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The Classification, Distribution, Control and Economic Importance of Aquatic Plants

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Abstract: The study reviews the classification, distribution, control and economic importance of aquatic plants to provide fish culturist information on some future challenges in culture fisheries management and practices. Aquatic plants have adapted to living in or on aquatic environments and constitute a problem in culture fisheries. They block navigational channels on the waterways and easily choke the propellers of boats. Many fish keepers keep aquatic plants in their tanks to control phytoplankton and moss by removing metabolites. Many species of aquatic plant are invasive species. However, some aquatic constitute the primary producers of aquatic ecosystems. They convert incident radiant energy of the sun to chemical energy in the presence of nutrients like phosphorous, nitrogen, iron, manganese, molybdenum and zinc. They are the foundation of the food web, in providing a nutritional base for zooplankton and subsequently to other invertebrates, shell fish and finfish. The productivity of any water body is determined by the amount of aquatic plants it contains as they are the major primary and secondary producers; hence, can be use as bio indicators. The study provides information on the meaning of aquatic plants, types of aquatic plants, characteristics of hydrophytes, adaptations, zonation, classification and control of aquatic weeds to provide the required information for fish culturists.

Keywords: Aquatic plants, classification, control and economic importance, distribution

INTRODUCTION

Aquatic plants are hydrophytes and occupy different ecological niche in the aquatic environment. Aquatic vascular plants can be ferns or angiosperms from a variety of families, including the monocots and dicots, single-celled phytoplankton, periphyton and multicellular macrophytes. These plants have adapted to living in or on aquatic environments and constitute a problem in culture fisheries. In the high inter tidal zone, grasses and ferns are prevalent in ponds. The high density of water makes aquatic organisms more buoyant, so aquatic plants invest less resources in support tissues than terrestrial plants. Because aquatic plants are surrounded by water, water loss is not a problem. Thus, submerged plants lack the structural and protective structures produced by terrestrial plants. The water hyacinth has become a pest in many areas in the Niger Delta. It blocks navigational channels on the waterways and easily chokes the propellers of boats. In the high inter tidal zone, grasses and ferns are prevalent in ponds. They are not restricted to one particular zone. Regular cutting or removal of these plants from the pond is important. Aquatic plants can be classified according to their various zones, habitats or taxonomic groups. Many fish keepers keep aquatic plants in their tanks to control phytoplankton and moss by removing metabolites. Many species of aquatic plant are invasive species. Aquatic plants make particularly good weeds because they reproduce vegetatively from fragments.

They constitute the primary producers of aquatic ecosystems. They convert incident radiant energy of the sun to chemical energy in the presence of nutrients like phosphorous, nitrogen, iron, manganese, molybdenum and zinc. In the aquatic ecosystem, the phytoplankton are the foundation of the food web, in providing a nutritional base for zooplankton and subsequently to other invertebrates, shell fish and finfish (Emmanuel and Onyema, 2007). The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers (Davies *et al*., 2009). Townsend *et al.* (2000) and Conde *et al*. (2007) reported that plankton communities serve as bases for food chain that supports the commercial fisheries. Davies *et al*. (2009) have also reported that phytoplankton communities are major producers of organic carbon in large rivers, a food source for planktonic consumers and may represent the primary oxygen source in low-gradient Rivers. Phytoplanktons are of great importance in bio-monitoring of pollution (Davies *et al*., 2009). The distributions, abundance, species diversity, species

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Fig. 1: Nymphaea alba, a species of water lily (htt://Wikipedia.org/wiki/file:Nymphae_alba.jpg)

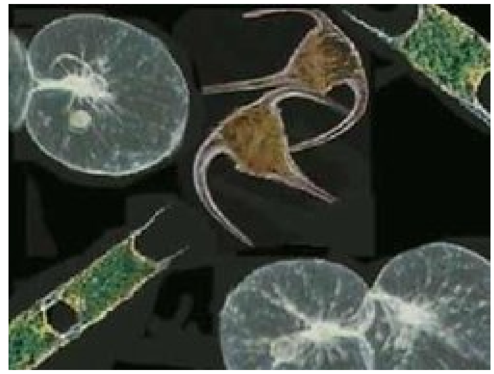


Fig. 2: Phytoplankton

composition of the phytoplankton are used to assess the biological integrity of the water body (Townsend *et al*., 2000). Phytoplankton also reflects the nutrient status of the environment. They do not have control over their movements thus they cannot escape pollution in the environment. Barnes (1980) reported that pollution affects the distribution, standing crop and chlorophy II concentration of phytoplankton. The abundance or pheriphyton also increases with increase in nutrient content. Periphyton can be an important source of food for herbivores. A review of the classification, distribution, control and economic importance of aquatic plants provides fish culturist information on some future challenges in culture fisheries management and practices.

Meaning of aquatic plants: Plants are many celled non-motile organisms, which contain the green pigment chlorophyll that enables them to make their own food by photosynthesis. Aquatic plants, also called hydrophytic plants or hydrophytes, are plants that have adapted to living in or on aquatic environments. Because living on or under water surface requires special adaptations, aquatic plants (Fig. 1) can only grow in water or permanently saturated soil. Aquatic vascular plants can be ferns or angiosperms (from a variety of families, including among the monocots and dicots). Seaweeds are not vascular plants but multicellular marine algae and therefore not typically included in the category of aquatic plants. As opposed to plants types such as mesophytes and xerophytes, hydrophytes do not have a problem in retaining water due to the abundance of water in its environment. This means the plant has less need to regulate transpiration (indeed, the regulation of transpiration would require more energy than the possible benefits incurred).

