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RESEARCH ARTICLE

Aquatic weed resources in India and South-East Asia

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ABSTRACT

Protein alternatives in diets for warm water and cold water fishes should replace their natural proteins not only in quantity but also in quality to provide adequate levels of essential amino acids (EAA). After making a thorough survey in the district of Midnapore, West Bengal, India, an inventory of non-conventional protein alternatives with special reference to aquatic weeds/macrophytes has been made. On the basis of nutritional value, 12 aquatic macrophytes, has been identified and evaluated to make a data bank of protein alternatives available in West Bengal and also made ranking of the macrophytes on the basis of the dominance in this region.

INTRODUCTION

Cook (1985) attempted to review the range extensions of aquatic vascular plants. Altogether 198 species were considered. Twenty-six species are very widespread or disjunct, it is unlikely that all of them are native throughout their ranges but the alien and native areas are unknown or disputed. Several species in this category are sometimes weedy: for example, *Ceratophyllum demersum* (coontail, hornwort), *Echinochloa crus-galli* (barnyard grass), *Eclipta prostrata, Eleocharis dulcis* ('Chinese' water chestnut), *Ipomoea aquatica, Oryza rufipogan, Phragmites australis*, *Pistia stratiotes* and *Azolla pinnata*. The remaining 172 species have all become established outside their native range. This does not mean that they are all weeds, in fact, many are useful and desirable but the majority is considered to be insignificant. Potentially, however, virtually all could become weeds if given the right conditions for luxuriant growth. Of the 172 species discussed by Cook (1985) about 30 per cent are common to the Old and New World, 32 per cent are exclusively native to the Old World and have become established in the New World while 38 per cent have made the journey from the New to the Old World. The migration of aquatic plant species between east and west is fairly well balanced. From the point of view of aquatic plant species, India is floristically very rich, probably as a result of its migration from the southern to the northern hemisphere during the Upper Cretaceous. Thirty-two species native to India have become established elsewhere, while 21 species have been introduced in recent times. Such give and receive calculations are rarely so well balanced.

Aquatic weed problems and management in Asia

The Asian landmass, the largest Continent on earth, is unique in many respects (Figure – 1). It is the most populated part of the world with more than half of humanity living there. It extends from the Equator to the Arctic: all climatic zones are represented. The continent exhibits a great diversity of landscapes: high mountains, vast alluvial plains, dense tropical and temperate forests, hot and cold deserts; innumerable ephemeral streams and seasonal ponds, mighty rivers, lakes, and reservoirs are all represented. The great diversity of natural and man-made aquatic habitats is matched by the diversity of aquatic vegetation, not always desirable from the viewpoint of human interests. Aquatic plants often interfere with the utilization of water resources. From an economic point of view the most important aquatic habitats in Asia are those associated with the production of food for man, either directly (fish ponds and paddy fields) or indirectly (irrigation reservoirs and irrigation channels). Naturally, the aquatic weeds in these habitats have attracted greater attention than in those used for navigation or recreation. During the past few decades, many new reservoirs have been constructed for irrigation, hydroelectric power generation, and flood control in all Asian countries. Many have become infested with native and/or exotic weed species. In this context, aquatic weeds have been the subject of scientific study for about a century. There is now a vast literature on the kinds of weeds, their global distribution (Figure – 2), ecological attributes, diversity of the problems they cause, and the efforts made to control aquatic weed problems in Asia.

Free-floating weeds

The most widespread and obnoxious of all aquatic weeds in Asia are two free-floating weeds of south American origin. Introduced by man at different times around the end of the nineteenth century (Gopal 1987) in Japan, Indonesia, India, Sri Lanka, China and other neighbouring countries, the exotic water hyacinth (*Eichhornia crassipes*) is today unchallenged as the worst aquatic weed throughout the tropics and subtropics. Much more has been published about water hyacinth than any other aquatic weed (Thyagarajan 1984; Gopal and Sharma 1981; Gopal 1987). The second ranking free-floating weed, *Salvinia*, is represented in Asia by three species. *Salvinia molesta* (earlier identified as *Salvinia auriculata*) is an exotic which was introduced possibly in the early 1930s in the tropical Asia through botanical gardens in Colombo, Sri Lanka (Williams 1956); Bogor, Indonesia (Nguyen-van-Vuong 1973b); and Calcutta, India (Kammathy 1967). It spread widely in Sri Lanka and possibly from

