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Sonar® weed control...

EDITORIAL

Approximately three months have passed since the 1986 Florida Legislative Session adjourned, and, as usual, there was some good legislation passed by our elected officials and some not so good, as far as aquatic plant management goes. On the positive side: a much needed pay raise for "critical class" career service biologists (State of Florida biologists are no longer the lowest paid in the nation!); the Coral Reef Restoration Fund; a bill requiring all hunters to wear at least 500 square inches of daylight (fluorescent) orange material; and a seat belt law.

Well, buckle up your government mandated seat belts, 'cause here's the "not so good" legislation that affects **our** *Aquatic Plant Management Trust Fund. First, the Legislature approved the unrequested $748,514 transfer to the Florida Game and Fresh Water Fish Commission. These funds are designated for "Administrative Overhead" so that commission biologists can review aquatic plant permit applications for their impact on fisheries and waterfowl habitat.*

Additionally, $200,000 was transferred to the Marine Biological Research Trust Fund for the revegetation of Tampa Bay with seagrasses. A potentially worthwhile project, but one with negligible benefits to the management of nonindigenous aquatic vegetation. And then there's the now infamous Lake Apopka Restoration Project. Ah, it could have been worse; the scuttlebutt early on in the session was that an additional 1.3 million dollars was going to be pilfered for the continuation of the project. The end result was surprising but nonetheless costly; a mere $500,000 was taken to complete the pilot project. Enough said.

These "transfers" amount to a little over 1.4 million dollars, enough to treat approximately 4,700 acres of the 53,000 acres of hydrilla now infesting state waters!

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ABOUT THE COVER

Waiting for Columbus? Perhaps. This ancient cypress tree can be found in the Cooper Basin of the Blackwater River.

Photo by: Jess Van Dyke

Aquatics

SEPTEMBER 1986/Volume 8, No. 3

CONTENTS

AQUATICS: Published quarterly as the official publication of the Florida Aquatic Plant Management Society. This publication is intended to keep all interests informaed on matters as they relate to aquatic plant management particularly in Florida.

EDITORIAL: Address all correspondence regarding editorial matter to Daniel Thayer, Editor, "Aquatics" Magazine, 7922 N.W. 71st Street, Gainesville, FL 32606.

American Frog's Bit

by
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Bureau of Aquatic Plant Management
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West Palm Beach, Florida 33411

Our England is a garden, and such gardens were not made
By singing: "Oh how beautiful!" and sitting in the shade,
While better men than we go out and start their working lives
At grubbing weeds from gravel paths with broken dinner-knives.

from "The Glory of the Garden," Kipling

Introduction

Our Florida, too, is a garden from which weeds must be conscientiously "grubbed." Typically the broken knives in Florida are aimed at over-achieving interlopers, those introduced weeds which tend to survive only too well here; non-natives that grow to the point of excluding many of those that were here first. Yet some of the native plants are subject to control operations when growth is deemed excessive. A native which is subject to some control in several locations statewide almost every year is American frog's bit, *Limnobium spongia* (Bosc.) Steud. It is when frog's bit assumes waterhyacinth-like growth in dense floating mats that this control is considered.

Habitat, Growth, and Confusion

American frog's bit commonly grows in floating mats or rooted on mud in marshlands. Seemingly it isn't too picky about pH or relative productivity of the water. Anything not too extreme seems to do. Frog's bit plants survive three or more seasons classifying them as perennial and form no woody tissue so are herbaceous. Introduction to new water bodies probably occurs by avian seed transport.

The species has two different growth forms. Young plants have leaves which rest on the water surface, growing in small (three to six inches across) rosettes of kidney- or heart-shaped leaves joined by stoloniferous stems that resemble the banana lily (*Nymphoides aquatica* [Gmel.] O. Ktze) or dollar bonnet (*Brasenia schreberi* [Gmel.]). The underside of the leaf has a central spongy, purplish disc. Yet from this form robust aerial leaves arise.

The aerially-growing form is almost a dead ringer for mature waterhyacinths. However, really big aerial frog's bit plants are usually only half the height of mature waterhyacinths. Long-stemmed leaves grouped in a cluster comprise one plant which will set off identical daughter plants at the ends of runners. The leaves have spade-shaped terminal blades while those on waterhyacinths tend to be ovoid. (Maybe, sort of, when you're looking kinda sideways after twelve hours in the August heat do the Limnobium leaf blades resemble a frog's bit or bite.) Also the veination of the leaves allows differentiation. Frog's bit leaf veins do not recurve to "meet" at the tip of the blade as on waterhyacinth. Rather, they extend in fairly straight rays from the base of the blade to the edge of the leaf. Also, the swollen leaf stem, or petiole, especially evident in young waterhyacinth plants is absent. Frog's bit petioles are slender along their entire length. Yet differentiation is a cakewalk if any sort of showy flower is present.

Frog's bit flowers readily, but never is the inflorescence borne high in a tasteless lavender display. Instead, a Miss Manners-approved separation of the sexes, rather diminutive male and female flowers arise independently, although on the same plant. They are shorter than most of the leaves and are apparent only on relatively close

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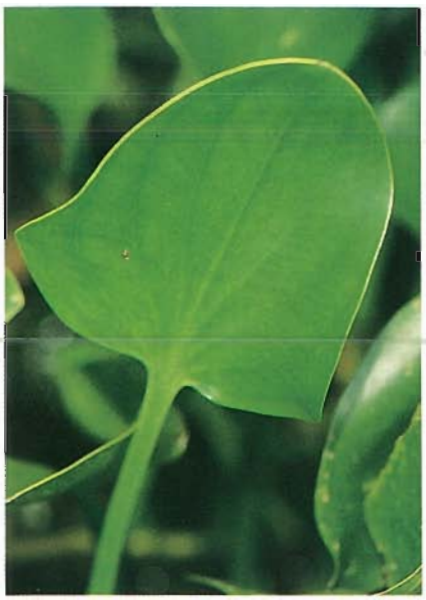

Leaf Blade: Limnobium

Limnobium: Mature Berry

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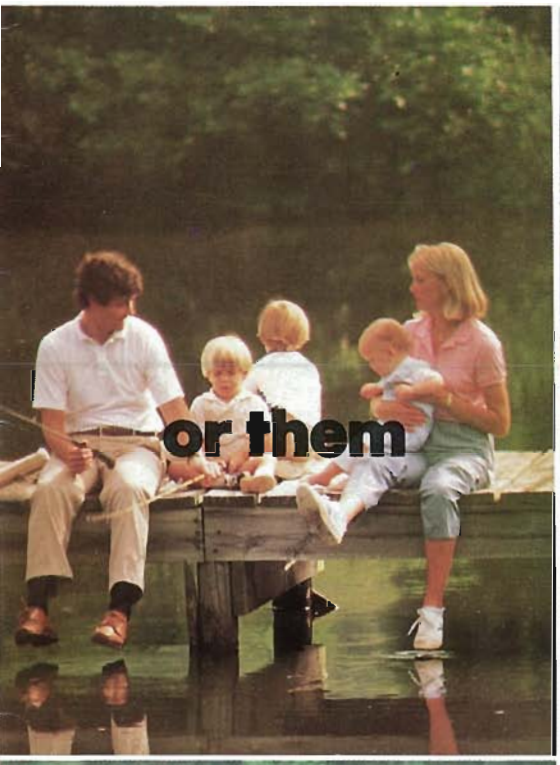

