EDITORIAL
Unfortunately, most important economical issues as well as environmental issues are driven and controlled mostly by politics. To say that surface water, wetlands and ground water concerns are politically hot is similar to calling Lake Okeechobee a good sized pond. In the past, we in Florida have had our share of controversy deciding what agency is responsible for directing aquatic weed control activities. Finally the F.P.A., Florida Dept. of Agriculture, Fla. D.E.R., H.R.S., Fla. Game & Freshwater Fish Commission, DNR. State universities, water management districts and even fish camp owners came to the American Assembly Conference in 1979. They structured an aquatic weed management lead agency to end the battle between DNR and the Fla. Game and Fish Commission. The solution consisted of DNR being the lead agency and would control permitting and funding of aquatic plant weed activities. None of DNR's trust fund was to go to the Commission. The Fla. GFC would be out of the aquatic weed business except in dealing in biological agents. Resolved — right? Wrong.

Each year since then the Game Commission mysteriously receives a very substantial portion of DNR's trust fund budget. It started with approximately $300,000 and now has grown to $400,000. DNR does not make the transfer voluntarily nor does the Game Commission reportedly 'seek' the funding. How and why does the transfer happen? Legend has it that a "good fairy" is on the Governor's staff and makes this annual delivery. Why?

If the Game Commission desires to work with new exotic fish each year and use DNR money on a dual permitting system then they should use their own funds, not DNR's aquatic weed trust fund money which is needed for weed control.

Aquatic managers in Florida are often referred to as rabble rousers — because many are. Maybe we just want things done right and above board in order that the public be properly served.

THE COVER

Summertime is here. Water recreation is the way to go on Lake Hall, McClay Garden in Tallahassee. Photo by David P. Tarver

JUNE 1984 / Volume 6, No. 2

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FAPMS 1984 OFFICERS

President
Paul Myers
310 E. Thelma St.
Lake Alfred, FL 33850
(813) 956-3037

President Elect
Clarke Hudson
8212 Sugarbush Ct.
Orlando, FL 32819
(305) 351-3295

Editor
David Tarver
2416 McWest St.
Tallahassee, FL 32303
(804) 562-1870

Treasurer
Mike Dupes
1477 Challen Ave.
jacksonville, FL 32205
(904) 791-2219

Secretary
Michael Mahler
2019 Brentwood Dr.
Auburndale, FL 33823
(813) 965-1214

Immediate Past President
Carlton Layne
217 Bolender Ct.
Auburndale, FL 33823
(813) 683-9767

Directors-At-Large

Bob Arnold
231 Stevanage Dr.
Longwood, FL 32750
(305) 830-7032

Bobby Corbin
P.O. Box 714
Crawfordville, FL 32327
(804) 926-3349

Eddie Knight
1468 River Lane
Green Cove Springs, FL 32043
(904) 328-1002

Joe Flanagan
Rt. 3 Box 64
Live Oak, FL 32060
(904) 362-1001

Beth Layser
P.O. Box 770
San Mateo, FL 32088
(904) 328-2393

Ray Spirknock
140 S. Wiggins Rd.
Plant City, FL 33566
(813) 754-6666

Jim Wilmeth
Rt. 1 Box 963
Palatka, FL 32177
(904) 328-8031

Larry Maddow
2442 Floridiana Dr.
Melbourne, FL 32935
(305) 524-1701

Terry Shepardson
1461 N.W. 10th St.
Miami, FL 33147
(305) 592-5680

Committee Chairmen

Membership/Publicity
Clarke Hudson
8212 Sugarbush Ct.
Orlando, FL 32819
(305) 351-3295

By-Laws
Len Bartos
2379 Broad St
Brooksville, FL 33512
(904) 796-7211

Awards
Gary Wilkins
Rt. 3 Box 1701
Palatka, FL 32177
(904) 328-1002

Local Arrangements
Andy Price
P.O. Drawer D
Plant City, FL 33566
(813) 752-1177

Program
Beth Layser
P.O. Box 770
San Mateo, FL 32088
(904) 328-2398

Governmental Affairs
Nick Sassis
2002 E. Michigan St.
Orlando, FL 32806
(305) 420-3102

Aquatic Plant Advisory Council Delegate
Herb Cummings
SPWMD
9001 N.W. 58th St.
Miami, FL 33178
(305) 592-5680

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

CORRESPONDENCE: Address all correspondence regarding editorial matter to David P. Tarver, Editor. “AQUATICS” Magazine, 2416 McWest St., Tallahassee, FL 32303
The spikerushes, genus *Eleocharis*, are included in the Cyperaceae or Sedge family. This is a large family of plants composed of 83 different genera with about 3,200 species distributed throughout the world. They are particularly abundant in the arctic and temperate regions of both the northern and southern hemispheres. These plants are found in damp, boggy, marshy, or riparian habitats.

