Aquatic Plant Communities of Irrigation Reservoirs in East Harima Area, Hyôgo Pref., Southwestern Japan: Typology Based on the Dominant Species

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Yasuro KADONO*: Aquatic Plant Communities of Irrigation Reservoirs in East Harima Area, Hyôgo Pref., Southwestern Japan: Typology Based on the Dominant Species

角野康郎*：兵庫県東播磨地方のため池の水生植物群落―優占種による類型化

Introduction

The studies of aquatic vegetation in inland waters are far behind those of terrestrial vegetation in Japan. Among other things, the studies of macrophytic vegetation of irrigation reservoirs are limited in number even though a large number of such habitats occur in Japan. KAMURO (1960, 1967, 1968) worked out the phytosociology of irrigation reservoirs located in southwestern and central Japan, but his works put emphasis on marginal (terrestrial) and littoral (amphibious) vegetation and dealt only briefly with floating-leaved and submerged vegetation. HAMASHIMA (1979) reported some community types observed in the irrigation reservoirs in Tokai and Kinki Districts. Recently SHIMODA (1985) made a phytosociological study of the macrophytic vegetation in irrigation reservoirs in Saijo Basin, Hiroshima Prefecture. However, information is very scanty or absent for other regions.

As to the description and classification of macrophyte vegetation, some methodological problems have been discussed. The strict application of the conventional method of the Zürich-Montpellier school has been subject to some criticisms (e. g. Den HARTOG & SEGAL, 1964; MÄKIRINTA, 1978). In some cases numerical analyses have been tried, but they do not seem to surpass the conventional method so far as classification is concerned (KURIMO & KURIMO 1981: for further discussion about the application of numerical analyses, see also WIEGLEB, 1980, 1983).

Dominant species have been used in the classification of lake types in Finland (MARISTO, 1941; RINTANEN, 1982). The plant communities of irrigation reservoirs in Japan are usally dominated by one or a few species. This situation makes possible the typology of macrophytic communities based on the dominant or co-dominant species. Here I will apply such an approach and give an outline of community types observed in the irrigation reservoirs of East Harima Area, Hyôgo Pref., southwestern Japan. The community types presented here do not imply any assignment to a fixed rank of orthodox phytosociology. They are open to more comprehensive future studies using any approach whatsoever.

Study Area and Methods

Field survey was conducted in more than 600 irrigation reservoirs located in East Harima Area during vegetative periods (July to October) of 1980 to 1984. Some floristic data and the distribution of frequent species were already reported (KADONO, 1984). The present paper is concerned with 449 reservoirs which contained vegetation of true aquatics.

In each reservoir visited, occurring species were recorded with a measure of dominance. The degree of dominance of each species was determined according to the following six-step scale similar to HAMASHIMA (1979, p. 41): 5, very abundant (coverage 75-100%); 4, abundant (coverage 50-75%); 3, frequent (coverage 25-50% or many patches of the plants); 2, occasional (several patches of plants); 1, rare (a few patches of plants); +, very rare (one to a few solitary plants).

The whole reservoir was treated as one community unit and the horizontal and vertical patterns of distribution of each species, if any, were regarded as an internal structure of the community within an individual reservoir. In this respect the present study is incompatible with the phytosociological approach of the Zürich-Montpellier school which is based on quadrats covering homogeneous vegetation of relatively small size.

The species ranked as 5, 4 or 3 of dominance scale were regarded as "dominant" in the follow-

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ing procedures. But when there were two species with a scale of 5 or 4 in a community, the species with a scale of 3 were left out of consideration. First of all, dominant species (in cases with one "dominant" species) or combinations of co-dominant species (in cases with more than one "dominant" species) were picked out as regards all the communities with dominant species. And when the community with a given dominant species or combination of co-dominant species was observed repeatedly three times or more, it was thought to represent one community type. When the community with some dominant species or combination of co-dominant species was observed once or twice, it was treated as "others" in principle. But in a few cases such one was included into the other most similar type tentatively for convenience. For example, the community composed of *Trapa* of rank 4 and *Hydrilla verticilata* of rank 3 was included into *Trapa* type (4d) without inventing "*Trapa-Hydrilla* type".

