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EVALUATION OF EIGHT SPECIES OF FISH FOR AQUATIC WEED CONTROL [1]

by

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EVALUATION OF EIGHT SPECIES OF FISH FOR AQUATIC WEED CONTROL

Abstract

A study was undertaken to determine the value of herbivorous fishes in biological control of aquatic weeds. Ctenopharyngodon idella controlled a wide variety of weeds when stocked in ponds at 49 to 99 per ha. Common carp, Cyprinus carpio, controlled filamentous algae and Eleocharis acicularis when stocked at 124 per ha. In this experiment common carp were not detrimental to fish populations when stocked at the above rate. Tilapia melanopleura controlled filamentous algae and a variety of higher plants when stocked at 2,470 to 4,940 per ha. At this stocking rate T. melanopleura did not produce adverse effects on other fishes. T. nilotica and T. mossambica showed little promise as weed control agents except for the control of filamentous algae. T. heudeloti did not feed appreciably on aquatic plants. Carassius auratus and Ictalurus punctatus when stocked at rates that would not interfere with other fish populations showed no potential for controlling aquatic weeds.

EVALUATION DES AVANTAGES RESPECTIFS DE HUIT ESPECES DE POISSON POUR LA LUTTE CONTRE LES PLANTES AQUATIQUES

Résumé

Des études ont été entreprises pour déterminer l'intérêt de certains poissons herbivores dans la lutte biologique contre la végétation aquatique. Ctenopharyngodon idella détruit une grande variété de mauvaises herbes lorsqu'il est introduit dans les étangs à raison de 49 à 99 par hectare. La carpe ordinaire, Cyprinus carpio, introduite à raison de 124 par hectare, détruit les algues filamenteuses et Eleocharis acicularis. Au cours de cette expérience, les carpes communes n'ont pas eu d'effets défavorables sur les autres poissons, même à effectifs plus élevés. Tilapia melanopleura déversé à raison de 2 470 à 4 940 par hectare s'attaque aux algues filamenteuses et à diverses plantes supérieures. Avec ces taux de peuplement, T. melanopleura ne nuit pas aux autres poissons. T. nilotica et T. mossambica n'ont pas donné de résultats prometteurs en tant qu'agents de lutte contre la végétation, sauf en ce qui concerne les algues filamenteuses. T. heudeloti ne semble guère apprécier les plantes aquatiques. Avec un taux de peuplement tel qu'il n'affecte pas les autres espèces de poisson, Carassius auratus et Ictalurus punctatus ne manifestent aucune aptitude pour le contrôle de la végétation aquatique.

EVALUACION DE ESPECIES ICTICAS ADECUADAS PARA LA ELIMINACION DE LAS MALAS HIERBAS ACUATICAS

Extracto

Se realizó un estudio para determinar el valor de los peces herbívoros en la lucha biológica contra las malas hierbas acuáticas. Ctenopharyngodon idella extirpó una gran variedad de malas hierbas cuando fue lanzado en estanques a razón de 49 a 99 individuos por hectárea. La carpa común Cyprinus carpio, cuando se pobló a razón de 124 individuos por hectárea, eliminó las algas flamentosas y Eleocharis acicularis. En este experimento, la carpa común no fue perjudicial para las poblaciones de peces cuando se pobló a razón de la densidad antes indicada. Tilapia melanopleura suprimió las algas filamentosas y una variedad de plantas superiores cuando se pobló a razón de 2.470 a 4.940 por hectárea. En esta proporción T. melanopleura no produjo efectos perjudiciales sobre otros peces. T. nilotica y T. mossambica ofrecieron pocas posibilidades como elementos para la lucha contra las malas hierbas en cuanto se refiere a la eliminación de las algas filamentosas. T. heudeloti no se alimentó en forma apreciable con plantas acuáticas. Carassius auratus e Ictalurus punctatus poblados en proporciones que no pudieran interferir con otras poblaciones ícticas, no mostraron posibilidades para la eliminación de las malas hierbas de los estanques.

1 INTRODUCTION

The control of undesirable plants in ponds is one of the major problems confronting fish culturists. Various methods have been employed with differing degrees of effort, cost and success. Recently the use of herbivorous fishes for weed control has met with much interest; however, little extensive research has been conducted.