Types of aquatic plants: Aquatic plants grow in shallow to deep water zones. The three main types of aquatic plants are:

- Single-celled phytoplankton
- Periphyton (algae growing attached to substrates)
- Multicellular macrophytes

Phytoplanktons: Phytoplanktons (Fig. 2) are plants (microscopic), drifting at the mercy of water current (Anene, 2003). They constitute the primary producers of aquatic ecosystems. They convert incident radiant energy of the sun to chemical energy in the presence of nutrients like phosphorous, nitrogen, iron, manganese, molybdenum and zinc. They are restricted to the aphetic zone where there is enough light for photosynthesis. The distribution, abundance and diversity reflect the physico-chemical conditions of aquatic ecosystem in general and its nutrient statue in particular, Anene (2003). Phytoplankton includes several groups of algae (e.g., green algae, golden brown algae, euglenophytes, dinoflagelates and diatoms) and one group of photosynthetic bacteria (Cyanobacteria). Planktonic algae may be either benthic (attached to a substrate) or planktonic (floating in the water column). There are large numbers of phytoplankton (>400 species) in many bodies of freshwater; phytoplanktons are most common in habitats with high nutrient levels.

In the aquatic ecosystem, the phytoplankton are the foundation of the food web, in providing a nutritional base for zooplankton and subsequently to other invertebrates, shell fish and finfish (Emmanuel and Onyema, 2007). The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers (Davies *et al*., 2009). Townsend *et al.* (2000) and Conde *et al.* (2007) reported that plankton communities serve as bases for food chain that supports the

Table 1: Phytoplankton species in Sombreiro river, Niger delta, Nigeria

S/N	Taxonomic group	Genus/species
	Bacillariophyceae	
1.		*Melosira granulata*
2.		*Melosira varians*
3.		*Melosira distance*
4.		*Melosira pusilla*
5.		*Navicula viridula*
6.		*Nitzschia sigma*
7.		*Cyclotella operculata*
8.		*Cyclotella omta*
9.		*Cosinodiscus lacustris*
10.		*Cymbella lata*
11.		*Fragilaria intermedia*
12.		*Gyrosigma acuminatum*
13.		*Pinnularia horealis*
14.		*Amphora ovalis*
15.		*Synedra affinis*
16.		*Synedra ulna*
17.		*Stephanodiscus asroea*
18.		*Tabellaria fenestrata*
	Chlorophyceae	
19.		*Volvox aureus*
20.		*Volvox globator*
21.		*Coelastrum reticulata*
22.		*Closterium intermedium*
23.		*Closterium pervulum*
24.		*Clostrium gracile*
25.		*Crusigenia puadrata*
26.		*Crusigenia truncata*
27.		*Netrium digitatus*
28.		*Netrium intermedium*
29.		*Gonatozygon aculeatum*
30.		*Spirogyra* sp
31.		*Spirotaenia condensata*
32.		*Desmidium* sp
	Cyanophyceae	
33.		*Anabaena spiroides*
34.		*Anabaena affinis*
35.		*Anabaena arnoldii*
36.		*Oscillatoria lacustris*
37.		*Oscilartoria princeps*
38.		*Raphidiopsis mediteranea*
39.		*Rivularia* sp.
40.		*Lynbya limnetica*
	Chrysophyceae	
41.		*Dinobryon sertularia*
	Xanthophyceae	
42.		*Tribonema minus*
43.		*Tribonema viridis*

Ezekiel *et al*. (2011)

commercial fisheries. Davies *et al*. (2009) have also reported that phytoplankton communities are major producers of organic carbon in large rivers, a food source for planktonic consumers and may represent the primary oxygen source in low-gradient Rivers.

Phytoplanktons are of great importance in bio-monitoring of pollution (Davies *et al*., 2009). The distributions, abundance, species diversity, species composition of the phytoplankton are used to assess the

Table 2: Number and percentage compositions of phytoplankton families in Sombreiro river

Taxonomic group	Total number of species	Percentage species composition
Bacillariophyceae	18	41.9
Chlorophyeae	14	32.6
Cyanophyceae	8	18.6
Chrysophyceae	1	2.3
Xanthophyceae	2	4.7
Total	43	100

Ezekiel *et al*. (2011)

Fig. 3: Periphyton

biological integrity of the water body (Townsend *et al*., 2000). Phytoplankton also reflects the nutrient status of the environment. They do not have control over their movements thus they cannot escape pollution in the environment. Barnes (1980) reported that pollution affects the distribution, standing crop and chlorophy II concentration of phytoplankton.

Ezekiel *et al*. (2011) recorded a total of forty-three (43) species belonging to five (5) taxonomic groups were recorded from Sombreiro River. Bacillariophyceae was represented by 18 species consisting of 41.9% by composition. This was followed by Chlorophyceae (14 species) consisting of 32.6%, Cyanophyceae (8 species) consisting of 18.6%, Chrysophyceae (1 species) consisting of 2.3% and Xanthophyceae (2 species) consisting of 4.7% (Table 1 and 2).

Periphyton: Periphyton (Fig. 3) may grow attached to other plants (ephytic periphyton) or on rocks and other substrate (epibenthic periphyton). Typically, periphyton is made up of a diatoms, a variety of filamentous algae (including *Spirogyra*, *Anabanea*, *Oscillatoria*, *Lyngbya*, *Pithophora* spp) and cyanobacteria. The abundance or pheriphyton also increases with increase in nutrient content. Periphyton can be an important source of food for herbivores.

