Volume 1, Issue 1 January 2005

Barr Report

Barr Report

Welcome to the Premier Edition of the Barr Report!

Special points of interest:

- Welcome by Tom Barr
- Feature Article "Aquatic Plant Life, Unifying Principles"
- and more .....

Welcome to the premier edition of the Barr Report. Over the course of the next year, we will introduce a variety of articles, aquascapes, do-it-yourself projects, and special features designed to assist both novice and experienced aquarists alike. In this premier feature, we will show you a real aquarium that is part of the Barr's Laboratory – a real world demonstration of principles in action. I will also introduce you to an introductory chapter on Aquatic Plant Life and the unifying principles that we seek to manage in our planted aquarium environments. And finally we will introduce you to featured aquatic plants each month as well as future do-it-yourself projects that will help give you the knowledge, the tools, and the technology to make it happen.

The Barr Report will continue to grow as we continue to add new subscriber only content on an ongoing basis. Your comments, feedback, and support will continue to improve what we are able to deliver to you – all made possible by you and your support.

Thank you!

Tom Barr

Just what is Tom cooking up now?

Inside this issue:

Aquatic Plant Life, Unifying Principles

Evolution: Theodosius Dobzhansky (1900-1975) said "Nothing in biology makes sense except in light of Evolution."[1] Aquatic macrophytes[2] possess a size and diversity that is truly spectacular in the plant kingdom. Aquatic macrophyte diversity covers roughly 440 genera covering 103 families of embryo bearing plants alone (Cook 1999). Cook suggest that embryo bearing plants have re entered the water at least 222 times and perhaps as much as 271 times in the past evolution of aquatic plants. Some of the oldest known angiosperm plants are aquatic, unlike past contentions that the world's aquatic seed plants returned to the water much later in evolution, there is evidence from fossils in China

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Is it a snake oil?

Aquatic Plant Life, unifying principles Continued

that show that *Archaefructus* was aquatic and among the first known flowering plants (Dilcher 2002, Stokstad 2000). This means that some angiosperm aquatic plants evolved in the water and stayed there while some did evolve on to land only to later return to their aquatic past. It should not be overlooked that not all plants followed this same evolutionary pathway nor did many algae. Table one shows the orders that possess families that have aquatic representatives.

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Barr Laboratory

Barscape of the Month

January 2005

“Why have I not had BBA for many years and others have?”

Plant of the Month
Kleiner Bar Sword—January 2005

The popular cultivar name Kleiner Bar is a popular Echinodorus sword cultivar developed in Germany in the early 90s. Kleiner Bar mean "Little Bear" is a compact sword reaching approximately 4 to 8 inches in height. In its submersed form and under highlight, this cultivar is develops rusty red to dark red leaves. This cultivar is not particularly sensitive to hardness, growing well in both soft as well as hard water. In low light settings older leaves may start to fade as in the picture above while new growth continues to develop with deep dark red leaves.

Is it a magic potion?

Aquatic Plant Life, unifying principles Continued

Order	Relative number of aquatic families/genera
Podostemonales	**Exclusively Aquatic**
Hydrocharitales	**Exclusively Aquatic**
Zosterales	**Exclusively Aquatic**
Nymphaeales	**Exclusively Aquatic**
Alismatales	**Exclusively Aquatic**
Typhales	**Exclusively Aquatic**
Pontederales	**Exclusively Aquatic**
Hippuridales	**Exclusively Aquatic**
Hydrostaciyales	**Exclusively Aquatic**
Hydatellales	**Exclusively Aquatic**
Lamiales	**Two or more aquatic families**
Haloragales	**Two or more aquatic families**
Myrtales	**Two or more aquatic families**
Caryophllales	**Two or more aquatic families**
Arales	**Two or more aquatic families**
Campanulales	**Two or more aquatic families**
Cyperales	**Two or more aquatic families**
Eriocaulales	**Two or more aquatic families**
Zingerales	**Two or more aquatic families**
Asparagales	**Two or more aquatic families**
Poales	Four or more aquatic genera
Primulales	Four or more aquatic genera
Araliales	Four or more aquatic genera
Anterales	Four or more aquatic genera
Gentlanales	Four or more aquatic genera
Fabales	Four or more aquatic genera
Saxifragales	Orders with three or less aquatic genera
Solanales	Orders with three or less aquatic genera
Capparidales	Orders with three or less aquatic genera
Droserales	Orders with three or less aquatic genera
Theales	Orders with three or less aquatic genera
Philydrales	Orders with three or less aquatic genera
Juncales	Orders with three or less aquatic genera
Euphobiales	Orders with three or less aquatic genera
Nelumbonales	Orders with three or less aquatic genera
Liliales	Orders with three or less aquatic genera
Piperales	Orders with three or less aquatic genera
Balsaminales	Orders with three or less aquatic genera
Gefamtales	Orders with three or less aquatic genera
Ranunculales	Orders with three or less aquatic genera

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Grape Vinewood

"Why can I induce BBA by lowering my CO2?"

