisulca* is non-existing.

The set up of batch experiments - a modification of Tilman’s experiment - was designed to reveal whether the exceptional situation in Lake Vesijärvi is due to nutrient competition. Both species were first grown separately to find out the most critical nutrient (phosphorus vs. nitrogen). On the basis of these experiments the actual competition experiment was then run with nitrogen. Besides nutrient experiments we carried out a shading experiment and constructed a photosynthesis –light –response curve to *L. trisulca*, to reveal the sensitivity of *L. trisulca* to shading by the above growing stands of *L. minor*.

In general, *L. trisulca* appeared to be more effective as a utiliser of nitrogen resources, but when grown together with *L. minor*, it somehow lost at least part of its competitiveness and *L. minor* suddenly outcompeted *L. trisulca*. Thus, it appears that in Lake Vesijärvi there must be other resources besides phosphorus and nitrogen limiting the growth of *L. minor* so much that it cannot form dense surface growths detrimental to stands of *L. trisulca*. *L. trisulca* appeared well adapted to low light conditions, i.e. *L. minor* should be able to form proper dense stands in order to considerably affect the growth of *L. trisulca*.
19 Changes in macrophyte composition in channels of the Bosut river basin (Eastern Croatia) between 1980–2006

A. Kočić1), J. Topić1), J. Horvatić1) and S.D. Jelaska2)
1) Department of Biology, Josip Juraj Strossmayer University of Osijek, Osijek, Croatia; 2) Department of Botany, Faculty of Science, University of Zagreb, Zagreb, Croatia

In this research we have compared species composition in channels using 55 published releves originating in the period 1980–1984, as well as recently conducted field surveys at 128 localities during 2005–06. These two datasets were used as a source of information on the spatial distribution of macrophytes in determining changes in vegetation.

Comparing the two datasets makes the disappearance of Hottonia palustris evident. The species was not abundant, but was frequent in the investigated associations in the 1980–84 period, and in a recent study it has entirely disappeared. The spatial distribution of Salvinia natans and Nymphaea alba in the Bosut River Basin has also considerably reduced during this 26 year period. In contrast, Ceratophyllum demersum was previously less frequent in literature data, but is considered today to be the most common and abundant species in channels. In shallower channels with developed free-floating vegetation, Lemna gibba is recorded as a newcomer. In literature data Trapa natans was associated with Nymphoides peltata. At the present, this association has become more rare as Trapa natans appears alone as a dominant species. There is a notable increase in the proportion of free-floating species in all free-floating rooted communities during the 26 year period. Originally, in the investigated area, wide rivers were the habitat of Trapa natans. However, a recent study shows the occurrence of stands of Spirodella polyrrhiza in deep and wide channels. The species often appears as a thick layer and suppresses all other species from the habitat, except Ceratophyllum demersum, which seems to prefer low light intensity and has a wide ecological tolerance. Although there have been no water quality investigations in the Bosut River Basin in the past, the decrease of the more sensitive macrophytes and the increase of the tolerant species indicate a higher eutrophication and more additional anthropogenic disturbances. There is a need for a further study of environmental changes that could be the cause of alteration in macrophyte composition in the Bosut River Basin. Changes in macrophyte composition reported here should be taken as warnings for maintenance of biological diversity in rivers and drains which harbour rare species.

References
20 Nutrient concentration in macrophytes of Mediterranean ponds: variation among species and ways of growth

G. Núñez, C. Fernández-Aláez and M. Fernández-Aláez
University of León, León, Spain

In this work we determined the concentrations of nitrogen and phosphorus, in three compartments: water, sediment and macrophytes (seven hydrophytes, *Ceratophyllum demersum*, *Myriophyllum alterniflorum*, *Myriophyllum spicatum*, *Polygonum amphibium*, *Potamogeton gramineus*, *Potamogeton lucens* and *Potamogeton trichoides*, and four helophytes, *Antinoria agrostidea*, *Eleocharis palustris*, *Glyceria fluitans* and *Littorella uniflora*), from fourteen ponds, mostly permanent, situated in the northwest of Spain.

The main goals were to establish the relationship between the nutrient contents of different species and biological types of macrophytes and their concentration in the pond sediment and water, as well as to determine whether the differences in the content of nutrients between species are induced by the external concentration or that the taxonomic influence is more important.

The concentrations of N and P measured in the plants indicate that helophytes have a lower nitrogen tissue concentration than aquatic species, what is justified by the higher biomass of the former, which in turn means an increase in supporting tissues lacking nitrogen. Moreover, the analysis of the N:P relationship, whit a value around 20:1 in both groups of macrophytes, highlighted the importance of phosphorus as limiting growth factor.

There was a positive correlation between the phosphorus tissue concentrations of four species (*M. alterniflorum*, *P. amphibium*, *E. palustris* and *A. agrostidea*) and the water orthophosphate. Likewise, the nitrogen content in *A. agrostidea* and *G. fluitans* was significantly related to the nitrogen concentration in the water. Only the concentration of nitrogen in the sediment was related to the content of this nutrient in *M. alterniflorum*.

Our results seem to indicate that the taxonomic influence is more important in the nitrogen uptake by macrophytes than the external nutrient concentrations, since the nitrogen contents in macrophytes growing under the same conditions were significantly different. However, as far as phosphorus is concerned, differences among species of the same lake were low and even non-existent. Consequently, taxonomic effects seem to have less importance with regard to this nutrient. These facts were corroborated by comparing populations of the most common species, which were *M. alterniflorum* and *E. palustris*. 
21 Using of hemispherical and lidar photos in investigation of structure of river bank riparian scubs

T. Kaluza¹, P. Tymbow² and P. Strzelinski³
1) Poznan University of Life Sciences, Faculty of Reclamation and Environmental Engineering, Department of Hydraulic Engineering; 2) Wroclaw University of Environmental and Life Sciences, Institute of Geodesy and Geoinformatics; 3) Poznan University of Life Sciences, Faculty of Forestry, Department of Forest Management

Introduction

Riparian bush changes the hydraulic conditions of floodplains in a significant way by increasing the surface roughness, and consequently increasing the water level ordinate. Determining the resistance coefficient for water in floodplain requires to characterise the geometrical parameters of the vegetation. Flow drag, due to high vegetation, is mainly linked to the resistance of the lump of vegetation which has been flown round. If there is a cluster of trees, the parametrisation of plants amounts to determining their average diameter dp and spacing ax and ay. When the area is covered by shrubs and young trees, and the flow depth includes a part of high trees’ crowns, the method should be enriched with a possibility of evaluating vegetation density (in vertical profile). However there are two approaches to manage with this problem: (1) treating shrubs as impenetrable elements – dp, ax and ay are macrostructural parameters of whole plant; (2) estimating geometrical parameters of all plant elements (branches) – microstructural approach. Results of investigation of structure of riparian bush species have been presented in the paper. Bushes were located on river Barycz bank (Central Poland).

Calculating bush structure coefficients using terrestrial laser scanning and hemispherical photography

Modelling plant body on the basis of point cloud in macrostructural approach can be carried out using well known 3D computing methods for finding convex hull. In this method internal points are filtering and the model is built as convex block. In this study several models were computed and results were compared to hand-made measures. Experiments show that this method doesn’t give satisfactory estimation of geometrical parameters. To improve modelling, authors proposed multi-stage method, in which the point cloud is divided into parts in vertical profile and each part is modelled as convex block. Authors’ research proves that macrostructural parameters computed in this way are much better adjusted to real measures. Microstructural models building have encountered more computing problems. Model based on cylinders fit in divided point cloud was tested in this investigation area. The point clouds are divided in vertical profile into small (app. 1–5mm) layers. Segmentation of clusters in every layer is done and the vertical-oriented cylinder is fitted out into each cluster. Comparison of computed parameter and manual measures shows that this method gives satisfactory results for not very dense distribution of branches growing approximately upright.
Generally estimating geometrical parameters of leafy trees’ crowns and shrubs on the basis of TLS is very hard. This approach is more sufficient for winter period measures.

Digital hemispherical photography has been also used for analysis of density structure. Leaf area index and canopy openness have been estimated on the basis of photography. Photographs have been taken with camera placed inside the bush at three levels: 0,5 m, 1 m, 1,5 m above the ground. Sections based on cloud of points from terrestrial laser scanning have been used in order to compare results.
22 The influence of *Ceratophyllum demersum* L. and *Stratiotes aloides* L. on richness and diversity of aquatic vegetation in the lakes of mid-eastern Poland

P. Sugier and B. Lorens

Department of Ecology, Maria Curie-Skłodowska University, Lublin, Poland

Coontail (*Ceratophyllum demersum* L.) and water soldier (*Stratiotes aloides* L.) are the most expansive species of hydromacrophytes in the lakes of the Łęczna-Włodawa Lake District (the concentration of lakes in Poland located outside the area of the last glaciation).

*S. aloides* is a Eurasian species which grows mainly in shallow stagnant eu- and mesotrophic waters. *C. demersum* belongs to the circumpolar plants and is widespread in Eurasia and North America. The species reduces mixing of the water column and may also contribute to an increase in water transparency by the excretion of allelopathic substances that inhibit phytoplankton growth. Both species are very common, often dominating in lakes, ponds, channels, ditches and other water bodies created by peat excavation in mid-eastern Poland.

The aim of this study was to estimate the influence of these plants on species richness and phytocoenotic diversity of aquatic vegetation in lakes. Field investigations were carried out in 32 lakes of the Łęczna-Włodawa Lake District in the summer seasons of 2005–2007. Range limits of macrophyte communities and phytosociological relevés were taken along transects. The number of transects was correlated with the area of a given lake. For each lake the study determined the total number of hydromacrophytes, the number of charophytes, elodeids, nymphaeids and lemnids, the mean number of all species in phytosociological relevés, the frequency of *Ceratophyllum demersum* and *Stratiotes aloides*, the Shannon Index, and the share of distinguished plant communities in the phytolittoral. Statistical analyses were carried out using the DCA and Spearman’s rank correlation.

The results show a positive correlation between the share of the *Stratiotes aloides* community area in the phytolittoral and the total number of hydromacrophyte species in the lake, and the number of elodeids. The frequency of *S. aloides* in phytosociological relevés of individual lakes was also positively correlated with the total number of hydromacrophytes, the number of charophytes and elodeids, and the mean number of species in phytosociological relevés. The influence of *S. aloides* on richness and diversity of macrophytes was especially distinct in stratified lakes. Water soldier is a very good indicator of species richness and diversity of aquatic vegetation.
The interactive effects of eutrophication, species identity and influence of species initial abundance on competition between an invasive and native *Lemna*: an investigation using RGRD analysis.

J. Njambuya and L. Triest  
Plant Science and Nature Management (APNA), Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium

**Aquatic weed context**

Competition, both within and among species, is one of the major forces influencing the distribution and abundance of plant species and the biodiversity of plant communities. Invasive species are considered to be more competitive relative to native species. *Lemna minuta* is native to America but has spread in Europe and has invaded ponds and ditches in Belgium. *Lemna minor* on the other hand is native to Belgium and is often found co-occurring with the invasive *L. minuta* and therefore interference between the two species seems inevitable.

**Objective**

The outcome of competition has mainly been deduced from estimates of relative sizes of *intraspecific* and *interspecific* effects among species or indices of competitive ability. The interactive effects of species identity, species initial abundance and nutrient enrichment in competition and biomass composition change is less studied and more so competition in free floating macrophytes exhibiting clonal growth. As such, a controlled environment experiment was conducted to assess the role of (1) species identity, (2) *intraspecific* versus *interspecific* interference (3) species initial biomass abundance and (4) eutrophication in determining the outcome of competition between *L. minuta* and *L. minor*. This was assessed using a relative growth rate difference (RGRD) model for two species in mixture.

**Eutrophication favours the invasive**

The estimated RGRD model indicates that there was a significant change in stand biomass composition of these two species in mixture, which was mainly driven by species identity and nutrient treatment. The relative growth rate (RGR) of *L. minuta* was significantly higher than that of *L. minor* in high nutrient but was significantly reduced in low nutrient and therefore a shift occurred from *L. minuta* in high nutrient towards *L. minor* in low nutrient level. Generally, there were strong *intraspecific* and *interspecific* effects on species RGR’s. Increasing the initial biomass of *L. minor* enhanced the difference in average RGR’s between the two species, while increasing the initial biomass of *L. minuta* had the opposite effect. The results of this experiment indicate that eutrophication facilitated the invasive *L. minuta* relative to *L. minor* and
that species identity is an important factor in determining the outcome of competition relative to *intraspecific* and *interspecific* interference. This is a strong indication that invasive plants species have a higher RGR than their non-invasive congeners and, as our results indicate, this may be modified by environmental conditions.
Composition, abundance and distribution of macrophyte communities in the lowland River Väike Emajõgi

A. Kõrs and S. Vilbaste
Centre for Limnology, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Riia 181, 51014 Tartu, Estonia.

Introduction

Compared to lakes and the coastal sea, the macroflora of rivers in Estonia has lacked investigation (Vilbaste et al. 2008). The floristic list of macrophytes collected from 396 reaches on 150 Estonian rivers and streams includes 124 taxa of vascular plants, 24 taxa of mosses, and 34 taxa of macroalgae (Järvekülg 2001). Recent studies (Trei & Pall 2004; Paal & Trei 2004, 2006; Paal et al. 2007) and monitoring data have shown that changes in the macroflora often proceed in different directions - species dissappeared and reappeared on the same site over years.

Macroflora in the River Väike Emajõgi

The macroflora of the R. Väike Emajõgi was studied in 2003-2005. Data on macrophyte communities were collected in 7 stream reaches in July. We observed changes in the floristic composition, number of species, total coverage (%) and composition of the dominating species. In total, 62 taxa of vascular plants were identified: 46 in 2003, 42 in 2004, and 41 in 2005. Helophytes were prevailing in the ecological groups and terrestrial plants were prevailing in the functional groups along the river. There were 43 true helophytes, 6 helophytes with heterophylly, 8 rooted plants with floating leaves or with submerged or partially emerged leaves, 4 floating plants, and 9 submerged plants. Four species belonged simultaneously to three different ecological groups. Three functional groups were represented: 1) true water plants (17 taxa), 2) amphibious plants (15), and 3) terrestrial plants (30). Nuphar lutea, Sparganium erectum s.l., Equisetum fluviatile were the most frequent species. Thirteen abundant (dominant or forming larger aggregations) species were found. The common dominants were N. lutea, Glyceria maxima and E. fluviatile. The majority of studied macrophytes were perennials. The vegetative period lasted from mid-May to early October, and coverage reached a maximum between the mid-July and mid-August.

The spatial distribution of macrophytes along the river depended on stream width and length. In the lower reaches of the R. Väike Emajõgi there were more macrophytes than in the upper reaches. Faster flow and respectively harder bottom in the upper course prevented the macrophyte to anchor. In the lower course the center of the river was mainly deep and without macrophytes.

The transect method of quadrates indicated a patchy distribution of macrophytes. Our study revealed temporal and spatial variation in species composition, frequency, frequency of domination and total coverage of macrophytes during the study period. These changes were multi-directional and unpredictable.
References


25 Plant cover of water bodies of the Vychegda river basin: composition, structure and conditions of formation

B. Tetryuk
Institute of Biology, Komi SC of Russian Academy of Sciences, Syktyvkar, Russian Federation

The Vychegda river is the main tributary of the Northern Dvina river. Its length – 1130 km, catchment-area – 121,000 km². The studied territory is located between N59°55′ – N64°30′ and between E46°30′ – E56°10′.

The aquatic flora of the Vychegda basin includes 199 species of vascular plants, referring to 44 families and 103 genera, and 77 species of Bryophyta from 40 genera and 18 families. Amongst leading families of vascular plants are: Potamogetonaceae, Poacea, Cyperaceae, Asteraceae, Polygonaceae, Ranunculaceae, Boraginaceae, Juncaceae, Apiaceae, Nymphaeaceae, Sparganiaceae, which is characteristic for the flora of boreal zone reservoirs of European Russia. The leading families among Bryophyta are Amblystegiaceae, Bryaceae, Sphagnaceae and Mniaceae. All 16 hydro-specialised families of vascular plants of the boreal zone flora of the region are presented in the water flora of the Vychegda basin. In the geographical structure of the aquatic vascular plant flora of the basin, the species of moderate latitudinal element prevail. Amongst longitudinal areal groups the holarctic, Euroasian species dominate. In the composition of the bryophyte flora the boreal species prevail. The presence of hypo-arcto-mountain and mountain moss species is related to the fact that a number of rivers originate in the Timan ridge. The ecological structure of the aquatic flora of the basin is a mesoeutrophic hypo-hydro-ortohydrophytal one. Six groups of types of hydric habitats are described. For some species new sites have been recognised.

Cenotic variety of the aquatic vegetation of the basin is represented by 60 associations and 5 non-rank communities from 20 alliances, 13 orders and 8 classes of ecologic-floristic classification of vegetation: Platyhynpidio-Fontinalietea antipyretica (1 ass., 1 comm.), Lemnetea (6 ass.), Potametea (27 ass.), Phragmito-Magnocaricetea (23 ass. and 2 comm.) Bidentitea tripartitae (2 acc.), Montio-Cardaminetea (1 ass.), Agrostidetea stoloniferae (1 ass.), Littorelletea (1 acc.). The regularly of diffusion of syntaxa depending on ecological and landscape conditions has been showed.

The obtained data on the composition and structure of the plant cover of water reservoirs in line with ‘riverbed – reservoirs of the valley’, made it possible to establish some regularities in its formation. As a result of the change of leading ecological factors (from lotic to lemnic), the structure of ecotopes has changed. The increase of the specific variety in reservoirs of the middle flood plain. At the expense of the transitional nature of ecological conditions in them, has been noted. Within the basin there are species of southern boundary of their spreading, lakes are their only habitat; species with northern boundary of spreading occur in river ecotopes as usual. The stage-line of structural changes of plant cover of reservoirs reveals itself more clearly at the cenotic level.

Based on floristic and cenotic criteria 4 hydro-botanical regions can be selected: Timan, Middle-Vychegda, Lower-Vychegda and North-Uval. These regions show essential differences in geological structure, while their water reservoirs differ by hydro-chemical characteristics.
26 Biology and species diversity of macro-algae in the Transition Zone (TZ) of the Eastern Gulf of Finland (EGoF)

Y. Gubelit\textsuperscript{1} and N. Kovalchuk\textsuperscript{2}
\textsuperscript{1}Zoological Institute of the RAS, St.Petersburg, Russia; \textsuperscript{2}Komarov Botanical Institute of the RAS, St.Petersburg, Russia.

Introduction

The macro-algae blooms, which are observed worldwide, are generally considered to be a symptom of eutrophication. The EGoF is known as a eutrophied area in the Baltic Sea. The shallow zone of the EGoF is characterised by stony-sandy littoral. Extensive shallow-water areas with favourable photic and topic conditions, combined with particular weather conditions, facilitate proliferation of fast growing filamentous algae. During the last decades the macro-algae blooms were recorded in the majority of the coastal areas of the EGoF.

Macro-algae blooms and species composition

Sampling was conducted on depths of 0.5, 1.5, 3, 5 m by a scuba–diving method. The dominating species causing macro-algae blooms in the shallow zone of the EGoF at a depth of 0.5–1.5 m was the green filamentous alga \textit{Cladophora glomerata}. Other species of macroalgae – \textit{Ulva intestinalis} (Chlorophyta) and \textit{Pilayella littoralis} (Phaeophyta), were also present, but contributed less than 10% of the total biomass. Our study has shown that in the shallow zone of the EgoF, in the period 2003 to 2008, \textit{C. glomerata} biomass peaks several times during a season and could reach up to 450±130 g DW m\textsuperscript{−2}. The same dynamics of \textit{C. glomerata} was reported in papers from Northern America, Europe and Australia (Higgins et al. 2008). The average biomass of \textit{C. glomerata} reached 111±37 g DW m\textsuperscript{−2}. It was twice more than the biomass of \textit{Cladophora}, reported from the northern Baltic (68±7 g DW m\textsuperscript{−2}) (Berglund et al. 2003). In the middle of July the algae detached from the substrate and formed loose mats or accumulated near the shore line. The thickness of the algal mats varied from 2 to 15 cm. Our study showed that in the TZ the macroalgal blooms cause deoxygenation in bottom habitats.

Some areas of the TZ occur in the regional complex sanctuary ‘Gladyshevsky’ (Vammesujoki).

The flora of macro-algae in PA “Gladyshevsky” consisted of 16 species. 13 species (belonging to 8 genera, 5 families, 3 orders) belonging to the Chlorophyceae. The Phaeophyceae were presented by two species, related to two genera, belonging to two families, and one order. The Rhodophyceae were presented by one species. Three species (the green alga \textit{Cladophora aegagropila}, the brown alga \textit{Pseudolithodera subextensum} and the red alga \textit{Hildenbrandia rubra}) are included in ‘The Red Data Book of Nature’ of the Leningrad Region.

Our study allowed us to correct earlier data of macro-algae species composition and to describe depth and horizontal distribution of macro-algae in the Gulf of Finland.
References
Molecular phylogeny of an aquatic plant, *Ruppia* (Ruppiaceae) based on chloroplast and nuclear DNA sequences

Y. Ito\(^1\), T. Ohi-Toma\(^1\), J. Murata\(^1\) and N. Tanaka\(^2\)

\(^1\) Botanical Gardens, Graduate School of Science, The University of Tokyo, Japan; \(^2\) Tsukuba Botanical Garden, National Museum of Nature and Science, Tsukuba, Japan

**Introduction**

The genus *Ruppia* is widely distributed across all continents and most islands, occurring in virtually all climatic zones, from tropical to polar. The species exhibits a submerged habit and grows primarily in brackish water, but some of them occasionally occur in inland saline lakes and freshwater alkaline lakes as well. The simplified morphology that characterises the species and the existence of polyploids has led to vague species circumscriptions and a confused sub-generic taxonomy. In an attempt to derive a more reliable systematic understanding of the genus, we performed molecular phylogenetic analyses using cpDNA (*rbcL*, *rpoB*, *rpoC1* and *matK*) and nDNA (*phyB*) sequence data and chromosome observations.

**Phylogeny and evolution of the genus *Ruppia***

The resultant trees were largely congruent across the data sets, but incongruence at two points: one is due to long branch attraction (LBA: Felsenstein 1978) and another is due to the existence of heterogeneous *phyB* sequences of several accessions. Based on a previous revision (Zhao & Wu 2008), several morphologically identified species had been placed as palaphyletics on both trees. After re-evaluation of the morphological characters, *R. megacarpa*, *R. occidentalis*, *R. polycarpa* and *R. tuberosa* as well-defined species, and the *R. maritima* complex comprising ‘Utahian’, ‘Diploid’ and ‘Tetraploid’ were discerned. ‘Tetraploid’ of the *R. maritima* complex was revealed as an allotetraploid, and at least paternal parent of that in Asia/Oceania was ‘Diploid’ of *R. maritima* complex in Europe/America. In addition, two cases of hybridization were found and their respective putative parental taxa were inferred: one is “Diploid Hybrid” between *R. megacarpa* and *R. occidentalis*, and another is “Triploid Hybrid” between *R. occidentalis* and ‘Tetraploid’ of the *R. maritima* complex. Unlike other brackish taxa in *Ruppia*, *R. tuberosa*, *R. occidentalis* and ‘Utahian’ of the *R. maritima* complex inhabit hyper-saline lakes in Oceania, inland alkaline lakes in North America, and inland salt lakes in North America, respectively. Although *R. megacarpa* has been generally considered to represent one of three Oceania endemic species (together with *R. polycarpa* and *R. tuberosa*), a disjunct population of *R. megacarpa* was found in northern Far East Asia. The similar Asia-Oceania discontinuous distribution was also observed in ‘Tetraploid’ of the *R. maritima* complex. Bird-mediated seed dispersal should be considered as a possible explanation for the two cases of the disjunct Asia-Oceania distribution pattern.

**References**


28 Population structures of \textit{Stratiotes aloides} in Finland

\textit{K. Karttunen} \textsuperscript{1}, \textit{J. Blomster} \textsuperscript{2}, \textit{K. Björklöf} \textsuperscript{1} and \textit{H. Toivonen} \textsuperscript{1}

\textsuperscript{1} Finnish Environment Institute, Helsinki, Finland; \textsuperscript{2} University of Helsinki, Finland

\textbf{Introduction, material and methods}

\textit{Stratiotes aloides} is a locally abundant, but regionally rare, nationally even classified as endangered, Eurasian aquatic plant. It grows in monocultural meadows floating only very loosely rooted, submerged or partially aerial. It is a large weed, up to one meter high, and dioecious: males and females usually growing in separate patches or in complete isolation. When pollinated it produces copious seeds, which germinate fairly well. Asexual propagation via disconnecting adventive branches is frequent (Smolders et al. 1995).

We studied 14 populations of \textit{Stratiotes} in Finland in three separate regions from 61º to 68º latitude north. The size of the populations varied from a few individuals to several hectares of plants and the studied sites from small ponds to large lake systems and from fairly isolated to well connected. For preliminary genetic analysis we used the RAPD method with 11 primers revealing 26 clear polymorphic loci and 44 faint bands. In addition we carried out ITS sequencing with two primers.

\textbf{Results and discussion}

Using RAPD the studied \textit{Stratiotes} populations showed a high amount of genetic variation and little clonality, although the plant reproduces solely asexually in Finland. There were no geographic correlations in the variation, nor any discernible effects of isolation. In a tree analysis of the ITS sequences we observed high intra-individual variability of ITS-sequence lengths. In sequence analyses two thirds of the samples were clustered jointly in one branch, while the rest resided singly in separate branches, but there was no geographic patterns.