In case that the vegetation was sparse and found were no dominant species it was assigned to some community type by the similarity of floristic composition and the relative abundance of respective species. But I did not try to assign all the communities to a definite type when it seemed difficult to do so.

The name of the community type was derived from the dominant or co-dominant species, and only generic name was attached unless ambiguous. It does not refer to characteristic or differential species in a phytosociological sense.

In the present study only the true aquatics are concerned. The helophyte and amphiphyte communities surrounding the reservirs are not dealt with here.

Table 1 Community types found in irrigation reservoirs of East Harima. The mean number of species in each reservoir is shown together with standard deviation (in parentheses).

Community Type	Number of Reservoirs	Mean Number of Species
1. *Nelumbo* type	13	2.8(1.7)
2. *Nelumbo-Trapa* type	20	3.3(1.2)
3. *Nelumbo-Salvinia* type	3	4.0(1.0)
4. *Trapa* type		
a. Pure subtype	100	1.0
b. *Trapa*-Lemnid subtype	22	2.3(0.5)
c. *Trapa*-Nymphaeid subtype	15	2.9(1.0)
d. *Trapa*-Elodeid subtype	61	4.0(2.1)
5. *Euryale-Trapa* Type	15	4.2(1.9)
6. *Trapa-Nymphoides* type	32	4.6(2.6)
7. *Nymphoides* type	21	4.6(3.0)
8. *Nymphoides-Brasenia* type	8	7.4(2.8)
9. *Brasenia* type	37	4.1(2.1)
10. *Brasenia-Nymphaea* type	6	2.3(0.8)
11. *Nymphaea* type	12	2.2(1.3)
12. *Nymphaea-Potamogeton fryeri* type	3	2.0(0.0)
13. *Nuphar subintegerrimum* type	8	3.5(1.5)
14. *Potamogeton distinctus* type	12	3.5(1.8)
15. *Potamogeton octandrus* type	6	4.2(2.4)
16. *Elodea* type	10	2.4(2.1)
17. *Myriophyllum ussuriense* type	8	2.0(1.3)
18. *Hydrilla* type	4	3.0(2.5)
19. *Lemnid* type	3	1.7(0.6)
20. *Salvinia* type	3	2.3(1.2)
21. *Eichhornia* type	3	1.3(0.6)
22. Others	24	——

Results

From the investigated reservoirs 74 species of true aquatics were recorded in total (KADONO, 1984, 1985). Based on the dominant species or combinations of co-dominant species 21 community types were recognized. The types are enumerated in Table 1. Species composition of each community type is shown in Table 2. The description of each community type follows.

1. ***Nelumbo* Type**: dominated by *Nelumbo nucifera*; often accompanied by lemnid species such as *Spirodela polyrrhiza*, *Lemna paucicostata* (=*L. aoukikusa* BEPPU et MURATA) and *L. valdiviana*, and sometimes with a small portion of *Trapa*.

2. ***Nelumbo - Trapa* Type**: co-dominated by *N. nucifera* and *Trapa* spp[1]., often accompanied by lemnid species.