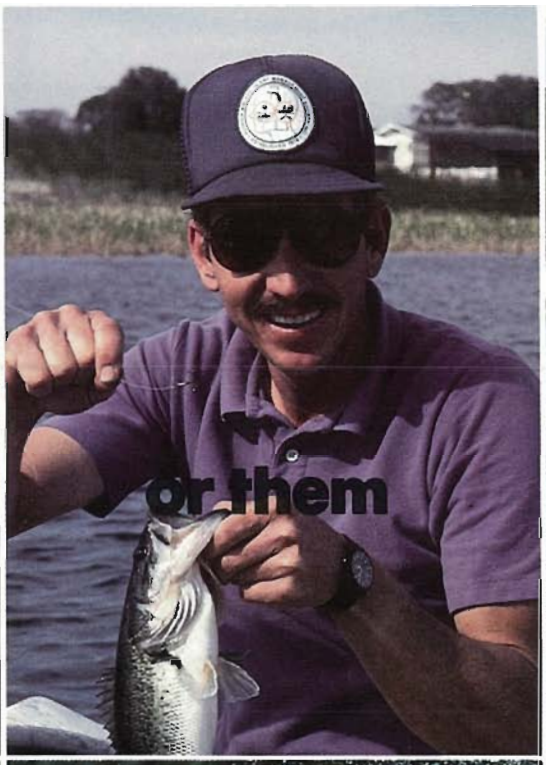

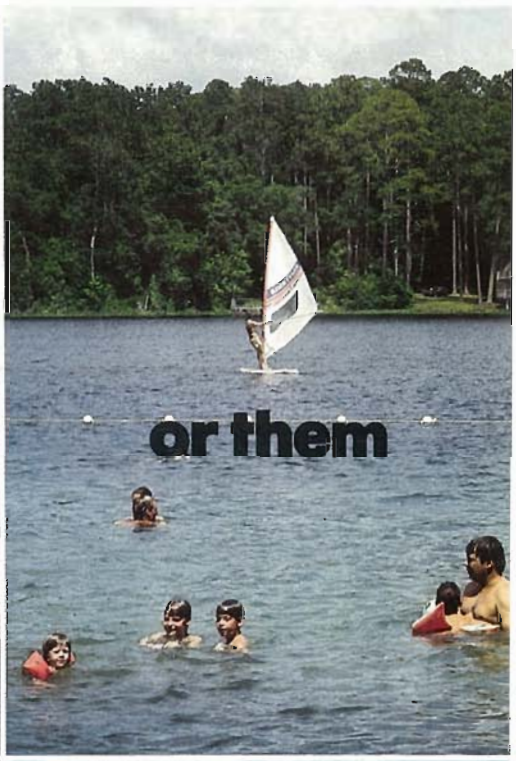

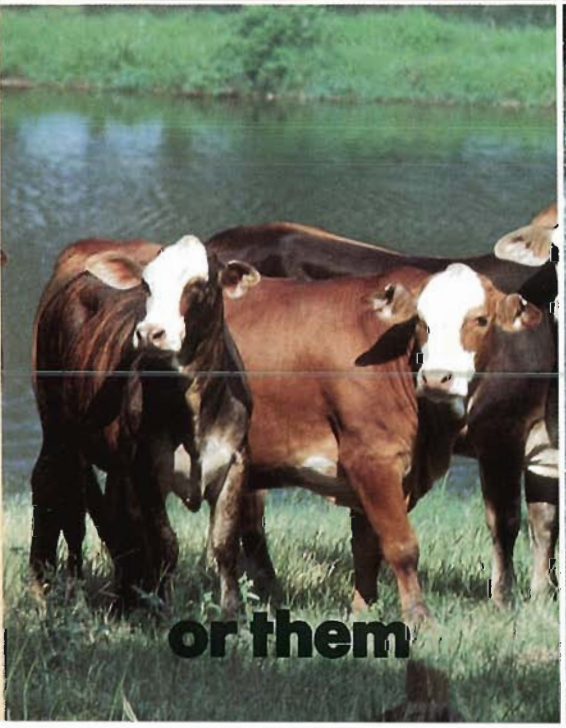

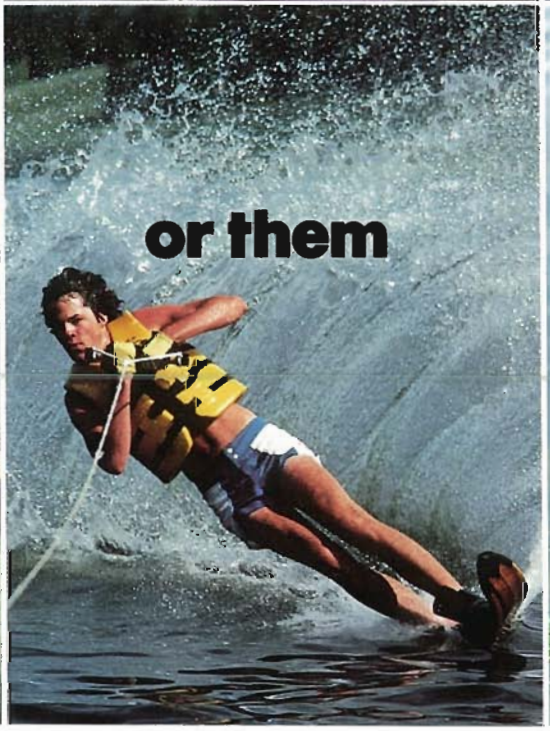

FROG'S BIT *from page 4*

inspection. Neither flower is particularly robust, yet they're stout enough to get the job done and many-seeded berries form, following insectivorous fertilization of the ovary. Single, cranberry-sized berries per female flower are also almost lost in the foliage on short, curved stems.

All In The Family

Frog's bit belongs to the Hydrocharitaceae family which contains many familiar aquatic plants world-wide. These include hydrilla, elodea species, egeria and vallisneria. Many of these have both male and female flowers only on the same plant while some, like hydrilla, have singly-sexed forms along with the bisexual strain. The Hydrocharitaceae family species inhabit fresh- and salt-waters from the sub-artics to the equatorial tropics. Several members of the family are marine "grasses" of great importance to Floridian, Bahamian, and Caribbean reefs and lagoons. Frog's bit survives from the central latitudes of the United States on down to south peninsular Florida waters.

Relative Significance in Florida and Conclusion

Frog's bit is reported in DNR's 1984 Florida Aquatic Plant Survey from only four water bodies covering ninety-five acres. More public water bodies than this harbor the species, yet undoubtedly its strong resemblance to waterhyacinth has befuddled many a botanist's bonnet. Control operations have been constant but limited. For instance, in 1984 only eight acres were controlled in the state's funded aquatic plant control program. They ranged from St. John's River runs and lakes to Lake Okeechobee bays.

Waterfowl feed on frog's bit fruit and many plant and animal species live in, on and around the structure the plant affords. Control operations will continue to be performed only when the species seriously inhibits water flow or navigation for in any garden some degree of vigilance is sensible lest we end up lamenting like Melville's Billy Budd, "I am sleepy, and the oozy weeds about me twist."

The Preparation of Aquatics for Identification

by
David Hall
209 Rolfs Hall
University of Florida

The University of Florida Herbarium is operated by the Florida State Museum Department of Natural Sciences and is located on the University of Florida campus in Gainesville. Among the services provided by the Herbarium is the plant identification service. Dr. David Hall is the IFAS Extension Botanist for the Herbarium and identifies aquatic and terrestrial plant specimens sent him in the mail. The Herbarium has an extensive library and plant collection on the flora of Florida and the Southeastern United States and will identify plants

Continued on page 22

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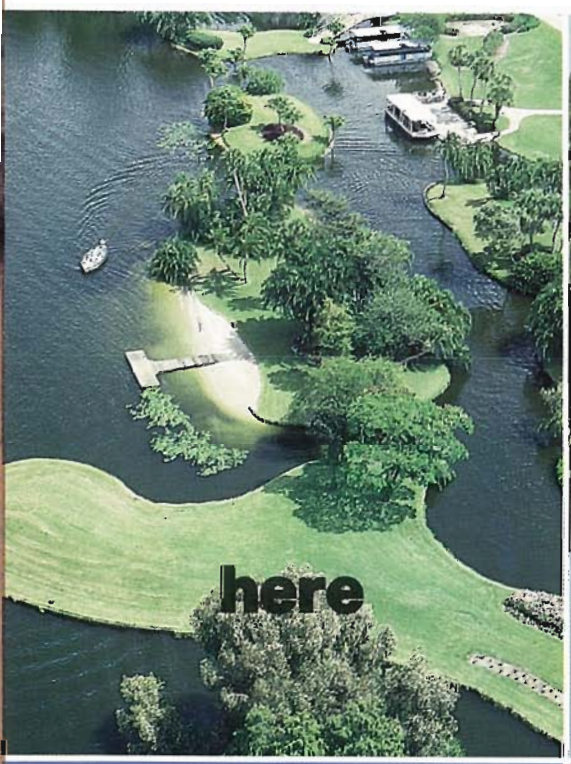