Fig. 4: Aquatic macrophytes

Aquatic multicellular macrophytes: Aquatic multicellular macrophytes (Fig. 4) include macroalgae (the green algae in the family Characeae), non-vascular plants (e.g., mosses), or vascular plants (the flowering plants). Aquatic macrophytes are water vegetations comprising macro algae and the true angiosperms. Aquatic macrophytes may be classified as emergent (e.g., cattails), free-floating (e.g., water lilies), or submerged macrophytes. Aquatic weeds are those undesirable plants, which reproduce and grow in water. When in excess, they choke the pond, creating problems for fish culture. Seaweeds and aquatic vegetation are such plants, which are pests to fish. The Monera are also discussed here as plant pests to fish. They are single celled, motile or non-motile organisms. Organisms are microscopic. Cell structure is simple with no definite nucleus. Aquatic algae make up this group.

A total of six (6) aquatic marophytes were recorded within the non saline Niger Delta region of Nigeria. *Nymphaea lotus* (rooted aquatic macrophyte with floating leaves) was observed in pools of water (Table 3). These macrophytes are not tolerant of highly saline environment. The implication of this is that the salinity level is very low in the field. Water hyacinth which is an exotic aquatic macrophyte in the Niger Delta was also encountered free floating. The water hyacinth has become a pest in many areas in the Niger Delta. It blocks navigational channels on the waterways and easily chokes the propellers of boats. The other aquatic macrophytes encountered were the bank types such as *Dissotis erecta, D. rotundifolia, Cyrtospermum senegalense* and *Acroceras* sp.

Differences between terrestrial and aquatic habitats lead to big differences in the characteristics of aquatic and terrestrial vascular plants. The high density of water makes aquatic organisms more buoyant, so aquatic plants invest less resources in support tissues than terrestrial plants. Because aquatic plants are surrounded by water, water loss is not a problem. Thus, submerged plants lack the structural and protective structures produced by terrestrial plants. For example, submerged aquatic plants lack a well develop waxy cuticle layer to prevent desiccation. Because submerged plants are capable absorbing water, nutrients and dissolved gases directly through their leaves, xylem (the part of the plant responsible for carrying water and nutrients from the roots to the leaves) is reduced or absent. Leaves of submerged aquatic vegetation lack stomata, the pores in the leaves through which terrestrial plants exchange gases such as carbon dioxide and water vapor with the environment. In terrestrial plants roots play an important role in the absorption of water and nutrients. Roots are often reduced (or lacking) in submerged aquatic vegetation and their only function is to anchor the plant to the ground. A checklist of aquatic plants by Shtt//www.aquaticcommunity.com/p/Aubiasbarterivekona.php in alphabetical order are:

Acorus calamus, *Acorus gramineus*, *Alternanthera ficoidea*, *Alternanthera reineckii*, *Alternanthera sessilis*, *Ammannia senegalensis*, *Anubias afzelii*, *Anubias barteri* '*marble*', *Anubias barteri v* '*Angustifolia*', *Anubias barteri v* '*ekona*', *Anubias barteri v.* '*caladiifolia*', *Anubias barteri v.* '*glabra*', *Anubias barteri v.* '*nana narrow leaf*', *Anubias barteri v.* '*nana*', *Anubias barteri v. nana* '*petite*', *Anubias gigantae*, *Anubias gilletti*, *Anubias gracilis*, *Anubias hastifolia*, *Anubias heterophylla*, *Anubias pyaertii*, *Anubias x.* '*Frazeri*', *Aponogeton abyssinicus*, *Aponogeton boivinianus*, *Aponogeton capuronii*, *Aponogeton crispus*, *Aponogeton distachyos*, *Aponogeton longiplumulosus*, *Aponogeton madagascariensis*, *Aponogeton rigidfolius*, *Aponogeton ulvaceus*, *Aponogeton undulatus*, *Aquatic clover*, *Azolla nilotica*, *Azolla pinnata*, *Bacopa australis*, *Bacopa caroliniana*, *Bacopa crenata*, *Bacopa lanigera*, *Bacopa madagascariensis*, *Bacopa monnieri*,

Table 3: Species diversity of aquatic macrophytes

S/No	Scientific name	Common name	Habit	Cover (%)
1	*Nymphaea lotus*	Water lily	Floating leaf type	3
2	*Pistia stratiotes*	Water lettuce	Free floating	2
3	*Eichhornia crassipes*	Water hyacinth	Free floating	5
4	*Dissotis erecta*		Bank type	10
5	*Dissotis rotundifolia*		Bank type	5
6	*Cyrtospermum senegalense*	Arrow head weed	Swamp type	10

SPDC (2012)

Bacopa myriophylloides, *Barclaya longfoilia*,*Blyxa aubertii*, *Blyxa japonica*, *Bolbitis heteroclita*, *Bolbitis heudelotti*, *Cabomba aquatica* and *Cabomba carolina*.