3. ***Nelumbo-Salvinia* Type**: co-

Table 2 Species composition of each community type. Number of occurrence is shown[1]. Dominant

Community Type	1	2	3	4a	4b	4c	4d	5	6	7	8	9	10	11
Number of Reservoirs	13	20	3	100	22	15	61	15	32	21	8	37	6	12
Nelumbo nucifera	13*	20*	3*	.	.	.	1	3	2	4	.	.	.	.
Trapa spp[2].	3	20*	.	100*	22*	15*	61*	14*	32*	10	4	3	.	1
Salvinia natans	.	.	3*	.	1	1	.	.	.	.	.	.	.	.
Euryale ferox	.	.	.	.	.	.	1	15*	.	1	.	.	.	.
Nymphoides indica	.	3	.	.	.	4	10	5	32*	21*	8*	3	.	.
Brasenia schreberi	.	1	.	.	.	2	2	.	.	7	8*	37*	6*	.
Nymphaea tetragona	.	.	.	.	.	.	3	.	.	1	1	15	6*	12*
Potamogeton fryeri	.	.	.	.	.	.	1	.	.	.	.	3	1	1
Nuphar subintegerrimum	.	.	.	.	.	2	2	.	1	1	1	5	.	.
Potamogeton distinctus	.	.	.	.	.	1	8	.	5	2	5	8	.	2
Potamogeton octandrus	1	2	.	.	.	2	18	.	8	5	4	11	.	1
Elodea nuttallii	.	.	.	.	.	.	16	1	4	1	2	.	.	.
Myriophyllum ussuriense	.	.	.	.	.	.	7	.	4	5	4	7	.	2
Hydrilla verticillata	2	3	1	.	.	.	29	2	15	11	7	9	.	1
Spirodela polyrrhiza	4	7	2	.	12	5	8	5	3	.	.	.	.	.
Lemna spp[2].	3	4	1	.	14	6	9	3	4	.	.	.	.	.
Eichhornia crassipes	1	.	1	.	.	.	2	1	.	.	.	.	.	.
Hydrocharis dubia	1	2	.	.	.	2	2	3	1	.	.	.	.	.
Ceratophyllum demersum	.	.	.	.	.	.	16	6	6	2	.	1	.	.
Vallisneria asiatica	.	.	.	.	.	.	4	.	6	5	2	2	.	.
Najas marina	.	.	.	.	.	.	.	.	4	.	1	1	.	.
Najas oguraensis	2	1	.	.	.	.	7	3	3	3	1	3	.	.
Najas minor	.	1	.	.	.	.	6	.	4	.	1	.	.	.
Najas graminea	.	.	.	.	.	.	3	.	1	1	1	3	.	1
Myriophyllum sp[3].	2	.	.	.	.	.	2	1	2	.	.	2	.	.
Potamogeton maackianus	.	.	.	.	.	.	1	.	2	4	1	.	.	.
Utricularia australis	.	.	.	.	.	.	10	.	3	2	3	13	1	3
Utricularia aurea	.	.	.	.	.	.	5	1	2	2	2	9	.	.
Limnophila sessiliflora	.	.	.	.	.	.	2	.	1	1	.	2	.	.
Caldesia reniformis	.	.	.	.	.	.	2	.	.	1	.	3	.	.
Isoetes japonica	.	.	.	.	.	.	1	.	.	.	.	1	.	2

1) Rare species are not shown.
2) *Trapa* spp. and *Lemna* spp. are treated collectively.
3) *M. verticillatum* or *M. oguraense*. They were recorded as *M. verticillatum* in the field survey, but later some of them

dominated by *N. nucifera* and *Salvinia natans*. Vigorous spread of the latter species was remarkable later in growing season.

4. *Trapa* **Type**: dominated by *Trapa*. It was divided into four subtypes according to the growth form of associated plants, if any.

4-a. Pure Subtype: Only *Trapa* was found.

4-b. *Trapa* - Lemnid Subtype: characterized by the co-occurrence of lemnid species. Among lemnid species common were *S. polyrrhiza* and *L. paucicostata*.

4-c. *Trapa* - Nymphaeid Subtype: characterized by the co-occurrence of a small portion of nymphaeid species such as *Nymphoides indica*, and *Brasenia schreberi*.