The Sedge family is characterized as fibrous-rooted grasslike herbs with very minute flowers subtended by chaffy bracts. These bracts are specialized leaves and the flowers arise from their axils. The stems, also commonly called culms, are mostly solid, often triangular, generally unbranched below the inflorescence (flower), and frequently leafless.

The spikerushes are separated from the other members of the Sedge family by the formation of a solitary terminal spikelet without obvious subtending bracts, hence the name spikerush. In some species the spike is thicker than the supporting stem below it while in others the spike is not distinctly thicker than the stem.

Physical aspects of the achenes (small dry indehiscent fruit with a relatively thin wall surrounding a single seed) are used to separate the species (Figure 1). The genus is also characterized without leaves so that the culm carries on the photosynthetic activities of the plant.

The genus name *Eleocharis* is derived from the Greek 'helos' for marsh and 'charis' for grace as described by Robert Brown in 1810 (7). The name is actually closer to the Greek 'helodes' for marshy and 'charisma' for favor or gift.

At times this genus has also been called *Helocharis*. This spelling has been rejected by most taxonomists but may occasionally appear in the literature. The species may also be called by the common name of hairgrass.

Some confusion exists in the literature as to the identification of the various spikerush species. In 1929 Svenson (7) separated the genus into 11 series each representing a natural group. Each group contained very similar appearing plants, and the grouping still provides a useful starting point for the identification of the spikerushes.

The species are difficult to identify because of their simple gross anatomical structure which consists primarily of a modified stem, the culm. The achenes must be examined for positive species identification, however they are so small that they must be examined microscopically to distinguish their characteristic markings.

Long and Lakela (3) list seven species occurring in southern Florida, and Godfrey and Wooten (1) list 33 species present in the southeastern United States of which 29 are listed for Florida.

Those spikerushes which are listed as occurring in the Panhandle of Florida include *Eleocharis interstincta* (Vahl) R. & S.; *Eleocharis*
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Lake Trafford test plot. Treated 3-17-81. Photographed 9-10-81.
agricultural plants in Florida (5), over 1,200 acres in Lake Okeechobee were reported to be covered with *E. cellulosa* (Figure 2). Another similar appearing species but with distinctive partitions in the culm which give it a bamboo-like appearance is *E. interstincta*. This plant was found in over 2,500 acres in Lake Okeechobee and ranked as the 19th most abundant aquatic plant in the survey.

*Eleocharis geniculata* is considered a tropical plant, but has been reported as far north as South Carolina. This plant is usually not strictly aquatic but occurs along ditchbanks and the shoreline areas of many bodies of water. It will also grow submersed.

*Eleocharis acicularis* is listed along with 20 other species as having the most extensive range of all aquatic plants throughout the world (6). In North America, *E. palustris* is probably the most widespread of the spikerushes (4).

The spikerushes grow marginally, emersed, or submersed but the culm must be emersed for flowering to occur. Their flowers contain both stamens and pistils. Some of the spikerush species are pollinated by the wind (6), while others, since they have both stamens and pistils on the same flower may be self-pollinating.

Seeds of the spikerushes exhibit prolonged dormancy which is characteristic of many aquatic angiosperms. The mature seeds are normally enclosed by air within one or more associated bracts and float freely until they become waterlogged (6).

Yeo and Dow (9) found that dormancy in dwarf spikerush

[Figures 3, 4, 5]
Male-flowering Hydrilla is Triploid in North Carolina

Hydrilla (Hydrilla verticillata), growing in lakes in Wake County, North Carolina, was identified by William Haller in 1980 and had apparently been established in the area for several years. In September 1982 Dr. Thai K. Van identified staminate (male) flowers on plant material being maintained at Fort Lauderdale, Florida, which was originally obtained from Washington, D.C. (Vandiver et al. 1982). Following Van's identification of male flowers in Florida we established that male flowers were being produced in North Carolina at the same time.

Two different hydrilla genotypes have been found for the United States based on chromosome counts and isoenzyme studies (Verkleij et al. 1983). USA hydrilla II (2N = 24) has been found in Washington, D.C., Maryland, and Delaware while USA hydrilla II (2N = 24) has been found elsewhere (except for a tetraploid in Alabama). Formerly, male flowers were only considered to be associated with diploid plants (USA hydrilla II); however, chromosome counts on North Carolina male-flowering populations thus far indicate that they are triploid.

Hydrilla in North Carolina (2N = 24) and USA hydrilla I in Florida (2N = 24) evidently have different phenologies. Tuber production in North Carolina begins in late June and continues to early November whereas in Florida (USA hydrilla I) this occurs from October to May (Haller 1978). Although floral initiation appears to coincide with tuber production in both North Carolina and Florida, male flowers have not been observed on Florida plants. Hydrilla in North Carolina (2N = 24) and USA hydrilla II (2N = 16) are similar in that both produce male flowers and tuber production in USA hydrilla II begins by August in Delaware (Joe Joyce, personal communication). Until chromosome counts were made, we assumed that North Carolina hydrilla would be the "northern" variant (USA hydrilla II). Apparently this is not the case.