From paleobotanical data we know that \textit{Stratiotes} populations in Finland are 9000 years old (Tolonen 1981) and the present distribution of the species follows closely the coast line of the Ancylus lake of that time. The genetic structure of the populations points to a uniform, ancient dispersal event of a genetically fairly variable stock of plants. We cannot exclude possible historical sexual reproduction or continuous reintroduction of clones as an explanation for the present genetic variation. Good clone survival in isolated populations, however, seems a more plausible cause for our results. Some other recent studies point also to fairly large amounts of genetic variation in old, well established populations of clonally reproducing plants.

\textbf{References}


29 Rare *Potamogeton* species in Hungary

A. Mesterházy and G. Király

Department of Botany, University of West Hungary, H-9400 Bajcsy Zs. U. 4., Sopron, Hungary.

The last review on the distribution of freshwater aquatic plants in Hungary was carried out by Felföldy (1990), who prepared distribution maps for all Hungarian freshwater aquatic plants, based on data from collections and the literature.

The authors of this work carried out the revision of former data coming from the field and collections, focusing especially on *Potamogeton* species. During the fieldwork in 2001–2008 we clarified the current distribution of pondweeds, their coenological role and conservation status in Hungary (Mesterházy 2006, Király et al. 2007).

We confirmed the former data of *Potamogeton acutiformis* and discovered several new locations in Hungary. Among the most typical habitats of the species are the bays of the branches of the River Danube and swamps in South Hungary. The previously published collection specimens of *P. compressus* actually belonged to this species, therefore that taxon was deleted from the Hungarian flora (Király & Mesterházy 2005). According to our results the occurrence of *P. filiformis* is also doubtful, since the specimens in the collections are identical to narrow leaved individuals of *P. pectinatus*. Four out of the five Hungarian data of *P. obtusifolius* turned out to be incorrect as well. In spite of intensive research, the species has not been found at the only location, where it had been observed previously, therefore it can be regarded as extinct. *P. trichoides* was recorded at 12 locations in the past, and our study revealed that the species occurs sporadically in modified water bodies (reservoirs, mine lakes), oxbows and swamps. Most of the data on *P. natans*, which was thought to be the most common Hungarian pondweed species, turned out to refer to the less known *P. nodosus*. The distribution of *P. natans* is quite scattered in Hungary. *P. coloratus* living in the outflows of springs and *P. gramineus* living in oxbows and free-standing water, became critically threatened due to the alteration of their habitats, and only a few occurrences are known currently.

References


30 New synthesis of the Hungarian freshwater aquatic vegetation: semi-natural and invaded stands

J. Csiky 1), D. Babai 1), Z. Botta-Dukát 3), F. Horváth 3), K. Lájer 3), A. Mesterházy 4) and D. Purger 5)

1) Department of Plant Systematics and Geobotany, Institute of Biology, Faculty of Sciences, University of Pécs, H-7624, Ifjúság u. 6., Hungary; 2) Department of Plant Ecology, Institute of Ecology and Botany, Hungarian Academy of Sciences H-2163 Vácrátót, Alkotmány u. 2-4., Hungary; 3) Eötvös József College, Technical and Economical Faculty, Department of Environmental Technology, H 6500 Baja, Bajcsy-Zs. u. 14., Hungary; 4) University of West Hungary, Department of Botany, H-9400 Sopron, Bajcsy Zs. u. 4., Hungary; 5) South-Transdanubian Environment Protection and Water Management Directorate, H-7623 Pécs, Köztársaság tér 7, Hungary.

The last syntaxonomical synthesis of the Hungarian freshwater aquatic vegetation (Borhidi 2003) listed 48 association of 4 classes (Lemnetea, Utricularietea intermediomorinoris, Charetea fragilis, Potametea). However, it does not contain any synthetic table or numerical analyses of great databases.

According to the methodology and nomenclature of the Hungarian Phytocoenological Database (CoenoDatRef) (Lájer et al. 2007) we selected 1500 relevés of different syntaxa. Most of the relevés were taken within the last 10 years.

Using the SYN-TAX (Podani 1993, 1997) and JUICE (Tichy 2002) programs we attempted to classify the relevés into statistically objective groups and to define the character of these ‘clusters’ at association and higher level of syntaxa.

We also calculated the fidelity values of invasive obligate aquatic taxa in different freshwater aquatic vegetation types and the frequency of coexisting native species.

Based on the numerical analyses three main types of freshwater aquatic vegetation was distinguished. These clusters principally can be identified with the following classic syntaxa: Lemnetea, Potametea and Charetea.

References
Decomposition and nutrient dynamics of *Phragmites australis* litter in Lake Burullus, Egypt

**E.M. Eid**, **K.H. Shaltout**, **Y.M. Al-Sodany**

1) Biological and Geological Sciences Department, Faculty of Education, Kafr El-Sheikh University, Kafr El-Sheikh, Egypt, 2) Botany Department, Faculty of Science, Tanta University, Tanta, Egypt

Reed beds in Lake Burullus, which is situated along the coast of the Mediterranean, east of the city of Alexandria, represent one of the largest reed ecosystems in the region. This type of habitat in the Mediterranean region is becoming rare and threatened. The reed stands along the shores of lake Burullus and around its islets represent the most common vegetation type in this lake.

In this study the decomposition and nutrient dynamics of *Phragmites australis* litter was investigated by means of the litter bag technique, to answer the following question: Are there differences in litter decomposition rate and nutrient dynamics between different *Phragmites* organs in Lake Burullus?

The present study indicated that the mean percentage of weight loss approximates 65.2 and 58.5% in leaves, 32.2 and 21.8% in rhizomes and 24.5 and 17.5% in stems during the first month under field and control conditions, respectively. Differences between litter types (rhizomes, stems and leaves) were significant (*P* < 0.001). Decomposition in the field was faster than under laboratory conditions (controlled conditions) (*P* < 0.001). Estimated breakdown coefficients of leaves, stems and rhizomes ranged from 0.00363 to 0.01172 and 0.0023 to 0.00715 per day under field and control conditions, respectively. In addition, there was an increase in nutrient elements following submersion, which decreased later on.
Indicator value of aquatic plants
Evaluation of the ecological quality of Cyprus rivers using aquatic macrophytes as biological quality elements

P. Manolaki, K. Stefanidis and E. Papastergiadou
Department of Biology, University of Patras, GR 26500 Patras, Greece

Introduction

Macrophytes are an important component of aquatic ecosystems and changes in community composition, or in the abundance of individual species, provide valuable information on how and why an ecosystem might be changing. Some of the macrophyte based indices, which are being used at the moment, are based on species indicator values. However, indices based solely on aquatic species are less sensitive in Mediterranean-type systems, where herbaceous vegetation is dominated by emergent species that occur on riverbeds under low flow conditions with a long dry period. A currently favoured method for stream assessment is the development of a multimetric index, based on a combination of metrics that were indicative of river quality condition. The goal of the multimetric approach is to incorporate in a single value different components of the biological community (Hering et al. 2006).

Development of a multimetric Index based on aquatic macrophytes for Cyprus Rivers

This study in rivers on the island of Cyprus is the first attempt of using plants to provide a standard method for assessing the ecological condition based on the functional patterns and compositional attributes of plant assemblages that reflect ecosystem processes and functions, using reference conditions as benchmarks. The selection of reference sites was performed according to the REFCOND Guidance criteria and from a total of 66 river sites, 15 were selected for being considered as ‘reference sites’. For the purpose of this research we used ‘reference sites’ in order to classify river sites into river types, and the result was the definition of two main river types (Papastergiadou et al. 2008). A core of appropriate metrics was selected, based on the results from the descriptive statistics. The metric calculation was based on a numerical value and on rating by means of five point-scales in river Type I and river Type II, respectively. The Multimetric Index was generated by adding the value of the metric for Type I and the value of the ordinal category for Type II. Finally, the index normalisation was accomplished by dividing each anchor (the anchors mark the indicative range of a metric) with the maximum observed value of the Reference Sites (Hering et al. 2006). The development of a National Multimetric Index using plant assemblages in Cyprus Rivers seems to be the best solution for ecological quality assessment in Eastern Mediterranean rivers, which are characterised by an irregular flow and harsh hydrological fluctuations.

References

33 Harmonisation and viewpoints in the Mediterranean WFD intercalibration exercise for river macrophytes

F.C. Aguiar¹, J. Cambra², C. Chauvin³, M.T. Ferreira¹, M. Germ⁴, U. Kuhar⁴, P. Manolaki⁵, M.R. Minciarddi⁶, J.L. Moreno⁷, A. Munne⁸, E. Papastergiadou⁵ and K. Stefanidis⁵

¹ Forest Research Centre, Agronomy Institute, Lisbon, Portugal; ² University of Barcelona, Barcelona, Spain; ³ CEMAGREF, Bordeaux, France; ⁴ University of Ljubljana, Ljubljana, Slovenia; ⁵ University of Patras, Patras, Greece; ⁶ ENEA Saluggia Research Center, Italy; ⁷ University of Castilla-La Mancha, Albacete, Spain; ⁸ Catalan Water Agency, Barcelona, Spain

Introduction

Macrophytes were recognised in the Water Framework Directive, WFD (European Council 2000) as one of the biological elements required for the ecological quality assessment of European surface waters. The Intercalibration Exercise, IC, aims to achieve a coherent implementation of the WFD between Member States, MS, by ensuring the comparability of the classification results of the monitoring systems for the biological quality elements (European Commission 2005). IC of river macrophytes has been carried out within Geographical Intercalibration Group areas (GIGs), i.e. areas where MS share the same intercalibration river types.

First steps on the Intercalibration Exercise for Med GIG river macrophytes

Limited data availability from the few participating MS and a poor advancement of national assessment systems for the river macrophytes were identified in the first phase of the IC for the Mediterranean GIG, Med GIG (http://circa.europa.eu 2007). The present IC (2nd phase, 2007-2011) involves all MS except Malta (i.e. Cyprus, France, Greece, Italy, Portugal, Slovenia and Spain), and can provide data from more than 800 sites, however with a limited number of reference sites and comparable MedGIG river types. Different MS viewpoints were detected for the data collection, quality assessing methods and reference criteria. Two Med GIG subgroups were identified: i) Cyprus, Greece, Portugal, and ii) France, Italy, Slovenia and Spain corresponding to different approaches of the river system, including the sampling facies and taxonomic groups observed, sampling season, and scope of the assessment method (trophic-oriented as opposed to compositional/structural-based methods). The different approaches result from the magnitude of summer drought experienced throughout the region. The IC of the Med GIG for river macrophytes represents a huge and interesting challenge since such diverse perspectives and will have to be discussed and harmonised towards the success of the exercise.

References


There are around 6000 lakes in England of which just under 10% receive protection as Sites of Special Scientific Interest (SSSIs) as examples of particular habitat types; for the species they support; for their geomorphology; or due to the fact that they have been subject to extensive scientific study. Additionally, around 80 of these lakes are designated as Special Areas of Conservation (SACs) under the EU Habitats and Species Directive (‘Conservation of natural habitats and of wild fauna and flora’ 92/43/EEC). As the body responsible for nature conservation in England, Natural England has a duty to monitor and report on the condition of these lakes at least once every 6 years. The aim is for each site to achieve ‘favourable condition’ a concept developed from favourable conservation status as defined by the EU Habitats and Species directive. Favourable condition is defined for each lake based on generic guidance by lake type, these objectives cover attributes of plant community composition and structure, water quality, hydrological regime, substrate and biological disturbance. The generic guidance has been published along with a standard macrophyte survey method, which is now being widely employed across the UK (JNCC 2005).

Macrophytes are a key component of favourable condition and the assessment process in recognition of their important role in structuring lake ecosystems and processes and a long tradition of using them to classify and type UK lakes (e.g. Duigan et al. 2007). A suite of targets have been developed for different aspects of macrophyte community composition and structure. The current status of a sample of English protected lakes will be described with reference to these targets and where appropriate to other sources of information on lake status e.g. water quality data, palaeolimnological reconstructions. The macrophyte data will be presented to give a snapshot of aquatic plant biodiversity in England and the role that the protected lake series plays in conserving this. The targets for macrophytes have largely been derived from ‘expert judgment’ and the validity and appropriateness of these targets will be considered. Finally, the status of the sample lakes will be placed in the context of known and perceived pressures affecting freshwaters in England.

References
35 RVI: a vegetation-based index for the assessment of the ecological quality in Iberian rivers

F.C. Aguiar, M.T. Ferreira, P. Rodíguez-González and A. Albuquerque
Forest Research Centre, Agronomy Institute, Tapada da Ajuda, Lisbon, Portugal.

Introduction

The implementation of the Water Framework Directive, WFD (EU/2000/60, European Council 2000) requires the bioassessment and monitoring of ecological quality for successful protection, enhancement and management of surface inland waters. Macrophytes were defined as a biological quality element within the WFD. In this context, this work presents the development and performance of a plant-based index of biotic integrity (Riparian Vegetation index, RVI) using structural and functional components of river plants. Moreover, this index considered the manifold human disturbances under the seasonality water-constrained environment of Mediterranean rivers.

Development and performance of the Riparian Vegetation Index

Aquatic and bankside plant species were sampled at more than 400 sites of Portuguese rivers, in Spring-Summer of 2004 and 2005. Over 300 plant attributes were pre-screened to select 32 candidate metrics. Two spatial scale-approaches were evaluated: the Local River Type (LRT), which includes 12 river types of the Portuguese river typology, and the Regional River Type (RRT), which clusters the LRT into North and South types. The most responsive metrics to disturbance across types were composition (e.g. cover and number of alien and endemic species) and functional attributes associated with life cycle (e.g. number of annual species) and reproduction or with trophic status (e.g. proportion of nitrophyllous species). Overall, the RVI displayed a reliable response to disturbance. Nevertheless, the local approach presented a higher discriminatory efficiency but the regional approach had a more consistent response to multifaceted human disturbances and a more robust performance, essential for environmental decision-making. Results are consistent with the hypothesis that plant-based indices of integrity are scale-dependent, an important consideration in the development of typological-adapted methods either for the WFD implementation or for other assessment and monitoring purposes. Nevertheless, future work is required to calibrate the index for inter-annual variability in plant structure and composition, which is especially relevant in Mediterranean-type rivers.

Reference

Does macrophyte-based lake status assessment according to the EU Water Framework Directive conflict with the EU Habitat Directive in Fennoscandia?

F. Ecke¹,², S. Hellsten³, M. Mjelde⁴, M. Kuoppala⁵ and S. Schlacke⁶
¹Division of Applied Geology, Landscape Ecology Group, Luleå University of Technology, Luleå, Sweden; ²Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden; ³Finnish Environment Institute, Oulu, Finland; ⁴Norwegian Institute for Water Research, Oslo, Norway; ⁵Faculty of Law, University of Bremen, Bremen, Germany

Recently, many member states of the European Union (EU) have finalised and implemented national systems for water quality assessment in lakes according to the EU Water Framework Directive (WFD). It is however unknown how the assessment of ecological status, according to the WFD, relates to the status of lakes according to the EU Habitat Directive (HD). High ecological status according to the WFD should mean high status according to the HD. To avoid any conflicts between different EU directives and national environmental objectives, surface waters protected as for example Natura 2000 sites should ideally show high ecological status according to the WFD. Also, high ecological status according to the WFD should imply the presence or potential for presence of red-listed species. Here, we studied the ecological status of 1014 Fennoscandian lakes (224 Norwegian, 491 Swedish and 299 Finnish lakes) according to the WFD and related it to the number of red-listed species per lake and to the status of the lakes as Natura 2000 areas. High ecological status according to the WFD did not mean high status according to the HD or according to national environmental objectives. In general, the number of red-listed species decreased with increased ecological quality ratios. In Norway 47%, in Sweden 78%, and in Finland 29% of lakes with red-listed species were classified as lakes of moderate or worse ecological status according to the WFD. In Sweden 39 of 68 studied Natura 2000 lakes had a moderate or poor ecological status according to the WFD. In Sweden and Norway, in contrast to Finland, macrophyte-based assessment systems are primarily a trophic index, i.e. penalising lakes with elevated phosphorous concentrations. The multimetric nature of the Finnish index probably contributes to the better agreement between the WFD assessment and the number of red-listed species in Finland compared to Sweden and Norway. In Sweden six of eight red-listed species occur in lakes with phosphorous concentrations considerably above reference conditions. Generally, it is assumed that biodiversity is favoured by intermediate nutrient concentrations. In addition, instead of phosphorous, Ca concentrations appear important for the occurrence of many red-listed species, especially for Charophytes. Rapid revision of the national indices is needed to increase compatibility between the two EU directives and to increase the agreement between the WFD and national environmental objectives.
Introduction

Aquatic plants can act as measurable indicators of ecological conditions of surface waters and they can be used to determine the ecological status of aquatic ecosystems. According to the new approach to water quality assessment, the ecological status should be expressed as a deviation of observed biological conditions to these expected in a non-disturbed (reference) state.

The aim of the study was to analyse the response of the aquatic vegetation in lowland highly alkaline lakes to anthropogenic pressures of different kinds and intensity in order to select the best responding macrophyte metrics to be used for ecological state assessment.

Materials and methods

The aquatic vegetation of 84 Polish lakes, surveyed in 1997-2006 by applying a phytolittoral mapping method, was examined. All aquatic phytocenoses occurring within a lake were identified and the maximum colonisation depth, total phytolittoral area and the percentage share of each macrophyte community in total phytolittoral area were estimated. Additionally, for all lakes data on water quality and anthropogenic pressure was collected.

The relationships between aquatic vegetation, anthropogenic pressure and water quality were analysed in two morphological lake types: deep (maximum depth >6,0 m; n=56) and shallow (n=19), individually. Additionally, ribbon-shaped lakes (n=8) with a very steep bed slope (>10º) and phytolittoral naturally sparsely developed, were considered separately. Several metrics describing macrophyte syntaxonomic composition, abundance, and spatial structure were tested by using Spearman’s rank correlation.

Results and discussion

Among all parameters tested, only some anthropogenic pressure parameters (percent of urban area and forests in catchment, pollution load from point sources) and all water quality indicators (TP, TN, chl, SD) significantly correlated with most of the macrophyte metrics, although in different lake types the strength and significance of relationships varied substantially. The macrophyte metrics best responding to anthropogenic pressure and water quality changes were:

I. in deep regular-shaped lakes: percentage of Chara phytocenoses in a total phytolittoral area, maximum colonization depth, and colonization index;
II. in deep ribbon-shaped lakes: the hydrophytes/helophytes area ratio, percentage of submerged and rush vegetation in a total phytolittoral area;
III. In shallow lakes: percentage of Chara phytocenoses in a total phytolittoral area.

These metrics were then used when elaborating a method of ecological status assessment based on macrophytes.
38 Macrophytes as indicators of stream condition in the Wet Tropics region, Northern Queensland, Australia

C. S. James, S. J. Mackay and A. H. Arthington
Australian Rivers Institute, Griffith University, Nathan QLD 4111, Australia

The Wet Tropics region of coastal north Queensland, Australia, is globally significant for its biodiversity and World Heritage values. Land clearing and agriculture in Wet Tropics catchments, however, are believed to pose a threat to the near-shore reef systems of the Great Barrier Reef (GBR) as a source of both sediments and nutrients. This paper forms part of the “Catchment to Reef” research program intended to develop appropriate methods for monitoring water quality and ecosystem health in catchments of the Wet Tropics and GBR World Heritage Areas (Arthington & Pearson 2007).

We investigated the efficacy of aquatic macrophytes as indicators of stream condition in catchments with varied land use and riparian disturbance in the Wet Tropics region of North Queensland. Four geographically close streams, of similar size and length but representing contrasting levels of anthropogenic land uses and riparian disturbance were selected for macrophyte surveys. Seven macrophyte metrics were trialled: total macrophyte cover, species richness, % alien taxa, % native taxa, % submerged taxa, % emergent taxa and % Poaceae. In addition, four of these metrics were calculated for edge habitats only, where much of the aquatic macrophyte growth was found to be concentrated. Upper catchment areas in all tributaries surveyed were dominated by mosses and a moss-like vascular species endemic to the region (Cladopus queenslandicus (Domin) C.D.K. Cook (Podestemaceae)). This assemblage occurred in areas with intact riparian canopy cover and good overall riparian condition. Macrophyte assemblages in lower catchment areas were distributed along gradients of riparian disturbance. Three assemblage metrics (macrophyte cover in edge habitats, % alien taxa and % Poaceae) were strongly correlated with measures of riparian disturbance in the Wet Tropics region but were not correlated with either land use or water quality parameters. This study makes an important contribution to the achievement of the Reef Water Quality Protection Plan which aims to protect and manage the adjacent catchments for their intrinsic values in sustaining freshwater species, biodiversity and ecological services.

Reference

39 Assessing the condition of lake habitats – a comparison of methods for surveying aquatic macrophyte communities


1Centre for Ecology & Hydrology, Penicuik, Midlothian, UK; 2Centre for Ecology & Hydrology, Wallingford, Oxfordshire, UK; 3RPS Ecology, St.Ives, Cambridgeshire, UK; 4Crediton, Devon, UK; 5Darwell Associates, Cumbria, UK; 6University of Stirling, UK; 7Scottish Natural Heritage, Stirling, UK

Introduction

Both the EU Habitats and Water Framework Directives (WFD) require lakes to be regularly monitored to assess their ecological condition. A key indicator group for characterising lake habitats is the aquatic macrophyte community. However, there are no published standard survey methods available for producing quantitative data which can be reliably used for detecting and assessing trends in aquatic macrophyte communities and thereby help inform the management of individual sites. For this purpose, we compare the effectiveness of three survey methods (perimeter strandline searches, shore-wader depth transects and boat-based transects) by analysing data from field trials at eight British lakes. The following key questions were examined:

• what is the relative effectiveness of the survey methods in determining species composition, overall species richness and species abundance?
• what are the time and financial costs associated with each of the survey methods?

All these methods are based on sampling representative 100 m sectors of lake shoreline rather than comprehensive in-lake surveys of aquatic macrophytes as this latter approach is considered impractical for extensive national programmes that are aiming to assess habitat condition and trends in biodiversity in a large number of lakes.

Results and discussion

In terms of the number of species detected and time/cost/practicality constraints, the shore-wader depth surveys were generally as effective as the boat transects and could be complemented by perimeter searches to pick up the presence of characteristic deep-water species. However, these shore-based survey methods were less effective in providing quantitative macrophyte data as species relative abundance was inherently underestimated (wader method) or could not be inferred (perimeter search). In addition, aquatic community structural attributes such as “characteristic zonation with increasing depth”, as required in condition assessments of particular types of lakes, cannot be properly evaluated using these methods. The boat-based transects provided a much better assessment of deep-water macrophyte communities. Therefore, for many sites, a combination of shore-wader and boat-based transects will be needed to reliably quantify whether there have been significant changes in the condition of the aquatic macrophyte communities. We discuss the wider implications...
of this research for monitoring work and the assessment of biodiversity trends in lakes. This methodology now forms the basis of the Site Condition (JNCC 2008) and WFD monitoring of lake aquatic macrophyte communities used by UK conservation and environment agencies.

Reference

First attempts to assess lake status by aquatic macrophytes in Finland – validation of the proposed classification system


1) Finnish Environment Institute, Research Programme for Integrated River Basin Management, Oulu, Finland; 2) North Savo Regional Environment Centre, Kuopio, Finland; 3) Finnish Environment Institute, Research Department, Helsinki, Finland; 4) Virolahti, Finland

Introduction

Implementation of the EU Water Framework Directive (WFD) has lead to development of a series of macrophyte classification systems in Europe. The classification should be ideally based on the reference condition approach, where potentially impaired lakes are compared to pristine or near pristine reference lakes. To enable valid comparisons, natural variability of lake characteristics and macrophyte communities should be stratified using an *a priori* lake typology or some other reference framework. The main aim of this study was to develop the classification system for aquatic macrophytes, to determine reference conditions by using reference lake approach and to evaluate the validity of the national lake typology in accounting for natural variability of Ecological Quality Ratio (EQR) of multimetric index.

Material and methods

The Finnish classification system is based on a multimetric index consisting of three metrics (Proportion of type specific taxa, Percent Model Affinity and Reference index) supposed to meet the normative definitions of WFD. Reference values for each metric are calculated using a reference lake typology consisting of 12 lake types based mainly on lake area, depth, water colour and additional division of lakes into northern and southern geographical region. Aquatic macrophyte data was collected in various surveys between 1970–2004 (Leka et al. 2008). Data consisted of 177 reference lakes and 131 impacted lakes with impaired status.

Results and discussion

The validity of the typology was evaluated using precision (reference lake SD of metrics) and sensitivity to human disturbance (proportion of lakes that were determined as impaired by the classification) as measures of performance of the classification. Classifications conducted using Finnish typology were compared with classifications of null models (no typology) and more simple WFD system A typology where geographical variation in macrophyte communities is accounted for by using only broad-scale ecoregions. As an additional measure of performance we used the strengths of the association between EQRs and stress-related environmental variables. According to our preliminary results, the Finnish system performs relatively well on
classification of large clear water lakes, whereas the results from small humic lakes were more variable.

Reference
A new genus level macrophyte index for assessing the trophic state of Spanish rivers under the Water Framework Directive

J.L. Moreno, P. Tomás, R.M. Ros, C. Durán, N. Prat and J. de las Heras
Centro Regional de Estudios del Agua, University of Castilla-La Mancha, Albacete, Spain; University of Navarra, Spain; Departamento de Biología Vegetal, University of Murcia, Spain; Confederación Hidrográfica del Ebro, Zaragoza, Spain; Departament d’Ecologia, University of Barcelona, Spain

Introduction

Macrophytes are recognised in the Water Framework Directive (European Commission, 2000) as one of the biological elements for assessing the ecological state of European rivers. For this purpose, the trophic indexes IBMR (AFNOR 2003) and MTR (Dawson et al. 1999) are being applied in several European countries. These indexes require a species level approach, which is sometimes difficult to reach, especially for algae and phanerogams at their vegetative stage.

