A PROJECT ON NYMPHAEID-DOMINATED SYSTEMS

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INTRODUCTION

In 1973 the Laboratory of Aquatic Ecology started with a research project on structure, dynamics and function of macrophyte-dominated aquatic communities; a begin was made with broad ecological research projects on various structurally different but ecologically linked aquatic macrophyte systems, such as the nymphaeid, the seagrass, the *Ruppia* and *Zannichellia-Potamogeton pectinatus* systems (DEN HARTOG, 1978) in analogy with the international seagrass project.

Nymphaeids are aquatic plants which possess mainly floating leaves, have their flowers above or floating on the water surface and are rooted in the bottom (Fig.1). They are distinguished as a growth form by all authors who have described growth forms, and they are very common in all freshwater areas of the Netherlands. In shallow water they can dominate the community. Nymphaeid-dominated communities have been studied by the author since June 1974. Various aspects have been studied separately, but also in relation to each other. Investigations were started on communities dominated by the nymphaeid species *Nymphoides peltata* (Gmel.) O. Kuntze (up to now mainly results of investigations on this community are published), *Nuphar lutea* (L.) Sm., *Nymphaea alba* L. and *Nymphaea candida* Presl. The fourth species was discovered for the first time in the Netherlands during these investigations and is now known from several localities (ROELOFS and VAN DER VELDE, 1977; GIESEN and VAN DER VELDE, 1978; MENNEMA and VAN OOSTSTROOM, 1979).

Till now only case studies on the nymphaeid systems were presented, but in the present study general remarks are made to explain the general line of the research project.

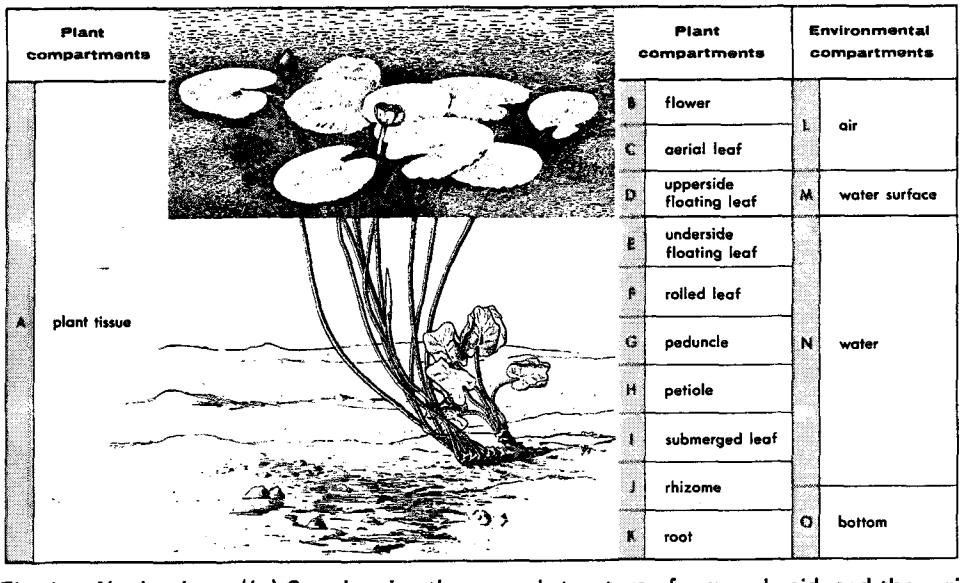

Fig. 1. *Nuphar lutea* (L.) Sm. showing the general structure of a nymphaeid, and the various compartments which can be distinguished in a nymphaeid-dominated system.

THE ROLE OF MACROPHYTES

Macrophytes have an important function in shallow water communities. The concept of the function can be regarded as a combination of all activities and performances of the organisms of a community, such as primary production, respiration, decomposition and nutritional relations and more specific non-energetic properties (DEN HARTOG, 1978). Macrophytes influence the physico-chemical properties of littoral and shallow waters (SCULTHORPE, 1967; HUTCHINSON, 1975; WETZEL, 1975; MARSHALL and WESTLAKE, 1978). They cause differences in oxygen content in the water between day and night due to photosynthesis and respiratory activity, they play a role in cycling of mineral and organic compounds in water bodies, they secrete organic compounds, which are important for the carbon budget in lakes and they absorb and store nutrients from water and sediments (PIECZYNSKA and OZIMEK, 1976). In water with high macrophyte biomass the amount of elements accumulated in macrophytes can be higher than the amount in water (BERNATOWICZ, 1969). Lime incrustations are formed on macrophyte surfaces (WETZEL, 1975). Wave action is often reduced by the presence of macrophytes. Further they change light conditions where they grow and can intercept light to a considerable extent (PIECZYNSKA and OZIMEK, 1976).