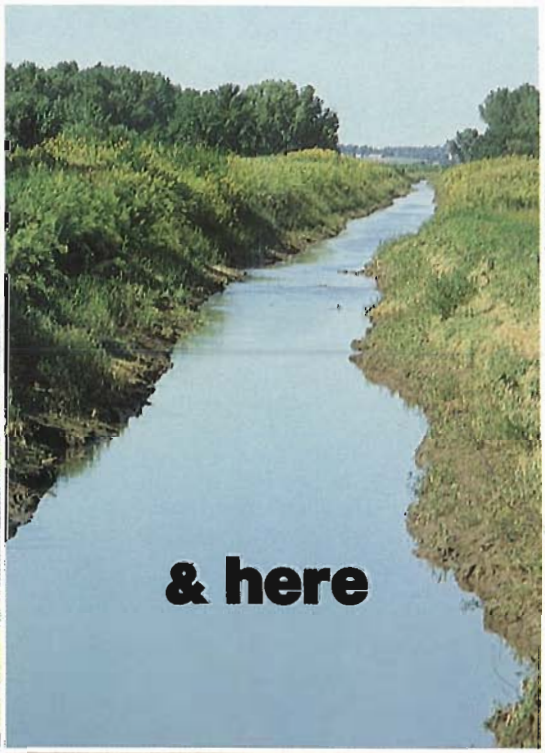

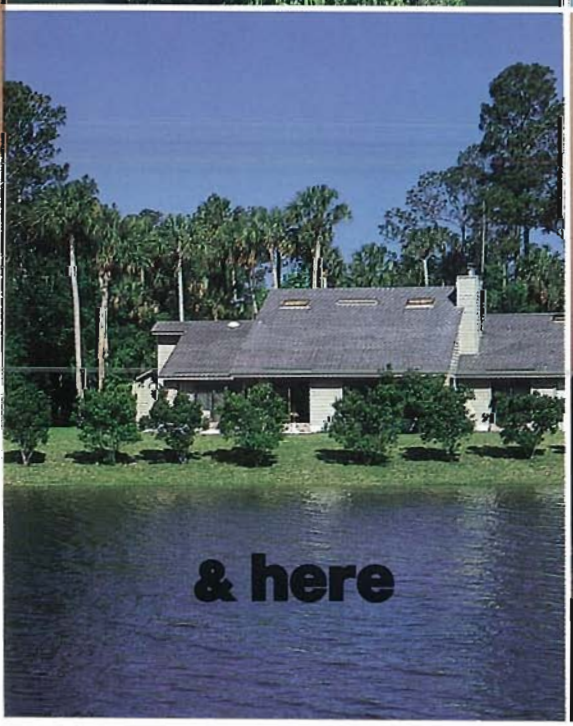

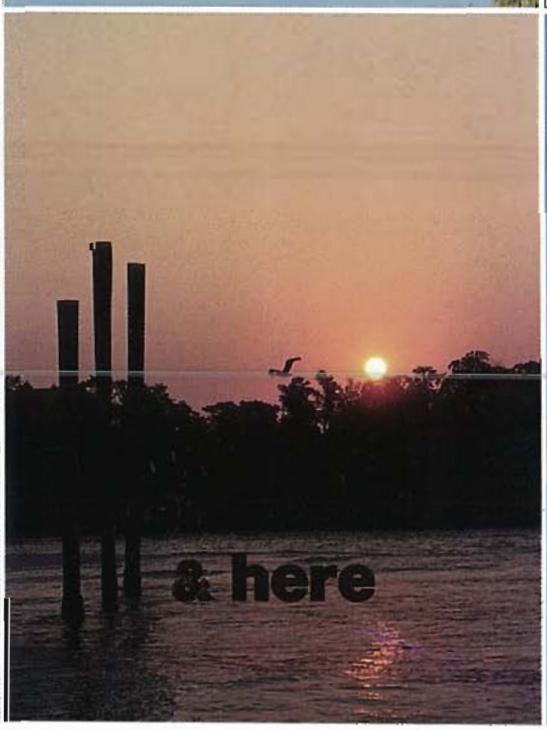

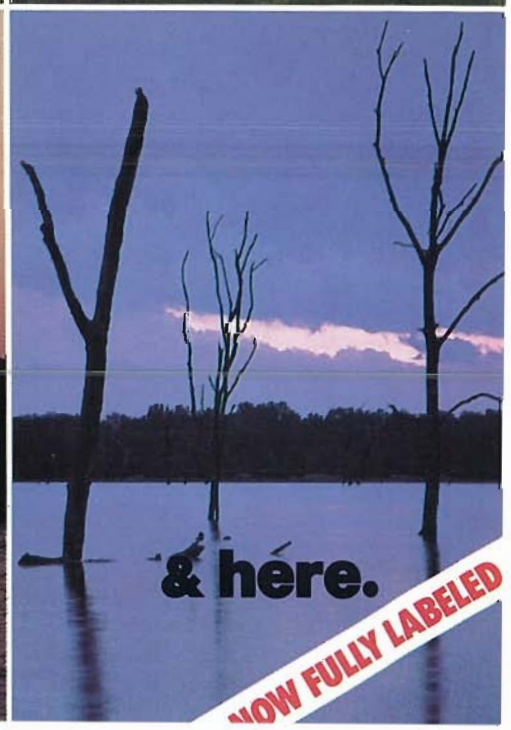

Use of Grass Carp to Control Hydrilla and Other Aquatic Weeds in Agricultural Canals

by
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I. Introduction

Many agricultural areas in Florida have canals and ditches to deliver water for irrigation of crop plants during periods of dry weather. These waterways also provide for drainage of water during periods of heavy rainfall to prevent crop damage from excessive amounts of water.

Canals and ditches in agricultural areas provide ideal conditions for growth of many aquatic plants. These waterways are generally shallow and have a high ratio of shoreline to surface area as compared to other types of water bodies. Water temperature in these canals and ditches tend to be high due to the protection of banks which extend above the water surface, thus preventing the wind from mixing the water. Many aquatic plants grow luxuriously under these conditions.

Abundant aquatic plant growth seriously retards movement of water vital for irrigation of crop plants during periods of dry weather. Also, excessive amounts of plants prevent the rapid removal of water during the periods of heavy rainfall that occur in Florida.

The sandy soil found in many agricultural areas is an additional factor that compounds the problems associated with aquatic weeds in these areas. The banks of canals and ditches dug in sandy soils are difficult to maintain because water flow and rain can easily erode the banks and alter their shape with a resulting reduction in water depth. Plant roots help prevent the erosion of the banks

Figure 1: Fish barrier constructed of a single row of heavy gauge PVC (Polyvinylchloride) pipe to contain grass carp in agricultural waterways.

Figure 2: Canal filled with hydrilla prior to use of any management methods.

Figure 3: Canal free of aquatic weeds after use of mechanical methods and grass carp to manage plant growth.

Figure 4: Water-lettuce plant which has had its roots eaten off by the grass carp. Plant on the left is from a canal not containing grass carp.

and stabilizes the sides and bottom of the waterways, but an abundant growth of weeds in the water reduces flow.

Successful management of aquatic weeds in agricultural waterways must take into account the amount of plants essential to maintain the integrity of the canals and ditches, but yet not let the plants become so abundant as to interfere with water flow. Consideration must also be given to the use of any aquatic weed management method that may result in damage to sensitive crop plants.

In order to provide additional information on ways that aquatic weeds can be effectively controlled in agricultural waterways, a research project was initiated in 1979 in canals and ditches of a citrus grove located near LaBelle, Florida.

The study examined the use of the herbivorous gras carp (*Ctenopharyngodon idella* Val.) alone and in combination with conventional mechanical and herbicidal methods to control hydrilla (*Hydrilla verticillata* Royle), torpedograss (*Panicum repens* L.), duckweed (*Spirodela punctata* (Meyer) Thomps.), water-lettuce *(Pista stratiotes* L.), and algae commonly present in these waterways. This article presents a summary of the significant findings of the study.

The initial results of the study were based on observations with diploid grass carp. Triploid grass carp were stocked beginning in 1984. The feeding behavior of the triploid grass carp in this study appeared to be essentially the same as the diploid ones. Therefore, the discussion in this article will refer only to the name 'grass carp' throughout the text.

Because of the potential reproduction of diploid grass carp, their use has been rather limited. However, the development of triploid grass carp for use under a permit system[a] now makes it possible for farmers and ranchers to use these herbivorous fish to control biologically many aquatic problems.

II. Barriers to Prevent Escape of Fish

Biological control of aquatic weeds with herbivorous fish depends on containment of the fish so they will control the target species. Because of the need to move water and prevent loss of the grass carp, a barrier was developed with these two objectives in mind. The first barrier to be used in this study

[a]An application for a permit to purchase and use triploid grass carp for management of aquatic weeds may be obtained by writing the Florida Game and Fresh Water Fish Commission, Bureau of Fisheries Management, 620 S. Meridian St., Tallahassee, FL 32301

consisted of two rows of vertical steel bars with one row offset behind the other. This design was later modified to a single row with heavy gauge PVC (polyvinylchloride) pipe (Figure 1) which was more cost effective and practical that the one with steel bars.

The smooth surface of the PVC allowed for better passage of some floating material through the barrier than the steel one. The PVC was also considerably less expensive than the one constructed with steel. Also, by securing the PVC pipe with cotter pins, a damaged pipe could be easily removed and replaced with a new one.

The vertical design of the barrier allowed for easy removal of floating debris which collected in front of the barrier. Horizontal supports were used to help prevent bending of the bars. The design of the barrier with the PVC pipe allowed for a variety of shapes to fit the various types of water control structures used in the citrus grove. This barrier allowed good movement of water but yet it retained the grass carp in the area in which they are stocked.

III. Use of Fish Alone

Hydrilla may grow very densely under the conditions found in the grove (Figure 2). In these waterways, the water column may be completely filled with hydrilla, and torpedograss and duckweed may grow on the surface of the hydrilla. Under these conditions, it is impossible to stock the grass carp because of the low amount of dissolved oxygen that will occur in the water during the early morning hours. The grass carp can only be used in these waterways when there is a low amount of plant material, or after herbicides or mechanical methods are used to remove the bulk of the plants.

IV. Herbicides Plus Grass Carp

The initial study in this grove was to evaluate an integrated method of herbicides and fish. Herbicides were first used to remove the weeds. Then grass carp were stocked to control regrowth. Various stocking rates of fish were evaluated in an attempt to determine the number required to prevent regrowth of the weeds.

Results from this initial study indicated that weed control in the lateral, small ditches in the grove was variable. However in the large, main ditches excellent weed control was achieved. Stocking rates of 10 to 250 fish per acre prevented regrowth of the weeds.

We found that the volume of water in the ditch and the amount of weeds present were two important factors influencing the use of the grass carp in the grove. One of the problems with this treatment was the difficulty of coordinating the application of the herbicides followed by stocking of fish prior to regrowth of the weeds.