The IVAM index

A new macrophyte index has been produced to assess the trophic state of Spanish rivers under the Water Framework Directive. The index is called IVAM (Macroscopic Aquatic Vegetation Index) and will be proposed as a Spanish metric to be intercalibrated in the Mediterranean GIG Intercalibration exercise. The considered taxonomic level was genus and the organisms were any macroscopic autotroph growing submerged, floating or on the splash zone of the stream channel. These criteria included algae, bryophytes, lichens, pteridophytes and spermatophytes (hydrophytes and submerged helophytes). Following a similar methodology developed for other indexes like the French IBMR, a value of tolerance (vt) and an indicator value (vi) is provided for each genus based on real ammonium and phosphate concentrations. The calculation of the index includes a three points cover value (vc), which is recorded for each genus in a stream reach around 100 meters long. The response of the index to nutrient loading was significant indicating that genus level is appropriate to assess eutrophication of Spanish rivers.

References

42 The Dutch water quality assessment metric for aquatic macrophytes

R. Pot
Roelf Pot research and consultancy, Oosterhesselen, The Netherlands

Introduction

The European Water Framework Directive obliges to assess water quality, among others using aquatic macrophytes, by comparison species composition and abundance to natural conditions and by identifying human impact. Usual metrics are based on indicator values of species to assess the impact of eutrophication, they are in fact metrics to identify trophic level. In a river delta, as most of The Netherlands is, moderate trophic level is natural and trophic level is a poor indicator for human impact. On the other hand, habitat diversity is heavily impacted in these systems. At natural conditions species richness is very high at moderate trophic level and natural habitat diversity.

Dutch metric

The Dutch approach is to indicate the general difference from natural species composition and overall abundance of specified growth forms (submerged, floating, etc). Reference species composition is derived from syntaxonomical literature and reference syntaxonomical composition of whole waterbodies. Any loss of expected species is regarded as loss of quality. Species vulnerable to any human impact are weighted up to 4 times and species that tend to increase with human impact are downweighted at increasing abundance. The metric is only applicable to multi sample monitoring data as a consequence of the approach: species diversity related to habitat diversity cannot be measured at single sites. Reference abundance of growth forms is derived from best sites. Any deviation is regarded as loss of quality.

Development

Extended discussions, both in national and international platforms, resulted in strong improvements recently (Pot & Coops 2009). Main problems were a strong correlation between assessment results and monitoring effort (number and choice of sites) and unbalanced share of impact species. These problems were much more obvious in river systems since monitoring practice is to sample single sites only and because amphibian species can outnumber the more vulnerable submerged species. Both problems are dealt with by changing the weighing factors of species, including the introduction of negative weight.

Weighing of scarce species in aggregation of samples and validation of growth form cover is still in discussion.
References
43 The ‘Macrophyte Method’ for river assessment implementation in the classification of running waters in lowland Poland

K. Szoszkiewicz, J. Zbierska, S. Jusik and T. Zgola
Poznan University of Life Sciences, Department of Ecology and Environment Protection.
Piatkowska 94C, 60-649 Poznan, Poland.

Introduction

Freshwater evaluation and classification by assessing their ecological status is a new approach in monitoring fulfilling requirements of the Water Framework Directive (WFD). Macrophytes belong to the groups of organisms considered by the WFD for river assessment and numerous studies confirmed the usefulness of aquatic plants in river classification (e.g. Hering et al. 2007). For the purpose of WFD several systems have been developed in Europe recently. The Polish method known as Macrophyte Method for River Assessment (MMOR), was developed in 2006 and it was introduced into the national monitoring of running waters. The method is based on quantitative and qualitative evaluation of freshwater plant species. The method allows to assess river degradation, mainly caused by eutrophication. In the process of ecological status estimation under MMOR, the Macrophyte Index for Rivers (MIR) is used and class boundary values consistent with the five class-scheme of the WFD were derived.

River classification according to macrophyte index MIR

The analyses used to develop the MMOR method were conducted in years 2002–2006. The survey program included 550 sites, placed in 208 lowland rivers. It was proved that diversity of freshwater macrophytes of Polish lowland rivers is grouped into three main macrophyte-based river types: organic rivers, siliceous rivers with sandy substrate and siliceous rivers with stony substrate. Moreover vegetation of large siliceous rivers indicated separate features, which must be treated as additional type. A strong correlation between MIR index and water phosphorous load was found. River classification according to MIR index indicated the wide range of degradation gradient of analysed watercourse and the whole range of five-class scale was utilised: 65 rivers represented very good status, good status was represented by 261 rivers, 167 rivers were classified as moderate, 44 as poor and 13 rivers represented bad ecological status. It was found that each of the identified river types, across the whole degradation gradient, was grown by the variety of plant species and their number was sufficient for estimating MIR index confidently.

Reference

The use of aquatic mosses in assessment of metal pollution: appraisal of type-specific background concentrations and establishment of environmental quality standards in boreal river ecosystems

K-M. Vuori¹ and H. Helisten²
¹Finnish Environment Institute, Research Programme for Integrated River Basin Management, Oulu, Finland; ²University of Oulu, Department of Biology, Oulu, Finland

Introduction

Aquatic mosses are ideal indicators of metal pollution. They are tolerant of metal pollution, widely distributed, long-lived and have a high accumulation capacity. Metal uptake occurs straight from the water, by adsorption and absorption through the cell surfaces. Due to the lack of roots or vascular systems, there is no internal transfer of metals (Nimis et al. 2002; Vuori et al. 2003; Pekka et al. 2008). The EU Water Framework Directive challenges member states to assess ecological risks of pollutants and establish environmental quality standards (EQS) for major pollutants, including metals (European Communities 2000). Besides anthropogenic factors, metal concentrations are affected by geochemistry of the catchment area. Hence, knowledge on the background variation of metal concentrations is a prerequisite for risk assessment and definition of EQS. Our study addressed the following questions: a) how variable are the background metal concentrations of *Fontinalis antipyretica* in different stream types with differing catchment geology, b) are there significant species-specific differences in moss metal concentrations and c) do the patterns of metal accumulation differ in differently polluted streams and different stream types?

Material, methods and major results

We analysed concentrations of Al, As, Cd, Cu, Fe, Pb and Zn in 73 river sites, including 25 unpolluted reference and 48 polluted sites. Concentrations were measured both in the youngest terminal parts (reflecting most current conditions) and in the whole vegetative shoot (long-term exposure) of mosses. For *F. antipyretica*, the concentration data was stratified according to the river type (peatland or moraine land rivers) and assessed for background concentrations and patterns of concentration gradients and possibilities for setting criteria for environmental quality standards. Further, we analysed species-specific differences in metal concentrations of *Fontinalis antipyretica*, *Dichelyma falcatum* and *Hygrohypnum ochraceum*.

The background concentrations varied more or less according to the river type; in general, peatland rivers had higher concentrations than moraine land rivers. The highest metal concentrations were found in peatland rivers contaminated by acid sulphate soils. For most metals, concentrations in *D. falcatum* and *H. ochraceum* were higher than in *Fontinalis antipyretica*. Rivers polluted by runoff from acid sulphate soils
are characterized especially by extreme Al and Cu concentrations in moss samples. Our results indicate that separate treatment of peatland and moraine land rivers and different moss species is a prerequisite for development of moss metal monitoring and EQS values in boreal rivers.

References
Can two submersed macrophytes be used to assess spatial gradient of lake trace element contamination?

Z. Mazej and M. Germ

1) ERICo Velenje d.o.o.; Environmental Research and Industrial Co-operation, Velenje, Slovenia; 2) Biotechnical Faculty, Ljubljana, Slovenia

Introduction

Due to the absence of systematic water quality monitoring, trace element accumulation in plants provides a cost-effective means for assessing short-term contamination that is within the lifespan of the plant organs in question (Baldantoni et al. 2005). Certain aquatic plant species can be used as indicators of low level contamination that might otherwise be difficult to detect in water (Cardwell et al. 2002). Bioaccumulation of metals varies considerably between plant species, as well as between morphologically similar species growing in the same area. Roots are the main place of accumulation of trace elements. Specially the mobility of As and Pb to above-ground plant parts was found negligible (Mazej & Germ 2009). Roots represent only a small proportion of the whole plant biomass and sampling of entire plants with roots is very demanding. To avoid difficult sampling, we tested the hypothesis that concentration of trace metals in above ground plant tissues can be used as indicator of lake pollution. Unfortunately, different lake’s characteristics limited the development of different macrophyte species, so in comparative biomonitoring only available species can be used. Najas marina and Myriophyllum spicatum grew in both investigated lakes, Velenjsko jezero and Družmirsko jezero.

Myriophyllum spicatum and Najas marina as bio-indicators

The upper parts of the plants, sediment and water samples surrounding the plants were collected at the corresponding sampling locations. The contents of metals and As in lake water, sediment and plants were determined following the Hewlett Packard ICP-MS Application Note: 228-312, 228-314, 228-343 and a modified standard method: ISO 17294-2:2003 on ICP-MS 7500c-Agilent.

The concentration of metals and As in water of both lakes was mainly below detection values. Sediment of Družmirsko jezero contained significant higher concentration of Cu, Pb, Zn and Cr than sediment of Velenjsko jezero. The concentration of trace elements in plant’s shoots did not confirm the trace element pollution of the lakes in the case of essential metals Cu and Zn. On the other hand in the shoots of both species from Družmirsko jezero, higher concentrations of Pb and Cr than in shoots of plants from Velenjsko jezero were measured. Myriophyllum spicatum as a perennial species contained higher concentration of trace elements in comparison to the shoots of Najas marina.
References
46 In which way are macrophyte communities suitable tools to assess the ecological status of Spanish lakes?

C. Ruiz\textsuperscript{1}, G. Martínez\textsuperscript{2}, A. Camacho\textsuperscript{3} and M. Toro\textsuperscript{2}

\textsuperscript{1}European Master of Inland Water Quality Assessment. Universidad Autónoma Madrid. Spain; \textsuperscript{2}CEDEX. Madrid. Spain; \textsuperscript{3}Universitat Valencia. Spain.

Biomonitoring provides essential information on the impact of chemical and/or physical alterations on living organisms and consequently on ecosystem health. Macrophytes fit very well to many of the criteria listed for an ‘ideal’ organism for water biomonitoring, since they lack movement, are visible with a naked eye, easy to collect and to handle, and relatively easy to identify in the field. Moreover, some species appear under specific environmental conditions such as along a trophic state gradient in waters, or with different heavy metals or nutrient concentrations in their tissues, reflecting the degree of anthropogenic environmental perturbations. In lakes from the Mediterranean region, where hydrological regime strongly changes seasonally, macrophytes respond to natural fluctuations of the water level, but also detect abnormal variations that are caused by anthropogenic impacts and pressures.

There are two main types of assessment based on macrophyte communities: diversity indices and trophic indices. Both evaluations work properly to assess eutrophication in the system. In this paper, we show the environmental ranges (phosphate and nitrates concentrations) in which different macrophyte species thrive. With this association, tolerant and sensible species to eutrophication in Spanish lakes can be indentified. The results can be used to define Trophic Ranking Scores and other metrics involved in the assessment of ecological status.

Nevertheless, trophic indices are not able to reveal enough information to assess properly other kind of stressors such land use and hydromorphological pressures. In our paper, the main hydromorphological pressures affecting the Spanish lakes are identified. Moreover, a relationship between the appearance of macrophyte species and the degree of hydromorphological alterations is also analysed in the study.

Our work is aimed to the recompilation and evaluation of the different assessment methods and macrophyte indices used by the EU members in order to apply the European Water Framework Directive. Additionally, other biotic indices from USA are also being checked. The main objective is to study the suitability of these existing macrophytes indices for the monitoring of the ecological status of Spanish lakes, as an example of those from the Mediterranean region. Moreover, the study focus in the assessment of hydromorphological alterations affecting Spanish lenitic water bodies, since they are also included in the development of the Water Framework Directive, although the consequences are poorly studied and the way by which macrophyte can reveal the information is not well defined yet.

References
47 Defining reference condition for nutrient-rich boreal lakes using historical data of aquatic macrophytes

J. Alahuhta¹², S. Hellsten², H. Mykrä², K-M. Vuori², M. Kuoppala² and J. Riihimäki²
¹University of Oulu, Department of Geography, Oulu, Finland; ²Finnish Environment Institute, Research Programme for Integrated River Basin Management, Oulu, Finland

Introduction

Aquatic macrophytes are used in ecological classification of water bodies accordant with European Union’s Water Framework Directive (WFD). Ecological classification of macrophytes should be based on the reference condition approach, where impacted lakes are compared to pristine or near pristine reference lakes. The WFD enables defining of reference condition by utilizing historical data representing pristine status of water bodies. The purpose of this study was to implement ecological classification of naturally nutrient-rich lakes, which are situated at agriculture dominated areas without proper reference conditions. First, we defined reference conditions for these lakes using historical survey data and assessed their ecological status with three macrophyte metrics. Second, we tested how well the classification system of nutrient-rich lakes responds to current land use pressures.

Material and methods

Historical data consisted of recorded macrophytes from 14 lakes belonging to “nutrient- and calcareous-rich lake type” from two previous surveys (1936-40; Maristo 1941 and 1980-85; Rintanen 1996). Seven lakes from the historical data were assessed to be in pristine condition based on the absence of nitrogen indicating species *Lemna minor* and *Spirodela polyrrhiza* and reference values were derived from the macrophyte communities of these lakes. Three classification metrics derived from Finnish classification system (FinEQ) were used: the relative proportion of lake type specific species of the total number of species, the reference index and Percent Model Affinity. The relationship between the classification results and land use pressures, such as proportions of fields, pastures and drainage ditches, and water quality variables (e.g. $P_{tot}$ and $N_{tot}$) were also studied.

Preliminary results

The preliminary results indicated that ecological status of most of the nutrient-rich lakes decreased during the study period. The ecological status of the nutrient-rich lakes was the highest (between high and satisfactory) in the 30s and decreased thereafter in all but one study lake (to good-satisfactory). Ecological status was negatively related to increased cover of arable land and total phosphorus concentration, but relationships were often weak.
References
Trophic level distribution of aquatic plants in the Western Greek rivers – comparison of ranking scores given by European Trophic Indices

P. Manolaki and E. Papastergiadou
Department of Biology, University of Patras, GR 26500 Patras, Greece

Introduction

Aquatic macrophytes belong to a group of organisms with well identified ecological requirements and their distribution is dependent upon a variety of abiotic and biotic factors, the most important of them are hydrological conditions, flow velocity, substrate, pH, nutrient concentrations, carbonate hardness, shading and anthropogenic impacts. The modeling of aquatic macrophyte communities can be performed using physiological and chemical relationships between macrophytes and environmental conditions. The existing macrophyte-based methods are mainly focused on detecting eutrophication and acidification and the evaluation of the ranking scores for each taxon was based on data of non-Mediterranean countries (Thiebaut et al. 2002, Szoszkiewicz et al. 2007). The approaches to assessing the habitat quality of a river ecosystem through macrophyte communities include the typology of aquatic plant communities in different types of water, the biological traits of river plants and finally the evaluation of water quality using weightings for indicator species.

Macrophyte Trophic Indices: towards an integrated approach

The aim of this study was the evaluation of the existing macrophyte-based indices under Mediterranean climate conditions and the estimation of necessary changes in the list of bioindicators taxa. Our attempt was to compare the trophic level distribution of the common plant species from existing European indices with the taxa we recorded in our study area. This study was carried out in riverine and lake ecosystems in Western Greece. The survey has been performed seasonally in two rivers (Acheron and Louros) and one lake (Zirou) from 2005 to 2007 and in a total of 36 sampling sites. Water parameters and aquatic vegetation surveys were performed. Most of the sites in the dataset used in these investigations were classified, using TWINSPLAN analysis, into vegetation types. Water chemistry data obtained from this survey have been used to classify sites into trophic categories. The distribution of aquatic macrophytes was predominately determined by water chemistry (nutrients, conductivity etc) in order to investigate the ecological tolerance of the aquatic species. Due to the fact that macrophyte community in most of the upper sites is poor in bio-indicator taxa and very rich in amphibious and hygrophilous species which are found on margins and on inner bank, the future goal will be the addition of other species, and the re-scoring of existing species, resulted in a considerable improvement in the relationship between MTR scores and nutrient variables in eastern Mediterranean.
References
Habitat conditions and indicator value of mosses in lake-side mires of North-Eastern Poland

P. Pawlikowski
University of Warsaw, Department of Plant Ecology and Environmental Conservation, Warsaw, Poland

Introduction

Mosses are often more sensitive to variations of environmental parameters in peatlands than vascular plants. The obtained knowledge about the habitat requirements of some species (e.g. Gignac et al. 1991), especially belonging to the genus Sphagnum, allows us to estimate some chemical properties of surface waters in mires from the species composition. The data on the indicative value of the remaining majority of species, first of all belonging to the ‘brown mosses’ group, are insufficient.

Lake-side mires are ecosystems with mosses being frequently the most prominent component of the vegetation, which are decreasing rapidly in the nemoral zone of Europe (Succow & Joosten 2001). The objective of the study is to determine the habitat preferences and indicator value of moss species in lake-side mires of NE Poland.

Methods

Surface water conductivity, pH, Ca\(^{2+}\) and Mg\(^{2+}\) concentrations were determined in 272 vegetation plots in mires bordering 42 lakes in north-eastern Poland. Moreover, the above four properties as well as carbonate hardness, COD-KMnO\(_4\), and concentrations of Na\(^+\), K\(^+\), P-PO\(_4^3-\), N-NO\(_3^-\), N-NH\(_4^+\) and total Fe were measured monthly in 20 plots adjacent to 16 lakes. The data were used to determine the relationship between habitat conditions and species composition of the moss layer. A total of 29 species were considered in the study, including 5 Sphagnum species and 10 members of the Amblystegiaceae family. Detailed analyses concerned 7 moss layer dominants.

Habitat preferences of moss species

Parameters related to the poor-rich gradient divided the studied species into two groups that hardly overlapped. Most of the mosses turned out to be indicators of base-rich conditions, except for Sphagnum species, Straminergon stramineum and Polytrichum strictum, which occurred in more acid environments. In the Sphagnum teres-dominated sites the conditions in the moss layer were clearly acidic, while the water under the mire surface was more alkaline. The property best differentiating the habitat of analysed species was magnesium. Scorpidium scorpioides (and its associates, e.g. Campyliadelphus elodes and Pseudocallicion trifarium) was an indicator of rather dilute and Mg-poor waters, as opposed to Calliergon giganteum and Hamatocaulis vernicosus, which were usually associated with Mg-richer conditions. Apart from the poor-rich gradient, other important characteristics of water included nutrient concentrations. They constituted at least partially independent gradients. Among the brown moss species, Sphagnum teres and Sph. fallax-dominated patches of vegetation had higher concentrations of K\(^+\) and N-NO\(_3^-\) than those of the majority of brown moss...
species analyzed (e.g. *Limprichtia cossonii*). At least some of the studied bryophytes were distinct with respect to surface water chemistry, especially when occurring abundantly.

**References**


Management of aquatic vegetation and side effects
Aquatic weed management in the tropics – a review

A.H. Pieterse
Wilsonstraat 83, 2131 PM Hoofddorp, The Netherlands

Introduction

Especially in the tropics, where growth is not hampered or stopped during a cold season, aquatic weeds may cause very serious problems in water bodies, which are for various reasons used by man. These problems include direct as well as indirect effects. The most important direct effects are blocking the water flow in irrigation and drainage canals, interference with hydro-electric schemes, impeding navigation in rivers and lakes, decreasing fish production and hampering daily activities of the local population, such as washing, laundering and bathing. Indirect effects include health hazards by forming favourable habitats for the development of human disease vectors.

Types of aquatic weeds

In general aquatic weeds can be divided into three growth-forms, i.e. floating, emergent and submerged.

Some of the most troublesome aquatic weeds in the tropics are free-floating, including the most notorious one, water hyacinth (Eichhornia crassipes), which is ranked among the ten most noxious weeds in the world. Originally it only occurred in South America, but was spread by man as an ornamental, due to its exotic, hyacinth-like flowers. At the present it occurs in almost all tropical regions in the world.

In addition to water hyacinth, two other free-floating weeds are creating problems world-wide in the tropics. These are Salvinia molesta, a water fern, which also originated in South America, and Pistia stratiotes (water lettuce), which is indigenous to tropical regions all over the world.

Various species of emergent plants, such as Phragmites spp. and Typha spp., may invade shallow water bodies, forming dense impermeable stands. For example, in the lower part of the Senegal River in West Africa, a large area became overgrown by Typha australis, after the construction of the Diama dam in 1986. The notorious alligator weed (Althenantha phloxeroides) also belongs to this group, although under certain conditions, it may produce floating leaves. This originally South American species, is currently a serious aquatic weed in the southern states of the USA and in Australia.

Several submerged plants may become aggressive weeds by explosively developing a dense vegetation which, in shallow waters, may occupy the entire water volume from the bottom to the surface. Examples include Hydrilla verticillata, Ceratophyllum demersum, Potamogeton spp. and Vallisneria spp. In a country like Egypt, where agriculture depends entirely on irrigation, submerged plants are the most problematic aquatic weeds. They form a pioneer vegetation after the canals have been cleared, but are eventually replaced by an emergent vegetation, if control measures are not carried out.
Management

Ideally, the management of aquatic weeds should focus first of all on preventing excessive growth. However, under most circumstances, especially in developing countries in the tropics, preventive measures are difficult to achieve. When there is not yet a problem it is difficult to activate the authorities. Consequently, measures are taken after dense growth of aquatic weeds has already become apparent and then much more labour is involved.

The use of chemicals should generally be avoided because of negative effects to the environment, although in the USA the herbicide 2,4 – D is still used against water hyacinth at a large scale. The use of machines, such as mowing buckets attached to a tractor or hydraulic excavator, weed cutting boats and large harvesters, is more preferably, but relatively expensive. From an environmental, as well as an economic point of view, biological control is the most attractive management option. Unfortunately it has proved only successful in a few cases. Very favourable results have been obtained with the control of the free-floating weeds Salvinia molesta and Pistia stratiotes by means of host-specific Curculionid weevils. Also against water hyacinth host-specific insect species, such as the Curculionid weevil Neochetina eichhorniae, are being applied. However, the effects not always result in a very marked reduction of the water hyacinth population.

Reference

Plants are natural and important components of the aquatic environment. However, abundant stand of these plants can have a detrimental effect on a water body and its inhabitants. Many shallow, nutrient-rich water bodies provide ideal conditions for excessive aquatic weed growth.

In tropical and sub-tropical conditions, aquatic weeds grow extremely well under highly ‘fertilised’ water conditions. Here water eutrophication plays an important role in the abundance of water weeds. Prevailing species in these regions of the world are nearly the same, three floating species: Water hyacinth (WH) (*Eichhornia crassipes* (Martius) Solms-Laubach), *Pistia stratiotes* L. and *Salvinia molesta* D. S. Mitchell as well as submerged *Hydrilla verticillata* (L. f.) Royle, and rooting *Typha* spp.

The most important weed is WH, a floating macrophyte native to the Amazon basin, which has spread largely throughout the world and it is present now in more than 60 countries of all regions of the world. This author considers that WH is in fact the worst weed in the tropical and sub-tropical regions. Its rapid increase and spread of the plant into new areas are due particularly to its vegetative reproduction, a single shoot being able to develop very rapidly a significant infestation and moving easily with water currents, winds or by other accidental means. The problems of high evapotranspiration, interruption of normal water flow, blocking irrigation canals and drainage systems, increased sedimentation, and seriously hampering fishing are well known. It also affects electrical power stations, and its abundant stand is a suitable habitat for human disease vectors. Although mainly found in hot-climate countries, WH is also now a problem in the Yangtze River basin in China and in Southern Australia, areas with soft climate and low temperatures during winter. The weed is also found in areas of Spain and Portugal bathed by the rivers Tajo, Guadiana and Ruecas, where the coldest temperatures in winter time are around 6-7.5 C. In FAO project conducted in China it was determined that WH seeds may effectively overwinter temperatures of -2 C.

Successful strategies for control should include the regular release of *Neochetina eichhorniae* and *N. bruchi* weevils as a long-term control measure in hot climate areas. It should be combined with previous removal of heavy stands either mechanically or by using a low toxic herbicide, e.g. glyphosate. In areas with slight infestations, biocontrol works effectively alone. The most recent success of WH control is found in areas of Lake Victoria and in Niger River (Mali sites). In both areas biocontrol was the main control strategy. First releases of the weevils started in 1991 and 1996, respectively. In other areas biocontrol has not been effective due to wrong or lack of monitoring of WH stands and establishment of the weevils, and lack of regular releases of the insects. Biocontrol based on specific insects does not seem to be an alternative in areas with a soft climate. The experience in China indicates that the weevils cannot overwinter and new releases should be conducted in early spring. Life demonstrates that WH control is a long-term exercise and the effectiveness of the control programme highly depends on the systematic action of all factors involved.

The other floating weeds, i.e. perennial *Pistia stratiotes* (water lettuce) of uncertain origin and *Salvinia molesta* (water fern or kariba weed) from south-eastern Brazil are common in quiet or slow flowing water bodies. These plants have the potential to
spread quickly and to replace native vegetation. As in the case of WH, they can clog water intakes to interfere with irrigation. Hopefully biological control of these plants is a real success.

Water lettuce is normally controlled with releases of the weevil *Neohydronomous affinis* Hustache. This insect has a life cycle of less than a month, it feeds on the leaf and the larvae effectively penetrate the leaf tissues. It normally established itself quite quickly. In areas heavily infested by the weed in Ghana and Cote D’Ivoire, more than 95% control of water lettuce was achieved in a period of 3 months after the release of the weevil

*Cyrtobagous salviniae* Calder & Sands is also a small weevil native to South America and it had been effective on heavy stands of *Salvinia* in areas of Papua New Guinea and Sri Lanka. In the recent past, abundant stands of *Salvinia* were effectively controlled in the Senegal River shared by Mauritania and Senegal, by massive releases of *C. salviniae* during a period of 14 months. The plant, as it happened in water bodies of Sri Lanka, may come back some years later requiring new releases of the weevils.