Also included are: *Cabomba furcata*, *Cabomba palaeformis*, *Canna americanallis variegata*, *Cardamine lyrata*, *Ceratophyllum demersum*, *Ceratophyllum submersum*, *Ceratopteris cornuta*, *Ceratopteris thalictroides*, *Cladophora aegagrophila*, *Crassula helmsii*, *Crinum calamistratum*, *Crinum natans*, *Crinum thaianum*, *Cryptocoryne affinis*, *Cryptocoryne ciliata*, *Cryptocoryne parva*, *Cryptocoryne pontederiifolia*, *Cryptocoryne x willisii Lucens*, *Cyperus alternifolius* '*Gracilis*', *Didiplis diandra*, *Dracena compacta*, *Dulichium arundinacium*, *Echinodorus* '*rose*', *Echinodorus* '*rubin*', *Echinodorus angustifolius*, *Echinodorus aschersonianus*, *Echinodorus berteroi*, *Echinodorus bleheri*, *Echinodorus bolivianus*, *Echinodorus cordifolius*, *Echinodorus cordifolius* '*Tropica Marble Queen*', *Echinodorus horizontalis*, *Echinodorus macrophyllus*, *Echinodorus opacus*, *Echinodorus osiris*, *Echinodorus palaefolius*, *Echinodorus portoalegrensis*, *Echinodorus rigidifolius*, *Echinodorus tenellus*, *Echinodorus tenellus v.* '*Tenellus*', *Echinodorus uruguayensis*, *Echinodorus x barthii*, *Echinodorus x.* '*Ozelot*', *Egeria densa*, *Egeria najas*, *Eichhornia azurea*, *Eichhornia diversifolia Eichhornia natans Eleocharis acicularis*, *Eleocharis montevidensis*, *Eleocharis vivipara*, *Elodea canadensis*, *Elodea nuttallii*, *Eriocaulon Setaceum*, *Eusteralis stellata*, *Frontinalis antipyretica*, *Glossostigma elatinoides*, *Gymnocoronis spilanthoides*, *Hemianthus micranthemoides*, *Hemigraphis exotica*, *Hemigraphis repanda*, *Heteranthera zosterifolia*, *Hottonia palustris*, *Hydrilla verticillata*, *Hydrocotyle leucocephala*, *Hydrocotyle sibthorpioides*, *Hydrocotyle verticillata*, *Hydrotriche hottoniiflora*, *Hygrophila corymbosa*, *Hygrophila corymbosa v.* '*Greta*', *Hygrophila corymbosa v.* '*Ruffle leaf*', *Hygrophila corymbosa v.* '*siamensis Broadleaf*', *Hygrophila corymbosa v.* '*Siamensis*', *Hygrophila corymbosa v.* '*Stricta*', *Hygrophila corymbosa v. Angustifolia* and *Hygrophila difformis*.

Others include: *Hygrophila polysperma*, *Hygrophila polysperma 'Rosanervig'*, *Isoetes lacustris*, *Lagarosiphon cordofanus*, *Lagarosiphon madagascariensis*, *Lagarosiphon major*, *Lemna minor*, *Lemna trisucla*, *Lilaeopsis brasiliensis*, *Lilaeopsis carolinensis*, *Limnobium laevigatum*, *Limnophila aquatica*, *Limnophila aromatica*, *Limnophila heterophylla*, *Limnophila indica*, *Limnophila sessiliflora*, *Ludwigia arcuata*, *Ludwigia brevipes*, *Ludwigia glandulosa*, *Ludwigia inclinata*, *Ludwigia inclinata var. verticillata*, *Ludwigia ovalis*, *Ludwigia palustris*, *Ludwigia repens*, *Lysimachia nummularia*, *Lysimachia nummularia v. 'Aurea'*, *Marsilea drumondii*, *Marsilea quadrafolia*, *Mayaca fluviatilis*, *Menyanthes trifoliata*, *Micranthemum umbrosum*, *Microcarpaea minima*, *Microsorum pteropus*, *Microsorum pteropus 'red'*, *Microsorum pteropus 'Tropica'*, *Microsorum pteropus 'Windeløv'*, *Microsorum pteropus v. 'narrow leaf'*, *Monosolenium tenerum*, *Myriophyllum aquaticum*, *Myriophyllum heterophyllum*, *Myriophyllum mattogrossense*, *Myriophyllum pinnatum*, *Myriophyllum simulans*, *Myriophyllum spicatum*, *Myriophyllum tuberculatum*, *Myriophyllum verticillatum*, *Najas conferta*, *Najas guadalupensis*, *Nesaea crassicaulis*, *Nesaea pedicellata*, *Nitella flexilis*, *Nuphar japonica*, *Nymphaea lotus*, *Nymphoides aquatica*, *Nymphoides peltata*, *Ophiopogon japonica*, *Phyllanthus fluitans*, *Pilea cadierel*, *Pogostemon helferi*, *Pontederia cordata*, *Potamogeton gayi*, *Potamogeton perfoliatus*, *Potamogeton schweinfurthii*, *Potamogeton wrightii*, *Proserpinaca palustris*, *Ranalisma rostrata*, *Ranunculus delphinifolius*, *Riccia fluitans*, *Rorippa aquatica*, *Rotala macrandra*, *Rotala rotundifolia*, *Rotala sp. 'Nanjenshan'*, *Rotala wallichii*, *Sagittaria platyphylla*, *Sagittaria subulata*, *Salvinia auriculata*, *Salvinia oblongifolia*, *Samolus valerandi*, *Shinnersia rivularis*, *Spathiphyllum tasson*, *Stratiotes aloides*, *Syngonium podophyllum*, *Syngonium podophyllum v. 'White Butterfly'*, *Tonina fluviatalis*, *Vallisneria americana*, *Vallisneria spiralis*, *Vesicularia dubyana*, *Zephyranthes candida* and *Zosterella dubia*.

Characteristics of hydrophytes: Aquatic plants are characterized by:

- **A thin cuticle:** Cuticles primarily discourage water loss; thus most hydrophytes have no need for cuticles.
- Stomata that are open most of time because water is abundant and therefore there is no need for it to be retained in the plant. This means that guard cells on the stomata are generally inactive.
- An increased number of stomata, which can be on either side of leaves.
- **A less rigid structure:** water pressure supports them.
- Flat leaves on surface plants for flotation.
- Air sacs for flotation.
- **Smaller roots:** water can diffuse directly into leaves.
- **Feathery roots:** no need to support the plant.
- Specialized roots able to take in oxygen.