4-d. *Trapa*-Elodeid Subtype: characterized by the co-occurrence of submerged plants such as *Hydrilla verticillata*, *Elodea nuttallii*, *Ceratophyllum demersum* and *Najas oguraensis*; sometimes accompanied by a small portion of lemnid and nymphaeid species.

5. *Euryale*-*Trapa* **Type**: co-dominated by *Euryale ferox* and *Trapa*, sometimes with a certain portion of *Hydrocharis dubia*, lemnid species, *C. demersum*, *N. oguraensis*, etc. Relative dominance of *Euryale* and *Trapa* changed drastically from year to year in a few reservoirs.

6. *Trapa*-*Nymphoides* **Type**: co-dominated by *Trapa* and *N. indica* in varying relative abundance of the two species; sometimes accompani-

1) *Trapa* species are treated collectively here because of the frequent occurrence of some intermediate forms which have not been elucidated taxonomically.

species are indicated by asterisk.

12	13	14	15	16	17	18	19	20	21	22
3	8	12	6	10	8	4	3	3	3	24
.	.	1	.	.	.	.	.	.	.	.
.	.	2	1	3	.	1	1	.	.	5
.	.	.	.	1	.	.	.	3*	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	1	.	1	.	.	.	.	.	4
.	3	1	.	.	.	.	.	.	.	1
3*	1	1	3	.	1	.	.	.	.	2
3*	.	.	.	.	.	.	.	.	.	.
.	8*	.	.	.	.	.	.	.	.	2
.	.	12*	3	.	.	1	.	.	.	5
.	1	3	6*	.	1	.	.	.	.	8
.	.	2	.	10*	.	1	.	.	.	5
.	2	.	1	.	8*	.	.	.	.	4
.	2	3	2	1	.	4*	.	1	.	6
.	.	1	.	.	1	.	2*	.	1	1
.	1	.	1	.	.	.	2*	1	.	.
.	.	.	.	.	.	.	.	.	3*	.
.	.	.	.	2	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	2
.	.	3	.	.	1	.	.	.	.	4
.	.	.	.	.	.	1	.	.	.	3
.	.	.	.	.	.	1	.	.	.	3
.	.	.	1	.	.	.	.	.	.	1
.	.	1	1	1	.	.	.	.	.	2
.	1	.	.	1	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	3
.	3	.	1	.	2	.	.	.	.	.
.	2	1	.	1	.	.	.	.	.	2
.	2	.	1	.	.	1	.	.	.	1
.	1	.	1	.	.	.	.	.	.	.
.	.	.	1	.	1	.	.	.	.	3

proved to be *M. oguraense* (see KADONO, 1985).

ed by *H. verticillata*, *C. demersum* and *Vallisneria asiatica*.

7. *Nymphoides* **Type**: dominated by *N. indica*, sometimes with a small portion of *Trapa*, *B. schreberi*, *P. octandrus* and submerged species such as *H. verticillata*, *V. asiatica*, *Myriophyllum ussuriense* and *Potamogeton maackianus*.

8. *Nymphoides-Brasenia* **Type**: relatively species-rich type co-dominated by *N. indica* and *B. schreberi*, sometimes with a small portion of *Trapa*, *Potamogeton distinctus*, *P. octandrus H. verticillata*, *M. ussuriense*, *V. asiatica*, etc.

9. *Brasenia* **Type**: dominated by *B. schreberi*, sometimes with a small portion of *Nymphaea tetragona*, *P. octandrus*, *P. distinctus*, *Utricularia australis*, *U. aurea*, etc.

10. *Brasenia-Nymphaea* **Type**: co-dominated by *B. schreberi* and *N. tetragona*, sometimes with a certain portion of *Potamogeton fryeri* and *U. australis*. This type of vegetation has been reported as Brasenio schreberi-Nymphaeetum tetragonae OKUDA and is characteristically found in oligo- or dystrophic waters.

11. *Nymphaea* **Type**: dominated by *N. tetragona*.