Rooting *Typha* spp or cattails are among the new water weed problems in several countries. It prevails in areas with shallow water depth. Increased sedimentation in water and eolic soil erosion of the surrounding areas are factors contributing to decreased water depth. Heavy stand of the plant is a suitable habitat for snakes as it is happening in areas of Senegal River, where farmers are compelled to fire the stand in order to get water for drinking and cooking. The plant is a serious problem along the Rio Grande, i.e. the border between Mexico and US. There mechanical removal is practiced at heavy cost and it implies the purchase of the appropriate machinery, fuel and maintenance of the equipment.

The submersed herbaceous perennial, *Hydrilla verticillata*, is becoming a serious problem in water bodies of Mexico, Central America and also in Asia, precisely in Sri Lanka. It grows effectively in any freshwater body and is a plant of warm climate. However, it can also be found in areas of soft temperatures. Except physical removal (mechanical or manual) no other control methods are practised in developing countries. A possible control method could be the release of herbivorus grass carp (*Ctenopharyngodon idella* Steindachner), which is at present released in sites of Rio Grande by USDA. To this end it is necessary to invest in equipments and laboratory for setting up a suitable unit for rearing triploid carps.

Successful control of these water weeds will only possible with a permanent and systematic work (regular monitoring and releases of biological control agents) of technical personnel working permanently on this issue in the affected countries. To this end it is necessary continuous governments support to these programmes, reduction of organic effluents into water bodies for reducing eutrophication, and more research to develop suitable control of cattails and *Hydrilla*. 
Lagarosiphon major control in a large Irish lake through light exclusion

J.M. Caffrey, S. Evers and H. Moran
Central Fisheries Board, Swords Business Campus, Balheary Road, Swords, Co Dublin, Ireland.

Lough Corrib is the second largest lake in Ireland. It is of major conservation importance and supports 14 habitats and six species that are listed on Annex I and Annex II, respectively, of the Habitats Directive. The lake is a nationally important angling resource and a major tourist angling destination. Since the recent discovery (2005) of the highly invasive submerged plant species, Lagarosiphon major, its rapid advance throughout the northern and middle basins of the lake has demonstrated its potential to compromise the environmental, social and economic value of this unique natural resource. To date, no Lagarosiphon has been recorded in lower lake and every effort is being made to halt the southerly spread of the plant into this large and shallow watercourse.

A wide range of control methods are being tested in Lough Corrib in an effort to control or eradicate this highly aggressive invasive species. One method that is currently receiving attention is light exclusion through the use of geotextile material. In 2007 black plastic geotextile was used to cover large trial plots of Lagarosiphon. Where it was possible to maintain the geotextile on the lake bed, a high level of effective weed control was achieved. However, the material was difficult to handle, caused problems in the lake for recreational users and required to be moved from the lake when the operation was completed. In 2008 a biodegradable jute geotextile was sourced and trials using this material were undertaken. A methodology to cover large areas of weed-infested lake bed was developed and a number of trial areas have been established. The results to date are encouraging and use of this control method will be significantly expanded in 2009. The paper will describe the methodology for geotextile placement that has been developed, the fate of the submerged geotextile over time, the impact on the target vegetation and the potential for natural recolonisation by indigenous macrophytes in treated areas.
Aquatic plant invasions: nipping invasions in the bud – weed risk assessment and the trade

P.D. Champion, J.S. Clayton and D.E. Hofstra
National Institute of Water and Atmospheric Research, Hamilton, New Zealand

Most current aquatic weeds (~ 75%) in New Zealand originally were imported as ornamental pond and aquarium plants. Many of these species and many others are still traded internationally. There are similar trends in other countries, with additional misidentified plants and contaminants also spread through the plant trade. Thus importation and sale of ornamental pond and aquarium plants is probably the most important pathway for the introduction of potential aquatic weeds into and subsequent spread of these within a country.

This paper discusses a weed risk assessment approach to evaluating new potential weeds assessing the potential invasiveness of an aquatic plant based on the habitat versatility, competitive ability, reproductive output and dispersal mechanisms, range of potential impacts, potential distribution and resistance to management activities. The Aquatic Weed Risk Assessment Model (AWRAM) has been used to evaluate potential aquatic weeds in New Zealand, Australia and the USA. The total score for each plant is a synthesis of characters relevant to the weed potential and management of a species and provides a means for managers and policymakers to prioritise weeds for control actions including managing the sale and distribution of potential weeds.

Banning the importation of species ranked highly by AWRAM effectively keeps biosecurity risks off-shore, whilst banning a species from sale and distribution is a highly effective way of restricting both long-distance dispersal and density of propagules. A cooperative approach involving researchers, policy and trade representatives has been an effective way to achieve regulation of this risk pathway.
54 Experimental study of competition between *Ludwigia grandiflora* and *Egeria densa*

**Aims and context**

In invasive macrophytes of river Don (Brittany, France), changes have been observed: Water Primrose (*Ludwigia grandiflora* ssp. *hexapetala* (Hook. & Arn.) Nesom & Kartesz.) was dominant in 2000–2002, and was replaced by *Egeria densa* Planch. in 2005–2007, when successful management of *Ludwigia* was carried out. Our hypotheses were that (i) there was a strong competition between both species, (ii) *Ludwigia* was dominant due to creeping stems and then dense mats above water surface, (iii) *Egeria* had a waiting strategy bearing shaded conditions and developed when *Ludwigia* was pulled off. To optimise the management of this invasive combination using competition, experiments have been carried out in 2007 and 2008.

**Experimental design**

Growth of both species has been measured in *ex-situ* outdoor experiments in ponds, when (i) growing them alone or altogether and (ii) increasing population densities. In addition, in 2007, measurements of *Ludwigia* stems have been performed on 10 to 15 plants.

**Results**

At the end of each annual experiment, biomasses did not present significant differences between both species giving almost the same productivity (*Egeria*: 196 ± 159 g of dry mass per m² (gDM.m⁻²) *versus* 235 ± 162 gDM.m⁻² for *Ludwigia*). No difference was observed between small or high densities likewise growing alone or altogether, showing that there are (i) self-regulation of populations in response of increasing density and (ii) neutral relationships between *Ludwigia* and *Egeria*. For each species, similar individual biomass confirmed this kind of neutral interaction, due to their different biological types: amphibious versus immerged, and also the great phenoplasticity as very characteristic of invasive species but can be an illustration of too small variation of the factor density.

Specific morphologic works on *Ludwigia* shows that total stem length increased when species were in contact (459 ± 446 cm versus 110 ± 128 cm when alone), due to legginess. At the opposite, decrease was noticed when density doubled, in monospecific (total length: 110 ± 128 cm *vs* 478 ± 402 cm) as well as in mixed populations (total length: 219 ± 232 cm *vs* 459 ± 446 cm) due to intra-population competition.
Conclusion

In our experimental conditions, evidences of neutral interaction between *Ludwigia* and *Egeria* are given and self-regulation occurs for growth parameters. For management purposes, it means that it is not relevant to use competition processes to get a better balance between both species, each of them developing its own strategy independently.
Optimising diquat use for submerged aquatic weed management

J. Clayton and F. Matheson
NIWA, National Institute of Water and Atmospheric Research, PO Box 11-115, Hamilton, New Zealand

Introduction

Diquat is a cost effective and valuable tool for submerged aquatic weed control. It has been used in New Zealand lakes and rivers for forty years but there has always been a risk of failure even when applied by experienced applicators under suitable weather conditions.

How to optimise diquat success

An experimentally derived prediction tool is under development that can assess the risk of failure based on water quality and plant condition factors. Water samples have been collected at three monthly intervals from lakes receiving large scale treatment for weed control. Samples have been analysed for turbidity, suspended solids, conductivity and dissolved anions. Samples have also been spiked with 1mg.l$^{-1}$ diquat to measure loss from adsorption and absorption. The objective has been to characterise physiochemical properties of key waterbodies to assess risk from reduced diquat effectiveness from either seasonal or water quality factors. Shoot samples have also been collected from targeted weed species at each sampling site and the amount of organic and inorganic deposits on plants has been measured and then added to a second diquat spiked sample to assess potential additional diquat loss from deposits on plants surfaces. In addition, a plant “dirtiness” scale has been devised to help predict the likely success or risk of diquat failure prior to any decision to proceed with treatment. Treatment procedures have also been revised to optimise contact time. Strategically timed follow-up applications have proven effective in depleting target weed recovery by destroying auxiliary vegetative buds before shoots of target species become more mature and resistant to diquat. Optimising the use and success of diquat is important not only in managing public confidence in use of aquatic herbicides, but also in minimising financial risk from failed treatments and for managing waterways used for commerce and other significant events such as the World Rowing Championships scheduled to be held in New Zealand in 2010.
An ecological approach to aquatic plant management: role of native plant restoration

R.M. Smart\textsuperscript{1) and M.J. Grodowitz\textsuperscript{2)\textsuperscript{)}}
\textsuperscript{1) U.S. Army Engineer Research and Development Center, Lewisville Aquatic Ecosystem Research Facility, 201 E. Jones Street, Lewisville, TX 75057 USA; \textsuperscript{2) U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199 USA}

Many of the aquatic systems in the U.S. that experience the most severe problems with nonindigenous aquatic weeds are man made. These artificial systems typically lack a healthy native plant community that could act as a deterrent to invasion by weedy species. Large natural lakes that suffer from chronic infestations of nonindigenous aquatic weeds also often feature open niches and a vulnerability to invasion that has been created by past disturbance.

Invasive aquatic weeds are disturbance specialists and take advantage of these open niches, frequently occurring in large monospecific beds and causing major problems for users of water resources. Traditional management approaches using herbicides, drawdown, or the stocking of herbivorous fish, can be effective, but typically provide only short-term results. In addition, these methods can be expensive and usually leave an empty niche that can contribute to future problems such as algal blooms or reinvasion by the same or another nonindigenous species.

A more prudent and ecologically compatible approach would be the use of an ecosystem-based, integrated pest management (IPM) program that relies heavily on ecosystem management and restoration strategies and addresses causative factors that contribute to invasive weed problems.

A key component of such a program is the establishment of a diverse community of native aquatic plants. These plants fill the empty niche and provide competitive pressure to deter, or at least delay, recovery of nonindigenous, weedy species. In addition, this approach increases the environmental and ecological value of the water body while providing a sustainable solution to the problem of nonindigenous weed infestation. By re-establishing competitive native aquatic plants and introducing a complex of host-specific herbivores and pathogens as part of an ecologically based IPM program, populations of nonindigenous weedy species can be held at non-problem levels.

There are several impediments to the recovery of a diverse native plant community in disturbed, weed-impacted systems and these generally require the application of active restorative measures. Obstacles to vegetative recovery typically include a lack of propagules, continuing disturbance, water level fluctuations, eutrophication, large populations of omnivores, and often, a recovering weed population. Our approach involves the use of founder colonies established from mature transplants introduced to favorable sites and protected from herbivory or biotic disturbance. These founder colonies then serve to vegetate the rest of the system. This presentation will examine, in detail, methods for restoring native aquatic plants as part of an ecologically based management approach.
57 Natural enemies from South Africa improve the prospects for biological control of *Lagarosiphon major* (Ridl.) Moss ex Wager (Hydrocharitaceae) in Europe

**J-R. Baars**¹, J.A. Coetzee², G. Martin², M.P. Hill² and J.M. Caffrey³

¹BioControl Research Unit, School of Biology and Environmental Science, University College Dublin, Belfield, Dublin 4, Ireland; ²Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa; ³Central Fisheries Board, Swords Business Campus, Swords, Co. Dublin, Ireland.

**Introduction**

The submersed aquatic plant, *Lagarosiphon major* (Hydrocharitaceae) is an invasive plant that causes significant problems in Europe and New Zealand. It was first recorded in Ireland in 1966 and has become noticeably invasive in the past few decades, particularly in Lough Corrib (Gavin et al. 2007). Conventional control methods are effective but alternative methods like classical biological control are necessary to achieve a sustainable control solution. Particularly as herbicides are being de-registered and the application of chemicals in waterways is considered inappropriate. Many species in the family Hydrocharitaceae, like *Egeria densa* Planchon, *Elodea canadensis* Michx, *Elodea nutallii* (Planchon), *Hydrilla verticillata* (L.f.) Royle are all significant weeds. Biological control investigations have been initiated on some of these and other submersed weeds, with significant field damage resulting from the release of a leaf-mining fly one *H. verticillata* in the USA (Owens et al. 2007).

**Survey Results from South Africa**

The genus *Lagarosiphon* is native to the African continent and Madagascar, and *L. major* is known from southern Africa (Symoens & Triest 1983). An exploratory survey was completed in South Africa from the southern parts of the Eastern Cape to Mpumalanga Province, with particular focus on the cooler parts in the east of the country along the Drakensberg mountain range. Records from herbarium specimens and other site records focussed the searches, and over 65 reservoirs and some rivers were investigated. Two species, *L. major* and *L. muscoides* Ridley were surveyed, and material was examined from each site and dissected in field laboratories. The plant material and insect specimens were maintained during the trip in order to rear out individuals, to initiate cultures and confirm identifications. A number of natural enemies were recorded during the two week period. The most promising candidate biocontrol agents include leaf-mining flies (Ephydridae), and leaf and stem feeding weevils (including *Bagous* spp.). The natural enemies recorded and their potential as biocontrol candidates is presented. The prospect for the biological control of *L. major* in Europe and the implications for other introduced submersed plant species are discussed.
References


58 Monitoring the effects of repeated herbicide application on *Lygodium microphyllum* and native vegetation at A.R.M. Loxahatchee national wildlife refuge

J.T. Hutchinson and K.A. Langeland
*University of Florida, Agronomy Department, Center for Aquatic and Invasive Plants, Gainesville, Florida, USA*

Introduction

Old World climbing fern (*Lygodium microphyllum*) is considered one of the most invasive non-native plants in natural areas of southern Florida. In 2005, this invasive fern covered ca. 50,000 ha in southern Florida since it was first documented in 1958. The rapid spread of *L. microphyllum* in Florida can be attributed to small (< 65 µm) wind blown spores that can travel long distances in normal prevailing southeast winds and spread even further by tropical storms and hurricanes. Infestations of *L. microphyllum* often occur in natural areas such as the Florida Everglades that are remote and inaccessible to vehicles and personnel due to inundated and mucky soils, making treatment difficult.

Results

In 2005, we began a four year project to evaluate the effects of aerial application of glyphosate (2.40 kg a.e./187 l/ha and 4.70 kg a.e./187 l/ha) and metsulfuron methyl (0.08 kg a.i./187 l/ha and 0.17 kg a.i./187 l/ha) to control of *L. microphyllum* and to monitor the response of native plants on tree islands at A.R.M. Loxahatchee National Wildlife Refuge. Initial aerial herbicide treatments reduced the coverage of *L. microphyllum* from >70% to <10%, but also resulted in significant loss of native vegetation. Additional aerial herbicide application would have resulted in the loss of most native ground cover and a substantial loss of tree canopy. In 2006 and 2007, all remaining *L. microphyllum* was spot-treated on a spray-to-wet basis by ground applicators at rates of 2 and 4 % product for glyphosate, and 0.06 kg a.i./379 l and 0.12 kg a.i./379 l for metsulfuron methyl. We found that application of metsulfuron methyl provided significantly better control of *L. microphyllum* on Everglade tree islands, resulted in less non-target damage to native plants and greater survival of canopy trees than glyphosate. Yet, even after three herbicides applications, we still observed new sporophytes and re-growth of *L. microphyllum* on tree islands indicating that management of the fern will require long-term commitments to monitoring and control. Complete results of the project will be presented at the meeting.
59 An ecological approach to aquatic plant management: role of insect biocontrol

M.J. Grodowitz¹ and R.M. Smart²
¹ U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199 USA; ² U.S. Army Engineer Research and Development Center, Lewisville Aquatic Ecosystem Research Facility, 201 E. Jones Street, Lewisville, TX 75057 USA

Nonindigenous aquatic weeds frequently occur in large monospecific beds, particularly in man-made, water resources projects such as multipurpose reservoirs and waterways, often causing major problems for users of these water resources. Traditional management approaches using herbicides, drawdown, or the stocking of herbivorous fish, can be effective, but typically provide only short-term results. In addition, these methods can be expensive and usually leave an empty niche that can contribute to future problems such as algal blooms or reinvasion by the same or another nonindigenous species.

A simple, yet often used concept of integrated pest or plant management (IPM) is one where all available management options are considered as part of a toolbox or arsenal. These tools/weapons are then used singly or in combination in an effort to maximize control without impacting the use of one or more strategies. While this approach can be effective it, too, tends to provide only short-term control by neglecting the underlying reasons for the formation of the infestations. A more prudent and ecologically compatible approach would be the use of an ecosystem-based IPM program that relies heavily on ecosystem management and restoration strategies and addresses causative factors that contribute to such formations.

A key component of an ecosystem approach is the use of host-specific biocontrol agents. Most of the economically important invasive/nuisance aquatic plants are introduced species that have escaped their host-specific herbivores and pathogens. In addition to the plants’ high intrinsic rates of increase, the lack of sustained feeding and resultant damage allows the formation of extensive monospecific infestations. By introducing a complex of host-specific herbivores and pathogens and re-establishing competitive native aquatic plants as part of an ecologically-based IPM program, populations of nonindigenous weedy species can be held at non-problem levels. This presentation will examine, conceptually, the role of insect biocontrol as an integral part of an ecologically based management approach. Examples will be drawn from a variety of sources with the majority arising from the hydrilla leaf-mining research conducted in the US over the last several years including tank, pond, and in-field studies.
60 Relationships between characteristics of the biomass production of *Ludwigia* species and features of colonised biotopes in France. Proposition of a simple model to improve their management

E. Lambert\(^1\), J. Coudreuse\(^2\), A. Dutartre\(^3\) and J. Haury\(^2\)

\(^1\)Centre d’Etude et de Recherche sur les Ecosystèmes Aquatiques (CEREA/IBEA – IREA), 44 rue Rabelais – U.C.O. - BP 10 808 – 49008 Angers cedex 01, France; \(^2\)UMR INRA-AGROCAMPUS OUEST Ecologie et Santé des Ecosystèmes, 65 rue de Saint Brieuc CS 4215 – 35042 Rennes Cedex, France; \(^3\)Cemagref, UR REBX, 50, Avenue de Verdun, 33612 Cestas Cedex, France

In France, *Ludwigia grandiflora* subsp. *hexapetala* and *L. peploides* subsp. *montevidensis* invade many types of soft ecosystems as lakes and ponds (25.0% of colonised sites), rivers (31.2%), oxbows (10.8%), channels and ditches (20.5%) and wetlands and water meadows (12.5%).

Evaluations of standing crop, in kg dry matter per m\(^2\) (kg DM.m\(^-2\)), show very variable results. In a meander of a eutrophicated still river, average *L. grandiflora* biomass reached 4.5, and only 0.5 in a swift river. In muddy oxbows completely covered by the species, biomass can reach 4.2. In still areas of lakes, mean biomass of *L. grandiflora* reached 3.5, while in wave-exposed habitat, it was only 0.9. In heavily colonised parts of shallow lakes it was around 2.3, but in competition with *Paspalum distichum* it dropped to only 0.2. For flooded wetlands, the mean biomass was 2.2 while in water meadows it was from 0.3 to 2.7 kg DM.m\(^-2\), depending on flooding and plant colonisation. In sunny conditions, optimal for these plants and in nutrient rich areas, biomass is more important. Waves, wind, current velocity have a negative effect on standing crop. Depth, flooding regimes, soil moisture, are key factors for plant production as well as for removal work.

The prediction of extracted plant biomass quantities for every control method could help considerably plant removal while permitting a better choice of mechanical material, or of necessary numbers of workers for hand pulling. In general work is done as soon as possible to remove aquatic morphological types of the plants more easily than terrestrial forms, and to avoid autumn maximum biomasses and fruiting. Removal must also be achieved when plants are strong enough not to break during manual extraction and in moderate conditions of current, with sufficient water depths letting the plants rise up out of sediments. In rivers, side arms or ponds, mechanical and manual extractions must be undertaken as soon as the accessibility is possible. In wet meadows, even if the biomass is lower, work and number of workers will be more important because mechanical work is generally not possible: thus intervention must occur when flooding, as drying leads to compact soils and to the impossibility of pulling plants. Transportation and processing of plant biomass after removal are also directly connected with plants quantities. Scattering of plant beds in the work site, accessibility for the mechanical material, boats, distance of transportation toward the sites of processing, should also be integrated.
Monitoring invasive *Ludwigia grandiflora* in the Vilaine Basin using multispectral remote sensing

A. Sourisseau¹, J. Haury², B. Bottner³, R. Amri ⁴ and H. Nicolas⁵

¹AGROCAMPUS OUEST Rennes; ²Agrocampus Ouest Rennes - Département Agriculture, Espace Rural et Environnement - Laboratoire d’Ecologie et Sciences phytosanitaires, 65 rue de Saint Brieuc, CS 84 215 F35042 Rennes Cedex; ³Institution d’Aménagement de la Vilaine, 56130 La Roche-Bernard. ⁴INAT; ⁵AGROCAMPUS OUEST - Département Sciences de l’ingénieur - Laboratoire Physique des surfaces naturelles et génie rural.

*Ludwigia grandiflora* (Water primrose) is an aquatic invasive species in the Vilaine Basin (North-West of France). It invades rivers, lakes and marshes and it can develop a terrestrial form in floodplains. Its dense mats cause changes in ecosystem functioning and undermine both human fishing activities and navigation. It is spreading through vegetative growth from cuttings and flooding allows dispersion far away. To control it, management must be realised at catchment river scale.

Maps of a large area and for inaccessible sites can be produced from remote sensing images. Remote sensing data are SPOT 5 data have been acquired during summer, when water primrose forms large and dense mats and is flowering, for the years 2003 and 2005. For these years, maps of *L. grandiflora* distribution are available. In order to use a supervised classification, nine classes have been identified with visual interpretation. Pixels are selected on a site where stands of *L. grandiflora* are large and dense. The defined classes are: water primrose, aquatic vegetation (few dense and with a lower spectral response in the near infrared than water primrose), 4 classes for crops, 2 classes for forest, and water. Firstly, no class for amphibious vegetation is defined, because it forms heterogeneous stands, with spatial variability in species and density. The classification based on these pixels is applied on two other sites, distant from 15 km: a marsh where mats of *L. grandiflora* are in mixture with water and other amphibious vegetation and a site with lakes and a network of channels. This extension is realised to assess if it is possible to map *L. grandiflora* on a large region, with data from a localised site. Results are compared with historical maps and experts knowledge about colonisation by water primrose of aimed sites. The distinction/confusion between water primrose and the other classes, and with amphibious vegetation is studied in order to define precisely the accurate of obtained maps. These results show that remote sensing is useful to map large stands of water primrose and is a base to monitor evolution of colonisation by this species. Complementary researches are needed to determine minimal size of mats that can be detected with this type of sensor and to define confusion sources, which appear during classifications.
Hyperspectral remote sensing of the aquatic invasive plant, *Ludwigia grandiflora*, in North-West France

R. Amri¹, H. Nicolas¹, A. Sourisseau¹, B. Bottner⁰ and J. Haury²

¹ and ²: Agrocampus-Ouest, 65 rue de Saint-Brieuc, 35042 Rennes Cedex (France)

1) UMR Sol - Agro et hydrosystème – Spatialisation, 65 rue de Saint-Brieuc, 35042 Rennes Cedex (France); ²UMR Ecologie et santé des écosystèmes, 65 rue de Saint-Brieuc, 35042 Rennes Cedex (France); ³Institut d’aménagement de la Vilaine, boulevard de la Bretagne, 56130, La Roche Bernard (France)

The Vilaine catchment (North West of France) is invaded by the water primrose *Ludwigia grandiflora*, since the 1980’s. Invasions by this aquatic weed in marsh and floodplain reduce the ecological quality of water habitats. This species is rapidly spreading through the river network within those fragmented habitats and its dispersion is mainly due to floods. Managers need precise maps of water primrose, which often grows in inaccessible areas. An early detection and a fast response to invasions are needed. Remote sensing appears to be a relevant tool for identification and detection of this invasive plant under those conditions and the objective of this study is to precise the feasibility of the remote sensing methodology in this context.

We recorded field measurements of the reflectance spectra from water primrose and other aquatic vegetations with a high spectral resolution hand-held spectroradiometer. Measurements were carried out between April and September 2008 on three sites representative of different development conditions of water primrose.

These measurements show high spectral and temporal variability of principal aquatic plant species. We showed by discriminant analysis that the variability of water primrose canopies reflectance is more influenced by the local environmental conditions than by the distance between two infested zones: intra-site variability is higher than inter-site variability.

A cartography of water primrose canopies seems possible at a large scale independently of the constraints associated with the remote sensing imagery.

We demonstrated that water primrose can be easily distinguished on the basis of discriminant analysis using reflectance data, in spite of this high spectral variability of water primrose canopies at particular period of year corresponding to specific phologenic stages.

We quantify the precision of the discrimination between several aquatic vegetal species using separability index calculated from contingency matrix. The optimal period for the remote sensing data acquisition extends from July to probably August. Around this period the precision decreases but remains sufficient for its discrimination in June and in September.

The most relevant wavelengths for discrimination are the Red-edge (730 nm), the near-infrared (higher than 750 nm) and the green (540 nm).

