NAJAS GUADALUPENSIS (SPRENG.) MAGNUS,

ITS ECOLOGY AND CONTROL

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By

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ITS ECOLOGY AND CONTROL

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INTRODUCTION

Within recent years land-owners in Oklahoma have been building farm ponds at an ever increasing rate. Many of these ponds have been constructed for the dual purpose of providing water for stock and for recreational uses. These new aquatic recreational sites have enabled more people to enjoy waterfowl hunting, fishing, boating and swimming than heretofore.

Successful recreational ponds must be successfully managed. Water turbidity, fertility, fish stocking ratios and control of aquatic plants are some of the major management problems. Those ponds that have been neglected in this respect have returned little in enjoyment of recreational activities (Tiffany, 1931).

Najas guadalupensis (Spreng.) Magnus is a submerged aquatic plant commonly found in clear water ponds. It affords a breeding place for aquatic insects, a refuge for fish and an excellent food for ducks.

In summer, N. guadalupensis often becomes so rank that it impedes boating, prevents swimming and discourages fishing. Forage fish hiding in beds of N. guadalupensis are practically unavailable as food to the larger game fish. This situation tends to create a food shortage. This one example illustrates how this usually beneficial aquatic can become an undesirable water weed. The word "weed" as used in this work is defined as a generally beneficial plant having the tendency of becoming objectionable. The pond owner and sportsman are directly concerned with the problem of controlling it.

Upon reviewing the literature, the writer concluded that the use of the chemical compound sodium arsenite, offered the best possibilities for control. In order to determine the proper concentration(s) of this herbicide for use in farm ponds, four separate series of experiments were done in aquaria in the laboratory. All known conditions were controlled with the concentration of sodium arsenite being the only variable. It was found that concentrations of 5.0, 5.5 and 6.0 p.p.m. (parts per million) gave the most satisfactory results.

It is intended that these data accumulated on one common aquatic plant in the state will add to the information necessary for successful farm pond management. Information gathered was obtained from library sources, personal field observations and laboratory experiments.

NAJADACEAE

Family and Genus

The genus _Najas_ is monotypic of the family. The members of the genus are: _Najas marina_; _N. flexilis_; _N. guadalupensis_; _N. Muenscheri_; _N. gracillima_ and _N. minor_.

Growth habit

Najas guadalupensis (Spreng.) Magnus, of the island of Guadalupe is a rather firm plant. The leaves are linear, obtuse or acute; deep green to purple in color. The flat or slightly crisped leaves are 0.5-2 cm. long; leaf margins gradually slope at the base with 3-10 somewhat basal spinules. Roots are somewhat elongated, fibrous and rather delicate. (Fig. 1)

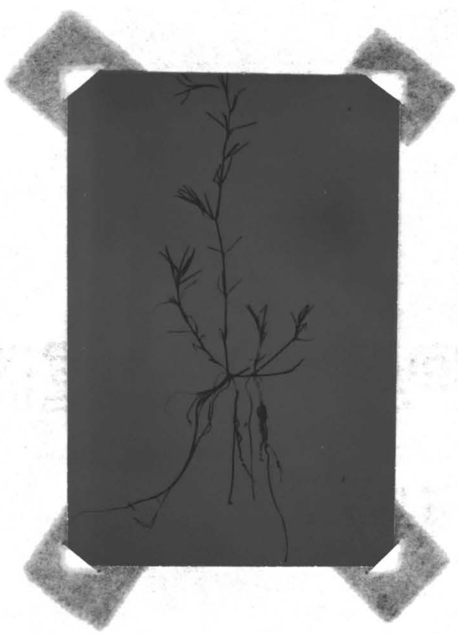

Fig. 1 _Najas guadalupensis_ (Spreng.) Magnus.

Reproduction

It is an annual. Flowers are unisexual, borne in the axils of branchlets and from sheaths of leaf-bases. Staminate flowers have a four locular anther. The pistillate has 2-3 stigmas, 0.1-0.6 m.m. long on a single style. The dull colored seeds are 1.5-2.5 m.m. long with 15-18 rows of clearly marked squarish areolae (Fernald, 1950; Fassett, 1940).

In the interest of simplicity, *Najas guadalupensis* (Spreng.) Magnus will hereinafter be referred to as *Najas*.

Distribution

Najas is quite wide spread in Central and South America. In North America it is found in S.E. Massachussetts, New York, S.W. Quebec, N.W. Pennsylvania, N. Ohio, S. Michigan, Minnesota, Idaho and Oregon (Fernald, 1950). It is quite common in all the Southern United States south of the Mason-Dixon Line and west to New Mexico inclusive. In the Great Plains it is found in W. and N.E. South Dakota and N. central Nebraska. Those states that border Oklahoma also possess this species: S. central and E. Kansas, N. central Colorado, New Mexico, N.W. and S. central Texas, E. Arkansas and S.W. Missouri (Clausen, 1936). Within the boundries of Oklahoma, it is found throughout the state (deGruchy, 1938).

ECOLOGY

Dissemination

The writer theorizes that seeds of Najas had adhered to the foot scales, body feathers, claws and hair of migrating waterfowl, shore-birds and mammals. The seeds were then unknowingly deposited into a pond. Favorable conditions then resulted in ecesis of the species. These animals have thus probably introduced this pioneer submergent into Oklahoma waters.