For example, some species of buttercup (genus Ranunculus) float slightly submerged in water; only the flowers extend above the water. Their leaves and roots are long and thin and almost hair-like; this helps spread the mass of the plant over a wide area, making it more buoyant. Long roots and thin leaves also provide a greater surface area for uptake of mineral solutes and oxygen. Wide flat leaves in water lilies (family Nymphaeaceae) help distribute weight over a large area, thus helping them float near surface. Many fish keepers keep aquatic plants in their tanks to control phytoplankton and moss by removing metabolites. Many species of aquatic plant are invasive species. Aquatic plants make particularly good weeds because they reproduce vegetatively from fragments.

Adaptations:
Floating plants: In an outdoor body of water, these receive more sunlight than submerged plants. They also rarely have to compete with one another for sunlight.

Submerged plants: The leaves of submerged plants receive lower levels of sunlight because light energy diminishes while passing through a water column.

All floating plants:

- Either has air spaces trapped in their roots, or else air spaces in their bodies (parenchyma) to help them to float, thus receiving adequate sunshine.
- Have hair on their leaves that traps air.

Structural adaptations:
Duckweed, water cabbage:

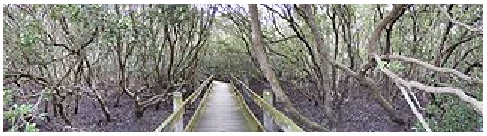
- Chloroplast found on the top surface of the leaves.
- Upper Surface has a thick, waxy cuticle to repel water and to help keep the stomata open and clear.
- Structural adaptation
- Small and light

Water lily:

- Structural material to reach higher points and receive more sunlight.
- Structural adaptation

Floating heart, water lily, lotus, yellow pond lily, water-shield:

- Their leaves tend to be broader without major lobbing, to remain flat on water surface, to enlarge their surface area and to make use of as much sunlight as possible.
- Their chloroplasts are found on the tops of their leaves.



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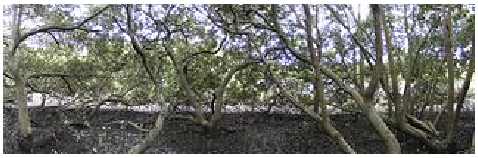

(b)

Fig. 5: Mangrove swamps (http://en.wikipedia.org/wiki/file:saltpancrk12 and 1a.jpg)

Structural/behavioral adaptations:

- Most partially-submerged ("emersed") plants.
- Air spaces within their tissues to keep them buoyant so that their leaves can reach the top of the body of water, in order to receive an adequate amount of sunlight.

Structural adaptation:
Dissected: Parrot's feather, hornwort:

- **Thread-like:** ditch-grass, quillwort.
- Highly dissected/divided leaves or thread-like ones, allows for a bigger surface area (surface to volume ratio).

Structural adaptation:
Hydrilla:

- Elongates rapidly to reach water surface and branches out at water surface; more light can be obtained at water surface.

Structural/behavioral adaptation:

- Xylem tubes are absent

Zonation: The tidal zone in a brackish water swamp is divided into three zones:
- Low inter tidal

- Mid inter tidal
- High inter tidal

The low inter tidal zone is bare without any vegetation. Fishponds are seldom constructed in this zone. The mid inter tidal zone is inhabited by true angiosperms, which include the mangroves (Rhizophora and Avicenia) Nypa and Bostrychia. Common mangrove trees (Fig. 5) include *Avicennia* (white mangrove), *Rhizophora* (red mangrove), Pandarus (screw pine) and *Raphia*. The mangrove forest shows zonation. The zone closest to the sea consists of trees such as Rh*zophora*. Their roots are covered by the tides most of the time (Levner *et al*., 2005). The muddy substratum is unsettled, allowing only a few types of plants such as the *Rhizophora* which has prop roots to grow. The middle zone consists of Avicennia. The tides cover only the roots and the substratum is stable. The landward zone consists of *Pandanus* and *Raphia*. The salinity is low in this zone. A great variety of plants are found here (Manahan, 2005).

Most of the animal life in mangrove swamps is associated with the mangrove trees. Polychaete worms, oysters, mussels, barnacles, prawns, shrimps and mudskippers are some of the animals found on the roots of mangrove trees.

Burrowing animals like clams, fiddler crabs and bristle worms are common in the muddy substratum. All these animals are similar to those found in estuarine habitats (Loeb, 1994). Animals associated with the parts of the mangrove trees above water include various insects, snakes and aquatic birds such as the kingfisher, sand piper, black tern and skimmer. Other aquatic birds include waders, ducks and herons (Levner *et al.*, 2005). The plants and decaying organic matter form the basis of food chains in the various marshes and swamps. Many of the small invertebrates are filter feeders. Birds and fishes are usually the final consumers.

These plants and algae can grow in fishponds and constitute a problem. In the high inter tidal zone, grasses and ferns are prevalent in ponds. They are not restricted to one particular zone. Regular cutting or removal of these plants from the pond is important. Aquatic plants can be classified according to their various zones, habitats or taxonomic groups.