Hydrilla filled the water column in many ditches creating a situation that made it impossible to use fish alone because of the low dissolved oxygen in the water. Some removal of plants was necessary to provide areas of refuge where the fish could live while they fed on the aquatic weeds.

The use of herbicides prior to stocking of grass carp should work well in situations where the fish can be stocked following a reduction in the aquatic weed biomass with chemicals, especially if the fish can be stocked prior to the regrowth of the weeds. Also, flushing the canals with water several weeks after the herbicide treatment would be one way to help provide water of good quality for the fish.

V. Mechanical Methods Plus Grass Carp

The use of mechanical methods followed by stocking of grass carp appears to offer unique opportunities for weed control in agricultural waterways. With mechanical methods it is possible to clear aquatic weeds from a portion of the ditch. In this way, an area of water suitable for good survival of fish is available. Then the fish can spread from these areas and forage on the aquatic weeds.

Two different ways of using mechanical methods and grass carp were attempted in these agricultural waterways. In the first, approximately 200 yards of a 1-mile canal was cleared of hydrilla. This was followed by stocking fish at the rate of 250 fish per acre. The fish were stocked in December soon after the lower end of the canal was mechanically cleared of hydrilla. The fish had cleaned the entire canal by the following spring.

In this case, the hydrilla beyond the cleared area was so dense that the fish could not swim up stream. They concentrated at the edge of the plants and moved up stream, clearing the hydrilla as they went.

In the second case, sections of canals completely filled with hydrilla were mechanically cleared of plants and stocked with 100 to 400 fish per acre. Again, the fish appeared to concentrate at the ends of the sections, and quickly cleared the canals

(Figure 3). In this way it was possible to have the fish feeding on different sections of the canals at the same time.

In both cases, the fish were stocked based on the total surface area of the canal. But because of the density of the weeds, the fish were concentrated in a small zone. This rather high density of fish per unit area resulted in rapid removal of plants from the zone of feeding. The fish cleared the canal as they fed on the hydrilla.

VI. Feeding Behavior on Different Weed Species

Hydrilla and torpedograss were the two primary aquatic plants encountered in the irrigation and drainage ditches present in this agricultural area. The grass carp effectively prevented regrowth of both of these plants.

Duckweed appeared to be controlled well regardless of the combination of methods used. Presence of algae was more related to the presence of plants. Once the plants were controlled the algae disappeared.

The grass carp fed on the roots of water-lettuce (Figure 4). The fish did not consume the entire plant, but the plant size was reduced considerably. Water-lettuce increased in several ditches after they were cleared of hydrilla, torpedograss, and duckweed. An occasional spot treatment with herbicides was necessary to completely remove these plants.

VII. Observations on Fish Movement

Visual observations on presence of aquatic weeds in the canals indicated that the grass carp initially remained in the area in which they were stocked. Fish moved through culverts upstream to new food sources but areas with weeds downstream were not fed upon when the fish had to swim with the current through culverts or water control structures to get to the weed infested areas.

VIII. Conclusions

Grass carp can be used effectively to control hydrilla, torpedograss, duckweed, and other aquatic weeds in agricultural waterways. Good control of these weeds was achieved when a portion of the dense amount of plant material present in the canals and ditches was removed by mechanical methods followed by stocking of grass carp to remove the remaining amount and prevent regrowth of the weeds. The grass carp were particularly effective in controlling weeds in those canals where water flow reduces the effectiveness or herbicides.

Barriers constructed with PVC pipe were effective in preventing escape of fish but allowed for passage of some of the floating debris in the water. The PVC barriers were easily adapted to a wide variety of water control structures found throughout the grove.

IX. Acknowledgement

The authors would like to thank the USDA, APHIS for their partial financial support of this project. Also, special thanks goes to Dr. Paul F. Sand, Dr. Robert E. Eplee, and Mr. Richard 'Web' Robnett for their valuable suggestions and cooperation with this research study.

Drift Control

by

Dan Thayer[1], Bill Haller[2], and Al Burkhalter[3]

[1]Biologist, Department of Natural Resources
[2]Professor, Center for Aquatic Weeds
[3]Monsanto Agricultural Products Company

Drift Control: The term is often used but not well understood. Drift problems bring visions of careless off-target movements of a pesticide, but drift may not always be a result of sloppy application and may in fact occur under seemingly ideal conditions. In order to discuss drift control, it is best to divide it into three factions so that one better identifies and understands the relationships involved in the various types of drift. For the sake of better understanding each component, let's divide drift into three areas.

1. Swath displacement
2. Small particle drift (fines)
3. Vapor drift

Swath Displacement Drift

Drift related to swath displacement is very simple to understand. Droplets of different size have different rates of fall. As a droplet falls, it can be displaced (drift) by wind or other forces away from the target area. The relationship is fairly simple. Larger droplets generally have faster rates of fall and, because of this, will be displaced only very little when compared to smaller droplets. Therefore, anything that will cause an increase in droplet size (larger nozzle sizes, lower pressure, viscoelasticity agents (polymers) or other drift control agent), will keep the displacement of the spray swath to a minimum. The applicator, however, may pay some price to attain this type of drift control as it relates to the efficient use of materials. Large droplets may have more of a tendency to hit a leaf surface and bounce or run off. Therefore, efficacy of the materials may suffer. Also, if a broadcast application is applied, too large a droplet may lead to poor coverage and each plant may not receive sufficient material. For droplet size to affect the efficacy of a material, it depends entirely on the material utilized. For instance, materials that are absorbed through foliage and root may still be available to the root. Material taken up by the foliage only may be wasted with excessive runoff.

Small Particle Drifts (Fines)

Many of the droplets produced by the hydraulic forces at the nozzle tip are sufficiently small, especially at higher pressure, that they are virtually unable to be detected with the naked eye. Because they are so small, their rate of fall is extremely slow. They are, therefore, subject to be moved great distances by even the gentlest of wind currents. In fact, slight breezes may keep them suspended for long periods of time. Droplets of this size (like fog) may be carried by wind and will lead not only to a displacement of the spray swath but also a diluting effect along the edge of the spray swath by the small drifting particles. This may cause some degree of problem, but these fine droplets can interact with certain weather conditions to cause even greater concerns. Under what is called weather inversion conditions these fines can cause extensive drift problems. In order to understand what is happening, one must understand what is called a normal lapse weather condition and how it differs from an inversion lapse.

Under a normal daytime period, if you were to start at ground level and travel upward, the temperature would gradually cool down. This is brought about by the warm air produced at ground level by the sun warming the earth. Warm air is lighter than cool air and, because of this, the warm air moving upward set up convection currents. Notice a buzzard, eagle, or hawk as he soars. He will not flap his wings very often and can stay aloft because he has learned how to take advantage of these subtle upward drafts. A fine droplet caught in such an updraft will tend to be carried away and, because the movement is upward as well as horizontal, it will soon be carried aloft. With sufficient time, it will be diluted so that if it falls back to earth or is mixed with dust or raindrops, its effect will be negligible.

In an inversion condition, the air at ground level is cooler than the air above. This condition may extend for some distance before a normal condition is encountered. Why might this occur? Let's take an example. It's early in the morning and a heavy dew is on the vegetation. In the sunlight, the droplets of dew begin to evaporate. But as water evaporates it causes a cooling effect and can cool the air around it. Remember how cold you are when you jump out of the shower, and before you dry off. This is the evaporative cooling effect. The lower layer of air because of this effect may be cooled below the temperature of the air above. In this condition the lower layer of air is heavy, will not rise, and usually there is no convection current or, for that matter, little wind movement. A small droplet trapped in the inverted cool air layer may cause the small droplets to be moved in mass from one area to another and dilute very little. Because there is little mixing of the cool air of the inversion layer with the warmer upper air, there is little chance for dilution effects. You now have an extremely dangerous condition for moving excessive amounts of a pesticide off a target area in an undiluted form.

Let's suppose that your conventional nozzle system puts out 10 percent of the pesticide in these fine droplets. If there is a sensitive crop or desirable vegetation nearby, it may easily be killed if it receives only a partial dose of the herbicide (i.e. 2,4-D and tomatoes). In addition, the small droplets may stick to the underside of a leaf or other area that may be more sensitive than the upper side of the plant. Therefore, not only can you have an effect related to the dose of the pesticide received, but according to the material used and the plant or animal confronted, the effect can be magnified by the smaller droplet size and how it behaves.

Inversion conditions can create severe problems, particularly in aerial

application, but can even create problems to the ground applicator. In aerial application, the material is normally placed in a fast-moving, horizontal stream of air. Therefore, the rate of the fall of the droplet is dependent on the size of the droplet. With ground or airboat application, the rate fall of the droplet is not only influenced by its size but also by the orientation of the nozzle. With this type of equipment, speed of application is usually slow and the droplet is not being injected into a fast-moving slipstream of air.

Let's take as an example a situation where I am on a high seat in an airboat and I am spraying down into vegetation. Even if fines are created, they are moving toward the ground or surface of the lake into the vegetation. The closer I am to the vegetation and the more my nozzle is pointing downward, the better chance that the fines will enter the vegetation before subtle currents may carry them off.