During the summer of 1983 male flowers were found in all four lakes studied in North Carolina (Lakes Anne, Wheeler, Crabtree, and Big Lake). Plants collected from all study lakes appeared to be monocious (male and female flowers on the same plant). Female flower production began in early to mid-July and continued to late October. Male flower production was evident by mid-August and also continued to late October.

Flower density was 140-165 per m² for female flowers and 70-130 per m² for male flowers. Neither fruits nor seedlings have been found.

Literature Cited

Waterhyacinth Control
In California
by Larry Thomas
Co-Author Dr. Lars Anderson

Sacramento-San Joaquin Delta

The Sacramento-San Joaquin Delta, originally a tidal marsh formed in an overflow area of the Sacramento and San Joaquin Rivers, is generally considered to be the area bounded by the City of Sacramento on the north, the City of Stockton on the east, the City of Tracy on the south, and the Suisun Bay on the west. Prior to 1910, the Delta area was utilized primarily for livestock grazing; however, by 1924 after more permanent levees were constructed, the Delta became one of the major cropland areas of California, producing agricultural commodities worth in excess of $400 million in 1981. The Delta includes approximately 270,000 acres of farmland considered to be one of the most fertile agricultural areas in the United States, containing 100 tracts and islands with the land surface ranging from 20 feet above sea level to 25 feet below sea level. The area is unique in that it is both a prime agricultural and recreational area as well as an invaluable fresh water resource and an important producing area of high quality natural gas.

The Delta, with approximately 150 marina facilities, provides a unique recreational opportunity for the entire State of California accounting for about 80 million dollars of recreational expenditures annually while providing 12 million recreational days for the public.

The Delta has approximately 700 miles of channels and sloughs which are utilized very heavily for navigation and irrigation. The Sacramento and San Joaquin River channels within the Delta are maintained for deep draft navigation to the cities of Sacramento and Stockton respectively. The remaining waterways of the Delta have water depths ranging from 5 to 10 feet at low water and are heavily used by both the boating public and the general public.

The Delta also plays a major role in the State of California's water transport system. Water storage in the foothill and mountain areas of northern California is released through the Delta during low flow periods. One-third of California (64,600 square miles) drains through the Delta area with outflow varying from 10 to 46 million acre feet annually with an annual average of 20 million acre feet. The major north to south water export point is on Old River near the City of Tracy where both the State of California and the Federal Bureau of Reclamation pump water from the Delta for export to the south. During periods of low flow in the Delta, this water exportation from the southern part of the Delta actually creates a reversal of flow in Old River downstream from the pumping plants as well as in other waterways of the Delta.

Additionally, Delta waters also support a large population of resident fish and anadromous fish ascending and descending the Sacramento, Mokelumne, Stanislaus, Calaveras, and San Joaquin River systems. The California Department of Fish and Game estimates that 25 percent of the State's warm water and anadromous sportfishing and 80 percent of the commercial salmon catch is dependent upon the Delta.

Background and History of Waterhyacinth Introduction

Waterhyacinth plants have been known to exist in California as early as 1904 when their presence was discovered in Yolo County in a slough near the City of Clarkburg. By 1947, waterhyacinths had become a problem in some areas of the Sacramento-San Joaquin Delta. The Bureau of Reclamation experimented with methods of chemical control and actually made some chemical applications in Rock Slough west of Delta Road. In 1972, the Army Corps of Engineers was asked to investigate, as a possible flood hazard, the blockage of the Merced River by waterhya-
The waterhyacinth population brought about the introduction of Senate Bill 1344 on January 13, 1982, authored by Senator Garamendi and co-authored by Assemblyman Patrick Johnston, with SB 1344, which became effective immediately upon signature by the Governor on June 14, 1982, appropriated $125,000 from the Harbors and Waterfronts Revolving Fund to the Department of Waterways as the designated lead agency to implement a short-term program for waterhyacinth control and develop a long-range control program for the Sacramento-San Joaquin Delta and the Suisun Marsh.

In July, 1982, the Department formed a Waterhyacinth Task Force comprised of representatives of those agencies either most directly affected by the waterhyacinth problem or those having expertise in the area. Listed below are the agencies and their respective representatives.

**State Agencies**
- Department of Boating & Waterways: Bill S. Satow/Larry J. Thomas
- Department of Health Services: Brian Finlayson
- Department of Fish & Game: Richard McMillan/Robert Hultquist
- Department of Water Resources Control Board: Doug Albin/John Cornacchia
- Central Valley Regional Water Quality Control Board: Wilton Pryer/Rudy Schnagl
- U.S. Department of Agriculture, Agricultural Research Service Aquatic Research Laboratory at U.C. Davis: Dr. Lars Anderson
- U.S. Bureau of Reclamation: Carl Tennis

**Local Agencies**
- San Joaquin County Agricultural Commissioner: Erwin Eby
- Contra Costa County Agricultural Commissioner: John H. deFremery
- An advisory council was also formed, which comprised representatives from Federal and State agencies for waterhyacinth control, local and regional governmental agencies, private citizens groups, and the general public to determine the extent of the problems and gather information relative to possible control measures. During this problem assessment period, a considerable amount of time was expended by the Department evaluating various control methods. The Department asked the Corps of Engineers’ Waterways Experiment Station (WES) to develop both a short and long term control plan. A draft of this plan was available in April 1982 and was then presented to the appropriate Federal and State agencies for review and comment. Very little revision was necessary, and the final plan was submitted to the Department on May 3, 1982.