This study brings the basic elements for the organisation of a remote sensing mission for the cartography of the water primerose. Further research is needed to study the extension from ground radiative measurements to aerial and satellite remote sensing. Another prospect is the analysis of remote sensing potentialities for the study of the risks of the dissemination of water primrose.
Mayaca fluviatilis Aubl.: an ornamental aquatic with invasive potential in Sri Lanka

K. Yakandawala
Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Sri Lanka

The ornamental aquatic plant industry in Sri Lanka has grown substantially during the last decade and there is a renewed demand for exotic species. *Mayaca fluviatilis*, a submerged plant used as a background plant in aquaria is not a naturally occurring plant in Sri Lanka. However, recent studies recorded it as naturally occurring in two water bodies in Sri Lanka and certain countries recognised it as a problematic plant. The knowledge of mode of propagation of the invading species is vital in efficient management of biological invasions. Therefore, the present study was conducted to investigate the propagation ability of fragmented vegetative parts of *M. fluviatilis*.

Terminal stem cuttings with five different lengths viz. 2, 4, 6, 8 and 10 cm were used as treatments and four cuttings for each treatment were planted in a glass container filled with 400 ml of water and 50 g of media. The containers were laid out in a completely randomised design representing 15 replicates per treatment and the experiment was repeated. All the cutting types increased their lengths and produced new shoots and roots. There was an effect of length of stem cuttings on number of roots (p < 0.0001) and number of shoots (p < 0.0022) produced. When the length of stem cuttings increased, number of roots also increased significantly except for cuttings between 4 and 6 cm long. Therefore, increasing lengths of stem cuttings have a significant effect on number of roots. When the length of stem cuttings increased, the number of shoots increased significantly only between 2 cm long stems cuttings and all the other cutting types. However, there was no significant difference among other levels. Nevertheless, as even the 2 cm fragment is capable of developing into a new plant, it is recommended to remove even the smallest fragments to control this plant.

Submerged plants can spread easily through fragmentation and mechanical control will likely increase its spread. Nevertheless, it is recommended for smaller areas (Aquatic Ecosystem Restoration Foundation, 2005). Therefore, repeated removal of plant parts can be suggested as ecologically sound management approach to prevent further spread of *M. fluviatilis* since it is in the early stage of establishment.

References
64 Spreading of emergent weed species and occurrence of invasive species in hydromeliorative facilities in the northern part of the Republic of Serbia

B. Konstantinovic, S. Stojanovic, M. Meseldzija and Lj. Nikolic
University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia

Introduction

Weeds in canals are plants that obstruct their normal functioning. Often, accumulation of these plants may seriously hamper the water flow. Non-native or exotic plant species are undesirable due to their growth potential and the fact that they replace native species. It is not very likely that they can be totally controlled, therefore they are considered as ‘naturalised florae’. Due to human intervention, new ornamentals, medical, spicy, melliferous and other plant species, have frequently been introduced into new areas. After a certain period, they may further spread and gradually become dominant, aggressive weeds, which are difficult to control. These introduced adventive plant species endanger the survival of native ones; including even some geographically important endemic species. Together with adventive plant species, organisms that are pathogenic to native plants but not for introduced ones, can be brought in. In such a case, epidemic diseases and significant biodiversity reduction in aquatic habitats can occur.

Introduced species in the hydrosystem Danube-Tisa-Danube

The hydrosystem Danube-Tisa-Danube is an anthropogenic ecosystem designed to solve water facility problems of Vojvodina, the northern part of the Republic of Serbia. In some parts of the second rank canals of the South Backa Danube, huge populations of the following invasive species have developed along the banks: Amorpha fruticosa L., Asclepias syriaca L. (Konstantinovic et al. 2008), Ambrosia artemisiifolia L., Solidago serotina Ait. and Reynoutria japonica Houtt. In the floating weed vegetation large populations of the mosquito fern Azolla filiculoides Lam. were observed, while in submersed populations the species Elodea canadensis Rich. appeared highly abundant, covering large stretches (Stojanovic et al. 2009). In the paper an ecological and phytocenological analysis of various invasive species will be presented. Concerning the control of these adventive weed species (Konstantinovic et al., 2007), these data also have a huge practical significance, as their management will increase optimal functioning of the irrigation canals.

References


65 Water pest (*Elodea canadensis* - Michx.) as an important ecological and economical problem for the hydro-power plant – Varaždin-North in Croatia

V. Lodeta¹, I. Somodi², N. Novak⁹, G. Zrinski²
¹ Institute for Plant Protection in Agriculture and Forestry, Svetošimunska cesta 25/V, 10040 Zagreb, Croatia; ² Croatian Power Board, Power Generating Area Hydro North, Međimurska 26c, 42 000 Varaždin, Croatia

**Introduction**

The Varaždin-North is one of the 22 hydropower plants (HPP’s) along the 720 km long Drava river. The number of HPP’s along the river in Austria, Slovenia and Croatia is respectively, 10, 9 and 3. To prevent the three HPP’s in Croatia from an overflow, multi-purpose reservoirs have been created, which play an important role in the cultural and social life of the inhabitants.

The area surrounding the Varaždin-North HPP and its reservoir are protected as a future NATURA 2000 area. It is a habitat for migrating birds of northern Europe. The reservoir is surrounded by agricultural fields and a few small settlements in Croatia and the city of Ormož, with a sugar plant nearby in Slovenia. As a consequence mineral and organic contamination of the reservoir and the river occurs. The water level of the river Drava and the reservoir highly depends on overall rainfall quantities upstream (rain and snow meltdown in the Slovenian and Austrian Alps) and varies to a large extent seasonally and yearly. Water levels considerably influence the dynamics of alluvion in shallow parts of the reservoir, where the water is relatively stagnant.

**Water pest as ecological and economical problem**

The dominant macrophyte species in the river is water pest (*Elodea canadensis*), which completely overgrows the bottom, and subsequently forms a dense vegetation. It hampers the water flow in the reservoir and large masses of plants, which become detached from the river bed, jeopardise surrounding villages as well as the hydroelectric facility.

Seasonal development of water pest begins in spring, after the increase of the temperature and the water flow. It reaches its maximum by the end of summer. In this period an increase in power consumption requires an increase in HPP production. As a result of the higher rate of the water flow off the reservoir, water pest masses float into the turbines of the HPP.

A sustainable development programme, which can be defined as ecohydrology, became imperative for harmonising the relationship between energy demand and environmental sustainability. Interaction between climate, ground, water flow and vegetation leads to differences in the biotopes.

In 2007, the three HPP reservoirs in Croatia became protected areas, as future parts of NATURA 2000. As a secondary biotope rich with ichthyofauna, they also became a SPA biotope (Special Protected Area, Council Directive 79/409/EEC).
As the rapid growth of water pest could endanger native wildlife and the functioning of the power-plant, the responsible authorities started an experiment to remove submersed water pest plants with a multi-purpose vessel dredge.

References
Bonacci, O. 2003. Ecohydrology Water Resources and Outdoor Watercourse, Faculty of Civil Engineering of Split, Institute of Construction Croatia, Zagreb, Croatia.
Invasive plants and their ecological effects
Impact of invasive species on ecosystem goods and services of wetlands

B. Gopal
School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110067, India.

Invasive species are generally the organisms which have been introduced intentionally or accidentally outside of their natural range, get established in natural or human-modified ecosystems, and cause significant changes in the ecosystem characteristics. Exotic invasive species have been recognised by the Convention on Biological Diversity as the greatest threat, next to habitat destruction, to the conservation of biodiversity. In wetlands, invasive plant species often become the agent of habitat destruction itself. These species are characterised by their explosive growth rates facilitated by a variety of factors, and better competitive ability than the native species which they replace. Among the major invasive plants in wetlands are water hyacinth (distributed worldwide in the tropics and subtropics), \textit{Salvinia molesta} in Africa and South/Southeast Asia, \textit{Ipomoea carnea} in India, \textit{Lythrum salicaria}, \textit{Phragmites australis}, \textit{Melaleuca quinquenervis} in North America, and \textit{Arundo donax} in western Europe. \textit{Phalaris arundinacea}, \textit{Polygonum cuspidatum}, \textit{Mimosa pigra}, \textit{Spartina anglica} and \textit{Tamarix ramosissima} are other common invasives. Sometimes, even the native species become ‘invasive’ in human-impacted systems. For example, \textit{Typha angustifolia} has invaded the Everglades by taking advantage of increased nutrient availability, particularly phosphorus, and replaces the characteristic \textit{Cladium mariscus}. Similarly, an increased supply of nitrogen favours colonisation of \textit{Phalaris arundinacea} and \textit{Phragmites australis}.

Invasive species are of special significance to the wetland ecosystems which, as a consequence of their location between terrestrial upland and deep open water habitats, are exposed to invasion by species from both ends. Natural variability in the habitat factors (such as water level, nutrient regimes and edaphic characteristics), and anthropogenic changes in habitats (e.g., creation of standing water bodies) contribute to the successful establishment of the invasive species. Water level changes, coupled with fire, are attributed to the success of \textit{Melaleuca} in replacing \textit{Taxodium distichum} in south Florida swamps. However, many invasive aquatic/wetland plant species significantly modify the hydrological and nutrient regimes which in turn affect the plant communities and their associated fauna, the food chain interactions and the pathways and magnitudes of ecosystem functions. Free-floating species modify the physico-chemical environment under them (cast shade, reduce gaseous exchange and create hypoxic to anoxic conditions with associated chemical changes), and consequently modify the biodiversity significantly. These changes translate into the loss of ecosystem goods and services from a large variety of wetlands in both tropical and temperate regions and in both inland freshwater and coastal wetlands. Species differ in their contribution to methane emission, carbon sequestration, nutrient cycling, evapotranspiration, providing habitats to fauna, impacts on water quality, and promotion of disease vectors. Invasive species often reduce the aesthetic value, recreational use or resource use of the wetlands. The globalisation and the projected climate change are likely to favour the spread of invasive species. This overview of our current understanding of the impacts of invasive species on wetlands emphasises the need for including their management in wetland conservation programmes.
67 Growth behaviour of the invasive species *Ipomoea carnea* Jacq. in the Nile Delta, Egypt

K.H. Shaltout\(^1\), Y.M. Al-Sodany\(^2\) and E.M. Eid\(^2\)

\(^1\) Botany Department, Faculty of Science, Tanta University, Tanta, Egypt; \(^2\) Faculty of Education, Kafr El-Sheikh University, Kafr El-Sheikh, Egypt

**Introduction**

*Ipomoea carnea* Jacq., a native shrub of South America, grows in dense populations along the river beds, banks, canals and other waterlogged (wetland) areas. It has become a naturalised species along the canals, drains, road sides and field edges in Nile Delta, Egypt. The rapid growth rate, spread, and adaptability from aquatic to xerophytic habitats, indicate that this plant may potentially become another ecological disaster, like water hyacinth, in Egypt.

**Methods**

Fifty stands were established to cover seven habitats (railway sides, waste lands, road sides, drain and canal banks, road dividers and field edges) in the Nile Delta. In each stand, several ramets were permanently marked to estimate monthly variations in some growth variables such as phenology, height and diameter of the ramet canopy, number of flowers, leaves, fruits and inflorescences.

**Results and Discussion**

The growth of *Ipomoea carnea* follows a seasonal pattern where it grows fastest during September and October. The present results indicated significant variation in its growth variables in relation to habitat types. Generally, *Ipomoea carnea* populations along the railway sides and field edges had the lowest values of most growth variables, while those of the road dividers, road sides and canal banks had the highest values. The highest values of most growth variables were obtained during September and October, while the lowest were during June and July. The highest flower and fruit production were obtained during September till December. Similarly, it was indicated that the flowering time varied in relation to habitat types; it began earlier at the road sides and canal banks, but later in the railway sides, road dividers and waste lands. Generally, the leaf area of the *Ipomoea carnea* population in the wet habitats (e.g. drain and canal banks) was higher than that in the other habitats. These results had been discussed and compared with other related studies.

**References**


Changes in littoral invertebrate communities in Lough Corrib in response to an invasion by *Lagarosiphon major*

**E. Keenan**, J-R Baars and J.M. Caffrey

1) BioControl Research Unit, School of Biology and Environmental Science, University College Dublin, Belfield, Dublin 4, Ireland; 2) Central Fisheries Board, Swords Business Campus, Swords, Co. Dublin, Ireland.

**Introduction**

Increased world-wide travel and trade has led to the introduction of many invasive plant species beyond their native countries. Invasive species have altered local ecosystems by changing species composition, population structures and trophic interactions. *Lagarosiphon major* (Hydrocharitaceae) a submerged aquatic species native to southern Africa was first recorded in one of Ireland’s largest freshwater lakes Lough Corrib, Galway, in 2005. Although rapidly expanding its distribution, infested bays have dense monotypic stands with a closed canopy near the water surface which restricts light penetration and out competes native and exotic macrophytes.

Submerged and floating aquatic macrophytes are an integral component of littoral ecosystems. They directly and indirectly affect the composition of other biotic components by creating complex habitats which provide refuge for aquatic organisms against predation, increase epiphytic algae, change nutrient dynamics, effect productivity, alter temperature profiles, and prevent the re-suspension of lake sediments (Carpenter & Lodge 1986; Warfe & Barmuta 2004; Bickel & Closs 2008). Although many plant species are fed on by phytophagous invertebrate species directly, macrophytes are generally considered to provide a substrate for colonisation and indirectly affect trophic web structure (Cheruvelil *et al*., 2002; Kelly & Hawes, 2005).

**Invertebrate changes in Lough Corrib**

The species richness, relative abundance, community structure and biomass of invertebrates were used to assess the changes that occur when plant communities shift from a native plant community to a monotypic invasive plant. Changes in the vertical complexity of submerged macrophytes were induced by a shift from a predominant *Charophyte* spp. plant bed (of up to 1m) to a vertically diverse plant stand of *L. major* (in up to 4 m of water depth). We investigate the hypothesis that the vertical changes in plant structure affect the distribution of invertebrates in species richness, abundance, and biomass. Samples were collected from three bays at seasonal intervals, and collected to assess the influence of depth using modified net samplers. Results indicate that species richness was similar, but invertebrate community structures were distinctly different in native and *L. major* habitats. No consistent pattern in biomass was found, in part due to the spatial changes in communities, but the most notable differences occurred in the vertical distribution of certain taxa, like *Bithynia tentaculata* (and other gastropods), Crustacea and Chironomidae. This study indicates how a dominant invasive macrophyte can change littoral ecosystems resulting in further trophic web changes.
References


69 Are phenotypic differences in invasive aquatic plant species caused by phenotypic plasticity or locally adapted ecotypes?

T. Riis\textsuperscript{1)}, B. Olesen\textsuperscript{1)}, C. Lambertini\textsuperscript{1)} J. Clayton\textsuperscript{2)}
\textsuperscript{1)} Dept. of Biological Sciences, Aarhus University, Denmark; \textsuperscript{2)} National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand

Invasive aquatic plant species usually have a great variety in phenotypic characters among populations and can dominate in a wide range of habitats. Basically two different hypotheses can explain this phenomenon: phenotypic plasticity hypothesis and ecotype hypothesis. The phenotypic plasticity hypothesis suggests that differences in plant characters and domination in a wide range of habitats among populations are caused by phenotypic plasticity induced by environmental conditions. On the other hand, the ecotype hypothesis suggests that there are locally adapted ecotypes in an introduced area, and that differences in plant characters and domination in different type of habitats among populations are due to genetic differences between populations.

In this study we sampled populations of three invasive species in the North Island of New Zealand (\textit{Egeris densa}, \textit{Lagarosiphon major}, \textit{Elodea canadensis}). Populations showed a great variety in phenology and occurred in a range of different habitats. The plants were grown in a common garden to explore if differences among populations were disappearing (supporting phenotypic plasticity hypothesis) or if differences among populations were sustained (supporting ecotype hypothesis). No results are yet available but will be presented at the meeting.
Impact of aquatic invasive species on native plant and benthic invertebrate assemblages in Belgian ponds

I. Stiers\textsuperscript{1)}, N. Crohain\textsuperscript{2)}, G. Josens\textsuperscript{2)} and L. Triest\textsuperscript{1)}

\textsuperscript{1)}Plant Biology and Nature Management, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium; \textsuperscript{2)}Ecologie et Systématique Animales, Université Libre de Bruxelles, Avenue F.D. Roosevelt 50, 1050 Bruxelles, Belgium

Aquatic weeds

Invasive plants are one of the most serious threats to native species assemblages and have been responsible for the degradation of natural habitats worldwide. Aquatic plants have been widely introduced around the world by horticulture and the aquarium trade. Because different aquatic plants can have contrasting effects on water chemistry, habitat structure and food resources, they can have dramatic effects on many parts of aquatic ecosystems. Aquatic invasive species such as \textit{Ludwigia grandiflora}, \textit{Myriophyllum aquaticum} and \textit{Hydrocotyle ranunculoides} create monotypic floating mats and may therefore alter the available structure in an aquatic habitat. However, little is known about the impact of these invasive species on native vegetation and their associated food webs at pond level.

Objectives

We investigated the hypothesis that both native plant species assemblage and macroinvertebrate community structure are affected by invasive species. We used the space for time substitution approach e.g. comparing invaded and non-invaded sites. Up to 32 Belgian ponds were selected for this study with a cover gradient of one of the studied invasive species (range 0-100\%). Most of them were located in sites of high biological value (nature reserves, Natura 2000...).

Impact of invasion

Our findings indicate that invaded ponds, regardless of the invasive species present, supported lower number of plant species and lower Shannon diversity compared to non-invaded ponds with submerged vegetation most vulnerable to invasion. Macroinvertebrate abundance was significantly lower in invaded ponds, while invertebrate taxon richness was not affected. No significant difference at the level of major invertebrate feeding guilds (detritivore, herbivore, predator) could be detected between invaded and non-invaded ponds. However, indicator taxa did differ significantly between non-invaded and invaded ponds, suggesting a change in species composition. Native plant species richness was significantly positively correlated with total invertebrate abundance among invaded sites suggesting a link between the replacement of native species by an invasive species and the reduction in overall invertebrate abundance. A density effect of the alien cover was shown for both native plant species and macroinvertebrates: with increased alien cover, the native plant cover, macroinvertebrate abundance and taxon richness decreased.
The data suggest that a shift from a rather diverse vegetated habitat to a highly homogenous habitat (e.g. invasive *Ludwigia, Myriophyllum* or *Hydrocotyle*) can pose a threat to native plant species and macroinvertebrate community structure.
Comparative performance between invasive alien *Eichhornia crassipes* and native *Ludwigia stolonifera* under nutrient non-limiting conditions: Lake Naivasha, Kenya

J. Njambuya and L. Triest  
*Plant Biology and nature Management (APNA), Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium*

**Aquatic weed context**

The spread of invasive alien species is now recognised as one of the greatest threats to the ecological and economic well-being of the planet. Invasive plants often grow aggressively and form monocultures by outcompeting less vigorous native plants for light and space. *Eichhornia crassipes* (Mart.) Solms, is an indigenous monocotyledonous species of tropical South America that has become a widespread exotic pest of tropical zones. The species first appeared in Lake Naivasha in 1988 and is now well established on the shore where it forms floating mats. These floating mats are often colonised by other aquatic, wetland and terrestrial plant species. *Ludwigia stolonifera* (Guill. and Perr.) P.H. Raven is a native creeping emergent macrophyte and is one of the most frequent herbaceous species that colonises these floating mats.

**Objective**

The ability of *L. stolonifera* to thrive in the presence of *E. crassipes* was investigated with an aim of determining the impacts of the highly invasive *E. crassipes* (competitive effects) on native plants with *L. stolonifera* as the model native macrophyte. An outdoor experiment comprising of both monocultures and mixtures under nutrient non-limiting conditions was conducted following an additive series design with eight combinations of planting densities and four replicates for 98 days.

**Ludwigia stolonifera outperforming Eichhornia crassipes**

Our results indicate that *L. stolonifera* had a significantly higher average relative growth rate (RGR) compared to *E. crassipes* and therefore accumulated more biomass relative to *E. crassipes*. A comparison between monocultures and mixtures of *E. crassipes* revealed no significant differences in RGR’s and root/shoot ratio. However, significant differences in RGR’s and root/shoot ratio between monocultures and mixtures of *L. stolonifera* were observed. Doubling the initial biomass of *E. crassipes* resulted to a significant increase in roots relative to shoots allocation in *L. stolonifera*. Analyses on effects of neighbours on a species RGR shows that, increasing initial biomass of a conspecific neighbour resulted to a greater reduction in a species own RGR relative to increasing initial biomass of a heterospecific neighbour. This signifies a stronger intraspecific than interspecific competition which, coupled with the significantly higher RGR of *L. stolonifera* relative to that of *E. crassipes*, enabled *L. stolonifera* to
outperform *E. crassipes*. This emphasises the relative importance of species identity in determining the outcome of competition and hence its relevance in identifying vulnerable native species that can be easily outcompeted by faster growing invasive alien species on basis of species identity.
72 Relationships between alien or invasive water plants and native or rare water plants at multiple spatial scales

N. Willby
Department of Biological and Environmental Sciences, University of Stirling, UK

The twentieth century has seen an increase in the numbers and populations of alien water plant species in Europe, and the parallel decline in many native species. Although it is commonly accepted that invasive species represent a major threat to freshwater biodiversity it is unclear how closely the above phenomena are inter related. Establishing an evidence base for invasive species impacts is a critical step in prioritising their management, undertaking risk assessments and justifying funding of control efforts. This paper (i) assesses the relationships between numbers of alien, invasive, native and rare native species at multiple spatial scales, regional (10 x 10km), water body and sub water body, using Britain as an example; (ii) examines the relationships between cover of invasive species and the number and cover of native and rare native species at water body and sub-water body scale, comparing these with the relationships between naturally dominant native species and the number and cover of native species; (iii) investigates the relationships between cover of invasive species at a water body scale and various environmental pressure indicators (e.g. nutrient concentrations, intensity of catchment land use) to determine whether invasive species can be regarded as a unique pressure, or whether they are effectively a symptom of other anthropogenic disturbances. Results indicate that the impacts of invasive water plants on native plant diversity are highly scale dependent, and are most readily apparent at much smaller sampling scales than those conventionally used when sampling or assessing aquatic vegetation. Thus at water body or coarser scales it is possible for diversity of native or rare native species to persist with high cover of invasive species but not at transect or quadrat scales. Consequently, the latter may be more appropriate than whole water body surveys for evaluating impacts of invasive species or for comparing the degree of impact of different species. There is clear evidence in the form of nutrient concentrations and catchment land cover that dominance of lakes by invasive taxa is principally a feature of disturbed catchments with high nutrient loading, thus illustrating the difficulty of isolating ecological effects of invasive species from those of external pressures.
73 Habitat characteristics of the alien species *Elodea canadensis*

**U. Kuhar, M. Germ and A. Gaberščik**
Department of Biology, Biotechnical Faculty, University of Ljubljana, Večna pot 111, 1000 Ljubljana, Slovenia

**Introduction**

Macrophytes are fundamental to the structure and functioning of river habitats exhibiting important roles in energy flow, nutrient cycling, and sedimentation processes. The presence of alien species in the watercourses indicates disturbed environment that needs special approach. Alien species are very successful in competing for resources with native species. Their spreading is mainly the consequence of habitat change, reduction and destruction. We presume that among alien species *Elodea canadensis* is the most abundant in watercourses in Slovenia. We also presume that it is less abundant in preserved watercourses e.g. in karst region where natural disturbances i.e. floods prevented intensive human activity (Šraj-Kržič et al. 2007).

**The presence of *Elodea canadensis* in Slovenian watercourses**

The distribution, abundance and habitat characteristics of alien species *Elodea canadensis* were surveyed in watercourses in Slovenia. The accompanying plant community was also examined. The distribution and abundance of macrophytes were assessed on stretches of different lengths using a 5-degree scale following the methodology of Kohler & Janauer (1995). The habitat assessment was based on 12 parameters of RCE inventory proposed by Petersen (1992). *Elodea canadensis* appeared in 132 out of 1217 stretches examined and in 12 watercourses out of 39 surveyed in whole. It was not found as single or prevailing species in any stretch. It was absent from the watercourses in karst region, due to frequent water level fluctuations and occasional intermittence. Its preferable habitat was mainly close to the shore in relatively deep water with low flow velocity and soft sediment. It frequently grew in the company of *Callitriche* spp., *Hippuris vulgaris*, *Sagittaria sagittifolia*, *Nasturtium officinale* and different species of *Potamogeton*. In Slovenia alien species *Elodea canadensis* does not express its invasive character presumably due to variable landscape and high heterogeneity of watercourses.

**References**

74 Aquatic plant invasions – predicting success

D. Hofstra, P. Champion and J. Clayton
National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand

New Zealand is an island nation, comprised of two large and many smaller islands, located in the South Pacific Ocean. It has a warm to cool temperate climate with moderate rainfall, and a landscape that was originally largely forested, with a wealth of pristine lakes and rivers, which have been dramatically altered since the arrival of people, primarily through changes in land use and the introduction of plants and animals. Settlers introduced a succession of new plants and animals: for food and cultivation as crops, as well as for ornamental and aesthetic reasons, and accidentally as 'hitchhikers' with other imports.

Aquatic plant species have had spectacular success in invading New Zealand lakes. Amongst the native aquatic flora there are 38 endemic species (which is relatively few compared with other temperate land masses) and there are a limited range of life form types (Coffey & Clayton 1988). The continued introduction and spread of invasive alien species has resulted in few water bodies retaining their natural or original indigenous aquatic vegetation, and a number of adverse changes can be associated with the establishment of the invasive aquatic weeds such as reduced biodiversity and amenity values. This highlights the need to accurately assess aquatic plant species that are already in the country and those outside for their potential to have a negative impact New Zealand’s lakes and waterways.

The competitive performance of known and potential weed species in New Zealand, including (Hydrilla verticillata, Hygrophila polysperma, Hydrocotyle verticillata, Cabomba caroliniana, Saururus cernuus) have been evaluated using controlled experiments in secure facilities. Potential weeds were evaluated alongside known alien weed species (e.g., Egeria densa, Lagarosiphon major, and Ceratophyllum demersum) and alongside desirable native plants (e.g., charophytes, Potamogeton ochreatus, Myriophyllum triphyllum). In some cases potential weeds were not considered to be a significant threat to New Zealand compared with observations from elsewhere (such as C. caroliniana) and other species required further evaluation under more varied conditions (such as flowing water for H. polysperma and Hydrilla verticillata).