Classification based on zones: There are four main zones:

- Bottom zone of vegetation
- Submerged rooted vegetation
- Zone of submerged free-floating vegetation
- Zone of surface vegetation

Plants at the bottom zone of vegetation are attached to bottom substrates. Example includes the diatoms and blue green algae. The submerged rooted vegetation plants are rooted in the pond soil but submerged, example of plants in this zone are *Vallisneria*, *Hydrilla*, *Potamogeton*, *Najas*, *Eichornia carasippes*, *Ipomea*, *Craninium natans* and *Vossia*. The roots of the plants in the zone of submerged free-floating vegetation are not rooted on any substrate but floats. Examples include Cerataphyllum, Utriculalaria, Chlorella, Euglena, Spirogyra, Monocysitis, Volvox and Cladophora. Plants in the zone of surface vegetation grow on the pond surface. Example include Nymphia, Pistia, Stratiotes, Salvinia, Molesta, Wolfia, Lemna and Azolla.

Classification based on habitat: Aquatic plants occupy different ecological niche in the aquatic environment. Hydrophytes are truly aquatic plants. These include *Eichornia carassipes*, *Hydrilla verticulla*, *Vallisneria spiralis* (Eelgrass), Pistia, Nymphia and Ipomea. Bank weeds grow mainly on the bank of the pond. These include *Typha phragmites*, *Cyperus articulatus*, *Cyperus distans* and *Pasplaum seirpus*. Shoreline weeds grow on the shorelines. These include Scripus, Comelina, Potamogeton, *Ponterileneris cordata*, *Sparagnaium eractum* and *Pandanus* sp. Ditch weeds grow in drainage and irrigation ditches. These are water hyacinth (*Eichornia carassipes)* and water peanunt. Phraetophytes are woody plants growing along streams. Colocarpus and Daubergia belong to this group. Marsh-land and swamp weeds are amphibious. They grow on land and water. Examples include. *Alternathera sessilus*, *Pancicum prolferum*, Scipus, *Hygrorrhiza aristat* and *Alisma aguatica*.

Classification based on biological groups: In this group are emergent weeds, floating leaves macrophytes and submerged macrophytes. The emergent weeds are new and developing and are present on the pond surface. Examples are Typha and Pharagmites. Floating leaves macrophytes, are relatively, large plants visible with the unaided eye, floating on the pond surface. Examples are salvinia, Pistia and Lemna. The submerged macrophytes are also relatively large plants visible to the unaided eye but submerged in the pond water. Plants and algal covers retard fish growth.

The covers prevent light penetration into the pond water and causes underneath darkness thereby reducing the amount of light for photosynthesis, which is the primary source of food in the pond. Plant and alga covers, affect the whole ecological system. Their presence can cause diurnal fluctuation of dissolved oxygen. When decomposed, aquatic plants exert high

Biochemical Oxygen Demand in water. Salvinia weed cover can reduce temperature by 12ºC and dissolved oxygen by one-sixth of 1 m below the surface. Aquatic plants and algae interfere with useful and efficient netting of fish in the pond. Excess plant growth causes impediment of water flow rate. Algal blooms and emergent weeds can cause water pollution and impair the aesthetic value of the pond. This is because when decomposed, alga and emergent weeds produces toxins and bad odor. The toxins can be toxic to fish. Aquatic plants can cause increased water loss from the pond through evapo transpiration. They also destroy lowland and water crops. Water canes, water chestnuts, water letus and rice farms are choked by aquatic weeds resulting in heavy losses. Disease can be spread through aquatic plants, since these plants are good breeding grounds for mosquitoes and other insects.

Aquatic plants hang on the propellers of engine boat. Mats of weeds such at water hyacinth can stop ships. Some water plants are known to contain high protein contents and can be used for food in fish, livestock and man. Some vascular aquatic plants have high ash and crude protein contents. Aquatic weeds are used for soil amendment and water culture media. Some have the ability to fix nitrogen for example, Potamogeton, Elodea and Lemna. Therefore, these aquatic plants are used in culture media. Plants such as *Acorus calamus* are used for the treatment of eye disease, indigestion and colds. Water letus and water cane are aquatic plants used for food.

Control of aquatic weeds: The control of aquatic weeds can be effective when certain pre-requisites are known. Mere existence of one or few plants in the water does not mean that they are weeds. It must be established that they are weeds, it must be established that they can cause losses or reduces some immediate and future gain. However, some aquatic plants must remain to replenish dissolved oxygen, prevent erosion and enhance aesthetic values. The balance can be based on local conditions. The control of aquatic weeds depends on the kind of weeds, extent and age of infestation, water depth and its regularity, accessibility to the methods available, impact of the technique on the entire ecosystem and costs. An integration of various techniques, including manipulation of several environmental factors, need be instituted. The combination of two or more methods seems more effective. Good timing is inevitable in the control of weeds. For instance, perennial plants can be removed through the production of seeds or enlarging their underground vegetative propagule.

These depend on varying degrees of susceptibility. For instance, water lilies, cattails and reeds show last regeneration when curbed at their flowering stages. This requires scientific information on the most vulnerable stage in the ontogeny of the weed species. Timing in aquatic weed control is important, because the water can remain weed free and usable when necessary. Assessment of the density and kinds of weeds are necessary for the choice of method to be used, especially in herbicidal pesticides, conventional quadrate method or eye-to-eye estimation can be undertaken for emergent or floating weeds. A bunch of strong heavy hooks secured to a rope can be let loose to remove submerged weeds. Manual control measures involve weeding the pond dykes regularly with a cutlass, as well as hand picking free-floating weeds. A net can be used to drag across the pond surface. This removes the weeds. Mechanical method involves the use of machinery (cranes) to remove large quantities of aquatic weeds especially when large ponds are infested. Chaining or dragging by two boats or bulldozers can be applied. This however depends on the width of the pond.