**Control Plan**

Long before the legislation was signed by the Governor, a series of meetings was held with State, Federal and local governmental agencies, private citizens groups, and the general public to determine the extent of the problems and gather information relative to possible control measures. During this problem assessment period, a considerable amount of time was expended by the Department evaluating various control methods. The Department asked the Corps of Engineers’ Waterways Experiment Station (WES) to develop both a short and long term control plan. A draft of this plan was available in April 1982 and was then presented to the appropriate Federal and State agencies for review and comment. Very little revision was necessary, and the final plan was submitted to the Department on May 3, 1982.

The plan developed by WES recommended an integrated program utilizing chemical, mechanical and biological control methods. The plan included the following components:

- **Chemical Control:** The use of herbicides such as 2,4-D and 2,4,5-T. The Corps of Engineers recommended the use of 2,4-D but did recommend and of- fered to participate in an annual investigation of the river.
- **Mechanical Control:** The use of mechanical methods such as water hyacinth harvesting equipment. The Corps indicated their willingness to participate in an annual investigation of the river.
- **Biological Control:** The use of biological agents such as algae-eating fish and insects. The Corps did not feel they could economically justify implementing such an approach.

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1. Assembly Joint Resolution No. 64, authored by Assemblyman Patrick Johnston and filed with the Secretary of State on June 11, 1982, requested the U.S. Army Corps of Engineers to cooperate with the State in undertaking an aggressive program for waterhyacinth control.
biological control measures (a detailed biological control plan was submitted later with specific sites identified for release and monitoring of biological agents).

The recommended short-term measures were to utilize mechanical and chemical means with the introduction of biological agents to provide the long-term control. Theoretically, as the biological agents become established, the need for chemical and mechanical controls can be reduced with a resultant decrease in the cost of the program.

Mechanical Methods
The WES plan identified several possible mechanical control measures, such as in situ chopping of the plants and/or mechanized removal as well as the use of barriers to retain or to redirect the movement of the plants. The Department staff met with numerous people to review the various mechanical means that might be possible for physically removing hyacinths from the Delta. However, it became apparent after investigating the mechanical removal methods and the costs associated with this type of control that the Department did not have the funding capability to carry out a sufficiently large removal program. The use of barriers, on the other hand, did appear to be a low cost mechanical measure that could have a significant benefit.

A test barrier was installed in Fourteen Mile Slough in the fall of 1982 to evaluate the feasibility of this method. This test indicated that barriers could, in fact, be successfully utilized to retain material in the nursery areas and prevent large masses of floating plants from blocking the navigable channels until the winter high flow period in the Delta. This concept is also being used to retain hyacinths in selected areas to provide habitat for the biological agents.

Chemical
The use of herbicides was identified in the plan as the major part of the short-term control program. The herbicides registered for use in California for this purpose in the summer of 1982 were Weedar 64® (2,4-D) and Diquat®. In the summer of 1983, Rodeo® (a formulation of glyphosate) was also registered. The chemical control program was to use 2,4-D wherever possible and to use Diquat® in those areas where 2,4-D could not be used.

Because the waterhyacinth control program was an entirely new program for the State of California and because of the multiple use of the Delta waters, it was necessary to develop a sophisticated water monitoring program for each herbicide application to be absolutely certain the label requirements were met and to build public confidence that herbicides could be used to control the hyacinth infestation without any degradation of the existing water quality. Therefore, in the summer of 1982 under the direction of Dr. Lars Anderson of the USDA/ARS Aquatic Weed Control Research Laboratory, two types of tests were conducted to determine the amount of 2,4-D or Diquat® that would enter the water following application of these herbicides for control of waterhyacinth. In one type of test, the actual amount of herbicide that reached the water surface after passing between waterhyacinth plants (or in some other way penetrating between foliage) was determined by using "floating" bottle samplers that were placed beneath the waterhyacinth canopy at the water surface. These float samplers contained known amounts of either distilled water or Delta water and were retrieved after application of 2,4-D or Diquat® in a test area. The amount of 2,4-D or Diquat® was then determined by standard analytical methods.