Ultimately competitive performance under New Zealand conditions provides data for the AWRAM (Aquatic Weed Risk Assessment Model) (Champion & Clayton 2000), making it a more robust predictive tool for aquatic weed species. This model has been used to direct policy decisions that impact plant imports, plant trading, weed management and ultimately the protection of native biodiversity.

References
Mapping of several shallow lakes in northern Åland (SW Finland) in the summer of 2008, seven years after a previous study, showed that some lakes were recently invaded by common watermilfoil, *Myriophyllum sibiricum* Komarov. This macrophyte absorbs nutrients from the sediments as well as from the water, and, upon breakdown, releases nutrients into the water. Thus it contributes to the internal nutrient cycling and loading. In 2001 no *M. sibiricum* was found in the lakes studied (Wargén 2002). In lakes where *M. sibiricum* had been noted in 2006 it had spread widely throughout the lakes by 2008. Massive growth of common watermilfoil occurred in three lakes with low spring water level and hence enhanced light availability. The dense vegetation caused high surface water pH values in summer, as well as bottom hypoxia and organic sediments. These conditions threaten the crayfish stock. The dense milfoil vegetation had caused considerable decline of other submerged macrophytes. The profuse plant growth and decaying biomass also deteriorate the water quality and reduce the recreational value of the lakes. As *M. sibiricum* reproduces by seeds and shoots it spreads very fast. Invasion of watermilfoil is a new environmental problem in Åland (Lindholm et al. 2008).

Lake Österträsk, a shallow, eutrophic, lake in northern Åland, was invaded by common watermilfoil in the 1990’s (Lindholm et al. 2008). The lake was studied during the summer of 2008. The milfoil had suppressed almost all other macrophytes, e.g. *Potamogeton* spp. in the lake and formed a shoot biomass at about 180g DW/m², when densest. An experimental manual harvesting of watermilfoil in Lake Österträsk showed that the shoot biomass, consisting of > 90% DW *Myriophyllum sibiricum*, was highest in late August. Removal of the macrophyte shoot biomass early in the growing season caused considerable regrowth. The concentration of phosphorous and nitrogen in the shoots was highest in mid-August indicating that this would be the optimum time for cutting the macrophyte shoot biomass to reduce the nutrient cycling.

References


Increasing number and abundance of non-indigenous aquatic macrophyte species in Germany – an underestimated threat?

A. Hussner\textsuperscript{1)}, K. van de Weyer\textsuperscript{2)}, E. M. Gross\textsuperscript{3)} and S. Hilt\textsuperscript{4)}, submitted. Increasing number and abundance of non-indigenous aquatic macrophyte species in Germany – an underestimated threat?

Non-indigenous aquatic plants are a major cause of biodiversity loss in many countries. In Germany, the number of non-indigenous aquatic plant species rose from 1 in 1860 to 10 in 1980, but more than doubled to 24 during the following 28 years. Of those, 13 species have permanently established. Total species numbers correlated with the population size and area in the German federal states, but there was no correlation between the species number and the number of water bodies and total area of freshwater in the federal states. The increase in species number and abundance was probably caused by enhanced trading, and the increased invasibility of water bodies might have been facilitated by eutrophication, re-oligotrophication and climate change. Regional mass developments often severely interfere with the anthropogenic, mostly recreational use of water bodies in Germany. Both established and not established species have caused problems, with \textit{E. canadensis} and \textit{E. nuttallii} being the most common and problematic species. Specific management measures that specifically target certain species based on their ecological traits and distribution pattern, have not yet been developed. So far, in almost all cases mechanical management options were used but with very little success. We argue that non-indigenous aquatic plant species are an underestimated threat in Germany, and predict a further spread of certain species (e.g. \textit{Cabomba caroliniana}, \textit{Crassula helmsii}, \textit{Hydrocotyle ranunculoides}, \textit{Lemna minuta}, \textit{Myriophyllum aquaticum} and \textit{M. heterophyllum}), and new invasions in the near future (e.g. \textit{Ludwigia grandiflora} and \textit{L. peploides}). In particular, floating mats of dense \textit{Hydrocotyle ranunculoides} and \textit{Myriophyllum aquaticum} stands caused first serious problems, affecting the hydrochemistry and the local aquatic plant diversity of the infested waters. Both plant species are still spreading and the number of infested sites will increase during the next years. We propose a trading ban for at least \textit{L. grandiflora}, \textit{L. peploides} and \textit{H. ranunculoides}. This will not stop their natural spread, but should reduce the risk of further unintended entry, and thus be a major control factor.

Reference

The submerged American waterweed *Elodea canadensis* dominates ecosystem structure and nutrient cycling in a small lake

**J. Sarvala**, P. Louhesto, A. Mäkinen, V. Saarikari and K. Vuorio

1) Department of Biology, University of Turku, Turku, Finland; 2) WWF-Finland, Helsinki, Finland; 3) Lounais-Suomen vesi- ja ympäristötutkimus Oy, Turku, Finland

**Introduction**

In Finland, the most prominent invasive aquatic plant is the submerged American waterweed *Elodea canadensis* Michx., which was intentionally introduced in the Botanical Garden of Helsinki University in 1884. In the shallow lake Littoistenjärvi in southwestern Finland *Elodea* appeared during the 1960s, and since the mid-1980s until the late 1990s it developed mass occurrences at 5–6 year intervals. Excessive plant growth caused problems for recreational use and drinking water supply, leading to attempts of plant removal to lower pH and to prevent winter anoxia (Sarvala & Perttula 1994; Sarvala 2005). The biota of Littoistenjärvi were studied in detail already in 1909-1912 and 1983, and a comprehensive ecological monitoring was initiated when *Elodea* began to cause trouble. Submerged macrophytes were studied in 1986–1989 and annually since 1991, including biomass measurements by a diver according to a stratified sampling design. Conventional water quality monitoring started in the 1960s, and was intensified in the 1970s, because the lake was used as a municipal water source until the end of 1998.

**Cyclic fluctuations of Elodea affect the whole ecosystem**

Water quality in Littoistenjärvi remained more or less stable from the early 1900s to the early 1980s. Since the mid-1980s, however, the lake experienced pronounced fluctuations of water quality, which were associated with the abundance of *Elodea* (in some years also *Ceratophyllum demersum*). The seasonal development of pH was a reliable indicator of submerged plant biomass, peaking in 1986, 1991 and 1997-1998. Sudden collapses of the macrophyte biomass in 1987, 1992 and 1999 were followed by a short, one-summer long turbid water phase with high nutrient concentrations, algal blooms and low transparency (<1 m). The intervening summers with increasing and moderate to high macrophyte biomass were characterised by clear water, high transparency (>2.5 m or down to the bottom in most of the lake area), low nutrient concentrations and low algal biomass. Zooplankton and fish communities also responded to these changes (Sarvala et al. 1998). Causes for the cyclic fluctuations characterising *Elodea* are not understood. *Elodea* is an example of an invasive plant that can completely dominate lake ecosystem structure and nutrient cycling.

**References**


Changes in the aquatic macrophyte vegetation in a neophyte dominated river (River Erft, North Rhine-Westphalia, Germany)

A. Hussner and S. Hilt
1) Institut für Biochemie der Pflanzen, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany. E-mail: Andreas.Hussner@uni-duesseldorf.de; 2) Leibniz-Institute of Freshwater Ecology and inland Fisheries, Müggelseedamm 301, D-12587 Berlin, Germany

The River Erft (North Rhine-Westphalia, Germany) is a medium-sized river with water temperatures above 10 °C all the year round due to geothermically heated water discharged from nearby opencast mining areas. It represents an ideal study system to investigate the effects of higher water temperatures on aquatic macrophyte communities in rivers of the temperate climate zone.

Macrophyte mapping in 2003, 2005 and 2007 revealed the presence of nine non-native aquatic macrophyte species (Azolla filiculoides, Egeria densa, Hydrocotyle ranunculoides, Lemna minuta, Myriophyllum aquaticum, Vallisneria spiralis and casual Hygrophila polysperma, Eichhornia crassipes and Pistia stratiotes) in addition to 14 native species. This exceptionally high percentage of neophytes in the aquatic macrophyte community indicates that climate warming may increase the chance for the establishment of non-native species. Interestingly, a significant correlation between numbers of neophytic and native species was found when comparing number of native and non-native plant species in 52 river stretches in 2003. A higher diversity of the native aquatic flora did thus not prevent colonization with neophytic species (Hussner & Lösch 2005). Repeated macrophyte mappings in 2005 and 2007 showed a significant loss of native species from about 5 to 3 species per stretch between 2003 and 2007, whereas the species number of neophytes remained constant. A significant correlation between the number of neophytes in 2003 and the number of native species lost between 2003 and 2007 indicates a negative impact of neophytes on the native flora. This assumption is supported by a significant decrease in the abundance of native species between 2003 and 2007, whereas that of neophytes did not change. It seems that particularly the evergreen neophytic V. spiralis spread rapidly during the monitored period and outcompeted the native Sparganium emersum. Our study indicates the potentially rapid and drastic changes of aquatic macrophyte communities when neophytic species can increasingly establish under the influence of climate warming.

Reference
Assessment of the long term impacts of alien aquatic macrophytes on native plant communities

Example of freshwater lakes and ponds of the coastline of Aquitaine (South-West France)

V. Bertrin, A. Dutartre and C. Laplace-Treyture
Cemagref, Unité de Recherche REBX, 50, Avenue de Verdun, 33612 CESTAS CEDEX.

The development of alien exotic aquatic macrophytes in all types of aquatic water bodies induces structural and functional disturbances on the native plant communities, directly linked with the characteristics of the colonisation and the abundance of these invaders. These disturbances are especially raised in stagnant water bodies as lake or ponds, where the physical features of the ecosystem rarely constitute a natural factor of regulation of this colonisation. They are generally the consequences of the interspecific competition for light or nutrients.

Alien species are very competitive with an important production of biomass and a high capacity of colonisation of several biotopes. For the native species the competition causes, first, a rapid loss of biomass production and, second, a decrease of the richness of the communities.

Since three decades, about fifteen freshwater shallow lakes and ponds of the coastline of the Aquitaine are the place of successive invasions of amphiphytes as Ludwigia grandiflora (Mich.) Greuter & Burdet, subsp. hexapetala (Hook. & Arn) Nesom & Kartesz, Myriophyllum aquaticum (Vell.) Verdc., and hydrophytes as Lagarosiphon major (Ridley) Moss and Egeria densa Planch.

All communities of native hydrophytes can be in competition with these alien species, from the shallow biotopes of the shore to the deepest zones of the lakes. Among these plants, protected species like Isoetes boryana, Littorella lacustris and Lobelia dortmanna are present: these species disappear when their biotopes are colonised by the alien species and when organic matter covers the sediments. Some species of Potamogeton, like P. natans, P. polygonifolius and P. crispus, two species of Myriophyllum, M. alterniflorum and M. spicatum, regressed at several sites.

The small size helophytes (height below 40 cm) such as Eleocharis palustris or Schoenoplectus pungens can also disappear in the zones colonised by Ludwigia.

To our knowledge, this competition does not cause the extinction of indigenous species in these lakes and ponds. The control and the management of Ludwigia by mechanical extraction or hand pulling allow new installations of hydrophytes in the cleaned biotopes. For this species, the frequent hand pulling management operations can allow the conservation of the native shoreline species in good conditions.

Finally, the investigations of the structure and the dynamics of the communities, on the water and sediment quality and on the physical features of the biotopes, allow us to present a first assessment of the ecological impacts of these invasive species in this particular ecological context.
80 Actual report on spread of invasive macrophytes in Hungary

A. Mesterházy¹, G. Király³, R. Vidéki³, D. Steták³ and J. Csiky⁴
¹University of West Hungary, Department of Botany, H-9400 Bajcsy Zs. u. 4., Sopron, Hungary; ²1: Doronicum Kft., H-9746, Felsőcsatár, Petőfi u. 81.; ³Institute of Ecology and Botany of the Hungarian Academy of Sciences, H-2131 Jávorka S. u. 14., Göd; ⁴Department of Plant Systematics and Geobotany, Institute of Biology, Faculty of Sciences, University of Pécs, H-7624, Ifjúság u. 6., Hungary.

In the past no comprehensive work on the invasive macrophytes of Hungary has been prepared, although there are some studies on different taxa (Steták 2004, 2006, Mesterházy et al. 2007, Vidéki et al. 2008, Király et al. 2008). Between 2001 and 2008 authors surveyed the occurrences of invasive macrophytes in Hungary, their phytocenological characteristics and invasive nature.

A group of invasive species is spreading in modified waters (such as canals and regulated watercourses), while another group of species occurs around water-pipes of medical and thermal baths (on latter places mainly thermophile species naturalised or introduced by the aquarists spread).

Elodea canadensis was established in Hungary in the 1880s, later became sporadic mainly in the Danube basin. E. nuttallii, which was established newly during the 1990s, displaced Elodea canadensis in several localities, and during one and a half decades became at least as frequent as Elodea canadensis had been before. (In some cases populations of both species exist in the same place.) Cabomba caroliniana established in thermal water at the beginning of the 1900s, than during the last decades surprisingly appeared in slow flow canals and formed overwintering populations. The discussed rooted submerged macrophytes generally occupy the territory of Potamogeton nodosus, P. pectinatus and Myriophyllum spicatum populations in watercourses. As far as the floating macrophytes are concerned Pistia stratiotes, which has escaped from thermal water bodies, spreads in the oxbows of the Danube and the river Körös. Lemna minuta and Azolla filiculoides have recently been introduced. They occur in the margin of smaller rivers and have displaced the indigenous Lemna species. In certain localities Azolla filiculoides displaces by the end of summer even the extremely invasive Lemna minuta.

In recent years monodominant stands developed around the water-pipes of thermal water bodies of the following species Vallisneria gigantea, V. spiralis, Hydrilla verticillata, Egeria densa, Sagittaria subulata, Myriophyllum aquaticum. Floating vegetation located in the slow flowing margin areas consists mainly of Najas guadalupensis, Utricularia gibba, Ceratopterys thalictroides, Rotala rotundifolia and Hydrocotyle ranunculoides. The latter one presently occurs in non-thermal watercourses as well. Former vegetation of thermal water-pipes has been thoroughly investigated in previous studies (Boros 1936). The established invasive species already outplaced the endangered Potamogeton coloratus and Utricularia bremii from these water bodies, and totally transformed the former typical Chara-dominant communities.

References

81 Alien taxa in European aquatic vascular plant families

P. Uotila
Botanical Museum, Finnish Museum of Natural History, University of Helsinki, P.O. Box 7, FI-00014 Helsinki, Finland.

The aquatic plant families Alismataceae (6 genera / 20 species), Aponogetonaceae (1/1), Butomaceae (1/1), Cabombaceae (1/1), Hydrocharitaceae (12/14), Najadaceae (1/7), Liliaceae (1/1), Lemnaceae (4/9), Posidoniaceae (1/1), Potamogetonaceae (3/27), Ruppiaceae (1/2), Sparganiaceae (1/5), Zannichelliaceae (2/9), Zosteraceae (1/3), Callitrichaceae (1/21), Ceratophyllaceae (1/5), Elatinaceae (2/9), Haloragaceae (1/1), Hippuridaceae (1/3), Nelumbonaceae (1/1) and Nymphaeaceae (2/3) were treated by the author for the checklist of European vascular plants in the Euro+Med PlantBase project. The preparation of the checklist was based on the information from ca. 100 recent European Standard Floras and checklists, which were complemented from additional monographic and floristic literature, when available. Information was collected from Europe and the Macaronesian Islands, the whole Mediterranean area and Caucasia, but only Europe and the Macaronesian Islands are treated here. The territories are mainly political entities (states), some are phytogeographically important islands, archipelagoes and peninsulas, and Russia has been divided into six parts. The total number of territories is 69.

The 21 families treated include in Europe 48 accepted genera and 159 accepted species (incl. seven provisionally accepted), and four of the species are divided into a total of 12 subspecies. All members of three families and 12 genera are alien in the whole area. 32 species (20 % of all aquatic species) are introduced in Europe, 19 species are introduced in some territories, being native somewhere else in Europe. In principle, only naturalized aliens should have been counted, but in practice also “problematic” cases have been accepted and only clearly casual and cultivated ones are excluded. Many species of the alien genera in North and Central Europe derive from North America (e.g. Elodea, Sagittaria). In the more southern and western parts of Europe there are also some Asiatic (e.g. Blyxa japonica, Najas orientalis, N. gracillima, Lemna aequinoctialis) and tropical African (Halophila stipulacea, Aponogeton distachyos, Bergia capensis, Lagarosiphon major) and even tropical American (Ederia densa) species. As to the territories, the greatest number of aliens were noted in Britain (17), followed by Italy (14), France (11) and Germany (11). Most of Central European countries have 5-7 alien aquatic species each, and only one to few have been reported from northern and eastern European territories. Notably few or no aquatic aliens have been reported from the Balkans and the Mediterranean islands. They are absent also from northern Atlantic islands, and only a few have been found in the Macaronesian Islands.

Elodea canadensis is by far the most widespread alien aquatic vascular plant in Europe. It is reported from 40 territories, and in most of them it is clearly naturalized. However, it seems to be absent in many Mediterranean territories. The next ones are far behind: E. nuttallii from 13, Lemna minuta from 12, Egeria densa from 10, Lagarosiphon major from 9 and Myriophyllum aquaticum from 8 territories. The most frequently introduced of the species native in Europe is Vallisneria spiralis, which is known to be alien in seven territories. Notably large number of aquatic plant species are known as alien only from one territory or from a few territories. This tells that many aquatic species have been and probably others still are able to establish themselves in Europe when introduced to a suitable environment. However, most of them seem to remain local and only a few have been widely naturalized and aggressive.
The figures presented of alien aquatic plants in Europe are quite inexact especially when considering their degree of naturalization. Moreover, there is enormous variation in the way the terms alien, introduced, exotic, naturalized are used and these even vary from country to country, although attempts have been made to introduce an agreed terminology and set of definitions. In some cases, when recent local Floras and checklists do not exist, the available information may be out of date because of the possible rapid spread of aliens. As to European species, often even the native or introduced status within a territory has been debated.

References
http://www.emplantbase.org/home.html
Environmental management in relation to aquatic plant development
Biomanipulation of hypereutrophic ponds: the role of submerged macrophytes

S. De Backer, S. Van Onsem, A. Peretyatko, S. Teissier and L. Triest
Plant Biology and Nature Management (APNA), Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium

Biomanipulation to improve ecological quality: does it work?

Hypereutrophic ponds in Brussels (Belgium) have shown a considerable degree of variation in phytoplankton biomass despite high nutrient concentrations and therefore have a good potential for successful biomanipulation (Peretyatko et al., 2007a, 2007b). Ten phytoplankton-dominated ponds were biomanipulated (emptied with complete fish removal) in order to restore the ecological quality and reduce the risk of cyanobacterial blooms. Data on nutrients, phytoplankton, macrophytes and zooplankton were obtained before and after biomanipulation. Fish removal initially resulted in a drastic reduction of phytoplankton biomass and a shift to the clear-water state in nine ponds. Lower phytoplankton biomass was associated with a marked increase in density and size of large cladocerans and/or a recovery of submerged vegetation. Our results suggest that submerged vegetation alone, in absence of large cladocerans, is capable of controlling phytoplankton and maintaining the clear-water state. On the other hand, large zooplankton alone can also control phytoplankton, as some ponds have developed very high densities of large zooplankton, keeping phytoplankton biomass low, despite the absence of vegetation. This is however a very unstable situation, as recolonization by juvenile fish that feed on large zooplankton will quickly shift such ponds back to the turbid state.

The importance of submerged vegetation recovery

During the period after biomanipulation the ponds have shown very different dynamics, mainly defined by planktivorous fish recolonisation and presence of submerged vegetation. In ponds where fish remained absent, large cladocerans were perfectly capable of controlling phytoplankton biomass, regardless of the presence of vegetation. All ponds that were not recolonised by fish as such remained in the clear-water phase. In ponds that were recolonised by fish however, a marked difference was observed between vegetated and non-vegetated ponds. In ponds where no or only sparse vegetation was restored, planktivorous fish recolonisation led to an immediate collapse of the larger zooplankters (reflected on zooplankton density and size) that were no longer able to control phytoplankton biomass, leading to a turbid state with the presence of bloom-forming cyanobacteria. In vegetated ponds, an effect of fish reintroduction on zooplankton densities and size and consequently on phytoplankton biomass was still observed. The presence of an abundant vegetation (often monospecific) buffered the impact of fish to a certain extent, keeping phytoplankton biomass low.
References


83 Interactions between water-level fluctuation and vertical extension of helophyte zones

A. Keto¹, S. Hellsten² and A. Tarvainen³

¹Fortum Service, Hydro and wind engineering, Espoo, Finland; ²Finnish Environment Institute, Research Programme for Integrated River Basin Management, Oulu, Finland; ³Finnish Environment Institute, Water Resources Management Division, Helsinki, Finland

Introduction

Water level fluctuation is generally considered to be one of the most important determinant of zonation and species composition of littoral plant communities (Spence 1982). Both the timescale and the spatial extent of water level fluctuations have been shown to affect vertical extension in submerged and marginal vegetation of lakes (Keddy 1983, Rørslett 1991). Water level fluctuation is a complex variable, which encompasses not only the range, but also the frequency and regularity of change.

Vertical extension of helophytes compared to water-level fluctuation in Finnish lakes

Altogether 238 macrophyte transects from 1 non-regulated and 5 regulated lakes were studied during the years 1996–2000. Water level durations were compared with measured vertical extensions of Carex sp., Equisetum fluviatile and Phragmites australis zones. The first aim of the study was to find how water level fluctuations explain the location of helophyte zones. The best correlation appeared to be for Phragmites, whose vertical extension correlated with the open water period (OWP) fluctuation ($r^2=0.77$). The same regression coefficient of Carex was 0.66 and Equisetum 0.56. The second aim was to estimate water level duration parameters, which describe upper and lower ends of different helophyte zones. The average water level duration parameters to describe vertical limits of Carex sp. were for upper level W36OWP and lower level W81OWP, Equisetum fluviatile W62OWP and W38OWP -1.0 m and Phragmites australis W57OWP and W410WP -1.0 m.

References

The flow regime is often considered to be the primary driver of biotic assemblage structure in lotic environments. However, hydraulic parameters such as substrate stability and shear stress are increasingly seen as important measures of disturbance to aquatic macrophytes. We investigated the relative contribution of hydrology and hydraulics to macrophyte assemblage structure in southeast Queensland, Australia. We hypothesised that if hydrology was an important driver of macrophyte assemblage structure then sites in different rivers but with similar flow regimes (in terms of the duration, frequency, magnitude and timing of flow events) should have similar macrophyte assemblage attributes. We surveyed in-stream macrophytes at 28 sites located in 14 river reaches. These reaches were dispersed over hydrologic gradients represented by discharge magnitude and variability. Hydraulic measurements and cross-sectional channel surveys were used to calculate substrate stability and bankfull shear stress. Hierarchical partitioning was used to identify hydrologic and hydraulic parameters that explained significant independent variation in macrophyte assemblage attributes.

Substrate stability and bankfull shear stress were found to explain greater variation in macrophyte assemblage metrics than hydrologic parameters such as flood frequency. However, total macrophyte cover tended to increase with increasing coefficient of variation (CV) of mean daily discharge. Sites where bankfull shear stress exceeded the critical shear stress required for substrate mobilisation had lower macrophyte cover than sites where the bankfull shear stress was lower than the critical shear stress. Sites with low substrate stability (i.e. substrates easily entrained at relatively low water velocities) supported extensive macrophyte growth, provided flood frequency was very low. Channel morphology and site position in catchment (particularly elevation) were also important factors in structuring macrophyte assemblages.

We conclude that hydraulic measures such as bankfull shear stress are more useful measures of disturbance to macrophytes than simple flow metrics such as flood frequency. The importance of substrate stability in comparison to flow metrics such as flood frequency demonstrates the importance of site-specific habitat conditions (channel morphology, bed slope, channel orientation, substrate composition) to macrophyte assemblage structure. We discuss the implications of our results for development of flow-ecology relationships and synthesise the results into a general conceptual model for aquatic macrophytes.
Recolonisation of submerged macrophytes in the shallow lake Loenderveen after restoration measures; the success of different life-traits

R. Pot1, G.N.J. ter Heerdt2
1) Roelf Pot research and consultancy, Oosterhesselen, The Netherlands; 2) Waternet, Amsterdam, The Netherlands

Introduction

Lake Loenderveen is a 2.3 km² shallow peaty lake with both peaty and sandy soil bottom. First half 20th century the lake was oligotrophic with Characeae dominating the submerged vegetation (Best et al., 1984). Due to eutrophication the lake shifted into a phytoplankton dominated community mid 80’s. From 1987 on hardly any submerged plants were found. Even after the reduction of nutrient load, phytoplankton domination continued. In spring 2005 fish stock removal caused a definite reduction of phytoplankton production and shift to the clear water state (i.e. Scheffer, 1998).

In 2005, after the intervention 13 species of submerged macrophytes recolonised the area in low densities. A year later Elodea nuttallii achieved to cover 10% of the lake in high density. Its biomass increased 10.000-fold, up to 300 g dw/m². In 2007 waterfowl started grazing heavily on the vegetation. In 2008 Najas marina took over dominance from Elodea. Potamogeton lucens, P. perfoliatus, and P. pectinatus increased steadily in cover over the years. Chara species achieved moderate cover in parts of the lake. Two very rare species (Nitella hyalina, Potamogeton praelongus) were found in 2007 and 2008.

Development of submerged vegetation after shifting to the clear water state was expected, monitoring and understanding the development of species composition was the aim of this research.