What if, however, I am trying to reach a distant plant and I arch my spray pattern. Fines created in the upward part of the arch have an upward trajectory and must fall downward under their own force. If they are small, this is not likely to occur for some distance. How does pressure relate to this? Did you ever increase the pressure on a nozzle and watch what happens to the formation of fines? Not only do I get more fines as the pressure increases, but the formation of these fines begin closer to the nozzle tip. The bottom line is this; increasing the pressure and arching the spray to get to that distant plant is an excellent way to produce larger numbers of driftable fines.

Viscoelasticity or drift control agents often have only a minimal effect on the percentage of fines created by a nozzle. Reducing pressure and nozzle orientation can help. Most gains, however, in preventing these types of droplets is made by the selection of specifically designed controlled droplet nozzles or applicators. Current equipment, however, may be applicable only in certain situations and there is still a great need for equipment research in this area.

Inversions can be brought about by many weather phenomena. They can be short in duration or long, and may cover large or small areas. A lake or river may create a local inversion on a land area at certain times. Land warms faster than water. At times of the year, the cooler air flow from water to the land can create a local inversion on the land. With herbicide spraying, most of the danger exists with a low level inversion and diminishes as the inversion goes higher or changes to a normal lapse condition.

There is an old adage in the industry that must be destroyed. "The air is perfectly still, therefore, it's a good time to spray to prevent drift." This is true if you are referring to swath displacement, but if you are referring to "fines" that may be created and allowed to drift, then the stagnant air you are spraying into may be an inversion!! Best conditions for drift control are usually present when the wind is light and coming from a constant direction. Strong or gusty winds should be avoided, but be aware of totally stagnant air and where it may eventually take the "fines."

Vapor Drift

This is the last category of drift and the hardest to absolutely define. Vapor drift refers to the tendency of a material to move from a solid or liquid state to a gas. Materials with low vapor pressures have an increased tendency to convert to a gaseous state. What do we mean by this? Think about what happens with your after shave lotion or you wife's perfume. These compounds are designed to have a low vapor pressure so that in the gaseous state we can get aroused from across the room as well as from close activity. If a herbicide has a low vapor pressure, it will increase in the likelihood of drift occuring from gases. Again, as with small droplets, this can interact with weather conditions in such a manner to create a problem. If vapor is being produced from an area sprayed with herbicide, it may affect surrounding plants. But if the vapor coming from the sprayed area is trapped in an inversion layer, it can lead to a concentrated movement of vapors of the pesticide from one area to another. The true vapor pressure of a material is hard to define and often depends on how it is measured. Many things may affect it. For instance, the amount of vapor coming from a material placed on a glass surface may depend on whether the material is applied as a thin film or beaded on the glass surface. If the material tends to bind to a leaf or soil particle, this too can affect the amount of vapor loss. Whether it is in a water solution, oil emulsion, or a solid state also may have an effect. Temperature also has an effect and will increase vaporization potential.

While materials may not be exactly evaluated as to their vapor potential, they can be characterized as to potential volatility. Some materials, in fact, may have restrictions on usage above certain temperatures due to risk of volatility.

While volatility may be affected to some degree by the droplet size and means of application, the vaporization potential of a herbicide is primarily affected by the material itself, how it is formulated and, to a degree, by what it may be mixed with.

Other Factors Affecting Water Droplets

Since most aquatic herbicides are water soluable rather than oil soluable materials, let's discuss for a short time some of the things that may affect the size of a water type droplet. Once a droplet is formed, it does not remain the same size as it falls. If will begin to evaporate, therefore, both heat and humidity can effect the size of a droplet as it falls. The higher the heat and the lower the humidity, the more evaporation that will occur and the more rapid the droplet will diminish in size. This may become a more critical factor in reducing smaller droplets to driftable fines or in aerial types of application where materials are applied from greater heights.

The size of the sprayed droplet and its speed of fall can also effect its size. If a large droplet starts at a sufficient height and attains a certain speed of fall, it may split into smaller droplets and produce fines in the process. Therefore, in some conditions, producing a large droplet can lead to drift problems particularly if the droplet falls or moves at a sufficient rate to cause it to split into smaller drops.

Many aquatic applicators may have mistakenly been lead to believe that herbicide drift is of concern only to aerial applicators or during hurricane force winds. Remember, there is more to drift than simply swath displacement or movement of fines. If its dead calm and smoke from your pipe is "hanging on the water" you may likely be dealing with a temperature inversion where invisible fines and volatile formulations are additional factors to be considered. Fortunately, most inversions in Florida occur early in the morning and are temporary. If you suspect an inversion, remember to direct the spray downward into the weed mats and reduce the nozzle pressure to reduce fines.

By now we have probably thoroughly confused you, if so, join the crowd. Application is part art and part science and there are few exact answers. However, if we better understand some simple relationships, there will be more opportunity to convert the science of application to the art of application.

TWAS THE DAY BEFORE FAPMS

By Ellie Ocharis

Twas the day before FAPMS and all through the lake;
Hydrilla was still growing, but at much slower rates.

Her flowers and petioles extended with care,
In hopes that "the sprayers" would never come there.

The turions were snuggled into each node,
Safe and secure in their little abode.

The pondweed with naiad tucked in her lap,
Had just settled down for a long winter's nap.

When out on the lake, there arose such a clatter;
Hydrilla sprang from the depths to see what was the matter!

Up through the water, she tore in a flash,
Breaking the surface with waves and a splash!

And what to her wondering eyes should appear,
But eight giant airboats..."God! The 'sprayers are here!"

Sun reflected from the boats in one giant ray....
Hydrilla knew in a moment, this must be "D-Day"!

More rapid than eagles, these great airboats came;
And each had an emblem displaying its name.

St. Johns, SWIFMUD, South Florida, Orange County
Northwest, Suwannee, Citrus and Polk County.

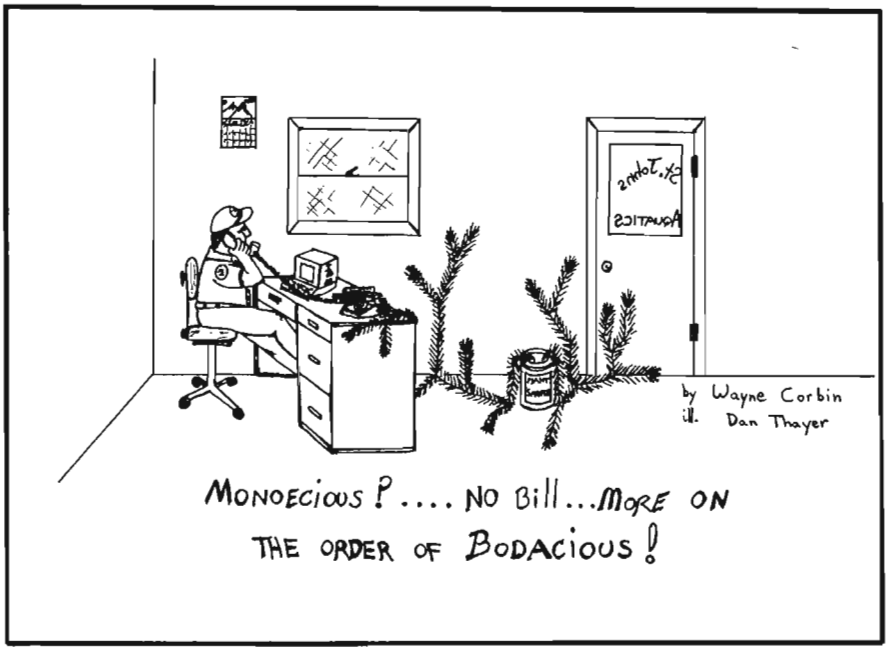
So right to the site, these airboats soon flew,
With plenty of herbicide and big spray guns too.

Down from their seats, "the sprayers" came with a bound;
Pulling chemical from boxes without a sound.

They said not a word, but went straight to their work,
And filled all their tanks, then turned with a jerk.

Each man grabbed a spray gun with a giant hose,
Back and forth 'cross the lake those airboats did go!

You could hear them exclaim as the boats raced out of sight:
"It curtains, Hydrilla.... And for you, it's GOOD NIGHT!"



Native Insect Enemies of Aquatic Macrophytes Other Than Moths and Beetles

by

Kim H. Haag[1], Dale H. Habeck[1] and Gary R. Buckingham[2]

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Introduction

Herbivores (plant feeders) convert the energy of the sun, stored by plant tissues, into animal biomass, thereby playing an essential role in the food chain. It is estimated that herbivorous, or phytophgous insects make up as much as 25% of all living species on earth. Insects vary greatly in their degree of dependence on plants. Some insects are very closely associated with a single plant species for food, support and protection during all stages of their life cycle. Others show almost no specificity, and can be found on a variety of plants, exhibiting little preference in food habits. This article is the third in a three-part series. It will deal primarily with insects, other than moths and beetles, which are highly dependent on aquatic plants, and consume living plant tissue during at least one of their life history stages. Several other non-insect arthropods often found on aquatic plants will also be discussed.