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Figure 1. World aquatic weeds distribution patters (much dominated in Oriental and Australian region, Ethiopian region and Neotropical region)

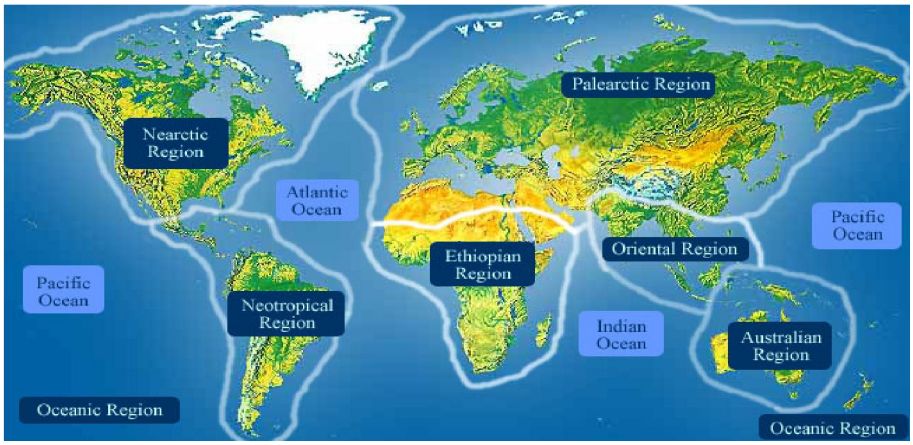

Figure 2. Different Zoo-Geographic region of our Globe (Oriental region, Australian region, Ethiopian region, Neotropical region. Nearctic and Palearctic region)

there into Kerala, Andhra Pradesh, and Tamil Nadu in India. In the north it spread from Calcutta to the whole of West Bengal, Orissa (Philipose *et al*., 1970), and Bangladesh; from Java to the rest of Indonesia, and neighbouring countries of the Indochinese Peninsula (Nguyen-van-Vuong and Sumartono 1979). It has also started colonizing waters in more northern latitudes (e.g. near Delhi). *Salvinia cucullata*, a native of tropical Asia (perhaps eastern India or Burma) has spread to the whole of south-east Asia due to introduction by man (Nguyen-van-Vuong 1973). *Salvinia natans*, the place of origin of which is not yet clear, occurs as a weed in Kashmir lakes (Kaul, Zutshi, and Vass 1976) and Indonesia (Nguyen-van-Vuong 1973b). Among other free-floating weeds, water lettuce (*Pistia stratiotes*) is most important. It ranks second to water hyacinth in Thailand (Chomchalow and Pongapangan 1976) and is a major cause of problems in irrigation channels in rice-growing areas of the Philippines (A.B. Higgins, ICI Agrochemicals, pers. Comm.). Several lemnids, particularly *Spirodela polyrrhiza*, species of *Lemma* and *Azolla pinnata* are considered important in several countries as they may form a thick, complete cover over the surface of water bodies.

Submerged weeds

Among the submerged weeds, *Hydrilla verticillata* is a particular problem (Dhahiyat *et al*., 1982; Probatova and Buch 1981; Pieterse 1981), together with *Vallisneria spiralis, Potamogeton pectinatus, Ottelia alismoides, Ceratophyllum demersum*, and *C. muricatum*. Species of *Utricularia, Lagarosiphon,* and *Zannichellia*, and the fern *Ceratopteris thalictroides* are often found in weedy proportions. *Elodea nuttalli* has been a major weed in Lake Biwa in Japan since 1961 but has been partly replaced by another submerged weed, *Egeria densa*, since 1971 (Ikusima 1983, 1984). Species of *Najas, Myriophyllum, Potamogeton* and *Ceratophyllum* are also widespread weeds in the Soviet Union and Middle East Asia.

Rooted floating-leaved weeds

Several members of the Nymphaeaceae, such as *Nelumbo nucifera, Nymphaea nouchali,* plus *Nymphoides cristata*, and species of *Marsilea* are considered as weeds since their leaves can cover the water surface completely. Many other species creep over the water surface while rooted in shallow water on the shores of the water body. These include species of *Ipomoea* (*I. aquatica, I. crassicaulis*) and *Jussiaea repens*.