Dredging, pulling of weed along with their roots with cranes fitted with clean out buckets, weed forks and shovels are slow, untidy and expensive. Draining to expose weedy canals and collection of weeds manually or ploughing the dry soil out to kill the exposed roots by heat; netting of weeds such as duck weeds and water ferns using drag nets, use of barriers, water weed cutters and harvester are other manual and mechanical methods. These methods are referred to as physical method of aquatic weed control. Advantages of this method are that it reduces dependence on foreign exchange for the importation of herbicides. Manpower is cheap in developing nations. This approach is safest in terms of environmental pollution, because it does not pose risk to non-target organism or the functioning of the ecosystem. Mechanical means have fewer changes of buildup of specific weed species. This method is non-specific. Another major advantage is that, the periodical removal of aquatic weed from the pond removes large quantities of excessive nutrients present in the eutrophic waters. Therefore, slows down the growth of non-target species. Disadvantages also exist.

The physical removal allows the weeds to geminate fast from their propagules, which often hide in the hydro soil, creating a fairly continuous process. Frequent weed removal and their subsequent need for fish food supply can reduce fish growth. The physical removal method spreads weeds to nearby waters, because of their high vegetative capacity.

Biological method of aquatic weed control: This method involves the use of plants or animals to control weeds in the fish culture systems. It is done using a bioagent/biocontrol agent which can be non-specific, when it preys on selected weed species. For instance, the grass carp, *Ctenopharynodon edella*, feeds voraciously on tender plants that enter the pharyngeal region. Example of such plants, include: Hydrilla, Najas, Ceratophyllum, Ottelis, Vallisneria, Potamogeton, Halphyla, Nyriophyllum, Elodes and leaves of Ipomea. These plants are, not easily digested by the fish. Therefore, the fish produce loads of excreta that, causes entrophication in the pond.

Less effective, but common fish bioagents are the silver carp, *Hypohthlmichthys molithrix* and the common carp, *Cyprinius carpo*. The two species consume bloomic phytoplankton (Pithophora) and scummy alga (Cladophora). The common carp is a plant grazer while the silver carp stirs up the hydro soil in search of insect larvae and uproots attached plants. Two other species that feed on algae are the Nile tilapia (*Sarotherodon* and *T. niloticus*). They are used for algal control in rice fields. *Tilapia rendealli* and *T. zilli* convert large masses of submerged weeds into edible fish flesh. The silver dollar fish (*Mylossoma argentums*) devours large tons of weed and cuts them down. Manatees or sea cow (*Trichechus* sp*)* is a large air breathing herbivorous mammal indigenous to seawaters and larger rivers of over 400 tropical waters. They consume large tons of different aquatic plants daily. The catfishes *Orcenectes caseyi* and *O. ndis* are herbivorous and can be used to control Potamogeton but on introduction to new waters can destroy plants and eat up fish eggs.

Ducks, geese and swans feed on small aquatic weeds and are used for weed control. Water buffalo, *Bulbalis bulbalis* of tropical and subtropical waters feed on submerged and semi-aquatic plants in swamps. It has the ability to swim and dive inside to feed on underwater plants. The aquatic rats, Caphybarus, Hydrochoerus and Mycocaster are large rodents. They can weigh as much as 60 kg and feed on water hyacinths, duckweeds, reeds and bulrushes. Insect bioagents can control the alligator weed, *Alternanthera philloxeriodes*. The flea beetle *Agasilles hydrophila*; alligator, *Amnothrips andersonu* and the alligator stem borer, *Vegtia mallio* can control the weed effectively. Other insects that can control water hyacinth are nevil (*Nechetina circhbornae*) warmer (*Atustache bruchi*) and hycinthmite (*Orthoguma terebranths*). *Paropoynk alliondis* and *Litodactylus leucogaster* can control the water milfoil, *Myriophyllum spicatium*. Two large freshwater snails, *Marisa cornuarietes* and *Pomacea australes* feed voraciously on the submerged weeds, Elodea, cow tails, water hyacinths and water lettuce. *Marisa survives* in polluted water but eat egg masses of other snail vectors and are disease free. Pomacea consumes less rice than Marisa. Both species of snail can be used for aquatic weed control. The common tropical snail; *Pila globosa* can control *Salvina molesta*. The fungus, *Cephato sporuim* causes heap spot on water hyacinth and is a possible pathogenic bioagent. *Alternaria eichhornui*, *Myriothecium roriduium* and Rhizoctina, control water hyacinth while pythium and scherotrium species are possible biocontrol agents for Hydrilla.

Chemical method of aquatic weeds control: The use of chemicals to control aquatic weeds is perhaps the best way in developed countries where these chemicals are manufactured and so easily available. In developing countries, chemicals can be used with caution because many chemicals are target specific and have long-term residual toxic effects.

It is very necessary to determine the pond area or volume of pond water to be treated because; the quantity of the chemical applied depends on the volume of water in the pond. Water hyacinth, Eichornia, can be effectively controlled by using 2, 4-Dichlorophenoxyacetic acid (2-4-D) at the rate of 5-7 kg/ha without harming the fish. Also 80% of 2, 4-D sodium salt (Taticide 80) added to water at 1-1.5% concentration mixed with Omo detergent at 0.25% concentration can effectively kill Eichornia. Simazine and Taticide -80 can separately kill pista when applied at the rate of 5 kg/ha. The Omo detergent at 0.25-1.00% concentration with 1.5% of 2, 4-D, uproots water lily plants. Urea at between 50-300 ppm uproots the submerged weeds, Ottelia and hydrilla but not toxic to fish above 50 ppm. Simazine used at a dosage of 0.5-1.0 ppm controls “scum” of mycocystis. This dosage is not harmful to fish. Detergent at 0.25% with, 2, 4-D at 3.7% effectively control the marginal weed, Ipomea.