Since 1957 eight species of fish have been evaluated for effectiveness in aquatic weed control in more than 250 ponds and 300 plastic-lined and concrete pools at Auburn University Agricultural Experiment Station.

Objectives of this study were to determine (i) the effectiveness of *Ctenopharyngodon idella*, *Cyprinus carpio* (mirror strain of common carp from Israel), *Tilapia melanopleura*, *T. nilotica*, *T. mossambica*, *T. heudeloti*, *Carassius auratus*, and *Ictalurus punctatus* in weed control; (ii) weed preferences of fish; (iii) stocking procedures concerning size and numbers of fish; (iv) the effect of herbivorous fishes on other fish species in ponds; and (v) the economics of using herbivorous fishes for weed control.

2 REVIEW OF LITERATURE

2.1 *Ctenopharyngodon idella*

In early work Hoffman (1934) and Chen (1934; 1935) reported the food habits of *C. idella* and Lin (1935) presented the first comprehensive account of its life history. Food habits of *C. idella* were also reported by Lin (1946), Reich (1954), Hickling (1960), Verigin (1961), Hora and Pillay (1962) and Prowse *et al.* (1963).

Use of *C. idella* for weed control was reported by Araki (1943), Hata *et al.* (1949), Nakamura (1950), Aoki (1953), Nakamura *et al.* (1954), Wurtz (1960), Aliev (1963) and Anon. (1963). Nakamura *et al.* (1954) found addition of this species to ponds did not interfere with production of other fishes. Schuster (1952) recommended culture of *C. idella*, *Chanos chanos* and *T. melanopleura* for controlling aquatic weeds. *C. idella* was reported by Swingle (1957) as one of the most promising fishes for the control of rooted aquatics. Kuronuma and Nakamura (1957) suggested stocking 30 *C. idella*, weighing over 35 kg per ha for weed control. Alikunhi and Sukumaran (1964) found that 49 to 99 per ha effectively controlled weeds in four to eight weeks. Effectiveness of *C. idella* for weed control was reported by Avault (1965b) from preliminary work.

2.2 *Cyprinus carpio*

The food habits of *C. carpio* were discussed by Grafen von Maltzan (1935) who found that older carp were mostly bottom feeders and that young stages prefer plankton. Moen (1953a; 1953b) found that animal material predominated in the diet of *C. carpio*, but that green plant material was taken mostly by large carp. Wunder (1944), Rehder (1959), and Assman (1961) also reported food habits of *C. carpio*.

This species is not a true herbivorous fish, but has been reported as controlling weeds by Hogan (1946), Black (1946), Wunder (1949), Robel (1961), and Mathis (1965). Both Tryon (1954) and Threinen and Helms (1954) attributed weed control by carp through the muddying of waters with their feeding habits. Use of this species to control filamentous algae, especially *Pithophora* sp., was reported by Swingle (1957), Grizzell and Neely (1962), Shell (1962), and Avault (1965a).

2.3 Tilapia

Hofstede and Botke (1950) found that T. mossambica is principally a plankton feeder, but that adults consumed filamentous algae and higher plants. De Bont et al. (1950), Fish (1952), Blanc et al. (1955), le Roux (1956), Yashouv (1960), and McBay (1961) also discussed food habits of tilapia. McBay (1961) stated that 15 to 23 cm T. nilotica utilized Pithophora sp. extensively. Lowe (1955) and Hickling (1961; 1962) reported that T. melanopleura and T. zillii fed readily on aquatic plants. Chimits (1955; 1957) presented a comprehensive documentation of tilapia literature in a bibliography of 173 papers.

Use of tilapia for weed control has been reported by de Bont (1949), Hofstede (FAO/UN, 1955), Swingle (1957), Hee (1957), van der Lingen et al. (1960), Shell (1962), Timmons (1962), Pierce (1965), and Avault (1965a). Hee (1957) stated that prior to use of tilapia for weed control chemicals and labour cost $3,373 to $5,194 per year at the Kekaha Sugar Company in Hawaii. After using T. mossambica no expense was incurred except for the initial cost of $25.