Beneficial Characteristics

Typically, ponds in the Stillwater area that do not contain any submerged species are rusty-red in color from colloidal clay particles. Clay colloidal particles are negatively charged; positive ions are required to inactivate them (Irwin, 1945). Conversely, clear-water ponds usually contain Najas in depths up to twelve feet. During its metabolic processes, Najas supplies a continual source of positive ions. These positive ions precipitate colloidal clay particles and maintain clear water. (Fig. 2) This ability is especially noticeable after a heavy rainfall. Usually two to five days restores a pond's original clarity.

Fig. 2 A farm pond kept clear by Najas.

In areas suitable to waterfowl, it has been recommended to artificially introduce this species (Anonymous, 1939). Hancock (1951) found Najas to be one of the most important duck foods in the vicinity of Stillwater. McAtee (1939) in analyzing duck stomachs found parts of Najas spp. in twenty species of American wild ducks. The Lesser Scaup Duck was the best patron of the genus. In an earlier study, McAtee (191) considered the families Potomogetonaceae and Naiadaceae as staple foods for ducks. A specific study of the Mallard Duck showed that 560 seeds of the pondweed family were found in a single stomach (McAtee, 1918). Mabbot (1920) found this aquatic family (Naiadaceae) had a diet preference of from 6.53% to 42.33% in seven species of ducks.

Beds of Najas provide a habitat for the desposition of eggs by aquatic insects. The writer has upon numerous occasions seen members of the Order Odonata, Dragonflies, Damselflies, etc. depositing eggs in the surface parts of this plant.

It is quite tolerant to brackish water (Martin, et al., 1951).

Objectionable Characteristics

During the summer, Najas tends to grow in dense rank beds. (Fig. 3) These beds provide too much protection to forage fish,

Fig. 3 Beds of Najas with floating Alga around the peripheries.

which are almost inaccessible to larger carnivorous species. These larger fish suffer from a food shortage. This shortage results in stunted game fish and an over-population of forage species.

Swimming in a pond containing beds of this weed is somewhat trecherous. Such weed-choked ponds could be hazardous to poor or non-swimmers.

Boating, while it is safer, soon becomes an unpleasant chore. It requires constant freeing of oars from entangled vegetation.

A pond that is stocked with fish is stocked to be fished. The fisherman upon retrieving nothing but parts of this weed soon gives up in dispair. Najas can thus be a barrier to harvesting fish used as human food.

In a dense, vigorous growth stage, Najas proposes a barrier to many recreational uses of a farm pond. It is in this condition that this plant becomes a noxious water weed if not controlled. (Fig.4)

Fig. 4 Alpha Pond - beds of Najas extend thirty yards from the shoreline.

METHODS OF CONTROL

There have been two overall methods of approach in the control of water weeds. One of these is indirect in that it attempts to adversely alter a plant's environment. This environmental change produces conditions unfavorable to the plant's survival. The other method is direct attack upon the plant itself.

Fertilization

The purpose of this process is to produce a "water bloom" of plankton by the addition of sufficient amounts of fertilizer in the right proportions. This artificially produced "water shade" prevents light from reaching submergents. Without light submergents thus do not synthesize necessary foods and therefore die (Spiers, 1948). Fertilizers have the advantage of increasing the abundance of fish food. Swingle and Smith (1938) in a two pond experiment used Nitrogen-Phosphorus-Potassium-Calcium carbonate commercial fertilizer in a ratio of 4:2:1:8. They obtained a fish production of 578 pounds per acre compared to 134 pounds per acre in the unfertilized control pond. The resulting "water bloom" controlled Najas flexilis, Ceratophyllum demersum, Potomogeton spirilis, P. spp. and Anacharis canadensis. This large fertilization project did not interfere with recreational activities of the lake. Care must be taken in using commercial fertilizers. The application of an unbalanced ratio may encourage rather than retard the growth of water weeds (Smith and Swingle, 1941b).

Physical Control

Physical methods of control involve hand cutting, raking, chaining, sawing and pond draining. In most instances these procedures usually involve hard labor and much time for appreciable results. Power-driven weeders and dredges operated from a boat or on the bank of a pond require less physical labor but they are costly. The object of pond draining proposes to dry out seeds, rhizomes and vegetative parts of objectionable aquatics. A specific example the writer observed was the draining of the C.R. Carberry Pond. This two acre pond was located 2 1/2 miles west; 1/8 mile south of State Highway 51, Stillwater, Oklahoma. While the purpose of draining the pond was for fish restocking purposes, it offered an opportunity to observe the effects on the aquatics present. The pond was drained by opening a gate-valve below the dam. The drained period was from February 1, through April 30, 1951. Weather conditions for this three month period were obtained from the Meterology Department Weather Station on the campus. (Table 1.)

Month	Temperature, °F.			Precipitation					Winds
						No. of days			
	Aver.	High	Low	Rainfall Total In.	Snow, Sleet Hail. Total	.01 or more	.50 or more	1.0 or more	
Feb.	43.0	75	-4	2.48	8	7	1	1	N,NW
Mar.	47.4	82	18	.63	.0	4	0	0	N,NW,W
Apr.	57.5	90	29	.65	T	5	0	0	N,NW,W,S

Table 1. Weather conditions during drained period.