Discussion

Life-trait differences between species are the key to explain differences in development and the relatively high species richness in the early stage of the secondary succession in this lake. High dispersion capacity favoured Elodea nuttallii, Chara species and Najas marina to arrive first. High vegetative reproduction capacity made Elodea to become dominant soon after. Waterfowl grazing in 2 years minimised biomass of Elodea and with that its reproduction capacity. In the meanwhile the annual Najas build up a seed bank and could take over dominance. Potamogeton species spread mostly by subsoil clonal growth, therefore expand much slower and are more successful on the long term. Because of the fast changes, space was left for several other species. Soil type and depth distinguished between the initial success of several species in different parts of the lake.
References


86 Species richness on differently managed shore stretches of Lake Peipsi, Estonia

K. Palmik and H. Mäemets
Centre for Limnology, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Tartumaa, Estonia

The list of taxa for Lake Peipsi (3555 km², non-regulated water level) for 1997–2007 includes 133 species of vascular plants and bryophytes, and eight taxa of large algae. Species number per observation was 1–40 with an average of 13.8 for 243 observations at 139 stations over the whole lake in 1997–2007 (the southern part less presented). Species number is related to the shore type and to water level in the study year; in warm low-water summers a rich shore vegetation appears in the denuded zone and in shallow water. The expansion of Phragmites australis towards the northern, earlier mesotrophic, part of the lake has taken place in the course of anthropogenic eutrophication. Reeds occupy the most species-rich zone near the water’s edge. As local people and holidaymakers are interested in using an open shore, extensive reed removal has been carried out during the last decade. The studied village of Vilusi is situated in one of the most species-rich lake area, on the till shore in the northwestern part. The effect of different methods of cleaning of shore stretches from reed and willows on species richness was studied in five different habitats in 2006 and in seven habitats in 2008 (including five earlier studied habitats). The total number of species found at Vilusi was 67 in 2006 and 80 in 2008, including 11 submergent species of open water in 2006 and in 2008. The list of taxa summarized for all studied habitats contained 32 of the 33 most frequent taxa in L. Peipsi together with four rare species for this lake and for whole Estonia.

The richest habitats were a recently cleaned pond (35–42 species) and three earlier bulldozer-cleaned and more recently mown shore stretches (18–36 species). The poorest (five species) was the stretch where a herbicide (glyphosate Roundup) had been used illegally. Two times more species (11) were found on a stretch where the main part of the willows and reed were preserved. Søerensen similarity coefficient for different shore habitats ranged from 0.27 to 0.63 in 2006, and from 0.15 to 0.47 in 2008. This coefficient for habitats visited in 2006 and 2008 ranged from 0.33 to 0.57.
The influence of local and catchment scale variables on the distribution of *Salvinia natans* and *Trapa natans* in channels in Eastern Croatia

A. Kočić1), S.D. Jelaska2) and J. Horvatić1)

1) Department of Biology, Josip Juraj Strossmayer University of Osijek, Osijek, Croatia; 2) Department of Botany, Faculty of Science, University of Zagreb, Zagreb, Croatia

In this research we have surveyed two different lowland areas in Eastern Croatia with the aim of improving understanding of the distribution of two conservationally important species, namely *Salvinia natans* and *Trapa natans*. Baranja, the north part of this region, is mainly agricultural land with a developed drainage network and partly a wetland area, while the Bosut River Basin, the southern part, is considerably covered by forest, with a dense network of rivers.

As explanatory variables we used channel morphology and land use on the two landscape scales. Site characteristics of channel and species distribution data were gathered in the field at 249 sites during 2005 and 2006, while catchment data: the proportion of land use, total drainage length, total upstream area and drainage density were collated in frame of the Geographic information system (GIS). The influence of groups of variables at different scale on the distribution of macrophytes was analysed with multiple regression analysis. Variance inflation factor analysis was used to eliminate environmental variables that are collinear.

Distribution of *Salvinia* was geographically predominant in the northern part of the investigated area and was mainly explained by the nearness to the wetland and the proportion of wetland in catchments, while the measured local physical variables were less important for its distribution. In contrast, distribution of *Trapa* was spatially predominant in the southern part of the research area and was mainly explained by the width of the channels. Catchment variables were less important, but the positive relationship with the total upstream area confirms the relation of the *Trapa* distribution to the wider rivers with the large catchment areas in Eastern Croatia. Results obtained for *Salvinia* confirm the importance of wetlands as the source of colonisation for macrophytes and the importance of wetlands conservation as a condition for the survival of rare macrophytes. The higher proportion of urban land use has a negative influence on the distribution of both species. It indicates the importance of including additional variables such as water quality data and other anthropogenic factors that could explain the influence of urban land use on aquatic systems. Results of our study indicate that macrophytes respond to their environment at different scales. Inclusion of the catchment scale variables gives us better insight into ecological processes. Therefore, different thematic and spatial scales should be taken into account in species distribution analyses with the aim of achieving predictive models adequate for conservation issues.

References


What conditions enable expansion of weedy *Bolboschoenus* taxa on arable land?

Z. Hroudová, P. Zákravský and M. Flegrová
Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice, Czech Republic

Introduction

Among Central European *Bolboschoenus* taxa, *B. laticarpus* and *B. planiculmis* inhabit wet, temporarily flooded field depressions, frequently as weeds on arable land (Hroudová et al. 2007). Considerable increase in localities on crop fields was recorded during the last decades in the Czech Republic (especially *B. laticarpus* has been expanding) and both species became undesirable weeds (Hroudová & Zákravský 2007). Their development depends on: 1. biology of the species (reproductive traits, spread, persistence); 2. management of arable land (changes in agricultural use). Efficiency of vegetative and generative reproduction of both species was studied under field conditions on arable land and completed by results of cultivation and laboratory experiments, in which drought resistance and influence of flooding of four Central European *Bolboschoenus* taxa were tested.

Importance of vegetative reproduction in populations on arable land

Although variation was found among localities as far as the amount of underground tubers was concerned, the tubers bring about a reliable means for plant survival, population renewal and spread over short distances (within managed fields). Seed production appeared to be more fluctuating, limited by crop management. Changes in agriculture management consequent to changing economy contributed to an increase of the groundwater level and a spread of vegetative propagules of *Bolboschoenus* in the upper soil layer.

Influence of different water regimes on winter survival of tubers and on subsequent plant development

Flooding during winter appeared to be the most suitable for tuber survival in all species, and it conditioned successful development of young plants, especially when further cultivated under wet conditions. The worst conditions for tuber survival appeared to be natural terrestrial conditions (probably due to fluctuations in temperature under alternating wet conditions). The weedy species *B. laticarpus* and *B. planiculmis* are better adapted to terrestrial conditions by a low tuber mortality during winter (according to the experiment) and higher production of rhizomes in plants cultivated under dry conditions (especially in *B. planiculmis*).

References

89 Reaction of macrophyte production to hydrological changes in reference to the nutrient cycle in a shallow lake

A.E. Lawniczak 1), A. Choinski 2), J. Zbierska 3) and W. Szczepaniak 3)

1)Department of Ecology and Environmental Protection, Poznan University of Life Science, Poznan, Poland; 2)Institute of Physical Geography and Environmental Planning, Adam Mickiewicz University, Poznan, Poland; 3)Department of Agricultural Chemistry, Poznan University of Life Science, Poznan, Poland

The effect of a reduction of the water level fluctuation on nutrient uptake and productivity of emergent macrophytes was analysed in a shallow, polimictic lake, located in western Poland (Lake Niepruszewskie). The water level was regulated for irrigation purposes from 1974 to 2002, with average amplitude of 0.8 m. In 2002, the water level fluctuation was reduced to 0.35 m during winter and to 0.55 m during summer.

Nutrient concentrations, nitrogen and phosphorus standing stocks and biomass production were compared among four vegetation types along a moist gradient in the littoral zone. The types were: seasonally-flooded Caricetum acutiformis, Glycerietum maximae, and Phragmitetum, and periodically-flooded Typhetum angustifoliiae and Phragmitetum. The study was conducted in the littoral zone of the lake during the growing seasons in the years 1999–2001 (1st period) and in the years 2005–2008 (2nd period). Eight permanent transects, perpendicular to the shoreline, were chosen in the zone with abundant vegetation. Each transect had two sampling sites: located at 1/3 and at 2/3 of the width of the littoral zone (seasonally and periodically flooded, respectively). The biomass production and nutrient concentrations in the dominant species were measured at the time of maximal shoot growth in August of each year. Additionally, nutrient concentrations in the water and sediments were measured.

The reduction of the water level fluctuation brought about a negative effect on biomass production (p<0.001). The decrease in the above-ground biomass production was more marked at sites that were less affected by drainage, i.e. where water was present throughout the year. In draw-down areas, plant growth also showed a decrease, however species like Phragmites australis and Carex acutiformis coped better with a lower amplitude of the water fluctuations than Glyceria maximae. Biomass production of the Typhetum community decreased by 45 % and that of the Glycerietum maximae by 29 % during the analysed periods.

There were no significant differences between nitrogen concentrations in the plant species between the studied intervals, except for C. riparia, in which a two-fold increase was observed. As far as the nitrogen standing stock in above ground biomass is concerned, this was only in C. acutiformis affected by the hydrological changes. The uptake of phosphorus and potassium decreased in all species, with the exception of C. riparia. However, the growth of this species strongly decreased, probably due to a reduction of the water volume.

Our study showed that a higher amplitude of the water level fluctuation leads to an increase in the nutrient uptake and the biomass production of emergent macrophytes. The efficiency of nutrient removal from the lake by the emergent vegetation is also reflected in a deterioration in the water quality after the water level fluctuation had been decreased, which coincided with an intensive algal bloom.
Aquatic vegetation and environmental relationships
90 Sediment and water interactions with macrophyte element concentrations and community structure

F. Ecke\textsuperscript{1,2)}, E. Engström\textsuperscript{1,3)}, R. Rentz\textsuperscript{4)} and E. Husson\textsuperscript{5)}
\textsuperscript{1)}Division of Geosciences, Luleå University of Technology, SE-971 87 Luleå, Sweden; 
\textsuperscript{2)}Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Box 7050, SE-750 07 Uppsala, Sweden; \textsuperscript{3)}ALS Scandinavia AB, Aurorum 10, 
SE-977 75 Luleå, Sweden

Littoral interactions among sediment, water and macrophytes are poorly understood. In particular there is a gap in knowledge concerning the importance of macrophytes as sinks and sources of trace elements. Such knowledge is however central for, amongst others, explaining potential mechanisms behind the community structure of macrophytes and for the development of macrophyte-based indicator values. We studied the interactions between the three matrices (sediment, water and macrophytes) at 19 sampling sites in Storträsket, a 1.7 km\textsuperscript{2} boreal lake at the land uplift coast of Northern Sweden in summer 2008. The catchment of Storträsket was dominated by coniferous forest of mainly the dwarf-shrub type and open wet mires. The upper sediment layers (0–6 cm) were dominated by fine detritus. Fine detritus dominated also the lower layers (>6 cm but ≤10 cm) at all but four of the studied localities where fine sediments (particle diameter <0.2 mm) dominated. Sediment and water element concentrations were related to element concentrations in the dominating macrophyte species, viz. Nuphar lutea (roots and leaves), Potamogeton natans (leaves) and Sparganium angustifolium (leaves) and to chlorophyll concentrations using uni- and multivariate statistics. We studied 27 major and trace elements. Estimations of abundance and biomass of N. lutea in eight bays was based on the evaluation of high resolution (2 cm) aerial photographs. The total biomass of N. lutea and standardized biomass (biomass per unit of area) differed significantly among bays. Also concentrations in all matrices as well as in chlorophyll showed significant spatial variation in the lake. N. lutea showed for several elements significant partitioning of elements between roots and leaves (e.g. Ca, K, Na, Fe, Pb, Zn). Correlations between element concentrations in sediment/water and in macrophytes were in general weak but significant for amongst others Si in water and leaves of P. natans and Co, Cu and Fe in water and roots of N. lutea. Interpreting correlations of elements between the sediment and macrophytes might in our study be impeded by potential incorporation of lithogenic material in extracellular macrophyte tissue. Our study identified especially N. lutea as a major sink (during vegetation period) and source (during autumn and winter) of several major and trace elements. Interactions between the matrices, chlorophyll concentrations and macrophyte community structure are further discussed as well as the implications of our results for the development of macrophyte-based indicator values.
Introduction

Aquatic plants drastically affect the retention of the suspended sediments in a stream, in order to produce more preferable living conditions in their habitats (Asaeda et al., 2005). *Sparganium* spp. (Sparganiaceae), widely distributed both in Europe and East Asia, adopt different forms like submerged, and emergent during their life cycle, depending on the environment. We hypothesised that the efficiency of sediment trapping and retention in the stands of *Sparganium erectum* are associated with the collapse and the succeeding emergence of the submerged shoots.

Method

To examine the effect of different growth forms on the sediment trapping by *Sparganium erectum* stands, the plant phenology and morphological characteristics, velocity distribution of the river flow, and sedimentation rate inside and outside the stands were intensively studied for a stand along the river channel, for over a period of three years. A decomposition experiment was also carried out to determine the respective fragmentation rates of the upper and bottom parts of *S. erectum* shoots and rhizomes.

Effects of phenology on the flow resistance and retention of suspended solids

Phenologically, *S. erectum* shoots undergo different distinct stages in their life cycle, such as submerged in winter, emerging in late spring, again collapsing in early summer, and the same process is succeeded by the later cohorts. The growth form substantially affected the flow condition inside and outside the stands. Although the sedimentation is high if shoots are submerged in early spring, the accumulated fine sediment layer is discharged in spite of their large biomass and the resulting low flow velocity, when they become emergent. However, the collapse of emergent shoots and formation of new submerged shoots of the later cohort in summer accelerate sedimentation of fine suspended solids again by increasing the blockage to the river flow. Consequently, they produce the preferable habitat for their soft roots and rhizomes. The collapse of the emergent shoots, therefore, seems to be an inherent part of their phenological cycle. Due to the high decomposition rate, the collapsed shoots also enhance the fine
sediment accumulation. The collapse of the shoots increases the flow resistance of the river by 50% even the stand area occupies one fifth of the channel.

Reference
Environmental factors influencing the distribution of macrophytes in middle-sized streams of Latvia

L. Grinberga
University of Latvia, Institute of Biology, Laboratory of Hydrobiology

In Latvia, there had been numerous studies on vegetation of lakes but very little research has been done concerning the vegetation in rivers and streams. Different studies worldwide obviously indicate that the knowledge of the macrophyte species composition and abundance reveals important information on the aquatic ecosystem. According to the EU Water Framework Directive macrophytes are among the biological elements needed for determination of the ecological status of running waters. The aim of this study was to examine the role of different environmental factors (stream width, depth, substrate, overgrowing, shading and flow type) for formation of macrophyte vegetation in middle-sized lowland streams by using the STAR (Standardisation of River Classification) project methodology. The species composition and abundance of macrophytes was estimated using a nine-degree scale. In total fifty middle-sized streams in Latvia were studied in summers 2007 and 2008. Among the estimated factors shading and substrate were the most important. The results revealed five groups of streams with typical macrophyte communities – fast flowing rivers on gravelly substrate, slow flowing rivers on gravelly substrate, fast flowing streams on sandy substrate, slow flowing streams on sandy substrate and streams with soft, silty substrate.

In fast flowing streams on gravelly and stony substrates, being characteristic for upland slopes, the macrophyte composition is species poor. In such habitats, mostly bryophytes on stony substrate and sparse helophyte stands occur. In narrow, fast flowing streams the formation of aquatic vegetation is limited by stream velocity and shading created by river banks. A more diverse species composition and a denser macrophyte cover is characteristic for slow flowing streams on gravelly and stony substrates, particularly if water depth does not exceed 1 m. Due to high stream velocity and unstable substrate conditions in fast flowing streams on sandy substrate the vegetation composition is species poor. In such streams typically *Sparganium emersum* and *Elodea canadensis* dominate. Commonly in slow streams with sandy substrate at deeper sites the number of macrophyte species is small, the plants occur mostly on shallower depths. In streams with soft, silty substrates the macrophyte vegetation is formed by sparse cover of helophytes, floating-leaved and submersed plants.

In total 56 different species and taxons were identified. The most frequent species in the investigated streams were *Sparganium emersum, Veronica beccabunga, Sparganium erectum* as well as the invasive species *Elodea canadensis*. The highest macrophyte diversity was found in slow flowing streams with a gravel substrate.
93 Effects of environmental variables on the distribution and percentage cover of the littoral helophytes in boreal catchments

J. Alahuhta1,2, M. Luoto1 & K-M. Vuori2
1) Department of Geography, University of Oulu, Finland; 2) Finnish Environment Institute, the Oulu Office

Introduction
Numerical studies of the relationship between limnological processes and their environment provide information on impacts of natural and human factors on aquatic ecosystems, but traditional regression methods face problems related to collinearity and spatial autocorrelation. In variation partitioning (VP) and hierarchical partitioning (HP) based on generalized linear modeling these problems are more or less overcome (Borcard et al. 1992, Chevan & Sutherland 1991). Hence, we utilized VP and HP to examine littoral helophyte distribution and percentage cover, spatial structure and relationship to environmental factors in 848 boreal catchments in whole Finland. Our specific aim was to determine the role of drainage ditches on the littoral helophytes in boreal catchments.

Material and methods
The helophyte distribution (presence/absence) and percentage cover data (% of catchment area) was derived from the national-specific subclass of Finnish CORINE land cover classification, which consists of littoral helophytes growing on silting water areas, flooded areas and wetlands without peat cover. Environmental variables consisted of nine land use, ten geomorphological and five climatic variables derived from different GIS datasets. Besides, drainage ditch intensity was assessed using GIS application for all the catchments. The VP approach was used to decompose the variation in littoral helophyte distribution and percentage cover among the three groups of predictors: land use, geomorphology and climate. In the HP analyses, the effects of individual environmental variables on the littoral helophytes were assessed.

Results and conclusion
The total effect of distribution and percentage cover models were 59 % and 45 %, respectively. Joint effect of land use, geomorphology and climate accounted for the largest fractions of variation in littoral helophytes. Furthermore, the most significant positive relation of different land use forms was between littoral helophytes and drainage ditch intensity. To our knowledge this is the first analysis to show that the ditch intensity increases the littoral helophytes at national level in boreal catchments.

Our models seem to explain both large and habitat scale variations of littoral helophytes. Moreover, the catchment characteristics mainly defined the distribution...
of helophytes, whereas limnological variables of catchment probably explained more
on the percentage cover of helophytes.

References
Borcard, D., Legendre, P. & Drapeau, P. 1992. Partialling out the Spatial Component of Ecological Vari-
94 Velocity patterns in, around and through a sequence of vegetation distribution patterns

K. Bal\textsuperscript{1)}, H. Vereecken\textsuperscript{2)}, E. Struyf\textsuperscript{1)}, F. Mostaert\textsuperscript{2)}, E. de Deckere\textsuperscript{1)} and P. Meire\textsuperscript{1)}

\textsuperscript{1)}University of Antwerp, Ecosystem Management Research Group, Universiteitsplein 1, 2610 Wilrijk (Belgium); \textsuperscript{2)}Flanders Hydraulics, Berchemlei 115, 2140 Antwerpen

Introduction

To reduce friction of lowland rivers aquatic vegetation is often removed to prevent high water levels resulting in increased flooding risk. This removal however has an important impact on the velocity profiles and thus biology of small lowland rivers. Therefore in this study the impact of three vegetation distribution patterns on stream velocity profiles, within and around a sequence of vegetation distribution patterns, was investigated for four different macrophyte species (\textit{Potamogeton natans}, \textit{Stuckenia pectinata}, \textit{Ranunculus aquatilis}, \textit{Callitriche platycarpa}). In all investigated patterns approximately one third of the wetted section was occupied by macrophytes. Velocity measurements were carried out in a flume, because this way discharge regimes could be carefully controlled, with a usable length of 11.25 metres (total length 25 metres, width 3 metres and height 0.8 metres).

Results

From the results it was seen that between the various vegetation distribution patterns ($F = 17, p < 0.001, df = 2$) and discharges ($F = 115, p < 0.001, df = 2$) significant differences in velocity profiles were shown. Lowest average velocities (between 2 and 5 cm s\textsuperscript{-1} for all tested discharges) were reached in vegetation patches which were grouped at one side of the river. If the vegetation patches were alternating between or on both sides of the river higher velocities within the vegetation were observed (between 3 and 9 cm s\textsuperscript{-1}). In these experiments also the effect of macrophytes on the stream velocities was evaluated. From these results it was seen that macrophyte species present in the vegetation blocks did not have a significant ($F = 0.32, p = 0.81, df = 3$) impact on the velocity patterns. This is somewhat surprising because morphological differences between the species were considerable. A possible explanation for this uniformity is that velocity within vegetation patches is also dependent on density (Nepf 1999) and flexibility (Kouwen & Uny 1973) of the individual stems. To translate these results towards river managers the friction caused by these distribution patterns was calculated. Hydraulic friction, expressed as Manning’s $n$, increased maximum 23 % compared with the empty situation.

In general we conclude that these macrophyte distribution patterns greatly increase the heterogeneity in velocities without increasing the flooding risk and are therefore a useful tool for river managers, e.g. protection of river banks against erosion.

References


The impact of environmental and anthropogenic factors on the distribution pattern of aquatic plants along the Louros River, Western Greece – 'Adoption' of a reference pattern of aquatic assemblages

P. Manolaki and E. Papastergiadou
Department of Biology, University of Patras, GR 26500 Patras, Greece

Introduction

The macrophyte species composition and abundance correspond to environmental factors in a river’s watershed area. The relationships between morphological, hydrological, physical, and water quality patterns of riverine systems and the aquatic macrophytes distribution have widely been investigated, although, mainly at the regional level. The aim of this work was to evaluate the pattern of the aquatic macrophyte species distribution along the Louros fluvial corridor and its catchment area in Western Greece, and to identify the impact of environmental parameters and anthropogenic influences on macrophyte species diversity. Additionally we tried to ‘adopt’ the reference pattern of the aquatic plant assemblages by assessing the patterns of species diversity and distribution in different habitats of the Louros fluvial corridor and then to determine the effect of selected environmental and anthropogenic parameters on the macrophyte species composition and abundance. The degradation sequences, which are usually proposed, follow the longitudinal gradient of the river. However, it is not possible for such vegetation references to be the same in the upstream and in the downstream section of the river (Daniel et al. 2006). A total of 18 sites were seasonally sampled (100 m) during the years 2005–2007, in order to represent the variability of the physical features of the river. Aquatic plants included all the species growing in the channel, margins and inner bank of the river.

Distribution pattern of aquatic macrophytes at regional and local scale

In order to distinguish the river types and to assess the general structure of the physical variables of the habitat, a Principal Component Analysis (PCA) was performed. To analyse plant assemblage patterns in defined stream types Canonical Correspondence Analyses (CCAs) were performed (McCune & Mefford 1999) and CCAs variable scores were used to summarise the variability in plant assemblage patterns within the stream types. Afterwards, an Indicator Species Analysis for the river derived from PCA was performed, using the types as a grouping variable. The indicator values were tested for statistical significance in terms of number of sampling sites present, plant species richness and plant species abundance. Furthermore, we examined how the physical stream environment affects the diversity and the distribution of macrophyte
communities. The assessment of human alteration of the aquatic habitats, is further discussed.

References
96 Macrophyte surveys in assessment of land use impact on the ecological status of rivers

T. Zgola and K. Szoszkiewicz
Poznan University of Life Sciences, Department of Ecology and Environment Protection, Poznan, Poland

Introduction

The main objective of the Water Framework Directive is to achieve a good ecological status of surface waters by the year 2015 (Water Framework Directive 2000). To accomplish this very ambitious plan, complex actions dedicated to the protection of catchment areas must be implemented. For the purpose of surface waters ecological status assessment and monitoring, new methods based on living organisms were developed across Europe. These methods respond to changes caused by human impact on freshwater ecosystems and their catchment areas and provide an efficient tool for ecological status assessment of rivers (Herring et al. 2006). The main objective of the present study is to assess the impact of different land use types observed in river catchments on the ecological status of different river types, measured by macrophytes abundance and composition.

Conducted surveys and obtained results

The study is based on surveys of river ecosystems located in Poland. About 270 river sites were analysed. Field surveys included assessment of macrophytes abundance and composition, chemical analyses, hydromorphology (using RHS) and identification of land use structure at a distance of 5 m and 50 m from the bank-top. Further analyses included assessment of land use structure of a rivers catchment according to the CORINE Land Cover database. This part of the analyses included identification of land use in 100 m, 500 m and 1000 m stretches along the river as well as analyses of a whole catchment land use from a field survey site upstream. Ecological status was assessed using European macrophyte-based methods. Response of different macrophyte metrics to changes in river catchment land use was analysed.

The results showed that macrophytes strongly react to land use changes. The most vulnerable for human activity are small rivers and their ecological quality deterioration is reflected in structure and composition of water plants. Along the process of aforestation and urbanisation of the catchment, macrophyte composition and abundance was changing. Trophic indices (MTR, IBMR and MIR) and diversity metrics (species richness, Shannon-Wiener, domination, evenness, Simpson) were reacting most strongly to the gradient between the share of forests and agricultural lands.

References


Assessing riparian vegetation structure and the influence of land use using landscape metrics and geostatistical tools

M.R. Fernandes, F.C. Aguiar and M.T. Ferreira
Centro de Estudos Florestais, Departamento de Engenharia Florestal, Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017, Lisboa, Portugal

Mapping riparian structural attributes in a fine scale resolution can provide useful information for the management, conservation and restoration of streams. The present work aims to identify potential landscape metrics that best describe and quantify the riparian structure and evaluate its response to land use pressure.