2.4 Other species of fish

Various other species of fish have been reported as feeding on plant material including Puntius javanicus (Vaas and Sachlan, 1952; Ilan and Sarig, 1952; Hora and Pillay (1962a and b); Osteochilus hasselti (Vaas and Sachlan, 1952; Hora and Pillay, 1962a and b); Carassius carassius (Swingle, 1957); Osphronemus olfax (Villadolid, 1936; Hickling, 1961); and Chanos chanos (Rabanal and Montalban, undated). P. javanicus, O. hasselti and O. olfax which are tropical species, are unable to overwinter in temperate climates (Swingle, 1957).

Other species include Alestes macrophthalmus and Distichodus sp. (Hickling, 1961); Archosargus probatocephalus (Gunther, 1945); Scarus sp. and Sparisoma sp. (Schultz, 1958; Randall, 1961; 1965); Hypophthalmichthys molitrix (Verigin, 1961); Mugil sp. (Grizzell and Neely, 1962); Iotalurus punctatus and Carassius auratus (Avault, 1965a); and Trichogaster pectoralis (Thiemmedh, undated). Vaas (1953) lists 13 species of fish that are periphyton or vegetable feeders in West Borneo lakes on the Kapuas River.

3 MATERIALS AND METHODS

3.1 Technique for evaluating weed control

A sampling apparatus devised by E. W. Shell was used to determine weeds quantitatively and qualitatively. This consisted of a bait casting outfit with a 30 g lead sinker to which four soft wire hooks were attached. A slip-float was placed on the line above the hook-bearing weight.

When the weight was cast into the pond it sank to the bottom leaving the float at the surface above it. The reel handle was then turned slowly several times, drawing the weight across the bottom and allowing it to collect weeds. After the hooks had been dragged along the bottom for 2 to 3 m, the rod was given a short jerk. The weight was raised from the bottom and held under the float, thereby ending the sampling at that station. The line was then reeled in rapidly to keep the weight off of the bottom. The species and abundance of weeds were recorded. Duplicate samples were taken at 3, 10 and 25 m from shore at each sampling station. Several samples were taken from approximately one-fourth of the pond's margin.

3.2 Pond experiments

Field tests consisted of stocking a potentially herbivorous fish at various rates per ha into a pond containing higher aquatic plants or filamentous algae and observing if there was a change in weed abundance. Most of the ponds stocked were privately owned and contained established populations of bluegill, Lepomis macrochirus and largemouth bass, Micropterus salmoides. Tests were also conducted in Auburn experimental ponds. These ponds were drained at the end of the experiments to determine survival and composition of the fish populations.

Qualitative and quantitative observations of weeds were made at the time of stocking and periodically thereafter. Occurrence of plankton blooms and turbidity were also recorded. Fish samples were periodically obtained by seining in many of the ponds to determine the effect of added fish on the pre-existing population.

3.3 Pool experiments

Plastic-lined pools (2.7 m in diameter and 0.9 m deep) and concrete pools (2.7 m x 6 m) with a bottom of 10 to 15 cm topsoil and clay subsoil were filled with well water. Aquatic plants were planted either as single species or in combination of species in pools to simulate a pond with a heavy infestation of weeds. Different species of fish were then stocked at various numbers per ha. The abundance of weeds was recorded at the time of stocking and at one or two week intervals thereafter. Weed abundance was estimated visually and recorded on the basis of the percentage of the total pool area. Observations on weed preference of the fishes, plankton blooms and turbidity were recorded.

4 RESULTS AND DISCUSSION

4.1 Ctenopharyngodon idella

4.1.1 Pond experiments

C. idella, 25 to 40 cm in total length, were stocked at rates of 49, 74 and 99 per ha in ponds heavily infested with weeds. Excellent control was obtained in one to three months of the following weeds: Chara sp., Potamogeton diversifolius, Eleocharis acicularis, and Rhizoclonium sp.

In one pond C. idella virtually eliminated an extremely heavy infestation of E. acicularis in less than three months when stocked at 74 per ha. The weed was clipped off as if it were grazed. After eliminating this weed, C. idella readily ate Eichhornia crassipes, when it was placed in the pond within a floating frame.

None of the ponds became muddy or developed phytoplankton blooms as a result of feeding activities of C. idella, but in some ponds a brown organic stain developed, probably from faecal wastes.

C. idella appeared to prefer pelleted fish feed to aquatic weeds in two holding ponds. When fish were fed 3 percent of their body weight per day, Chara sp. invaded one pond and E. acicularis invaded a second and increased in abundance. When feeding was discontinued the fish in both ponds began eating weeds and eventually eliminated them.