During August 1949 and 1950 it was noted that a huge mass of Najas completely dominated the shallow West end (6 inches to 10 feet) as well as the shore line of the entire pond. (Fig. 5) During the latter part of August, 1951, Najas had regained almost its original area of dominance with little retardation. (Fig. 6) It is noteworthy

Fig. 5 April 7, 1951. C.R.Carberry Pond-drained. Extent of dominance of Najas in background of pond area.

Fig. 6 August 13, 1951. C.R.Carberry Pond - full. Extent of recovery of Najas and invasion of Polygonom spp.

also that draining at this time of the year had little effect on the seeds and/or rhizomes of Potomogeton americanus, Typha latifolia, Carex frankii and Eleocharis spp. It is evident that with a resumption of growth of these species that seeds and/or rhizomes remained viable in moisture-laden pond soil for a long time. The final results of control were slight.

Pond draining at this time was impractical in view of results obtained. Drainage at best gave little significant control of common aquatics in the C.R. Carberry Pond. More significant control might result if this pond were drained at some other time of the year.

This method of water weed control prohibits recreational use of a pond. Drainage of large ponds or lakes without built in gate-valves would be a major water-pumping operation. Domestic animals must have some other source of water. The fish from the water area must be cared for until a satisfactory water level is regained.

Chemical control

Copper sulfate is well known as a controller of many filamentous and non-filamentous Algae (Hale, 1948). It is also effective against noxious Protozoa, Rotifera, microscopie Crustacea, Schizomycetes, Fungi, Blood worms and Gnats usually found in or on water. Various concentrations serve to deter the growth but not destroy Chara spp., Nitella spp. and Potomogeton spp.

Chlorine, an active halogen is best known for its use in purification of drinking water supplies. As an aquatic herbicide, in the form of sodium chlorate or Chloramine, it forms hypochlorous acid in water. Hypochlorous acid, an active oxidizing agent kills by burning up a plant's energy resources. Bleaching of affected parts is the visible effect of this action. This compound while very effective is dangerous. When placed in water it has a tendency to explode (Spiers, 1948).

The hydrocarbons, Benaclor and diesel oil eliminate a plant's mechanism for obtaining light energy. They dissolve chlorophast bodies in plant tissues (Spiers, 1948).

Phenol and its derivitives inhibit plant mitosis, thus preventing growth. It also decreases the ability to take in oxygen, which further decreases available energy resources necessary to sustain life (Spiers, 1948).

Ammonium sulfate (Ammate) will kill emergents. It is believed to be effective against submergents, but its cost inhibits its use in large areas (Surber, 1949).

Nigrosine, a black dye which eliminates light has been used successfully on Myriophyllum spp. Its cost and objectionable color it gives to water discourages its general use (Eicher, 1948).

The growth hormone 2,4-Dichlorophenoxyacetic acid (2,4-D) is effective on the emergents Nelumbo lutea, Willd. (Water lotus); Nuphar spp. (Spatterdock); Typha spp. (Cat-tail); Sagittaria spp. (Arrowhead); Dianthera spp. (Water willow); Jusseia spp. (Water Primrose); Potomogeton spp. (Pondweeds); Pontederia spp. (Pickerelweed); Acorus calamus, L. (Sweetflag); Alisma spp. (Water Plantain and Lemna spp. (Duckweed). When this herbicide falls into the water from sprays, it gives fish such a disagreeable taste as to make them unpalatable for human consumption. A related hormone 2,4,5-Triethanolamine ester (2,4,5-T) was used in a concentration of 10 p.p.m. to kill Najas flexilis in a large lake. Costs were about $100 an acre. The toxicity of this herbicide killed 1/5 the fish population in one experiment (Spiers, 1948).

Of the known herbicides used to control submergents, sodium arsenite is one of the most effective and cheapest chemicals. Surber (1949) stated that during the summer, 4.0 p.p.m. sodium arsenite would kill the most dense growths of submergents in both hard and soft waters. For control in small ponds submerged weeds may require from 5.0 - 7.0 p.p.m. depending upon weed density and water hardness (Jackson, 1949). A spray containing sodium arsenite killed the leaves, but did not injure the rhizomes of Nuphar advena Ait, (Spatterdock) (Smith and Swingle, 1941a). Chara spp. apparently is quite resistant to sodium arsenite in concentrations of 2.0 - 5.0 p.p.m. Spirogyra spp. and Oscillatoria spp. do not appear to be affected by this concentration range. The floating pond scum Algae Hydrodicton spp.; Oedogonium spp.; Cladophora spp. and Zygnema spp. are controlled better with sodium arsenite than with copper sulfate (Surber, 1943). Potomogeton crispus; P. foliosus; Najas flexilis and Anacharis canadensis are readily destroyed by concentrations of 2.5 - 5.0 p.p.m. of sodium arsenite (Surber, 1943). Adult forage and game fish evidently have a tolerance range of from 11 - 12 p.p.m. (Surber, 1949). Wiebe (1930) in experiments on the effects of sodium arsenite on fingerling forage and game fish found a tolerance range of up to 7.0 p.p.m. Its effects on amphibians and reptiles are not known. It is toxic to man and other mammals. Domestic stock should be kept from treated waters for about one week (Surber, 1949). Sodium arsenite can be used in a select area or in an entire pond. Care must be taken in its application. Rubber gloves should be used in mixing solutions. In the outdoors, solutions should be made in an area protected from the wind to prevent particles being blown on the arms, face and hands. The powdered form of this herbicide is combined at the rate of 5.3 lbs. in 64,080 cubic feet of water to yield 1.0 p.p.m. For a concentration of 5.5 p.p.m., 28.15 lbs. of powdered sodium arsenite would be required; 6.0 p.p.m. would require 31.8 lbs. sodium arsenite. Sodium arsenite commercially is available at a current price of $1.80 per pound. If a spray is to be used, it is obtainable in liquid form. One gallon of the solution to 64,080 cubic feet yields 1.0 p.p.m.; 5.5 gals/64,080 cubic feet = 5.5 p.p.m.; 6.0 gals/64,080 cubic feet = 6.0 p.p.m. Its current price is $2.40 per gallon. The final concentration of sodium arsenite remaining in a pond will not be harmful to fish or man (Jackson, 1949).