12. *Nymphaea-Potamogeton fryeri* **Type**: co-dominated by *N. tetragona* and *P. fryeri*. This type of vegetation may be some variation of Nymphaeo-Potametum fryeri SHIMODA.

13. *Nuphar subintegerrimum* **Type**: dominated by *N. subintegerrimum*, sometimes with a certain portion of *B. schreberi*, *U. australis*, etc.

14. *Potamogeton distinctus* **Type**: dominated by *P. distinctus*, sometimes with a certain portion of *P. octandrus*, *H. verticillata*, *etc.*

15. *Potamogeton octandrus* **Type**: dominated by *P. octandrus*, sometimes with a small portion of *P. distinctus*, *N. tetragona*, *H. verticillata*, etc.

16. *Elodea* **Type**: dominated by *E. nuttallii*.

17. *Myriophyllum ussuriense* **Type**: dominated by *M. ussuriense*.

18. *Hydrilla* **Type**: dominated by *H. verticillata*.

19. *Lemnid* **Type**: dominated by lemnid species such as *S. polyrrhiza* and *L. paucicostata*.

20. *Salvinia* **Type**: dominated by *S. natans*.

21. *Eichhornia* **Type**: dominated by *E. crassipes*.

22. Others: 24 reservoirs were not assigned to any type mentioned above, due to the absence of any definite dominant species or the lack of repeated observations and dissimilarity to any type. The latter cases included the communities dominated by, for example, *Nuphar japonicum*, *Potamogeton maackianus* or *Najas graminea*.

Discussion

Aquatic vegetation sometimes shows drastic changes in a few years without any apparent changes of surrounding conditions. Thus the community types based on dominant species can not be regarded as fixed ones in individual waters. However, some community types are prevailing in a given area under the influences of environmental conditions of the area. LINKOLA (1933) pointed out the regional differences in species occurrence in Finnish waters and ascribed them to the climatic and edaphic factors. Frequent community types are also different from region to region (RINTANEN, 1982).

At the present time few substantial data are available about macrophytic communities of irrigation reservoirs from other regions of Japan, except for Saijo Area, Hiroshima Prefecture (SHIMODA, 1985). So it is still premature to compare and discuss the regional characteristics of community types and associated environmental factors in detail. Information from other regions is greatly needed.

The present results will serve for comparison with the studies in other regions and also for confirmation of progressing changes of macrophytic communities caused by human activities.

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摘　　要

水生植物群落の記載と分類の方法については，さまざまな問題点が議論されてきた。植物社会学的方法の有効性を疑問視する意見がある一方で，数量的方法も，こと群落の分類に関する限り，一般的な優

* in Japanese
**in Japanese with English summary

位性をもたないことが指摘されている。特にため池のように構成種の少ない群落では，研究の目的に応じて融通性をもったアプローチが必要であろう。

本報では，ため池の水生植物群落は通常，少数の種によって優占されている現実に着目し，兵庫県東播磨地方のため池449個の水生植物群落を，優占種あるいは優占種の組み合わせによって類型化することを試みた。その結果，次の21型を認めることができた。( )内にはため池数を示す。 1．ハス型(13)，2．ハスーヒシ型(20)，3．ハスーサンショウモ型(3)，4．ヒシ型(198；共存種の生育型によって4つの亜型に細分)，5．ヒシーオニバス型(15)，6．ヒシーガガブタ型(32)，7．ガガブタ型(21)，8．ガガブタージュンサイ型(8)，9．ジュンサイ型(37)，10．ジュンサイ—ヒツジグサ型(6)，11．ヒツジグサ型(12)，12．ヒツジグサ—フトヒルムシロ型(3)，13．ヒメコウホネ型(8)，14．ヒルムシロ型(12)，15．ホソバミズヒキモ型(6)，16．コカナダモ型(10)，17．タチモ型(8)，18．クロモ型(4)，19．ウキクサ型(3)，20．サンショウモ型(3)，21．ホテイアオイ型(3)，22．その他(24)。