In the second type of testing, water samples were taken before and at various times after application of the herbicides to waterhyacinth mats. The locations of these water samplings were made so that the amount of herbicide entering the water immediately adjacent to the mats and at various distances downstream could be determined. The results from the first type of testing indicated that from 8 to 12 percent of the amount of herbicide applied to the plants was able to reach the water surface. These tests also
indicated that, in the case of Diquat®, very little residue was detectable in the float samplers containing Delta water. This is primarily due to the rapid adsorption of Diquat® to dissolve and particulate organic materials in the Delta water. The results of the second type of testing showed that occasionally 2,4-D residues of 5 to 15 or 20 ppb were found immediately adjacent to the sprayed waterhyacinths, and that downstream, even less than one-fourth of a mile, levels were generally non-detectable or below 10 ppbw.

The information gained by these tests during 1982 was used to develop the monitoring and water sampling protocol for the operational program in 1983. Through the cooperative agreement between WES and the Department, in the fall of 1982, WES staff persons implemented larger scale field tests using both 2,4-D and Diquat® to determine the efficacy of the herbicide program developed by the task force and what residues could be anticipated. During this test period, a series of 1, 2 and 5 acre test plots were treated with 2,4-D using approximately 4 pounds per acre. Again, water sampling and analysis conducted by the USDA/ARS Aquatic Weed Laboratory indicated that the maximum level of residue found during this test was 13 ppb. Larger test areas were treated with Diquat®; however, these tests were primarily to determine the effect of late summer growth because the earlier tests by Dr. Anderson indicated that Diquat® residue is tied up so quickly due to the clay particles and organic material in the water that residue a few yards from the application site was non-detectable. The results of these tests and the water data gathered from them were used as the major data source in establishing the 1983 control program.

**Biological Agents**

Meetings were held with biological control specialists from the U.S. Department of Agriculture, WES, and the California Department of Food and Agriculture to determine which biological agents were effective in waterhyacinth control. The decision was made to initially introduce Neochetina bruchi, a small, host-specific weevil. Dr. Lloyd Andres, Research Entomologist with the USDA/ARS in Albany, California, had done experimental work with this weevil and was familiar with the necessary background data that must be available to the reviewing agencies before permission could be obtained to import a non-native biological control agent into California. Therefore, he agreed to make inquiries of the control agencies. After receiving the necessary clearances from the controlling agencies and importing sufficient numbers of weevils, a positive identification and checks for any possible diseases were made. The weevils were maintained on waterhyacinth at the ARS Aquatic Weed Laboratory for several weeks before the first releases of the waterhyacinth-eating weevil, *Neochetina bruchi*, were made in Old River on July 2, 1982, with a second release on July 15.

Following the initial releases of *Neochetina bruchi*, Dr. Andres also obtained permission to introduce *Neochetina eichhorniae* and *Sameodes albignitales*. The weevils, *Neochetina bruchi* and *Neochetina eichhorniae*, were all collected from the field by WES personnel and then imported by Dr. Andres where they were positively identified and checked for pathogens before they were released into the nursery areas of the Delta. The *Sameodes albignitales*, a moth species, is being raised in the laboratory of the State Department of Food and Agriculture by the Biological Control Unit personnel and is then released into the selected sites.

The *Neochetina bruchi* have over-wintered in California and are spreading from the initial release sites. The other biological agents have not been in the field long enough to determine if they will over-winter and reproduce; however, it is anticipated that they will.

**The 1983 Program**

In developing the 1983 program, because of the limited funding, it was apparent that the most economical control method would have to be employed if any degree of control could be expected and, further, this control would have to be directed only at known problem areas. After discussions with WES, it was determined that a chemical control program would be the most cost efficient plus a limited amount of mechanical control. The mechanical means to be employed would be the mechanical barriers rather than mechanical removal of the plant material. Additionally, continued releases of the biological agents were scheduled for four sites, with a subsequent release the latter part of October 1983 in a fifth site.

The major area of waterhyacinth infestation in the Delta is that area bounded on the north by State Highway 12, on the south by Old River, on the east by Interstate 5, and on the west by the Sacramento River. This large area was divided into four approximately equal smaller areas for herbicide treatment. Each of the smaller areas was assigned a team to be responsible for that specific area.

In California, permits are required from the County Agricultural Commissioner before the restricted herbicide 2,4-D can be applied, and the permit must be "site" specific. Based on the amount of hyacinths that might be expected in any specific area and the water data gathered in the 1982 field tests done by Dr. Anderson and WES, the major infestation area was divided into 2 to 3 mile "sites." Prior to any chemical applications being made, an overall county permit was obtained from each Agricultural Commissioner; and, before field operations began in any site, a Notice of Intent was filed for each site at least 24 hours prior to application of herbicide. Although the process may appear to have been rather cumbersome, in actuality it went very smoothly and did not delay the program.

During the field operations, a control team could treat a maximum of five acres per "site" and then had to bypass an adjacent site before beginning treatment again. The rationale for this limitation was based on the water data obtained from the 1982 field work done by Dr. Anderson and WES as a means to insure a wide safety margin. The Task Force felt confident that the water residue would be minimal if a maximum of five acres per site were treated.