Emergent weeds

The rooted emergent weeds dominate shallow lakes, fish ponds, margins of reservoirs, and irrigation channels. They include a large variety of plants of which the dominants are species of *Typha, Monochoria, Alternanthera, Cypernus, Eleocharis, Scirpus, Tuncus*, and a number of grasses. *Typha angustata* (Mehta, 1979) is widespread throughout Asia including southern USSR. *Typha elephantina* occurs throughout northern India and extends into the USSR (Saha 1968). *Typha javanica* is a common weed in Sri Lanka (Kotalawala 1976). *Monochoria vaginalis* occurs widely in northern India. In eastern India and south-east Asia, China, Japan and Korea, *Monochoria hastata* is a common weed. Other dominant taxa include *Eleocharis plantaginea, Scirpus grossus, Hygrophila auriculata*, wild rice (*Oryza rufipogon* and *Hygroryza* spp.), *Paspalum distichum*, *Panicum repens* (Siregar and Soemarwoto 1976), *Isachne globosa* and *Limnocharis flava* (Kotalawala 1976). *Alternanthera sessilis* is a native of Asia commonly occurring as a weed. However, in recent years, *Alternanthera philoxeroides* has been introduced and is spreading fast. In the countries of the Middle East *Phragmites australis* is the most important aquatic weed species (Robson 1976b).

The establishment of vegetation in a water body can follow different patterns

(1) dominance by species not present immediately prior to management;
(2) dominance by those species which were dominant immediately prior to management;
(3) dominance by species which were present before management but not dominant.

Practical uses of aquatic weeds

The Center for Aquatic Plants' computerized aquatic plant information retrieval system was queried in order to obtain a listing of articles on the utilization of aquatic plants on a world-wide basis. This literature search yielded 215 review citations and over 1764 (1300 of which were written since 1975; 75 from India) individual citations covering reported uses of aquatic plants, which ranged from human food to wastewater treatment and the production of biogas. Attempts to review this wealth of literature and subjectively determine those uses which are 'practical' is difficult for two fundamental reasons; (a) the amount of material is exhaustive, and (b) the definition of 'practical uses' is subjective and open to potential bias as discussed below (Table – 1 and 2).

Table 1. Noxious aquatic weeds of South and South-East Asian countries and their ranking in different countries

Species	India (a)	Indonesia (b)	S. E. Asia (c)
Eichhornia crassipes	1	1	1
Salvinia spp.[a]	10	2[a]	2[a]
Salvinia cucullata			10
Pistia stratiotes	9		3
Azolla pinata	6	2	3
Lemna spp.	6		
Hydrilla verticillata	4	3	4
Najas indica		5	
Ceratophyllum demersum		6	
Vallisneria spp.	7		
Potamogeton spp.	8		
Potamogeton malaianus		9	
Nymphaea stellata	2		
Nymphoides sp.	3		5
Nelumbo nucifera	3	7	5
Typha spp[b]	5		8[b]
Scirpus grossus		4	6
Panicum repens		8	7
Monochoria vaginalis			9
Mimosa pigra		10	

Table 2. Noxious aquatic weeds dominated in aquatic area of West Bengal and their ranking (selected for study)

Eichhornia crassipes Solms-Laub.	1
Nymphoides cristatum (Willd.) Buchn.	2
Pistia stratiotes Linn	3
Azolla pinnata Lamarck	4
Hydrilla verticellata Casp.	5

An overview of the literature indicates that 'practical uses' of aquatic plants is at best a function of the economic base of the country in which the plants are present. For example, aquatic plant species such as water hyacinth (*Eichhornia crassipes*) are the subject of extensive research and operational use for the treatment of sewage effluent to meet stringent surface water quality standards in Western countries. At the same time the water hyacinth is subject to strict control measures in public waters in the south-eastern USA due to its interference with recreational and commercial uses of waterways. In contrast, in less developed countries like India, where labour costs are less and the manufacturing base is not as dependent upon fossil fuels, much interest has been shown in the use of these plants for fertilizer, animal and human food, biogas, paper, thatching, etc. Thus, for the purposes of this discussion, 'practical uses' will be a function of the economic base and degree of geographical isolation of the areas in which the plants occur. Here, the main aim is to use/convert these aquatic weeds for human food through fish.

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