Orthoptera — Katydids and Grasshoppers

Although almost all othopterans are terrestrial plant pests, a few are considered to be semiaquatic because they are so well adapted to living on emergent aquatic vegetation. Most species have a one year life cycle, in which eggs are laid in loose soil or plant tissue. Nymphs undergo gradual metamorphosis and feed by shredding live plant tissue. Adults are usually present in the late summer and early autumn, sometimes in very large numbers. In the family Tettigoniidae (katydids), species of *Conocephalus* and *Orchelimum* are commonly found inhabiting marshes and the aquatic vegetation along the margins of freshwater habitats, including rushes, grasses, cattails and waterhyacinth. *Orchelimum agile* has been observed diving and swimming to submerged objects. *Paroxya clavuliger*, in the short-horned grasshopper family Acrididae, is often seen in late fall swarming and feeding in large numbers on waterhyacinth mats.

Homoptera — Aphids and Hoppers

Aphids are common pests on terrestrial plants. They use a sharp beak to pierce plant parts and suck out the plant juices, causing curling and wilting of leaves. They often occur in very high numbers, and both adults and immatures (nymphs) cause feeding damage. *Rhopalosiphum nymphaeae* is an aphid which feeds on waterlilies, waterlettuce, waterhyacinth, water fern, water velvet, pondweed and many other aquatic plants in the U.S. and worldwide. Adults and nymphs are small (4-5mm), pear-shaped, reddish-brown insects with long antennae and two finger like projections (cornicles) on the posterior edge of the abdomen. They may or may not have wings. Aphids have a very high reproductive potential and can be seen in clusters on the upper surfaces of leaves, feeding both day and night. They have numerous enemies, especially predaceous ladybird beetles and parasitic wasps.

The leafhoppers, in the family Cicadellidae, are a very large group of insects which also feed on plants by sucking out juices with their sharp beaks. Feeding usually results in discoloration, wilting or stunting of infested plants. *Draeculacephala inscripta* is a species which can be found on the emergent leaves of waterhyacinth and spatterdock, as well as sedges and grasses. It is small (5-8mm), and is usually pale green, with a yellow head. The head is triangular and sharply pointed in front. The body is slender, and the hind legs have rows of sharp black spines on them. A related species, *D. portola*, has been found on emergent leaves of dock.

Pissonotus piceus is a planthopper (Delphacidae) which has been recorded from smartweed, waterprimrose, and alligatorweed. Similar in shape to the hoppers described above, it is brown or black and has short antennae which rise on the sides of the head beneath the eyes. *Megamelus davisi* is a related species found on spatterdock.

Trichoptera — Caddisflies

The caddisflies are a large group of insects which are entirely aquatic. Adults are small (5-22mm) flying insects whose grey brown wings are covered with tiny hairs. Eggs are laid in the water on a submerged substrate such as rocks, twigs or plant parts. Larvae spend their lives in the water, feeding on a wide variety of materials ranging from detritus (decaying plant material) to living plant tissue to other insects. Most build small cases which they live in and carry around with them. Pupae live within these cases also, closing off both ends and attaching them to the substrate.

The Hydroptilidae, or microcaddisflies are very small (less than 5mm). Larvae build oval "purse-shaped" cases of silk, sometimes also with sand grains attached. Larvae are pale yellow or white, with a worm-like body, a dark brown or black head, and 3 pairs of short legs at the anterior end of the body. Species in several genera (*Orthotrichia, Hydroptila, Oxyethira*), live in beds of submerged aquatic plants where they feed on cellular contents of filamentous algae. Species in the genus *Stactobiella* are shredders, feeding on plant stems and entire algal filaments.

In the family Leptoceridae, several species live among beds of aquatic vegetation. Larvae of these insects are also pale in color, and have a fleshy hump on their first abdominal segment to help hold them in their cases. Larvae of *Triaenodes* build spiral cases

Continued on page 17

NATIVE INSECTS *from page 16*

(10-15mm long) of short plant fragments. They move about carrying their cases, propelled by 3 pairs of jointed legs which often have many long hairs on them. *Triaenodes* species feed on vascular plant tissues, including cultivated rice. *Nectopsyche (=Leptocella) tavara* also builds a case of plant fragments along with sand grains and pine needle fragments. The diet consists of vascular plant tissues including southern naiad, fanwort and hydrilla. Members of the genus *Ocetis* also live among beds of aquatic plants. These larvae build cylindrical cases of sand grains. They seem to feed on a mixture of animals and plants, and have been reported to feed on rice plants in Japan.

Larvae in the genus *Micrasema* (family Brachycentridae) inhabit flowing water and live in beds of vegetation, especially mosses and attached algae. Larval cases are composed of ribbon-like pieces of plant material wound around the circumference. The diet of these insects also consists of fragments of plant matter.

Diptera — True Flies

Ephydrids, a family commonly known as shoreflies, have adults which are small (5mm) and dull-colored. Eggs are laid on exposed portions of the food plant. After hatching, larvae can move to several habitats. In the genus *Notiphila*, larvae move to the bottom of a lake or pond and attach to plant roots with their posterior respiratory spines. These spines serve as a means of attachment and also provide an oxygen supply. *Notiphila* is most often associated with spatterdock, waterlilies, and pondweeds. Larvae feed on detritus and other decaying plant material. Larvae of the genus *Hydrellia* bore directly into the leaves and stems of hydrilla and pondweeds, and begin to mine, generally between the upper and lower epidermis of leaves. A larva will seek fresh food and move to a new leaf if the leaf in which it is mining dies. Larvae in this genus also insert their repiratory spines into plant tissue in order to obtain oxygen. *Hydrellia* are often heavily parasitized by wasps. Larvae in the related genus *Lemnaphila* burrow and mine in the leaves of duckweed.

Hydromyza confluens is a species of aquatic fly in the family Anthomyiidae. The adults are small (less than 10mm) with grey wings. Eggs are laid on the underside of floating leaves of

Continued on page 21

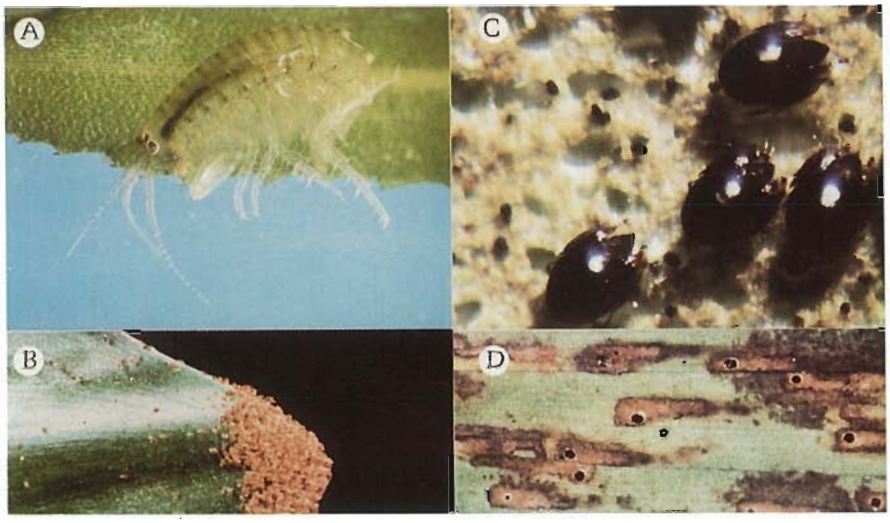

Figure 1. A. *Hyalella azteca* on hydrilla. B. Large population of *Tetranychus tumidus* on waterhyacinth. C. Adults of *Orthogalumna terrebrantis,* the waterhyacinth mite. D. Damage due to feeding by waterhyacinth mites.

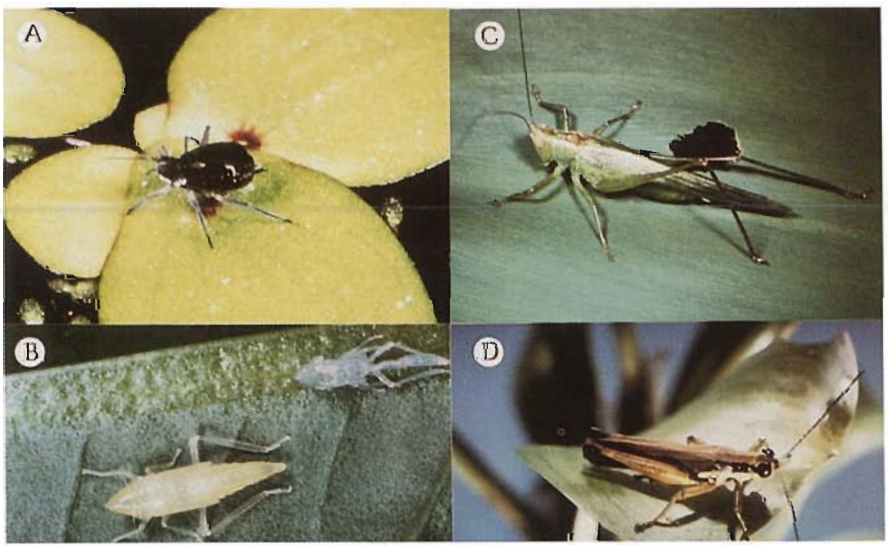

Figure 2: A. *Rhopalosiphum nymphae* on duckweed. B. *Draeculacephala portola* nymph on dock. C. *Orchelimum* sp. on waterhyacinth. D. *Paroxya clavuliger* on waterhyacinth.