As more or less non-energetic properties their function as a substrate for other littoral and shallow water organisms such as algae, bacteria, fungi and various groups of animals, and as shelter, nursery and spawning site must be mentioned. The living plant tissue can be consumed by various animals (GAEVSKAYA, 1969), while decaying macrophyte material plays an important role in the detritus food chain. In this way macrophytes contribute to the formation of a sapropelium layer on the bottom; due to this process the water can become shallower so that succession towards a marsh can take place. The macrophytes stabilize bottom sediments and protect banks (MARSHALL and WESTLAKE, 1978). They form structured communities.

The concept of the community structure can be defined in various ways; according to DEN HARTOG (1978; 1979) at least three major components can be distinguished. A. the floristic and faunistic composition of the community. B. the arrangement of the organisms in space and time. C. the relations between the organisms within the community, as well as their relations with the surrounding environment.

There are several reasons why macrophytes in shallow waters can be considered to be the basic frame of an ecosystem, *viz.* they form a bulk of biomass and by their morphological differentiation (structure) they offer many possibilities for the settlement of other organisms. Important factors with respect to this settlement are the patterns of leaf production and leaf-shedding, the decomposition and the turn-over of the various plant parts. The morphological differentiation of the aquatic macrophytes differs considerably so that a great number of growth forms based on the habit of the plants can be recognized; these seem to be linked with a certain habitat type and determine the physiography of the community to a high degree (DEN HARTOG, 1978). The growth forms of aquatic plants have been amply described by DEN HARTOG and SEGAL (1964), SEGAL (1968), DEN HARTOG (1967, 1977), HOGEWEG and BRENKERT-VAN RIET (1969), HUTCHINSON (1975) and MÄKIRINTA (1978).

STRUCTURAL ELEMENTS OF A NYMPHAEID-DOMINATED SYSTEM

The vertical differentiation of the nymphaeid vegetation offers niches to many other organisms, and so several compartments within the nymphaeid system can be distinguished each with its characteristic species combination (Fig. 1). Certainly, there is an exchange in species between the various compartments; the possibility to occur in different compartments varies for each species and depends on its adaptations, *e.g.* whether it is adapted to one or two

different media. Water forms a barrier for most terrestrial insects, so only some specialized groups can occur in nymphaeid-dominated systems. When more parts of aquatic plants are situated above the water surface more insect species are able to utilize the plant tissue as food, as illustrated by GAEVSKAYA (1969), who summarized the animal species which consume freshwater plants all over the world. According to her 78 species of Coleoptera have been found to feed on semi-submerged plants (helophytes), 21 species on floating-leaved plants, 7 on completely submerged plants, and only 11 species were recorded as feeding on all three categories. For Diptera these figures are 78, 21, 18 and 31, for Lepidoptera 63, 4, 0 and 8, respectively.

The complex life cycles of certain fauna elements, for instance that of the ephydrid fly *Notiphila brunnipes* R.-D. (see VAN DER VELDE and BROCK, 1980) make it possible that one species can occur in several different nymphaeid compartments during the various stages of its development. The beetle *Donacia crassipes* (F.) (Chrysomelidae) occurs as an imago in compartment D, the eggs are deposited in compartment E, while larvae and pupae occur in compartment K; another chrysomelid beetle, *Pyrrhalta (Galerucella) nymphaeae* (L.) f. *typica* occurs during all its life stages (imago, egg, larva, pupa) in compartment D. These two beetles complete their whole life cycle on *Nymphaea* and *Nuphar*. It is also possible that only one stage in the life cycle of a species occurs in a nymphaeid compartment, while it is further completely independent of the system, for example imagos of Apidae which are flower visitors (VAN DER VELDE and VAN DER HEIJDEN, 1980). So there are also important biological relations with the surrounding environment of the nymphaeid community. It is clear that for each species the relation with the nymphaeid system has to be investigated and that ecological studies on important species are urgently needed to understand the complex processes in the compartments and at last the nymphaeid system as a whole.