During the chemical control effort, Dr. Anderson’s staff, under the field direction of Robert Pine (ARS) took samples of the water before and immediately after each herbicide application and per-
formed the water analysis for 2,4-D. Throughout the chemical control effort, the water analysis detected only minimal (if any) residue that was well below Federal tolerances of 100 ppbw. An example is shown in the following table.

The County Agricultural Commissioner’s staff provided field data regarding the specific location of any sensitive agricultural crops. Because of their input into the waterhyacinth control program, there was no reported damage to any agricultural commodity in any county.

**Environmental Concerns**

When the use of herbicides was proposed as the major short term control method, the Contra Costa Water District became concerned because the water district extracts water from Old River at Rock Slough and transports the water across the Delta to the East Bay for use as a domestic water supply to several cities. Throughout the discussion of the use of herbicides to control waterhyacinth in the Delta, the representatives of this district had expressed their concerns relative to the use of 2,4-D in the Delta and in particular any where close to Rock Slough. The California Department of Health Services wrote a letter to the Contra Costa Water District which indicated that they felt 2,4-D could be used safely and that their opinion was based on water analyses from earlier test plots as well as their experience in working with 2,4-D. The Health Department stated that they felt the residue would be minimal or non-detectable. In addition, the water treatment facilities use activated charcoal in treating the water for domestic consumption which will remove any 2,4-D from the water. However, the district still expressed concern so an agreement was reached whereby no spraying would occur in Rock Slough or in Old River one mile above or below the intersection of Rock Slough and Old River or in Werner Dredger Cut north of the railroad track at Orwood Resort.

Throughout the 1983 program, beginning in the late spring, there were a number of environmental concerns raised by some State legislators, local political leaders, the Contra Costa Water District and a few private citizens in Contra Costa County. Those few private citizens petitioned the Superior

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Court in Contra Costa County and were successful in obtaining a Temporary Restraining Order on May 11, 1983, against the use of 2,4-D in that county. Shortly thereafter, the Department, through the State Attorney General's Office, notified the Superior Court Judge of its intent to utilize the herbicides Diquat® and Rodeo® in an attempt to alleviate some of the infestation. The private citizens again petitioned the Judge to prevent the use of these herbicides as well; however, on July 29th, the Judge refused to extend the restraining order to Diquat® and Rodeo®. The Department then began immediate applications of Diquat® in Contra Costa County.

Results of the 1983 Control Program

The control program in San Joaquin County has been very successful this year and, as a result and in direct contrast to last year at this time, the waterways of San Joaquin County are clear of hyacinths. Marina operators, farmers, and recreationists are all very pleased with the results of the waterhyacinth control program. In Contra Costa County, however, due to the court order against the use of 2,4-D, the waterhyacinth problem became quite severe by the fall of 1983. This infestation coupled with the tidal currents and the predominately westerly winds moved the hyacinth mats into previously cleared areas in San Joaquin County. The Department is monitoring the situation very closely and has retreated some of the reinfested areas of San Joaquin County.

The Control Program for the Future

The 1984 control program has not, at this time, been finalized and will depend to some extent upon the outcome of the trial in Contra Costa County. Additionally, there is a strong possibility that a significant reinestatement from the upstream area of the San Joaquin River may occur next year. If this does occur, it will mandate another all-out effort early in the spring to reduce the total biomass as early as possible. Probably the same basic control plan will be used, utilizing 2,4-D as the preferred herbicide, barriers to trap or divert the hyacinth mats, and additional biological agents.

It is anticipated that certainly by the end of 1985 (barring an unfavorable decision from the Superior Court in Contra Costa County) there will be a significant reduction in the waterhyacinth population resulting in a corresponding reduction in herbicide applications. By that time also, the colonies of biological agents should be established to the point that their impact on the hyacinth population should become apparent.

Total eradication of the waterhyacinth in the Sacramento-San Joaquin Delta will probably not occur. We are confident, however, that the control measures developed by the staff of WES and the Waterhyacinth Task Force will be very effective in attaining as near total eradication as possible while protecting the environment of the Sacramento-San Joaquin Delta, human health, and wildlife habitat.

Acknowledgments

The number of individuals involved in the Waterhyacinth Control Program is too extensive to list. However, the cooperative spirit and assistance from all the public agencies and individuals from the marina and agricultural communities involved with the program was outstanding. It was this cooperative spirit and assistance that made the program successful.

Common Reed

Phragmites australis (Cav.) Trin. ex Steudel

Ted R. Batterson1 and David W. Hall2

The large grass, Phragmites australis (Cav.) Trin. ex Steud., is both a boon and a bane to man. It has been said that it is the most widely distributed flowering plant in the world being found throughout the United States, South America, Europe, Asia, Africa, and Australia. It extends throughout Eurasia to a latitude of 70 degrees north and into the south temperate zone. It is most abundant in temperate regions, especially in the Old World, but it is also prevalent in sub-tropical areas. It is native to North America and in the United States extends from the Canadian border to the southern portion of Florida. In many areas that it occurs it is considered a weed and is listed in one book as one of the world's worst. However, in some areas, this abundant growth has been put to good use for both man and wildlife.