Don't forget Plantfest 2005!

Aquatic Plant Life, unifying principles Continued

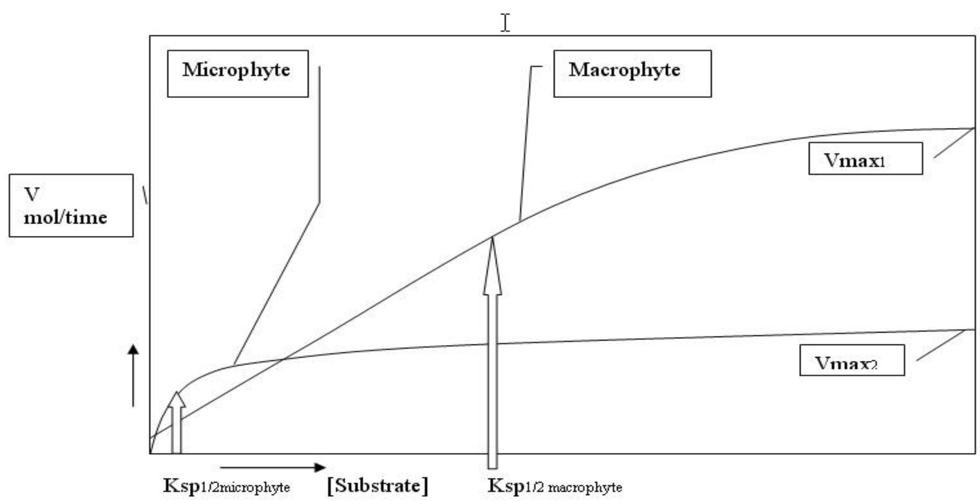
The organization of living things can be seen like a pyramid or tree with seven major levels or categories: ***Kingdom, Phylum, Class, Order, Family, Genus, Species***. The kingdom Plantae has recently included green algae and red algae on the basis of molecular and biochemical criteria (Campbell 1999). Traditional organizational schemes considered green and red algae in other kingdoms in the past but the new research shows a clearer lineage than past methods and the DNA techniques have elucidated many unknown relationships and answer many questions while raising many questions as well (Bhattacharya and Medlin L 1998). Many plant discoveries have been made using algae, such as CO_2 fixation reactions in photosynthesis by Calvin, Benson, and Bassham in the 1940's and 1950's (Calvin 1989). Many researchers will often refer to many marine macro algae as "plants" (Littler and Littler, Chapman, et al) they are large and leafy much like flowering plants. Freshwater macro algae such as *Chara* and *Nitella* are often mistaken for vascular plants such as *Najas*. Marine kelps such as *Protelsia* look very much like small palm trees and *Caulpera* possesses rhizoids and stolons runners much like that of vascular plants. There is a general public perception that algae are *less advanced*, but in many ways, they are more advanced for the habitat that they live.

"There is a general public perception that algae are less advanced, but in many ways, they are more advanced for the habitat that they live."

While a number of algae possess habitats in soil and terrestrial systems, the terrestrial and aquatic "embryophytes" plants are what most of the public tend to think of when they speak of plants and algae. These include bryophytes (*Riccia*), lycophytes (*Isoetes*), pteriophytes (*Microsorium*) and seed plants (*Hygrophila*). Aquatic researchers use the term "Macrophytes" to include similar morphological plant like algae such as *Nitella* and many times the term "Microphyte" for smaller algae. Some Cyanobacteria are considered macrophytes such as *Lyngbya* while some green algae such as *Cladophora aerogiphilia*, (Marimo balls) would be considered macrophytes as well. *Chara* (Stone wort) would be considered a macrophyte, while *Ankistrodesmus* (Green dust algae) would not be. These two "plants" are in different ecological niches (Bowes 2004). This difference requires each to have different strategies for growth and genetic persistence in the aquatic environment.

The Niche concept: Many aquarist fall into the trap of equating small microphytes into the same niche as the larger Macrophytes. A single celled alga has very little nutrient demand to survive and grow while billion celled *Echinordorus* will need a much larger concentration to maintain the similar rates of growth relative to the size ratios (See figure 1).