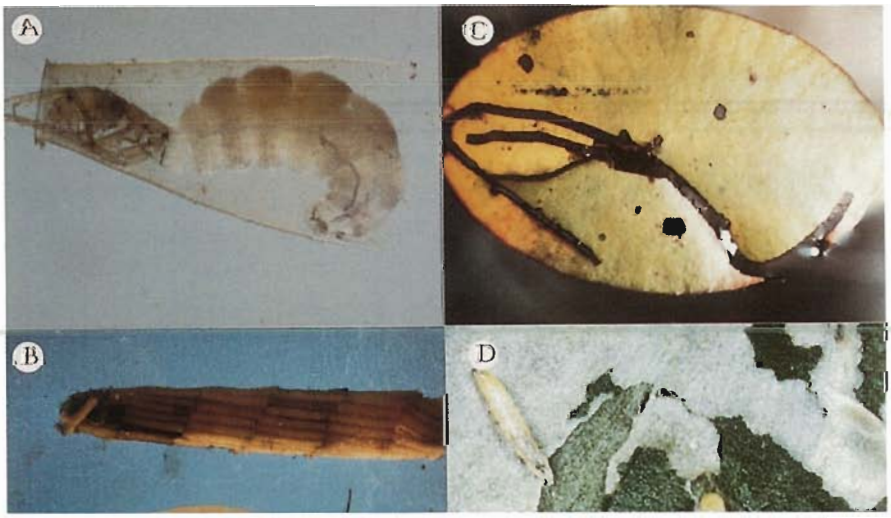

Figure 3. A. Larva of *Oxyethira* sp. in silk case. B. Larva and spiral case of *Triaenodes* sp. C. Damage on watershield due to feeding by *Polypedilum brasseniae.* D. Larvae of *Hydrellia* sp. on frogbit.

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Native Insects *from page 17*

spatterdock. The small whitish larvae hatch in 6-8 days and bore into the mesophyll of the floating leaves. Their feeding produces mine galleries throughout the leaves and petioles. In the petioles, frass or waste material causes ovoid swellings in the petioles. Larval damage to the plant is primarily a result of feeding on the conductive tissue which connects roots to leaves. Leaves soon yellow and show signs of deterioration. Pupae remain in the petiole. The adult escapes through a small "trap door" opening cut in the petiole epidermis by the larva before it pupates. Adults frequently swarm around newly opened flowers of waterlilies, feeding on nectar and pollen. Larvae of *Cordilura* bore irregular galleries which extend from side to side in the white, growing bases of the culms and bullrushes. As a result, the culms stop growing, slowly wilt and eventually die. Adults in this genus also escape the plant stem through a "trap door" cut by the larvae.

Chironomids, often called midges, are some of the most abundant and widespread aquatic insects. Larvae in this family feed on a great variety of organic substrates. Of particular interest are those genera which feed on vascular plants. These leaf and stem miners include numerous species of *Polypedilum* (on spatterdock, waterlilies, pondweed and watershield), and *Cricotopus* (on pondweed). Larvae of both chironomid genera are elongate, slender and cylindrical, ranging from 2-30mm in length. They have a pair of short fleshy prolegs on both the first thoracic and last abdominal segments. They often have small gills on the next to last abdominal segment. Color ranges from white to yellowish to pinkish. Larvae feed on leaves, either mining within the leaf, or mining galleries only on the upper epidermis and mesophyll leaving the lower epidermis intact. A larva may pause in its feeding to wiggle and undulate its body, thereby increasing the opportunity for oxygen absorption from the surrounding water.

Non-Insect Aquatic Arthropods

Amphipods are variously known as scuds or freshwater shrimp. They are whitish, 5-20mm long and have 7 pairs of legs. They often move by flexing and extending their entire body, and appear to wriggle as they roll over onto their side or back. They are voracious scavengers, and on

aquatic vegetation they can be seen browsing on the film of microscopic algae, plankton and organic debris which covers leaves, stems and other plant surfaces. They have also been reported to consume living plant tissue. *Hyalella azteca* is the species most often seen in Florida. Fish are their chief predators, although birds, amphibians and predaceous aquatic insects also feed on them. They are intermediate hosts for a number of parasites of waterfowl, fish and birds.

Mites are in the order Acarina. They have 2 body regions — a cephalothorax and an unsegmented abdomen. The body is oval and often very small (1-2mm), with 4 pairs of legs in the adult. They are either parasitic or free living, and a number of the free living mites are plant pests. *Tetranychus tumidus*, the tumid spider mite, is found on waterhyacinth. Infested plants appear to be covered with tiny red specks. The leaves curl due to loss of plant juices from mite feeding, and often look bronze or brownish. *Tetranychus* belongs to a group called "spinning" mites because it produces a silk web of tiny white threads which can be seen on the leaf surface. *Orthogalumna terrebrantis,* called the waterhyacinth mite, attacks waterhyacinth and other plants in the family Pontederiaceae. The female mite lays a series of eggs, each one in a separate lamina of the leaf blade. When the larvae emerge they begin tunneling under the leaf epidermis, usually away from the petiole. These tunnels or mines are readily observed in the field. The sun dries the tunneled leaves, killing them and producing an effect somewhat similar to the first stages of herbicide damage.

Crayfish (Crustacea:Decapoda) are not often thought of as weed control agents, but their effect on aquatic plants has been known for at least 50 years. One species, *Orconectes causeyi*, is omnivorous. When abundant, it has been reported to control a number of submersed aquatic plants, including pondweed, coontail, watermilfoil, fanwort and elodea. Weeds are typically cut off next to the substrate and entire filaments are consumed in this way.

In Conclusion

This is the last in a three-part series of articles concerning phytophagous insects which feed on aquatic macrophytes. We have included only a few of the many invertebrates which use aquatic plants as a food source. It is hoped that our words and pictures have both increased awareness and stimulated interest in this group of organisms and their relationships with the aquatic plant community. There is much yet to be learned and ample opportunity exists for new contributions at all levels.

Acknowledgements

We would like to thank Jeff Lotz and Jane Windsor, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, for their assistance in photographing a number of specimens included in this article. K.H. Haag is supported in part by the Agricultural Research Service, U.S. Department of Agriculture, and the Institute of Food and Agricultural Science, University of Florida, under Cooperative Agreement No. 58-7B30-3-570.

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Identification *from page 6*

found in those areas. Those in other areas of the world should contact local and national herbaria for plant identification.

For a botanist to make an accurate identification of a specimen he needs to have good material, collected, packed, shipped and labeled correctly. The most important part of the plant for identification are the fruits and flowers. These need to be collected whenever possible. Some identifications can be made from vegetative material, but to be certain he must have flowers and/or fruits. The entire plant should be collected if possible. If not possible, what is not collected should be described in terms such as height, diameter, tree, shrub, herb or vine. In the classification process the botanist looks as such characteristics as flower, leaf and fruit color, shape and size. Stems, hairs and roots are also examined during the classification process. Colors and shapes need to be described in words as these both often change during shipment or are pressed out of shape. A comment such as "The flowers are white with purple stripes; fruit is black, oblong and 1 inch long." is of great help. Other information essential for the botanist is the location of the specimen's habitat and a description of the habitat, in relation to major landmarks which would appear on maps. For example, "Specimen found in shallow water on north side of Watertown Lake, 3 miles east of Watertown on highway 37, 100 feet east of George's boat ramp.", will enable the botanist to locate the site on a map.

Plant specimens should be placed into paper when collected. Under no circumstances should specimens be placed in plastic. Plastic retains water and facilitates the more rapid decay of the plant. The plant will often disintegrate during transit and become unrecognizable glop. Place specimens between pages of a book (phone books are excellent) or pieces of folded newspaper. Fold the specimen if necessary, or if too large to fold cut the plant and place the pieces in consecutive sheets. Information can conveniently be written on the margins of the paper in pencil. Ink will run if wet. Ship the specimens flat between pieces of cardboard or other firm backing. The sender should include his name, address and phone number inside the package, as well as on the outside. A short note should be sent stating what information is being requested, i.e., name, range, toxicity, maximum height, etc.

The address of the University of Florida Herbarium is: The Herbarium, 209 Rolfs Hall, University of Florida, Gainesville, Florida 32611.

AquaVine

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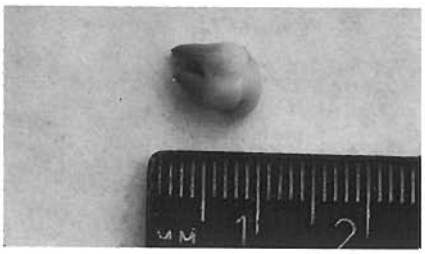


Notice anything different about this hydrilla tuber? This oddity, collected by David Sutton, University of Florida, Fort Lauderdale, has two apical meristems (growing points). Neither David nor any other scientist we spoke to has ever seen this before. Does a two-headed hydrilla tuber mean twice the headaches?