Copper sulphate pentahydrate ($CuSO_4 5H_2 0$), the commercial blue stone is the most popular algaecide. It is relatively cheap and fairly innocuous to non-target organism. At 0.1 ppm, it checks nasty water blooms of Cladaophora and Hydrodictyon. However, copper is toxic to fish and invertebrates. Copper is non degradable and accumulates in the hydro soil. The toxicity of copper does not affect humans and other mammals. The safe limit of copper sulphate pent hydrate ranges from 2.3 to 12.0 ppm for portable waters than for alkaline waters. Other formulation; algaecide, algistat, citrine and malachite green are more effective in hard waters.Sumazine and Diuron exist in two forms: Grandalar and powdered applied at 0.5-1.0 ppm. These chemicals are used for the control of Cladophora and Chara, but can also kill the submerged weeds, Potamogeton, Najas and Ceratophyllum.Discholone at 0.02-0.05 ppm controls algal blooms but can be toxic to fish at 0.15 ppm. The chemical is a good herbicide at 2.7-10.8 ppm, particularly for the submerged weeds, Ceratophyllum and Najas. However it can cause skin irritation.

Aromatic solvents when emulsified are broad-spectrum contact herbicides of aquatic weeds at 40-80 ppm. Aquatic fauna are sensitive to dissolved emulsified solvent. They can temporally impact distaste to animal and human drinking waters, irritation of skin, eyes and respiratory systems. Their application to water bodies can only be done under expert supervision. Anhydrous ammonia is applied under pressure. At 10 ppm, it is phytotoxic against the submerged weeds Hydrilla and Naja. Endeball is shoot active contact herbicide. It is used as sodium, potassium and aluminum of amine salts.Sodium Arsenate ($N_aA_sO_{2)}$ is considered the all -round cheap aquatic herbicides, but highly toxic to mammals. The treated water is often unsafe for agriculture and recreation until 3-15 days interval of post pest application. Silvex (fenoprop) is short translocated herbicide used for alligator weeds and water lily at 0.5-4.0 pm for 2-3 weeks.

It is applied in granular or liquid form. Silvex treated waters can be safe for livestock, but not for agricultural use. Disquat and paraquat are ammonium compounds, which act as non-persistent desiccants of green weeds at 0.25-1.5 ppm. Dichbenil is pre-emergence, subterranean herbicide used in the granular form at short persistence and low toxicity to wild life and fish when applied at 5-k 10 kg/ha. Dalapon is a foliage active, systemic herbicide active against robust grass and other grass-like weeds. It can be mixed with silver to give a broad-spectrum herbicide applied at rate of 10-30 kg/ha. Amitole acts like Dalopon at 5-15 kg/ha. This is same for Ammonium sulphamate (NH_4 So_2 NH_2). Malefic hydrazidi is a plant growth retardant.Glybosafe is non-residual, non-selective highly foliage mobile herbicide. Most of these herbicides are formulated in granules, slow release pellets and capsules, wet table powders or emulsions. There are two distinct advantage of employing herbicides for aquatic weed control:

- They are very effective, where other control measures are inaccessible.
- The herbicides can prevent the growth of weed much longer.

Besides, with herbicides, the weeds sink and decompose at the hydro soil, recycling and the plant nutrients delocked by them. This can cause problems of increased biochemical oxygen demand in confined water body. Herbicides are best used in circumstances where non-to chemical or integrated methods can be used. It is often causing hazards for fish, wild life or any component of the food chain. Most herbicides can be dangerous if they are not carefully used or whenever adequate preliminary ecological studies are not done prior to their use. Because of their potential toxicities and possible bioaccumulation with persistent use, they are often required to be cleared for use by DHSS (UK) and other committees. It is preferable to exhaust all other means before resorting to them. Its use in fishpond in developing countries has been discouraged.

Human nutrition: Many aquatic plants are used by humans as a food source. Note that especially in (South-east) Asia edible but uncooked hydrophytes are implicated in the transmission of fasciolopsiasis. Some edible aquatic plants include:

- Wild rice (Zizania)
- Water caltrop (*Trapa natans*)
- Chinese water chestnut (*Eleocharis dulcis*)
- Indian Lotus (*Nelumbo nucifera*)
- Water spinach (*Ipomoea aquatica*)
- Watercress (*Rorippa nasturtium-aquaticum*)
- Watermimose, Water mimosa (*Neptunia natans*)
- Taro (*Colocasia esculenta*)
- Rice (Oryza) is originally not an aquatic plant.
- Bullrush, Cattail, (Typha)
- Water-pepper (*Polygonum hydropiper*)
- Wasabi (*Wasabia japonica*)
- Totora (*Scirpus californicus*)

Animal nutrition: Some examples of aquatic plants used for animal nutrition are:

- Water hyacinth (Eichhornia)
- **Duckweed:** Lemna, Spirodela and Wolffia
- Trichanthera gigantea

Some examples of aquatic plants:

- Most algae and all seaweed and kelp
- Utricularia (from the Latin, utriculus, a little bag or bottle) is a genus of slender aquatic plants, the leaves of which contain floating air bladders. They are called bladderworts.
- Water lettuce

CONCLUSION

Adequate knowledge of the classification, distribution, control and economic importance of aquatic plants is necessary to provide fish culturist information on some future challenges in culture fisheries management and practices.

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