MATERIALS AND METHODS

In treating ponds of an acre or more, uncertain elements can be eliminated greatly by controlled experiments in aquaria (Surber and Meehean, 1931). Experiments were conducted in aquaria to effect a "kill-control". Kill-control reduces but does not eliminate the objectionable plant species and has no harmful effects upon other organisms. To determine a satisfactory concentration for a kill-control upon Najas in farm ponds, these controlled experiments are prerequisite. Chemically pure sodium arsenite was the herbicide used. The dense vigorous summer growth of Najas was the stage of the plant to be controlled. Plants and pondwater were obtained from ponds in the Stillwater area. These ponds were: The C.R. Carberry Pond, 2 1/2 miles west, 1/8 mile south of State Highway 51; the "Tom" Berry Pond, 5 miles east, 3 miles south, 1/8 mile west of State Highway 51; the Emil Kastel Pond, 6 miles south, 2 miles east, 1/8 mile north of State Highway 40 and the Alpha Pond, east end of Veteran's Village, 1/2 mile north west of the Oklahoma Agricultural and Mechanical College Campus, Stillwater, Oklahoma. These ponds had an approximate surface acreage of 2;2;5;5 acres respectively.

Six aquaria were used in an experimental series. These same aquaria were used each time in the three following series. Each series was named. The first series was called "Concentration Determination". This first series provided a working concentration range. The C.R. Carberry Pond served as the source of materials. The three succeeding series were done to verify the preliminary findings. These series are indicative of source: "Berry's Pond", "Kastel's Pond" and "Alpha Pond". Experimental series were conducted in the order mentioned.

In describing one series of the four conducted, the same field and laboratory methods were followed in as nearly the same pattern as possible. The writer feels he has thus avoided needless repetition. Other pertinent data have been included into a comprehensive table on page 28.

At each pond Najas was obtained about six feet from the edge. The species was most accessible in dense beds in about three feet of water. Each mass of plants was carefully scooped up by hand with the intention of removing enough pond mud to surround plant roots. A handfull containing mud, roots and stems was then placed immediately in one of two two-gallon open-mouthed earthen jars. These jars were rinsed in pond water and filled about one-half. Water for aquaria was obtained from the same site as plants. Three four-liter glass jars were first left in the pond while plants were being collected. The procedure mentioned helped to reduce the temperature of the glass to that of the pond water. These glass jars were then rinsed briskly in pond water. Each jar was then submerged under water until full. While under water, the narrow mouths were corked.

Immediately after each field collection, the plants and water were taken to the laboratory. The laboratory area consisted of the window ledge and radiator shield of the Graduate room of the Botany Department, Room 102-C, Life Sciences Building, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma. (Fig. 7)

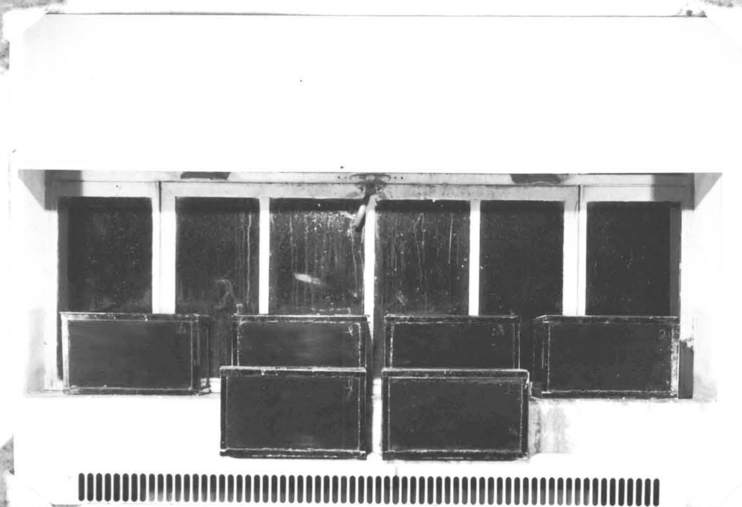

Fig. 7. Laboratory area of aquaria experiments.

Each aquarium was 14" X 6" X 6" with a volume of 8,000 ml. All aquaria were rinsed in pond water and then emptied before introducing plants. Plants were then divided into six approximately equal portions in a clean pan containing pond water. With the mud and root ends down, plants were then placed on the bottom of each aquarium. Stems were arranged in a natural position over the roots and mud. Pond water from the glass jars was then poured slowly into each aquarium. When nearly full each aquarium was covered with a pane of glass cut to size. Glass covers had been washed in pond water. These glass covers served to eliminate water loss from evaporation. They also kept out insects, dust and foreign substances that might interfere with the experiments. The aquaria were then labeled at random. A series was then allowed a period of ecesis in this new enviornment.