According to the mode of space utilization, the following structural elements can be distinguished within the nymphaeid system. 1. The nymphaeid itself, which is differentiated into parts above and on the water surface, parts in the water column and underground parts. The space utilization of nymphaeids is very extensive. From the rhizome in the substratum groups of long-stalked floating leaves and peduncles develop; sometimes there are also some submerged ground leaves. Although the floating leaves may cover the surface for nearly 100 %, the water column itself contains only the petioles and peduncles, and possibly some accompanying macrophytes. 2. Associated macrophytes (compartment L-O; Fig.1). 3. Phytoplankton (compartment N). 4. Epiphyton (compartment E-J). 5. Endophytes (compartment A). 6. Microbial organisms (compartment A-O). 7. Mining fauna (compartment A). 8. Sessile aquatic epifauna (compartment E-K). 9. Vagile aquatic epifauna (compartment E-K). 10. Terrestrial fauna (compartment D, B). 11. Neustonic fauna (compartment M). 12. Aerial fauna (compartment L). 13. Zooplankton (compartment N). 14. Nekton (compartment N). 15. Benthic infauna (compartment O). 16. Vagile bottom fauna (compartment O).

Our knowledge of the various elements is till now insufficient to conceive a model of the whole ecosystem based on species composition, species characteristics, dynamics, seasonal aspects, energy flows and so on. Of several structural elements only preliminary data are available and some have not yet been studied at all. Each structural element should be studied in each compartment for at least a year by using transects so that the temporal and spatial patterns and the changes of these patterns become known. Connections between processes in different compartments can only be elucidated by an integrated study of these compartments during at least a whole year.

As the nymphaeid system is very complex it is studied by a team of scientists now. The research group consists of: Dr.G.van der Velde (general research, nymphaeids, macrofauna), Dr.J.F.M.Geelen (plankton), Mr.Th.C.M.Brock (nutriënt cycling, macrofauna and decomposition), Mr.E.J.P.Delbecque (epiphyton), Mr.R.M.M.Roijackers (phytoplankton), Prof. dr.C.den Hartog, Mr.J.G.M.Roelofs (chemistry).

PUBLICATIONS ON THE PROJECT

G.VAN DER VELDE, 1976. The significance of nymphaeid vegetations for animal life. Proceedings 1975. Nederlandse Dierkundige Vereniging. Neth.J.Zool., 26(3):445-446.

P.A.J.FRIGGE, M.OLDE LOOHUIS and G.VAN DER VELDE, 1976. Fasciaties bij bladeren van de Watergentiaan. Korte Mededelingen. De Levende Natuur, 79:208.

J.G.M.ROELOFS and G.VAN DER VELDE, 1977. *Nymphaea candida* Presl, een waterlelie nieuw voor Nederland. De Levende Natuur, 80:170-186 (with English summary).

Th.G.GIESEN and G.VAN DER VELDE, 1978. De verspreiding van *Nymphaea candida* Presl en *Nymphaea alba* L. in Nederland. Gorteria, 9(3):61-66 (with English summary).

E.H.R.R.LAMMENS and G.VAN DER VELDE, 1978. Observations on the decomposition of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae) with special regard to the leaves. Aquat.Bot., 4:331-346.

M.HEINE and G.VAN DER VELDE, 1978. De muskusrat, *Ondatra zibethicus* (L.) in de Ooypolder bij Nijmegen en zijn invloed op nymphaeide vegetaties. De Levende Natuur, 81:122-128 (with English summary).

G.VAN DER VELDE, Th.C.M.BROCK, M.HEINE and P.M.P.M.PEETERS, 1978. Flowers of Dutch Nymphaeaceae as a habitat for insects. Acta.Bot.Neerl., 27(5/6):429-430.

G.VAN DER VELDE, 1978. Structure and function of a nymphaeid-dominated system. Proc.EWRS 5th Symp. on Aquatic Weeds, 1978 (Amsterdam):127-133.

G.VAN DER VELDE, Th.G.GIESEN and L.A.VAN DER HEIJDEN, 1979. Structure, biomass and seasonal changes in biomass of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae), a preliminary study. Aquat.Bot., 7(3):279-300.

G.VAN DER VELDE, 1979. *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae) as a food plant for *Cataclysta lemnata* (L.) (Lepidoptera, Pyralidae). Aquat.Bot., 7(3): 301-304.

G.VAN DER VELDE and Th.C.M.BROCK, 1980. The life history and habits of *Notiphila brunnipes* R-D. (Diptera, Ephydridae), an autecological study on a fly associated with nymphaeid vegetations. Tijdschr. Ent., 123(5):105-127.