The study was conducted in four rivers of the Tagus fluvial system (Portugal). Data were achieved from the on-screen photo interpretation of airborne digital images (RGB-NIR spatial resolution 0.5 x 0.5 m, spring 2005). River stretches were divided in Sampling Units of 250 meters long, and patches of riparian woody vegetation (tree, shrub and herbaceous strata) were delineated. Eight landscape metrics, namely Number of Patches (NP), Mean Patch Size (MPS), Patch Size Coefficient of Variation (PSCV), Mean Shape Index (MSI), Mean Fractal Dimension Index (MPFD), Mean Nearest-Neighbor Distance (MNN), Mean Proximity Index (MPI) and Interspersion and Juxtaposition Index (IJI), related with the spatial configuration, isolation, interconnectivity and distribution of riparian vegetation, were calculated for all strata. The influence of proximal and distal land use (30 m and 200 m buffers, respectively) in the riparian structure was analysed using redundancy analysis. Geostatistical analysis (semivariogram, global and local Moran’s I) were used to describe and incorporate the spatial component of the data and to assess the spatial autocorrelation of the riparian structure.

The results showed that the combined interpretation of metric values can consistently describe the patterns of riparian structure especially for the tree cover class. The inclusion of spatial independent sample units increases drastically the contribution of the land use variables to the total explained variance of the riparian structure. Disturbed riparian woods due to major land use pressure, such as agriculture, presented a low number of small patches (low NP and MPS values) with simple and homogenous shapes (low MSI, MPFD and PSCV values), reduced patch connectivity (high MNN values and low MPI values), and a non interspersed patch distribution (low IJI values). Also it is shown that the proximal land use is more determinant in shaping within-stand riparian structure, therefore protection areas should both envelop riparian zones and an adjacent buffer.
Two studies have been performed in watercress beds in Maisse (91- France) along River Essonne to assess macrophyte successions in these particular agricultural wetlands. Different stages of fallow (between watercress cropping to *Phragmites* stands) have been studied with two sampling methods: surveys on homogeneous stands (August 2007), and systematic quadrat surveys (October 2008) along each watercress bed.

The data collected with both sampling designs have been analysed by principal component analysis. The results of both studies revealed the succession of a different status of the watercress beds after the abandonment of cropping, in terms of vegetation.

Hydrophytes (*Lemna minor*, *Azolla filiculoides*, stoneworts – *Chara* sp., and *Callitriche stagnalis*) tended to colonise the water as the area covered by *Nasturtium officinale* decreases. Simultaneously, *Agrostis stolonifera* developed from the banks, thanks to its creeping stems.

The second step of colonisation was characterised by the appearance of the anemochorous species with *Typha latifolia* and *Epilobium hirsutum* as dominant species. In some places, *Equisetum palustre* appeared, due to rhizome developments.

Later, beds were covered by *Eupatorium cannabinum* and even more by *Phragmites australis*. As ultimate stage, around the study place, old watercress beds abandoned since the 1970’s to the 1980’s were colonised by willows.

Although the macrophyte successions highlighted by both analyses were the same, the study based upon the systematic quadrat survey (2008) provided further information about intra-bed heterogeneity, and changes in the morphology of the beds after abandonment of watercress cropping.

The upstream zone seemed to be more suitable for watercress and hydrophytes (mostly floating species), whereas the downstream zone is less covered by vegetation, and preferentially by helophytes rather than hydrophytes.

In the upstream zone, the relative constancy of the water temperature close to the boreholes (water supply was at 12.3°C) protected the watercress from the frost during winter, and prevented this species from being supplanted by another after the abandonment of cropping.

In the downstream and deeper zone, the absence of floating species can easily be explained by their inability to anchor in the sediment: when there are no helophytes to retain them, these species are swept away to the discharge channel.

In the downstream and deeper zone, the absence of floating species can easily be explained by their inability to anchor in the sediment: when there are no helophytes to retain them, these species are swept away to the discharge channel.

The more recently abandoned stages were characterised by deeper water, compared to the beds that have been abandoned for a longer period. For the ultimate stages, no water flow has been observed, revealing that the beds were steadily filled by the litter resulting from the decomposition of the vegetation.
Assessment of eutrophication effect on charophytes in Mediterranean ponds (North-West Spain)

R. del Pozo\textsuperscript{1)}, C. Fernández-Aláez\textsuperscript{1)}, M. Fernández-Aláez\textsuperscript{1)} and N.F. Santiago\textsuperscript{2)}

\textsuperscript{1)}Area de Ecología, Universidad de León, León, Spain; \textsuperscript{2)}Area de Botánica, Universidad de Valladolid, Palencia, Spain

The distribution of charophyte vegetation of 55 steppe ponds located in the Duero river basin (Northwest of Spain) was studied in relation to eutrophication. A total of 11 charophyte taxa were recorded in 39 ponds. However, only \textit{Chara fragilis} Desv., \textit{Chara connivens} Salzm. ex A. Braun and \textit{Nitella translucens} (Pers.) C. Agardh were found in more than 17 % of the ponds where charophytes occurred.

Conductivity, pH, total phosphorus, total nitrogen, mass ratio of TN:TP, orthophosphate, nitrate, chlorophyll-a, total and volatile suspended solids, turbidity and Secchi disk depth were recorded for each pond.

In order to determine whether those trophic state variables could discriminate between ponds with and without charophytes, the Mann-Whitney U-test was used. Stepwise multiple regression was carried out in ponds where charophytes were present to look for possible relationships between cover and richness of charophytes and the trophic state variables.

Significant differences between ponds with and without charophytes were found for the following parameters: volatile suspended solids (Mann-Whitney U-test; p<0.001), total suspended solids (Mann-Whitney U-test; p<0.01), turbidity (Mann-Whitney U-test; p<0.05), chlorophyll-a (Mann-Whitney U-test; p<0.05), nitrate (Mann-Whitney U-test; p<0.05), and total phosphorus (Mann-Whitney U-test; p<0.05). These variables were significantly lower in ponds where charophytes were present.

Charophytes were found along a wide range of total phosphorus concentration (20-6884 µg/l). However, taxa showed different sensitivity to phosphorus concentration. In this way, \textit{Chara connivens} Salzm. ex A. Braun, \textit{Chara fragilis} Desv and \textit{Nitella translucens} (Pers.) C. Agardh reached their optimum TP concentration at 1875, 551 and 76 µg TP/l, respectively.

Stepwise multiple regression showed that richness of charophytes was significantly correlated to turbidity and volatile suspended solids (R = 0.45). However, cover of charophytes was not related to any trophic state variable.

In relation with charophyte taxa, the total phosphorus concentration was significantly correlated to the cover of \textit{Chara connivens} Salzm. ex A. Braun (R = 0.43). Whereas, the cover of \textit{Chara fragilis} Desv. and \textit{Nitella translucens} (Pers.) C. Agardh were not correlated to any trophic state variable. On the other hand, significant correlation was observed between \textit{Nitella translucens} (Pers.) C. Agardh cover and pH (R = - 0.39).
The influence of connectivity and fertility on aquatic plant communities of riverine backwaters

A. Keruzoré, N. Willby and D. Gilvear
School of Biological and Environmental Sciences, University of Stirling, Scotland, UK

The impact of connectivity in river systems has become a major research theme for freshwater ecologists. Floodplain connectivity and disturbance regime are closely related. Floods are the major disturbance process occurring in floodplains, connecting surface and subsurface waterbodies and organising both geomorphological and biological features. According to the Intermediate Disturbance Hypothesis, species diversity is expected to reach a maximum under intermediate disturbance. Extreme disturbance regime allows only tolerant species to survive and develop. Low disturbance regime leads to competition and dominance processes between plants.

However, trophic status of aquatic habitats also varies within and between river floodplains and is therefore likely to control the response of aquatic vegetation to hydrological disturbance. Fertility of aquatic systems within floodplains varies mainly in relation to the extent of catchment agriculture. Nutrients are essential for plants as they drive their ability to survive, grow and reproduce. Plant diversity and productivity potentially differ greatly according to nutrient concentrations. Fertile or infertile environments are likely to show low plant diversity due to stress tolerance or competitive exclusion. Conversely under moderate fertility highest plant diversity is expected to occur.

In aquatic environments hydrological connectivity and fertility interact. Both factors in combination create a complex matrix of abiotic conditions for aquatic plant settlement, growth and reproduction. The influence of fertility on aquatic plants is often assigned a dominant role in bioindication systems yet fertility cannot be considered independently of disturbance in fluvial environments. Similarly the influence of connectivity cannot be considered independently of fertility. Backwater habitats provide an ideal situation in which to consider these two variables in tandem.

Aquatic habitats, such as backwaters, are a major reservoir of floodplain biodiversity. They are believed to act as a refuge for numerous organisms including aquatic plants, and potentially represent a hotspot for regeneration and recruitment. Nevertheless their ecological importance in river systems is often underestimated as they are often overlooked in conventional sampling. In consequence basic controls and functional ecology of backwaters are poorly understood whereas they are believed to play a major role in maintaining diversity in river floodplains.

This poster will report the results of an investigation into the parallel effects of hydrological connectivity and fertility on the aquatic plant communities of backwaters distributed along several major Scottish river systems.
101 Influence of willow bushes elasticity on roughness coefficients

T. Kalka, L. Rembeza and I. Jesse
Poznan University of Life Sciences, Faculty of Reclamation and Environmental Engineering, Department of Hydraulic Engineering

Introduction

Apart from hydrodynamic parameters, the influence of vegetation on flow conditions greatly depends on the plant species, plant development phase and geometric and their mechanical properties. The mechanical property most strongly depends on elasticity of plants. This parameter makes the plants bend, to various degrees, under the force of flowing water. Its determination, in particular for flexible vegetation of the inter-embankment zone, is crucial for forecasting the behaviour of vegetation and determining the hydrodynamic drag forces resulting from vegetation. It is also directly linked to the water table in the channel.

Analysis of impact of flexible vegetation on hydraulic conditions of flow in vegetated channels

In the framework of a collaborative research project undertaken by the Institute of Environmental Engineering at the Wroclaw University of Environmental and Life Sciences and the Department of Hydraulic Engineering at the Poznan University of Life Sciences, laboratory experiments have been carried out to estimate the biomechanical and hydraulic properties of the flexible vegetation covering river valleys. Measurements were carried out for branches of willow allowing for the determination of the modulus elasticity, modulus of non-dilatational strain as well as density and humidity. Fresh and dried material was included in the experiment. It was found that the mechanical property depended on the humidity and the species. Moreover, research proved the importance of the duration of force application. Experiments carried out on branches of willow showed that when plants are placed under strain and left in this state, the deformation increases with time. When the load is removed, the deformation is gradually decreasing. Knowledge of the scope of relaxation allows to forecast whether vegetation can return to its original state after a flood wave or is durably broken or bent under some angle and also what is the impact on flow parameters. Deformation of willow branches caused by flow of water has been investigated. Relationship between elastic deformation of branches and roughness coefficients has also been estimated. A numerical model is introduced that serves as a means for investigating the influence of the several factors that contribute to flow resistance induced by flexible vegetation. The model has been partially calibrated from data obtained in experiments with flexible vegetation. All measurements have been done in a hydraulic laboratory.
Aquatic vegetation as an indicator of littoral habitats and various stages of lake overgrowth in North Poland

M. Szańkowski and S. Kłosowski
Department of Plant Ecology and Environmental Conservation, University of Warsaw, Poland

The habitats of 356 phytocoenoses of the class Potametea were investigated. The species-water and species-substrate relationships were demonstrated by means of Canonical Correspondence Analysis. Altogether 14 properties of water and 12 properties of substrate were analysed (for laboratory methods, see: Szańkowski & Kłosowski 1999). Fifteen dominant species representing the phytocoenoses studied were displayed on CCA diagrams: Ceratophyllum demersum (CERDEM), Elodea canadensis (ELOCAN), Hydrilla verticillata (HYDVER), Myriophyllum spicatum (MYRSPI), Myriophyllum verticillatum (MYRVER), Nuphar lutea (NUPLUT), Nuphar pumila (NUPPUM), Nymphaea alba (NYMALB), Nymphaea candida (NYMCAN), Polygonum amphibium (POLAMP), Potamogeton lucens (POTLUC), Potamogeton natans (POTNAT), Potamogeton perfoliatus (POTP), Ranunculus circinatus (RANCIR), Stratiotes aloides (STRALO).

It is demonstrated that among properties of water, Na+, pH, total Fe, Ca2+ and SO42- were most important in differentiating the habitats studied. Considerable differences were found between Ranunculus circinatus (hard, alkaline waters, rich in Na+), Nuphar pumila (waters with high levels of total Fe) and Stratiotes aloides (waters with high concentrations of Ca2+ and SO42-). In the case of substrate, the properties which best differentiated the habitats were: PO43-, hydration, organic matter, total N and pH. Two distinct groups of species can be distinguished: (1) species growing on mineral substrates: Potamogeton perfoliatus, Myriophyllum spicatum, R. circinatus and Polygonum amphibium, (2) species associated with organic substrates: C. demersum, Hydrilla verticillata, Myriophyllum verticillatum, N. pumila, Nymphaea alba, N. candida, and S. aloides. Particularly noteworthy are: R. circinatus, which inhabits substrates richest in PO43- and S. aloides, growing on substrates poor in PO43-, as well as C. demersum, associated with substrates rich in PO43- and richest in total N.

The investigated phytocoenoses represent different stages of lake overgrowth.
The patches of *P. perfoliatus*, *R. circinatus*, *M. spicatum* and *P. amphibium*, which develop on mineral substrates, initiate the process of succession, whereas those of *M. verticillatum*, *N. candida*, *N. alba* and *S. aloides*, which inhabit highly hydrated organic substrates, are characteristic of the late stages of lake overgrowth.

**Water and substrate properties - codes used in the diagrams:**

- [pH] = pH
- [C.hardness] = carbonate hardness
- [T.hardness] = total hardness
- [COD] = chemical oxygen demand
- [Colour] = colour of water
- [T.Fe] = total iron
- [T.N] = total nitrogen
- [Hydration] = water content in fresh substrate
- [Organic] = organic matter content in substrate
- [Ca] = Ca$^{2+}$
- [K] = K$^+$
- [Na] = Na$^+$
- [NH4] = NH$_4^+$
- [NO3] = NO$_3^-$
- [PO4] = PO$_4^{3-}$
- [SiO2] = SiO$_2$
- [SO4] = SO$_4^{2-}$

**References:**


Practical uses
103 Water soldier (*Stratiotes aloides* L.) as a new potential source of active compounds with anti-inflammatory, anti-gout and antioxidant effects

P. Sugier¹ and U. Gawlik-Dziki²

¹Department of Ecology, Maria Curie-Skłodowska University, Lublin, Poland; ²Department of Biochemistry and Food Chemistry, University of Life Science, Lublin, Poland

*Stratiotes aloides* L. grows mainly in shallow stagnant eu- and mesotrophic waters and plays a very important role in aquatic ecosystems. During the last decades *S. aloides* has declined considerably in Europe, where it grows at its northern and eastern limit, mainly due to excessive eutrophication. On the other hand, this very common species is often dominant in lakes, ponds, channels, ditches and other water bodies created by peat excavation in mid-eastern Poland. In numerous cases *S. aloides* has been removed by anglers, because it is prone to taking over a whole pond or a small lake. It has become increasingly popular to investigate a range of different plants as potential sources of antioxidants. For that reason we determined the biological activity of *Stratiotes aloides*. Plants were collected from a small shallow pond in September 2008. Two kinds of extracts were prepared from leaves and roots of *S. aloides*: the water extract determining the activity of hydrophilic compounds, and the methanolic and water (1:1 v/v) extract for lipophilic compounds. In both samples the total content of phenolics, flavonoids and phenolic acids was determined. For the evaluation of biological activity, the ability of inhibiting lipoxygenase and xanthine oxidase was determined. Apart from that, the antioxidant activity was also measured once radical scavenging abilities and chelating and reducing powers were estimated. Higher phenolics amounts were found in leaves (1.30 mg/g fresh mass), whereas their level in roots amounts to 1.30 mg/g f.m., irrespective of extraction procedure. Lipophilic compounds from *S. aloides* showed medium antiradical activity (26.02% in leaves and 10.02% in roots), whereas the activity of hydrophilic compounds ranged from 7.06% in leaves to 3.35% in roots extracts. Lipophilic compounds isolated from leaves and roots of *S. aloides* possessed a strong ability to chelate metal ions (88.34% in leaves and 81.35% in roots extract).

The results show, interestingly, that lipophilic compounds isolated from roots inhibit xanthine oxidase (about 80 %), while phytochemicals from leaves have a high ability to inhibit lipoxygenase (about 55 %). Obtained results show that *Stratiotes aloides* can be used as a new potential source of active compounds with anti-inflammatory and anti-gout effects.
Evaluation of water purification of an artificial agricultural drainage in a dairy farming watershed

Yamamoto, Tadao, Inoue, Takashi and Nagasawa, Tetuaki
Laboratory of Land Improvement and Management, Division of Environmental Resources, Research Faculty of Agriculture, Hokkaido University, Hokkaido, Japan

Introduction

We studied the effects of water quality improvement in drainage channels containing small pools in a small catchment area where dairy farming was practiced, in eastern Hokkaido, Japan. The improvements entailed installment of sandbars upstream in order to retard the current, which produced pools and a meandering flow. For water quality measurements, water samples were taken upstream and downstream in the drainage channel, and discharge was observed at V-notch weirs at those points. Pre-improvement field surveys were carried out between April and October 2004; post-improvement field surveys were carried out between September 2005 and November 2008. In addition to this research, vegetation and bottom sediments in the drainage channel were sampled three times in 2008, and the nitrogen content was analysed.

Effect of purification in drainage channel

In the four years since this work, various plants, including reeds, have formed dense stands in the drainage channel. These improvements increased the flow by a factor of almost 30 and achieved greater reduction in nitrogen and phosphorus load during downflow than observed for the previous conventional straight earthen channel. The reduction in total nitrogen (TN) concentration was greater after channel improvement than before. Before channel improvement, both TN and suspended solids (SS) concentrations were reduced, which is attributed to the elimination of nitrogen by SS sedimentation. A reduction in NH$_4$-N and an increase in NO$_3$-N concentrations were observed before channel improvement. The reductions in total phosphorus (TP) and PO$_4$-P concentrations were greater after improvement. The reductions in TP and PO$_4$-P concentrations are attributed to elimination by SS sedimentation and to absorption by the channel bed, an attribution that was also made for TN. The effect on nitrogen purification was especially remarkable, which can be attributed to absorption and uptake by vegetation and denitrification. In 2008, the nitrogen (NO$_3$-N) fixation rate by the vegetation was estimated to be 24 %, with 1 % remaining in pool bottom sediments and 75 % released to the atmosphere by denitrification. These results suggest that denitrification is more efficacious for reduction of TN than absorption by vegetation in the present drainage channel. Moreover, the denitrification rate was estimated at 0.31 (gm$^{-1}$d$^{-1}$), which was consistent with previous research.
Addition to Invasive plants and their ecological effects: Increased growth of submerged aquatic vegetation (SAV) in Finnish lakes at the beginning of the 2000's – is excessive SAV growth still ongoing?

A. Mäkelä & I. Sammalkorpi
Finnish Environment Institute, Water Resources Management Division, Restoration of Watercourses

Introduction

Emergent macrophytes overgrowing lake shorelines has long been a problem for recreational use of shallow lakes or lake bays in Finland. Mowing and dredging procedures have widely been applied for their control. However, since 2003 Finnish regional environmental authorities have received several reports on excessive growth of submerged aquatic vegetation (SAV). The submerged plants, which are highly desirable from an ecological point of view, have caused problems for the recreational use of lakes, especially for swimming, boating and fishing. SAV is also causing difficulties for the conservation of habitats of some endangered plant species. A national survey carried out in 2005 highlighted 72 cases with a nuisance level overgrowth of SAV. In most of them the excessive growth of SAV was a new phenomenon. The nuisance was generally caused by Elodea canadensis, Ceratophyllum demersum, Myriophyllum spp, Potamogeton spp. and aquatic mosses. The problem mainly occurs in southern Finland (60-62°N). Some cases were reported from areas close to the polar circle and from Aland archipelago, too. Medium water quality values of the lakes were mesotrophic (Tot-P 33 ug/l, chl-a 10.4 ug/l, transparency 1.2 m). The phenomenon had probably been triggered by an exceptional drought, resulting in low water levels in 2002-2003, coupled with temporary higher water temperatures, and reduced leaching of suspended solids and nutrients from the catchment areas. In some cases SAV growth was amplified by intentionally effective fish removals in food-web restoration projects, or by extensive winterkills of cyprinids caused by low water and oxygen levels, or even total oxygen depletion, during the long ice-cover period in the winter of 2003. The objective of this study is to clarify the significance of the excessive SAV problem on a national scale and to estimate in this context the needs for restoration, research and education.

Increase of the SAV problem in Finland

More than 900 sites with an excessive overgrowth of macrophytes were listed during a national lake survey in 1999 (Turunen & Äystö 2000) and removal of macrophytes to reduce local overgrowth is still one of the most frequently used restoration methods in shallow Finnish lakes (Keto et al. 2004). The problems were then mainly caused
by the emergent and floating-leaved species, *Phragmites australis, Scirpus lacustritis, Nuphar lutea* or *Nymphaea* spp. In contrast to this, nuisance caused by submerged aquatic vegetation (SAV) was then only reported from a few lakes. However, a few years later, especially in 2003 and 2004, the Finnish environmental authorities received several reports about excessive growth of SAV locally hampering the recreational use of lakes. A national status report on excessive growth of SAV was prepared (Laita et al. 2007), a new information campaign for the public was launched in 2008 and data collection was initiated by means of observations by volunteers.

In 2008 15 new SAV cases were reported. New species causing excessive growth included *Chara* spp., *Callitriche cophocarpa* and *Hippris vulgaris*. There are some indications that SAV decreases in Lake Tuusulanjärvi, but in general, we can conclude that the excessive SAV growth is still ongoing.

**References**


**Abstract**

The publication includes abstracts of the presentations and posters of the 12th European Weeds Research Society Symposium, which was held at the Agora center of University of Jyväskylä (Finland) on August 24-28, 2009. The symposium was organised by European Weed Research Society (EWRS), International Society of Limnology (SIL), Finnish Environment Institute (SYKE), University of Jyväskylä and the Waterpraxis project. The symposium was attended by more than one hundred weed scientists and experts from over thirty countries.

The main theme of the symposium was 'Aquatic invasions and their relation to environmental changes', with the following specific sessions:

- Biology, ecology and distribution
- Indicator value of aquatic plants
- Management of aquatic vegetation and side effects
- Invasive plans and their ecological effects
- Environmental management in relation to aquatic plant development
- Aquatic vegetation and environmental relationships
- Practical uses

**Keywords**

Aquatic plants, invasive plants, aquatic ecosystems, environmental management, ecology, distribution
**Julkaisija** Suomen ympäristökeskus (SYKE)  
**Julkaisuaja** Elokuu 2009

**Tekijä(t)** Arnold Pieterse, Anne-Mari Rytönen ja Seppo Hellsten (toim.)

**Julkaisun nimi** Aquatic Weeds 2009 Proceedings of the 12th European Weed Research Society Symposium

**Julkaisusarjan nimi ja numero** Suomen ympäristökeskuksen raportteja 15 / 2009

**Julkaisu teema**

**Julkaisun osat/ muut saman projektin tuottamat julkaisut** Julkaisu on saatavana myös internetissä: www.ymparisto.fi/publications


Sympoosion pääteemana oli ’Vesien vieraslajit ja niiden suhde ympäristömuutoksiin’ ja alateemoja olivat:

- Biologia, ekologia ja Levinneisyys
- Vesikasvien indikaattoriarvo
- Vesiväili suvun hallinta ja sivuvaikutukset
- Vieraslajit ja niiden ekologiset vaikutukset
- Ympäristönhoito suhteessa vesiväili suvun kehitykseen
- Vesiväilisuus ja ympäristösuhteet
- Vesikasvien hyötykäyttö

**Asiakasväit** Vesikasvit, vieraslajit, vesiekosysteemit, ympäristönhoito, ekologia, Levinneisyys

**Rahoittaja/ toimeksiantaja**

**Rahat**

**ISBN** 978-952-11-3499-9 (nid.)  
**ISBN** 978-952-11-3500-2 (PDF)  
**ISSN** 1796-1718 (pain.)  
**ISSN** 1796-1726 (verkk.)

**Sivuja** 177  
**Kieli** englanti  
**Luottamuksellisuus** julkisen  
**Hinta (sis.alv 8 %)** -

**Julkaisun myynti/ jakaja** Suomen ympäristökeskus (SYKE), asiakaspalvelu  
PL 140, 00251 Helsinki  
Puh. 020 690 183, faksi (09) 5490 2190  
Sähköposti: neuvonta.syke@ymparisto.fi

**Julkaisun kustantaja** Suomen ympäristökeskus (SYKE)  
PL 140, 00251 Helsinki  
Puh. 020 610 123  
Sähköposti: neuvonta.syke@ymparisto.fi, www.ymparisto.fi/syke

**Painopäikka ja -aika** Edita Prima Oy, Helsinki 2009

Huvudteman i symposiet var "Akvatik invasion och dess relation till miljöförändring" med följande sessioner:

- Biologi, ekologi och utbredning
- Vattenväxters indikatorvärde
- Vattenväxters kontroll och sideffekter
- Invasionarter och deras ekologiska effekter
- Miljövård och vattenväxtersutveckling
- Vattenväxter och miljörelationerna
- Praktiska applikationer

**Nyckelord**
Vattenväxter, invasionarter, vattenekosystem, miljövård, ekologi, utbredning

**Finansiär/upphofsgivare**
Finlands miljöcentral (SYKE), kundservice PB 140, 00251 Helsingfors Tfn. +358 20 690 183, fax +358 9 5490 2190 Epost: neuvonta.syke@ymparisto.fi
Aquatic Weeds 2009

Proceedings of the
12th European Weed Research Society Symposium
August 24–28 2009, Jyväskylä, Finland

Arnold Pieterse, Anne-Mari Rytkönen and Seppo Hellsten (eds)