The acclimation of Najas was determined as being completed by observation. When plants gave off oxygen bubbles in strong sunlight and produced a noticeable number of lighter green branchlets and leaves, acclimation was considered accomplished. A temperature range for this period was recorded. (Table 3)

At the point of acclimation, varying between four to seven days, the aquaria were removed from the window and photographed. The arrangement of aquaria for photography was a matter of convenience. Their positions in photographs do not necessarily correlate with the positions they had on the window ledge or radiator shield. After photographing, the aquaria were returned to their original places.

With no allowance for displacement by mud and plants, sodium arsenite was calculated on a basis of parts per million. (Table 2) Each weight, Milligrams per 8,000 ml. was weighed on a 100 Milligram capacity chain balance.

In applying the herbicide, each glass cover was removed. Into a 50 ml. beaker containing water from one aquarium the sodium arsenite was dissolved. This solution was then poured throughout the aquarium.

Parts per million (p.p.m.)	Milligrams/8,000 ml. (One aquarium)
4.0	32.0
4.5	36.0
5.0	40.0
5.5	44.0
6.0	48.0

Table 2. Concentrations of sodium arsenite.

Between aquaria the beaker was rinsed thoroughly first in tap water and then in water from the aquarium next to be treated. All six aquaria were treated in the same manner. The glass covers were replaced after each solution was poured into the aquaria. The treated series was then permitted a reaction period which varied from 12 to 15 days. During this period the aquaria were not disturbed.

After definite signs of ultimate reaction (leaf browning, drooping, kill-control or complete destruction) all aquaria were tested for a general temperature range of the series. The aquaria were then taken from their places and photographed. Again, arrangement of aquaria was a matter of convenience. The aquaria were arranged in the same position they had in the period of acclimation. This facilitated photographic comparisons. After photography, an experimental series was considered completed. The aquaria were then emptied of their contents, washed and scrubbed in tap water and made ready for the next series.

RESULTS

Results from the effects of sodium arsenite in various concentrations varied from no reaction, leaf browning, drooping, kill-control to total destruction. Two aquaria showed no external reaction to sodium arsenite during the period of herbicidal action. The first noticeable effects of sodium arsenite was a brownish appearance of leaves. The primary effects of herbicidal action was interpreted as leaf browning. It exhibited itself separately in one aquarium and in combination with drooping and/or kill-control. Plants that supported themselves weakly in an abnormal position were interpreted as drooping. It corresponds to the appearance of wilting land-plants. This secondary effect of herbicidal action was coupled with leaf browning. While kill-control resulted in the death of a large proportion of plants, the visible gross effects varied considerably. In those aquaria having kill-control, some plants gave the appearance of being uprooted. These plants rose to the top of the water. (See Fig. 9, aquarium "F", page 23). It was difficult to distinguish between aquaria showing 90% kill-control and one aquarium showing total destruction (or 100% - above the range of kill-control). A comparison led the writer to assign a figure of 90% kill-control to those aquaria visibly less affected.

Plants did not always acclimate themselves or did so in a doubtful manner. Aquarium "B-2" in the Berry Pond series; all aquaria in the Alpha Pond series were considered failures for acclimation. Consequently, these aquaria were not considered in evaluating herbicidal action.

A compilation of these data are shown in Table 3, on page 28. The detailed effects of the concentrations used will now be described by individual series.

Concentration Determination

Sodium arsenite in two aquaria, "A" and "B", containing a concentration of 4.0 p.p.m. gave no noticeable effects as compared to their acclimation periods. (Fig. 9) In one aquarium, "C", leaves became slightly brownish in color. Aquarium "D" showed increased leaf browning and a slight drooping of plants. In "E" all leaves were brownish, drooped and 25% of the plants were killed. Lastly, aquarium "F" showed the most significant effects with 75% killed. (Fig. 9)

Berry's Pond

Except for aquarium "B-2", the plants in all aquaria were acclimated. (Fig. 10) Aquaria with concentrations of 5.5 p.p.m. sodium arsenite showed leaf browning of living plants and 75% were killed. The two valid aquaria containing 6.0 p.p.m. denote a 90% kill-control and even more marked leaf browning. (Fig. 11)

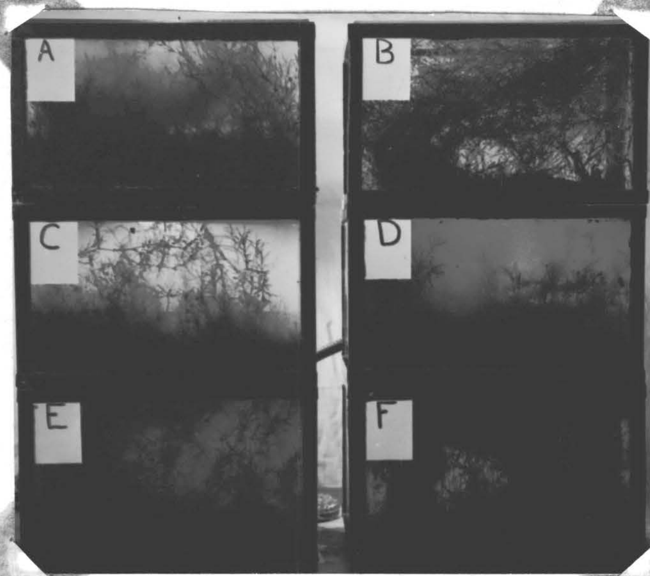

Fig. 8 July 6, 1951. Concentration Determination series - acclimation period.