G.VAN DER VELDE, 1980. Studies in nymphaeid-dominated systems with special emphasis on those dominated by *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae). Thesis Nijmegen. Studentenpers Nijmegen. 163 pp.

G.VAN DER VELDE, 1981. Development and decomposition of floating leaves of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae) in two concrete tanks. International Colloquium on Aquatic Vascular Plants (Brussel), 1981. Abstracts:55.

G.VAN DER VELDE, and L.A.VAN DER HEIJDEN, 1981. The floral biology and seed production of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae). Aquat.Bot., 10(3):261-293.

Th.C.M.BROCK and G.VAN DER VELDE, 1981. An autecological study on *Hydromyza livens* (Fabricius) (Diptera, Scatomyzidae), a fly associated with nymphaeid vegetations dominated by *Nuphar*. Tijdschr.Ent., (in press).

R.M.M.ROIJACKERS, 1981. The use of cubic splines as a method to approximate chlorophyll-a versus time curves and a plea for an at least weekly phytoplankton sampling program. Ecological Modelling, manuscript.

SUMMARY

In the present paper the general line of the research project on nymphaeid-dominated systems of the Laboratory of Aquatic Ecology (Catholic University, Nijmegen) is explained and a list of publications is given. In the nymphaeid system 16 structural elements could be distinguished which are spatially distributed over 15 compartments. As the nymphaeid system is very complex compared with other macrophyte-dominated systems, a team is working now on the project.

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REFERENCES

BERNATOWICZ, S., 1969. Macrophytes in the lake Warniak and their chemical composition. Ekol.pol. A, 17:447-467.

DEN HARTOG, C., 1967. The structural aspect in the ecology of seagrass communities. Helgoländer Wiss. Meeresunters., 15:648-659.

DEN HARTOG, C., 1977. Structure, function and classification in seagrass communities. In: C.P. McRoy and C. Helfferich (Eds.) Seagrass Ecosystems, a scientific perspective. Marine Science, 4:89-121.

DEN HARTOG, C., 1978. Structural and functional aspects of macrophyte-dominated aquatic systems. Proc.EWRS 5th Symp. on Aquatic Weeds, 1978 (Amsterdam):35-41.

DEN HARTOG, C., 1979. Seagrasses and seagrass ecosystems, an appraisal of the research approach. Aquat.Bot., 7:105-117.

DEN HARTOG, C., and S.SEGAL, 1964. A new classification of the water-plant communities. Act.Bot.Neerl., 13:367-393.

GAEVSKAYA, N.S., 1969. The role of higher aquatic plants in the nutrition of the animals of freshwater basins. Translation edited by K.H. Mann. National Lending Library for Science and Technology, Boston Spa, England, Vol.1-3, 629pp.

HOGEWEG, P. and A.L.BRENKERT-VAN RIET, 1969. Structure of aquatic vegetation: a comparison of aquatic vegetation in India, the Netherlands and Czechosloviaka. Trop. Ecol., 10:139-162.

HUTCHINSON, G.E., 1975. A treatise on Limnology III. Limnological botany. Wiley, New York, 660pp.

MÄKIRINTA, U., 1978. Ein neues ökomorphologisches Lebensformen-system der aquatischen Makrophyten. Phytocoenologia, 4:446-470.

MARSHALL, E.J.P. and D.F.WESTLAKE, 1978. Recent studies on the role of aquatic macrophytes in their ecosystem. Proc.EWRS 5th Symp. on Aquatic Weeds, 1978 (Amsterdam):43-51.

MENNEMA, J. and S.J.VAN OOSTSTROOM, 1979. Nieuwe vondsten van zeldzame planten in Nederland, hoofdzakelijk in 1978. Gorteria, 9:347-364.

PIECZYNSKA, E. and T.OZIMEK, 1976. Ecological significance of lake macrophytes. Int.J.Ecol. Environ.Sci., 2:115-128.

SEGAL, S., 1968. Ein Einteilungsversuch der Wasserpflanzengesellschaften. In: R. Tüxen (Ed.). Pflanzensoziologische Systematik. Den Haag:191-219.

SCULTHORPE, C.D., 1967. The biology of aquatic vascular plants. Edward Arnold, London, 610pp.

WETZEL, R.G., 1975. Limnology. W.B. Saunders Company, Philadelphia. 743pp.