Nutrient uptake dynamics



Ksp$_{1/2}$microphyte [Substrate] Ksp$_{1/2}$ macrophyte

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Aquatic Plant Life, unifying principles Continued

Where V = velocity of uptake by organism, V max is the maximum uptake rate, V's units are mol/time so this is a "rate of uptake". Ksp ½ is the half saturation constant used to compare two different organisms uptake rate. When the Substrate is very low, the microphyte has the advantage and the uptake line goes almost to zero at the origin. The macrophyte uptake rate stops before zero and this means that it takes a certain critical concentration of substrate before the macrophyte will induce substrate uptake. When the concentration of the substrate increases further, the macrophyte them has the uptake advantage. This model is counter to past assumptions from aquatic plant hobbyist about excess nutrient substrates causing algae blooms as it shows that the macrophytes have the uptake advantage in the ideal model.

See footnote for more information[3].

This is one reason why algae can persist for months even when the aquarist performs many water changes, uses nutrient chemical removers and activated carbon. The plants just stop growing and waits, algae can do the same thing and produces resting spores that are activated when ammonium (NH_4^+) or large CO_2 variations occurs (Barr 1998). There are other algae inducers, generally these involve a **lack of something rather than an excess.** Algae possess much higher surface to volume ratios than plants, this allows them to be far more competitive and responsive at low concentrations of nutrient substrates. Many algae possess enzymes that allow cleavage of organically bound PO_4 and NO_3 (Münster, Heikkinen and Knulst 1998). Algae also do not have internal transport of nutrients (nuisance algae, Kelps and other larger macrophytes have transport systems and morphology). Past literature on culturing aquatic plants dealing with algae nuisances over looked this niche concept and nutrient uptake dynamics. This has lead to many myths and problems relating to plant growth health and problems with algae.

"A single celled alga has very little nutrient demand to survive and grow …"

Size: The Victorian Water (*Victoria amazonica*) lily possesses some of the largest leaves known in the plant kingdom (7 feet in diameter!) and are able to support a small 65 pound child floating on the water while the tiny *Wolffia* is one of the world's smallest flowering plants, at 1 to 1.5 mm long yet even these two seeming opposite plants are very similar. Both plants have the same fundamental similar processes and have the same basic architecture. Both plants have flowers, chloroplast, emergent floating leaved aquatic plants, similar biochemical pathways and nutrient needs. Both are genetically very similar. Are they in the same niche?

Temperature: Other macrophytes such as *Chara* and *Veronica* can be found in the desert south west of the United States in springs at 40C or higher (Barr 2002) and *Hydrilla* is also found up to 40C in some locations (Bowes 2004). *Echinodorus berteroi* can be found in similar conditions in its native range in the Santa Ynez river valley (Barr 2003). On the other extreme, *Potamogeton filiformis* and *Hippuris vulgaris* have been found under frozen ice lakes in Greenland (Pedersen and Brodersen 2003).

Depth: Various aquatic mosses *Chara* have been found in Lake Tahoe to several hundred meters (Hutchinson 1975) and Crater lake has reported some of deepest embryophytes observed at 253 meters and a sample was collected at a depth of 221 meters while most vascular plants are limited to the upper 10 meters (Larson 1988, Sculpthorpe 1967). The aquatic habitat is very heterogeneous, it changes through time, hours, days weeks, months and years and sometimes decades or longer.

Ecology: Ecology deals with changes of organisms through space and time. The Aquatic habitat changes dramatically through a year's time. Consider the Amazon basin. Water levels change up to (Melack et al 2001, Sioli 1984) 15 meters are common. The amount of light reaching the plant changes dramatically under these conditions. Vascular plants cannot survive for

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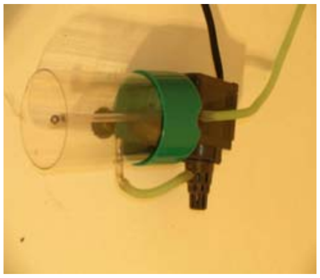
Aquatic Plant Life, unifying principles Continued



Coming Soon …
A Venturi DIY Article …

Can you build this yourself?

"There are other algae inducers, generally these involve a lack of something rather than an excess."

long periods below 10 meters or so due in large part hydrostatic pressure but also light will play a critical role due to attenuation of light by the water and changes in turbidity (Brenner 2003, Payne 1982, Dale 1981, Bodkin et al 1980). Wet seasons are punctuated by large debris covering and dislodging plants. While a through discussion may seem appropriate here, a Limnology text is a good source for more on the theory of light attenuation and a more thorough coverage in another later chapter will address this topic in full. The main point here is that Submersed Aquatic Plants(SAM's) have enormous changes in their environment through space and time.