The Common Reed is a tall (2-5 meters) perennial grass that has an extensive rhizome system. Many times stolons are present also. The stems are leafy from the base to the seedhead and when older are cane-like and quite smooth. The leaves are composed of a sheath, ligule, and blade (Figure 1). The sheath is the lower part of the leaf which surrounds the stem and is always open on one side. The blade is the long, broad, flat portion at the upper end of the sheath. At the junction of the sheath and the blade of the stem is the ligule. The ligule is composed of a membrane which can be up to 4.0 mm long with a fringe of hairs up to 0.5 mm long. The flat leaf blades can be as wide as 2.8 cm and 63 cm long with a few hairs just above the ligule at the base of the blade. The dense seedhead is 27 to 70 cm long and is composed of many small spikelets. Each spikelet is from 9 to 16 cm long and is composed of a cluster of 2-4 flowers. The individual flowers are from 10 to 13 mm long. The minute stalks for each flower are hairy but the flowers themselves are not and have a smooth appearance. Mature plants of Phragmites are easily

1Center for Aquatic Weeds, IFAS, Ft. Lauderdale Research and Education Center, University of Florida
2IFAS, Department of Natural Sciences, Florida State Museum, University of Florida
separated from two similar weedy grasses, Giant Reed (Arundo donax L.) and Burma Reed (Neuraudia reynaudiana (Kunth) King & Hitch.), by the silky beard at the base of the seedhead. This beard is not present on Giant Reed or Burma Reed.

Common Reed is classified as a semi-aquatic plant that grows in a variety of habitats. It is tolerant of saline conditions, as indicated by its occurrence in salt marshes, but its performance decreases with increasing salinity. Studies have shown that 15-20 parts per thousand is the upper limit of salinity (approximately 50% of seawater). It is quite remarkable for its strong, tall aerial stems which are similar in form and anatomy to terrestrial grasses of drier sites. However, the basal parts are surrounded by much the same environment as a totally submerged plant and in turn have similar morphological characteristics to them. Because its roots are always in water or saturated soil and its stems high in the air, the plant has developed air passages to supply the roots and other submerged parts with oxygen.

The extensive, deeply penetrating perennial rhizome system of a reed stand can constitute up to 75% of the total biomass. The rhizomes are hollow and up to several centimeters thick. They serve as a storage area for nutrients and photosynthetic products, facilitating rapid regrowth independent of photosynthesis. They can also serve as source for spreading the plant within a community, growing at a rate of up to 2 m per year. Individual rhizomes can be up to 20 m long. Plant parts, such as the rhizome, do not live much more than 3 to 8 years, but clones of the plant have been reported to be up to 1,000 years old. Studies conducted in Europe have shown that 30 year old stands have shown no decline in productivity. Even though the rhizome serves as the main source of reproduction, seed production is usually quite high; but where the reed is already well established, optimal conditions for germination are not easily met. The seed, unlike the mature plant, cannot tolerate more than a few millimeters of water for successful germination. The growth is initially very slow, since the seedling is very sensitive to competition for light and nutrients.

The plant grows on a wide

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continued on page 20
INTRODUCING THE FIRST TRULY BROAD-SPECTRUM HERBICIDE FOR AQUATIC SITES.

RODEO® HERBICIDE
BY Monsanto
For broad-spectrum control of emerged weeds.
NEW RODEO IS LABELED FOR YOUR TOUGHEST GRASSES AND BROADLEAF WEEDS, INCLUDING:

<table>
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<th>Alligatorweed*</th>
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<tr>
<td>Guineagrass</td>
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<td>Partial Control</td>
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Now there's one aquatic herbicide that can handle a broad spectrum of obstructive emerged weeds. New Rodeo® herbicide keeps the constant spread of even your toughest weeds within manageable limits, from perennial grasses like torpedograss and paragrass, to broadleaf weeds like alligatorweed, to brush species like willows. In fact, Rodeo does the job of many aquatic herbicides, controlling more than 90 kinds of weeds, roots and all.

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Herbicides and Hybrids
Dr. John A. Osborne1 and Ms. Janine L. Callahan2

INTRODUCTION

The hybrid grass carp, a cross between the male bighead carp, *Hypophthalmichthys nobilis* Rich., and the female grass carp, *Ctenopharyngodon idella* Val., has a characteristic low feeding rate associated with slow growth; feeding rates (consumption expressed as a percent of body weight per day) for 1980 hybrid grass carp have been reported to vary between 24% (Callahan and Osborne, 1983) and 35% (Hestand et al., 1983). Due to this low consumption rate, the hybrid grass carp, in most field trials in Florida, has been incapable of hydriella control even when stocked at relatively high rates (118 fish metric ton -1 fresh weight hydriilla) (Osborne, 1982). On the other hand, grass carp have been shown to eliminate plant in the world. What is interesting about our results is that they are only for the above-ground portions of the plant which probably only constitute 25% of the total plant biomass. The remaining 75% is below-ground, giving rise to the next year's growth.