FAPMS ANNIVERSARY

The annual meeting of the FAPMS will be held at the Plant City Holiday Inn, October 14-16. Because it's the 10th anniversary of the Florida Chapter, a special meeting full of activities, gifts and other notable events has been arranged. The program of speakers should be the best ever. The board meeting will be held Monday evening, Oct. 13, at 7:30 P.M.

2,4-D RULE

The Florida Department of Agriculture has a new rule concerning the use of 2,4-D products in the State. If you use 2,4-D in your herbicide program, you need to be aware of this new rule. To get a copy, contact Mr. Jim Downing at 904-487-2130 Mayo Bldg., Tallahassee, FL 32301.

NEW APPOINTMENT

The Department of Fisheries and Aquaculture, University of Florida, has recently hired on a new fisheries scientist. Chuck Cichra comes to Florida from Texas A & M where he received his Ph.D. Chuck's experience with fish management, population dynamics and general fisheries ecology will make him a valuable asset to the Department's research and extension program. Chuck can be reached at the Center for Aquatic Weeds, Gainesville, 904-376-0732.

NEW EXTENSION AGENTS

Ken Langeland, a familiar face to the FAPMS, has recently moved back to Florida. Ken will help in establishing an aquatic weed extension program at the Center for Aquatic Weeds, Gainesville. You may remember that Ken moved to Raleigh in 1983 to accept a position in the Weed Science Department at N.C. State University. Well, he's back and anxious to get back into the thick of it.

Also new to the Center is Mike McGee of Auburn University. Mike will be involved in initiating an extension program for the Department of Fisheries and Aquaculture concerning the States fisheries resource. If you have questions for either Ken or Mike, they can both be reached at the Center, at 904-376-0732.

IN MEMORIAM

On May 26, 1986, the aquatic weed control industry lost a close friend with the passing away of Jimmie Leland Lightsey. Jimmie Leland was a long time, dedicated member of the Aquatic Weed Control Program at the Okeechobee Field Station Division of the South Florida Water Management District. He joined the District in January 1968, and worked under the Aquatic Weed program until his death. We extend our sympathy to his wife, Fay, and his family.

EDITORIAL *from page 3*

Reiterating the last issue's anonymous (?) editorial, ***you*** *can do something to stop these quasi-beneficial transfers from the trust fund. Inform your legislators of the impact these activities have on your program!*

The Department currently has a combined total of 10.4 million dollars for the Cooperative Aquatic Plant Control Program and the State Aquatic Plant Control Funding Program. For Fiscal Year 1986-87, only $8,019,089 was allocated for these programs by the legislature. In addition, the Corps of Engineers is changing its cost share in the Cooperative Aquatic Plant Control Program next year from 70% Corps funds/30% DNR funds to a 50/50 match. This means an ***additional*** *$622,000 of state dollars needed to maintain the program at its current level*

Money is getting tight and will continue to do so. If your legislators aren't informed about the necessity of weed control and the associated costs, the green menace may once again become reality. Don't be too quick to unbuckle those seat belts, I think we're still in for a pretty rough ride!

Greg P. Jubinsky

Letters to the Editor

Dear Editor:

While reading your reprint of "Death in the Dose" in the June 1986 "Aquatics", for some reason I kept getting the same feeling that I get watching the "news" put on by the 700 Club. It seems that the "scientific truisms" and "hard, cold facts" reported by both have been massaged a bit. I've always been amazed at just how malleable "hard, cold facts" are, especially in the hands of the "creationists" (the evolution debate) or when viewed from the debit-credit ledger. The arguments are reminiscent of the debunked "dilution is the solution to pollution" paradigm. Maybe such propaganda serve to comfort those who are unsure of their occupational safety.

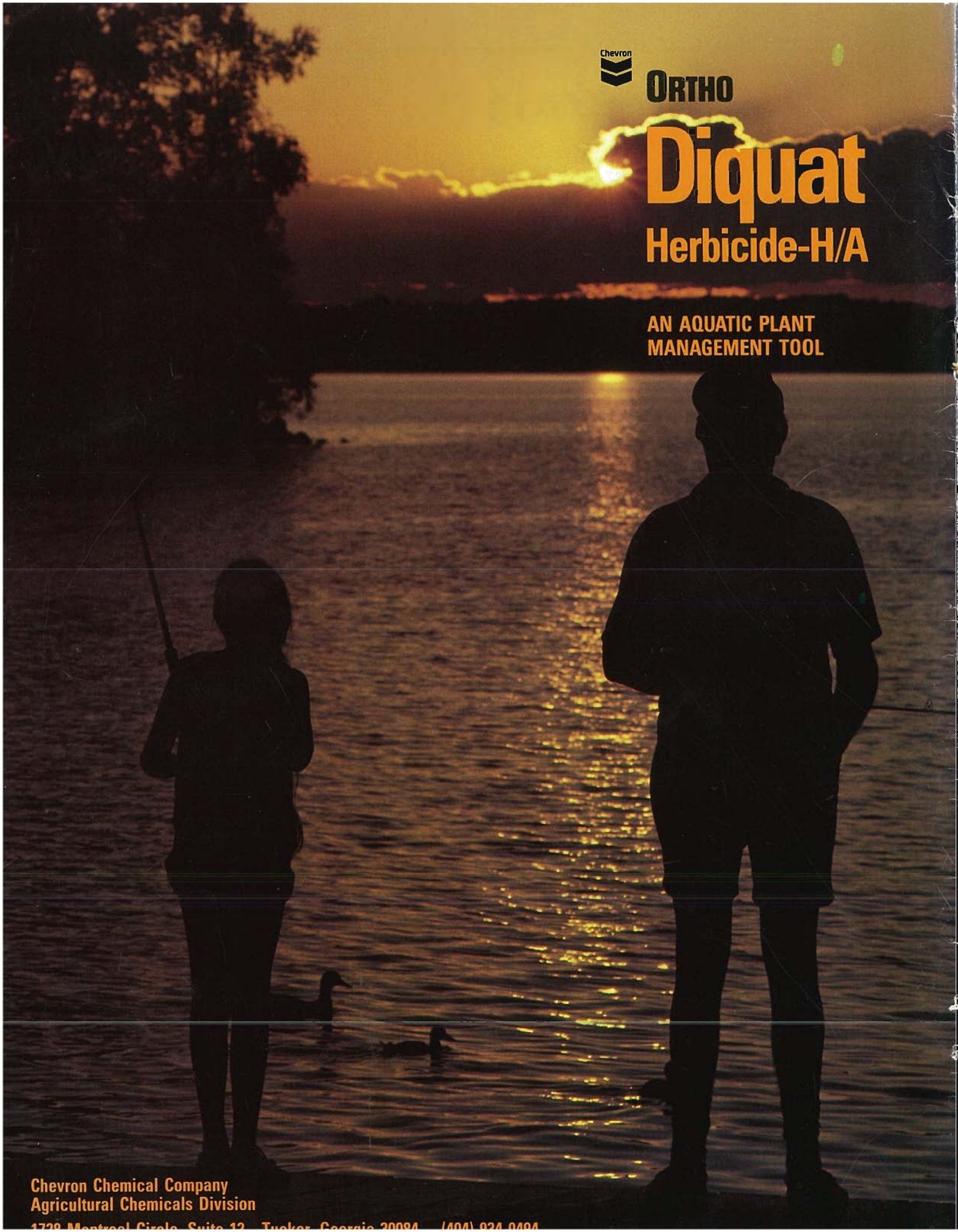
Scientists at a 1985 international conference on occupational and environmental significance of industrial carcenogens (sponsored by the National Cancer Institute and the American Cancer Society, among others) apparently disagree with the thesis presented in "Death in the Dose". These scientists agreed that:

1) The idea that there is a safe threshold of exposure to toxic chemicals should be abandoned. There appears to be no level below which cancer-causing chemicals will not cause cancer.
2) Chemicals shown to cause cancer in animals should be considered cancer-causing agents in people. They should be considered guilty until proven innocent.
3) Massive efforts must be made to screen the most suspicious chemicals for their potential to cause cancer and to test any new chemicals before they are allowed in the environment.

I don't know, maybe guys like Arthur Upton (head of NYU Medical Center's Institute of Environmental Medicine) are closet, reactionary, wild-eyed treehuggers.

There is no doubt that we need the chemicals, but not the BS. The DNR is mandated to do plant control (fortunately herbicides labeled for Florida aquatic use are relatively safe) and at the same time protect the health and welfare of the people and the environment. I think to emend the Delaney Clause and decrease legal liabilities (tantamount to giving Industry Carte Blanche) would violate the public trust. Industry has a poor record of self regulation, I don't see how we could expect a sudden turnabout. These people are in business to make money and protect their shareholders, not to altruistically feed the world or rid Florida of hydrilla. Everything takes a back seat to profit margin — this is a truism. It is also a truism that great strides in environmental and product safety since the 1950's are due to a strong environmental lobby and the resulting legislation.

Drew Leslie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