Rate of growth: Growing well and growing slowly are different terms. If a tank has lower light, then the plants can grow slower but still "well". If a tank has high light and some plant growth, but not fully utilized, the aquarist can have some plant growth and it can appear to grow well enough for their taste, but algae will also persist and grow as well. This can lead the aquarist to search for algae killers, "snake oil" remedies and a general focus on the algae's needs rather than that of the plants. Our goal in planted tanks is generally to grow the macrophytes. So we should fully examine their requirements for health and growth. Nuisance algae can be dealt with any number of ways but unless the plant growth is addressed, the aquarist will have repeated infestations of algae and lack luster plant growth. Many new plant aquarist do not realize how well plants will truly grow when they have their needs fully met and maximized. Some aquarist feel that they need a leg up and should still use algae killers to help them get over this temporary issue. The cause of the problem was plant growth and most algae killers are not plant nutrients and also harm the plants in some way. Various method exist that work well to grow SAM's in aquariums. Some do not involve CO_2 or carbon enrichment while some do. Both methods work for the same reasons, but the growth rate is different, in both cases the plant's nutrients and assimilation needs are being met for that light intensity and CO_2 level. Adding more light drives more CO_2 demand in SAM's. Adding more CO_2 drives more NO_3 uptake and so on down the list of nutrients. When aquarist change their methods, they need to address these demand changes by the SAM's. This issue alone has caused great confusion in the hobby of aquatic plants. The "best method" allows the aquarist the rate of growth they desire. This should be considered when approaching a method.

The goal: The goal in this series of chapters is to help the aquarist to grow plants not based on a particular product or system, nor to suggest a single method, but rather general concepts that can be applied to any routine or system to fit their needs and goals for growing plants. Where possible, references to the scientific primary literature are used to show support of the observations in planted impoundments and aquariums. This is seldom done in plant hobby levels books in the past with a notable exception to Diana Walstad's book, The Ecology of the Planted Aquarium. This book focuses on non-CO_2 enrichment methods exclusively and is highly suggested for anyone serious about growing SAM's. This series will cover non-CO_2 methods as well and compare them to CO_2 and higher light methods as well as marine SAM growth and methods as well as education of weed related problems. There are many methods that can grow plants but they all have some unifying concepts: good plant growth, dense plant biomass in the aquarium, routine maintenance and some source of nutrients. Each component of growth must be scaled up to meet the needs of the plant's growth rate. At lower light, there is more flexibility in methods as the rate of nutrient assimilation is slower. Many of the older methods dealt with lower light aquariums and plants. As time has progressed, many aquarist have begun to use higher lighting such as power compact fluorescent and metal halide lighting rather than older T-12 fluorescent lamps. This placed more demand on the CO_2 and the nutrients than past methods. A very good thing came of this process, the nutrient needs and uptake rates became much clearer and easier to tease apart. It is the goal of this series to get the aquarist to the point where they can grow the plants well and not deal with algae but also to understand **why**. Most aquarist seeking a planted tank seek to grow plants well, a few will also aquascape and think of the over-

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Aquatic Plant Life, unifying principles Continued

The Barr-Meister himself ...

"The goal is to help the aquarist grow plants based on general concepts that can be applied to any routine or system to fit their needs."

all look at first. Once they accomplish the growing part, they can focus their energies on their aquascapes, designs, produce vibrant examples of aquarist plant growth and artistry. This series will focus always be on the plant's needs rather than the algae. This approach is the long-term solution to the noxious algae problem and works with all methods used today. This concept is unique in the hobby as many methods have never been shown and discussed with this philosophy in mind in one single text. This book is a response to a large lack of literature that has truly attempted to give credence to a unifying methodology for aquatic plant growth principles in aquariums and pulls in elements from Limnology, practical testing, Botany, Phycology, Biology, biogeochemistry, research literature, and other aquarist experiences. Theory and lab studies are not the same as practical applied aquatic plant aquarium, but carefully considering the application of the research as it applies to aquarium plants is very useful.

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So ... is it a plant or a weed?

Aquatic Plant Life, unifying principles Continued

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A nice list of further references on depth of vascular plants: http://el.erdc.usace.army.mil/aqua/apis/ecology/html/referen3.html

[1] http://people.delphiforums.com/lordorman/light.htm.

[2] Aquatic macrophytes are aquatic plants that are large enough to be apparent to the naked eye; in other words, they are larger than most algae

Can you really grow plants in hard water? GH=24, KH=11