These preliminary results and knowledge of the reeds biology would indicate that this plant should have tremendous potential as an energy crop, an alternative to our dependency on fossil fuels. In addition, its wide dispersal and genetic variability (which should be able to be manipulated through genetic engineering) should give the plant universal appeal.
Hydrall when stocked in spring at the rate of 20 1-year-old fish metric ton -fresh weight hydrall. Since large grass carp (greater than 11 kg) have a feeding rate similar to the hybrid grass carp and much lower than 1-year-old grass carp (Callahan and Osborne, 1983; Osborne and Sassic, 1979) and are known to control hydrall when assisted with hydrallicide (Lake Jane, Orlando, Florida), it was thought that perhaps hybrid grass carp might be useful under similar circumstances, i.e. used as a bio-regrowth-control agent after vegetation reduction with hydrallicide. A hydrallicide-hybrid trial was undertaken in Blue Lake, Longwood, Florida to determine the feasibility of this approach.

Methods and Materials
Blue Lake, a 1.0 acre hydrall infested pond, had been used as a test site for 1979 hybrid grass carp previous to this study (Osborne, 1982). Blue Lake was renovated with rotenone in August, 1979, to remove the wild fish before the 1979 hybrids were stocked. At the termination of the 1979 hybrid grass carp trial, Aquathol (150 lb/acre) was applied to the lake in June, 1981. The 1981 hybrid grass carp, purchased from J. M. Malone and Son Enterprises, were stocked into Blue Lake to start the hydrallicide-hybrid trial at the rate of 750 fish acre (80 fish metric ton -fresh weight hydrall) in November, 1981. Blue Lake was again treated with hydrallicide (Aquathol, 100 lb/acre and Diquat, 2 gal/acre) in August and September, 1982 to reduce the hydrall biomass in order to remove the hybrids. The hydrallides were removed with 0.1 ppm rotenone in October, 1982 (after 325 days). These fish were housed in an experimental pond on the UCF campus until February, 1983, at which time they were returned to Blue Lake (224 fish). An additional 65, 1981 hybrid grass carp were stocked into Blue Lake making a total of 289 hybrids (667 fish metric ton -fresh weight hydrall). After 209 days and following an application of hydrallicide (Aquathol K, 5 gal/acre) to reduce the vegetation biomass, the hybrid grass carp were removed in September, 1983 using 0.1 ppm rotenone.

The effect of the hydrallides and hybrids on the hydrall in Blue Lake was determined by monitoring the vegetation biomass on a bimonthly schedule (October, 1981-October, 1983) using the Osborne submerged aquatic plant sampler (APHA, 1981).

Results
Of the initial number of hybrid grass carp stocked in Blue Lake in November, 1981, only 41.1% remained by October, 1982; this accounted for an average loss of 42 fish month^-1. A total of 368 fish were removed from the lake. Since Blue Lake did not contain a wild fish population, the high mortality of the hybrid grass carp was probably due to genetic deficiencies caused by hybridization. The 1981 hybrids had a mean growth rate of 1.3 gm fish -day^-1 and a mean weight of 504.8 gm fish^-1. The growth rate of these fish was 28.2% faster than for the 1979 hybrid grass carp that had been previously stocked into Blue Lake (Osborne, 1982). For comparison, grass carp stocked into Florida hydrall infested lakes generally have a growth rate approaching 15 gm fish -day^-1. The mean total length of the 1981 hybrid grass carp increased from 18.3 cm to 34.7 cm within the 325 day trial. There was little variation between the size of individual fish.

The hydrall biomass in Blue Lake at the time of the initial stocking of the 1981 hybrids was 1.88 kg m^-2-fresh weight (December, 1981). At this time, the hydrall biomass began an immediate increase which continued throughout the 1982 growing season. By August, 1982 the hydrall biomass had reached 3.99 kg m^-2-fresh weight, Figure 1. The percent frequency of occurrence (coverage) over the sampling period (December, 1981-August, 1982) was 100%. There was no indication of feeding by the 1981 hybrid grass carp on the hydrall. It is suspected that the hybrid grass carp, being principally a leaf feeder (Osborne, 1982), probably stimulated the high rate of plant production in Blue Lake by causing the hydrall to branch.

After hydrallicide was applied in September, 1982 the hydrall biomass declined rapidly, Figure 1. It had decreased to 1.42 kg m^-2-fresh weight by October, 1982 at which time the 1981 hybrid grass carp were removed. The biomass continued to decline throughout the winter and was only 0.08 kg m^-2-fresh weight in February, 1983 when the 1981 hybrid grass carp were removed.