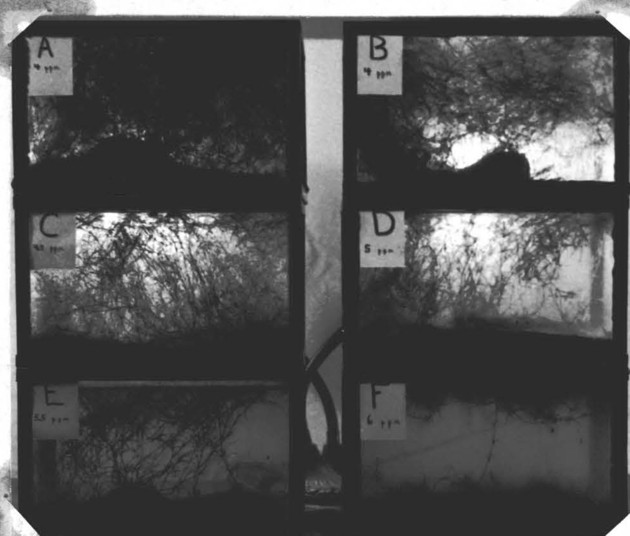

Fig. 9 July 21, 1951. Concentration Determination series - result of herbicidal action.

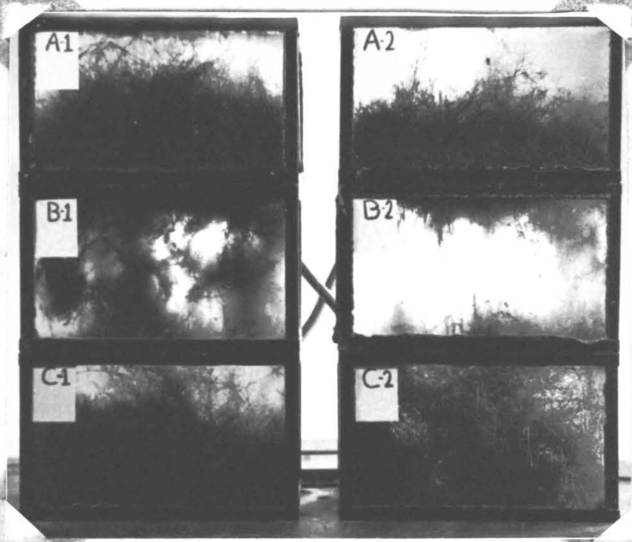

Fig. 10 August 2, 1951. Berry's Pond series - acclimation period.

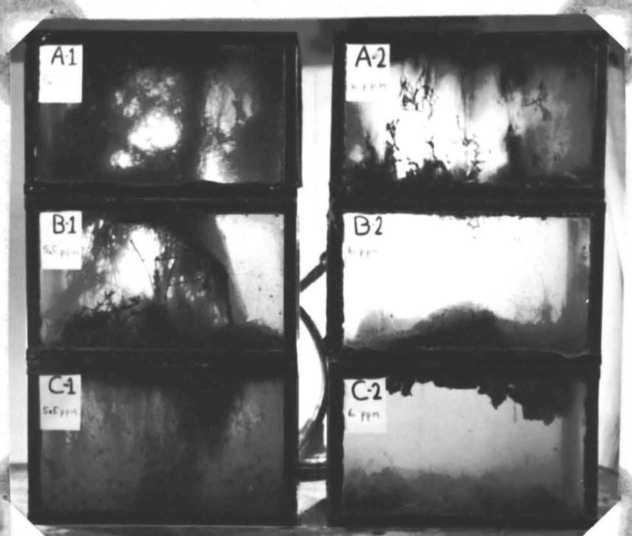

Fig. 11 August 13, 1951. Berry's Pond series - result of herbicidal action.

Kastel's Pond

All plants in aquaria of this series acclimated excellently. (Fig. 12) Considering the original mass of living Najas, the effects of herbicidal action were quite startling. (Fig. 13) Leaf browning of living plants was prevalent in aquaria "I - V" inclusive. Approximately 90% of ıll plants in all five aquaria were killed. Total destruction resulted .n aquarium "VI". (Fig 13)

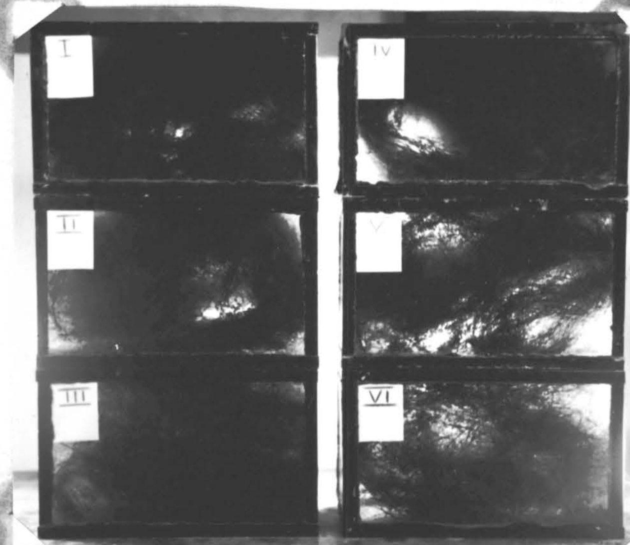

Fig. 12 August 16, 1951. Kastel's Pond series - acclimation period.