優占種による類型化は繁雑な操作を必要としないきわめて簡単な方法であり，群落を相観的に把握できるという特徴をもつ。特定地域の水生植物群落の概略を知るためには，このような簡単な方法の意義も小さくないと考えている。ここで示された群落型と植物社会学上の植生単位との相互関係は，今後の検討課題である。

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○ **植生史研究** 第1号。植生史研究会。1986年8月18日発行。B5判，68頁。年1冊発行。研究会年会費2000円（研究会に入会しなくとも雑誌の頒布は受けられる。第1号は2000円）入会申し込み，雑誌の頒布希望は植生史研究会事務局（〒558 大阪市住吉区杉本3-3-138 大阪市立大学理学部生物学教室内，TEL 06-605-2583)。

日本生態学会の大会の際に開かれていた自由集会に，植生史談話会があった。植生史研究会はこの談話会が昨年の春の京都大会の時に発展独立したもので，そのいきさつを研究会代表の辻誠一郎氏が冒頭にある「植生史研究第1号を発行するにあたって」の中で簡単に触れている。氏は独立の理由に自由集会の限られた場所と時間の制約からはなれて定期的に植生史に関する突っ込んだ話のできる会を持ちたい，自由集会で話された内容をきちんとした形で残したい，という参加者の希望が強かったことを挙げている。そこで研究会の活動として，生態学会時の自由集会の他にシンポジウムを行うこと（昨年は秋に大阪市立大学の私市植物園で「植物化石群集の形成過程とその性格をめぐって」のテーマのもとに1泊2日で行われている)，「植生史研究」を年1冊発行すること，がうたわれている。

昨年夏に発行された植生史研究第1号には次の様な論文が収録されている。日本の第四紀植生史研究の諸問題（辻誠一郎)，第四紀大型植物化石研究の課題と問題点（南木睦彦)，陸生珪藻による古環境の解析とその意義——わが国への導入とその展望(小杉正人)，スギとアケボノスギの花粉形態——その研究の歴史(相馬寛吉)，近畿地方のスギの変遷（高原光・竹岡政治；要旨）と5編の論文の他，書評と雑録がついている。この5編のうちあとの2編は春の生態学会の自由集会の記録であるが，前の3編は植生史研究における総説である。辻氏のそれは花粉分析，南木氏のは大型植物遺体，小杉氏のは珪藻化石を中心としたもので，各々の研究の現状，問題点，将来の問題が論じられている。

現在の植生を捉えるのは現地調査を通して可能であるが，過去の植生，即ち古植生を復原するのは容易でない。植生が存在していたことの直接的な証拠は植物化石であるが，この植物化石とて生えている木がそのまま化石になっているわけではなく，葉や花，花粉，果実，種子，枝，木材として各部分がバラバラになっている。これらの小さな部分から植物の種を同定するわけだが，そこには同定に関するたくさんの問題がある。同定が済んだとするとそれから植生を復原するわけだが，そこには化石を含んだ地層の堆積物の性質，堆積環境，古地形などが絡んでくる。さらに第四紀の後半，完新世では人間の人文活動が盛んになり，植生に対する人間の影響も無視できなくなる。この様に古植生の変遷を明らかにするには植物化石をたんに同定すれば良いのではなく，そこをベースにして自然科学，人文科学のいろいろな分野の共同した研究が必要になる。その意味でこの研究会は古植生復原のおおもととなる化石の同定の問題から始まって，他分野との共通理解を深め，基礎資料が曖昧なままとかく結果だけがセンセーショナルに喧伝される事の多い第四紀における植生の変遷をより具体的に明らかにしていこうとしている。そのこともあってこの雑誌は原著論文集ではなく総説誌を目指していることが，和文で書かれていること，引用文献がきちんと挙げられていることから分かる。 (鈴木三男)