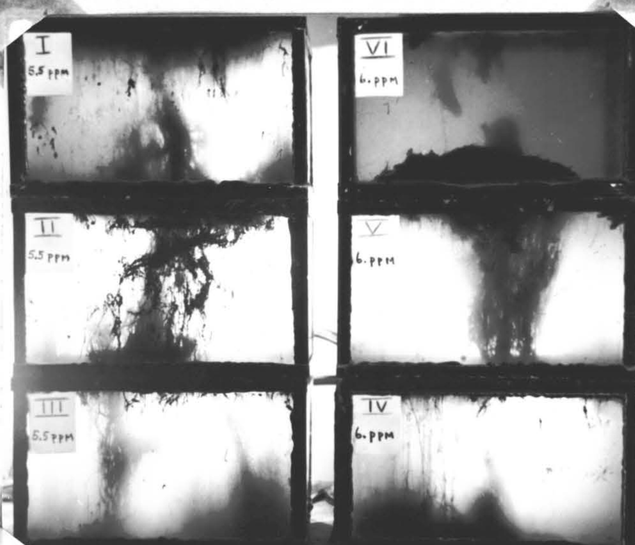

Fig. 13 August 28, 1951. Kastel's Pond series - result of herbicidal action.

Alpha Pond

Fig. 14 September 4, 1951. Alpha Pond series - acclimation period.

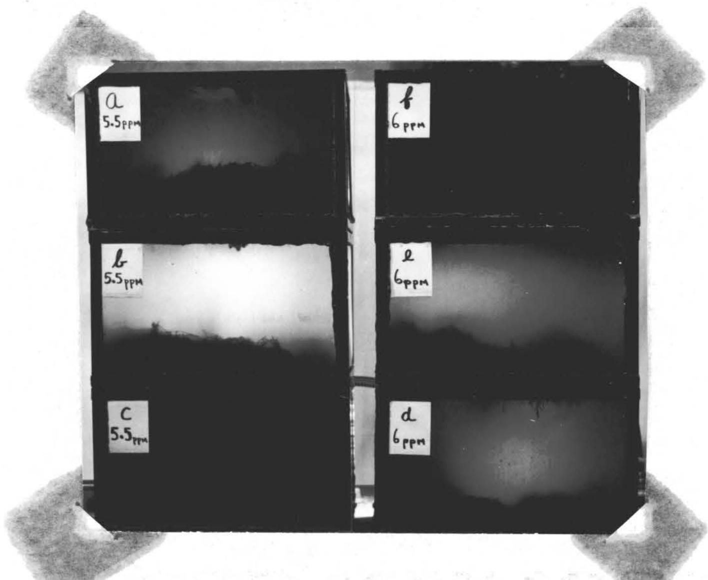

Fig. 15 September 16, 1951. Alpha Pond series - result of herbicidal action.

Two aquaria, "c" and "d", definitely show that the plants therein did not acclimate themselves. (Fig. 14) The water in all the aquaria of this series stayed turbid throughout the entire experiment. It was impossible to determine if the remaining aquaria "a", "b", "e" and "f" had acclimated plants. The writer assumes that they did not. Aquaria in previous series containing plants that had definitely acclimated, kept the water relatively clear. Even in view of non-acclimation, the experimental series was carried to completion. After seeing little difference in herbicidal action (Fig. 15), it was then concluded this entire series was a failure. It was a failure as far as successful acclimation of plants and valid effects of herbicidal action are concerned. Its significance will be brought out in the discussion.

Series	Concentration Determination						Berry's Pond						Kastel's Pond						Alpha Pond					
Time Period	July 1-21 (22 days)						July 27-August 13 (19 days)						August 13-28 (16 days)						Aug.29-Sept.16 (19 days)					
Aquar.	A	B	C	D	E	F	A-1	B-1	C-1	A-2	B-2	C-2	I	II	III	IV	V	VI	a	b	c	d	e	f
Per.of Acclim.	July 1-6 (6 days)						July 27-August 2 (7 days)						August 13-16 (4 days)						Aug.29-Sept.4 (7 days)					
Water Temp.	27.5°C. - 29°C.						29°C. - 30°C.						29°C. - 30.5°C.						29°C. - 30°C.					
Per.of herb. action.	July 6-21 (15 days)						August 2-13 (12 days)						August 16-28 (13 days)						Sept.4-16 (13 days)					
Water temp.	28°C. - 29°C.						29.5°C. - 30.5°C.						29°C. - 31°C.						29.5°C. - 30.5°C.					
Sod.Ars. (p.p.m.)	4.	4.	4.5	5.	5.5	6.	5.5	5.5	5.5	6.	6.	6.	5.5	5.5	5.5	6.	6.	6.	5.5	5.5	5.5	6.	6.	6.
Result	x	x	y	y,z	y,z 25	y 75	y 75	y 75	y 75	y 90	*	y 90	y 90	y 90	y 90	y 90	y 90	100	*	*	*	*	*	*

x No reaction
y Leaf browning
z Drooping
100 Total destruction; lower numbers (25-90) indicates % of all kill-control
* Failed to acclimate

Table 3. Experimental series.

DISCUSSION

Najas guadalupensis (Spreng.) Magnus is one of the most beneficial submergent plants in the Stillwater area. Throughout the state it probably has equal significance. More farm ponds would benefit by artificially introducing this species. Its ability to maintain clear water, provide a favored duck food and a place for the deposition of insect eggs has few equals.

However, Najas in an over-abundant state of growth can offset its generally beneficial characteristics by becoming a noxious water weed if not controlled. It can cause a stunted, unbalanced fish ratio, hazardous swimming conditions, tedious boating and discouragement of fishing. The extent of its dense vigorous growth stage in summer thus generally inhibits recreational enjoyment of a farm pond. Fig. 4 shows that beds extended 30 yards into one pond, thus exemplifying this condition.

Of the various methods used to control submerged water weeds, no one method is perfect. They all have their disadvantages.

Fertilization is useful in adding fertility to farm pond water. Its use in the control of Najas is often difficult to accomplish. A proper ratio must be used. It usually requires a relatively long period of time for appreciable results. In large bodies of water it can be laborious and costly.

Pond draining as a control method is questionable. In the C.R. Carberry Pond it had insignificant effects on the seeds and/or rhizomes of Najas guadalupensis, Potomogeton americanus, Typha latifolia, Carex frankii, and Eleochoris spp. during the weather conditions of late winter and early spring in this area. It may prove more beneficial at some other time of the year, for a longer period and more intense weather conditions.

Considering its cheapness, simplicity of application and immediate effects, sodium arsenite appears to have the properties of doing the most effective job on Najas when its control is needed. A pond owner may wish to keep one or more dense beds in a pond. This chemical can be used selectively by treating one area of a pond at a time or an entire pond. The vegetation killed by this herbicide will add somewhat to the fertility of the pond water.

Experiments conducted in aquaria on Najas obtained from ponds in the Stillwater area were of significance. It was noted that plants in aquarium "B-2" of the Berry's Pond series (Fig. 10) and all plants in all aquaria of the Alpha Pond series (Fig. 14) did not acclimate. The writer can only suggest probably causes. Plants may not have acclimated due to error(s) in field collection and/or transplanting processes. Water turbidity throughout the Alpha Pond series probably prevented an adequate rate of photosynthesis to enable plant ecesis. An increasingly high per cent of kill-control was obtained from August 13, 1951 to August 28, 1951. Next, the Alpha Pond series failed to acclimate. (Table 3) These data appear to indicate that as the species matures and reaches its flowering and fruiting period it is even more susceptible to toxic agents and the physiological shock of transplantation than at any other period of its life cycle.

A concentration of 4.0 p.p.m. of sodium arsenite had no noticeable effects on Najas in aquaria. Concentrations of 4.5, 5.0 had slight effects of leaf browning and drooping respectively, but no kill-control. A kill-control of 75% to 90% was obtained from concentrations of 5.5 p.p.m.

and 6.0 p.p.m. of sodium arsenite. One aquarium had 100% kill or total destruction above kill-control. These results would indicate that concentrations of 5.0 - 6.0 p.p.m. of sodium arsenite would be the one(s) to try in a farm pond to control Najas. These concentrations could be expected to give an approximate kill-control of from 75% to 90% in a treated area whether it be a selected section or an entire pond. The common game and forage fishes would tolerate these concentrations in pond water.

SUMMARY

The management of farm ponds for recreational use involves many problems. One of these is the control of submerged weeds. While generally beneficial, Najas guadalupensis (Spreng.) Magnus tends to become an objectionable water weed. This species is quite common in the Stillwater, Oklahoma area. It is found throughout the state and is also present in those states bordering Oklahoma. Najas has probably been originally introduced into the state by water associated animals.

All methods in water weed control have their disadvantages. One observation on controlling aquatics by draining proved ineffective. Of the chemicals, sodium arsenite offers the best immediate results for kill-control on Najas.

Prior to pond treatment, aquaria experiments should be made to eliminate many uncertainties. Four controlled aquaria experimental series were conducted. Water and plant materials were obtained from four ponds around Stillwater. The laboratory consisted of a window ledge and radiator cover, upon which the aquaria were placed. The four series were photographed both at the pont of acclimation and the end of the period of herbicidal action.

A concentration of 4.0 p.p.m. was ineffective; 4.5 p.p.m. produced leaf browning; 5.0 p.p.m. resulted in leaf browning and drooping; 5.5 p.p.m. showed leaf browning, drooping, 25%, 75% and 90% kill-control from sodium arsenite in aquaria. Plants subjected to 6.0 p.p.m. demonstrated leaf browning, 75% and 90% kill-control. One aquarium had total destruction with a concentration of 6.0 p.p.m. Seven aquaria failed to acclimate. These aquaria were not considered in estimating herbicidal effects.

Some suggestions as to acclimation failure are given.

Calculations are given for pond use of sodium arsenite concentrations found effective in aquaria. Data from aquaria experiments indicate concentrations of 5.0 p.p.m., 5.5 p.p.m. and/or 6.0 p.p.m. sodium arsenite would be most effective in obtaining a kill-control in a pond.

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