4.1.2 Pool experiments

Previous tests (Avault, 1965b) revealed that 25 to 30 cm C. idella when stocked at the rate of 1,693 per ha in plastic-lined pools eliminated within two to three weeks Najas quadalupensis, P. diversifolius, Elodea densa, Chara sp., Spirodela polyrhiza, Utricularia biflora, E. acicularis, Vallisneria americana, and Pithophora sp. After elimination of these weeds, there was an interim of two to three weeks during which the fish discontinued feeding. Following this period Alternanthera philoxeroides, Myriophyllum brasiliense, M. spicatum, and E. crassipes were eaten and finally eliminated within an additional two weeks. None of the pools became muddy even at the high stocking rate of 1,693 per ha, but a dark organic stain developed in most pools.

At the end of the experiment all the pools were drained and the fish removed. In most pools no trace of vegetation could be found. The pools were refilled with water and allowed to stand. The following spring P. diversifolius and E. acicularis reappeared in some of the pools.

C. idella approximately 25 cm long were stocked in concrete pools at a rate of 494 per ha. Within one to two months the fish virtually eliminated Chara sp., N. guadalupensis, P. diversifolius, Bacopa rotundifolia, E. densa, E. acicularis and Pithophora sp. In two pools where complete control was apparent the fish were removed. Within one month Chara sp. and E. acicularis reappeared. A. philoxeroides, M. brasiliense and E. crassipes were controlled in some pools but not in all.

Most of the pools developed a brown organic stain. Chemical analyses of water revealed a 300 percent increase in potassium content but none in sodium, nitrogen or phosphorous.

Preference by C. idella for certain species of weeds was observed in pool and pond experiments. Additional tests were conducted in aquaria. C. idella were offered equal amounts of various combinations of weeds and the preference recorded; there was some overlap, especially among the more preferred species. The following plants are listed in decreasing order of preference: (i) Chara sp., (ii) N. guadalupensis, (iii) P. diversifolius, (iv) E. acicularis, (v) Ceratophyllum demersum, (vi) B. rotundifolia, (vii) E. densa, (viii) M. spicatum, (ix) V. americana, (x) E. crassipes, (xi) M. brasiliense, and (xii) A. philoxeroides.

4.2 Cyprinus carpio

4.2.1 Pond experiments

Common carp, 15 to 25 cm in total length, were stocked at a rate of 124 per ha in ponds containing bluegill, Lepomis macrochirus and largemouth bass, Micropterus salmoides. The common carp were effective in reducing or eliminating Pithophora sp., Rhizoclonium sp. and E. acicularis but in some ponds two to three years were required for control. Best control was obtained in ponds that developed phytoplankton blooms.

The long period of time required for control in some ponds appeared to be due to stocking small fish, which had to attain a sufficient size before utilizing plant material and becoming bottom feeders. Control was attributed both to feeding on the weeds and to silting of the weeds caused by feeding activities. When carp were stocked at 62 per ha, variable results were obtained. Failures were attributed to poor survival.

In all cases where control of filamentous algae and E. acicularis was obtained, the carp were in sufficient numbers for some to be caught by fishermen. When stocked at 62 or 124 per ha, this fish rarely spawned in ponds that contained an established population of other fish species. None of the test ponds became muddy.

Carp, 15 to 25 cm in total length, stocked in bass-bluegill ponds at rates of 62 to 124 per ha, failed to control E. densa, Nymphaea sp., Brasenia schreberi, Chara sp., Hydrocotyle umbellata, N. guadalupensis, B. rotundifolia, S. polyrhiza and Hydrochloa sp.

In bass-bluegill ponds stocked with fingerling carp at more than 124 per ha little benefit in weed control was obtained. Predation by largemouth bass appeared to account for the failures as few carp survived.

In ponds stocked only with common carp, submersed aquatic plants were always eliminated. In these ponds the carp spawned, and as a result large numbers of individuals were present. Under these conditions fish usually stirred sufficient silt to make the ponds muddy.

Mortality of carp was the main limiting factor to their use in weed control. Mortality was attributed to: (i) loss of carp during flooding, (ii) removal by fishing, (iii) natural mortality, and (iv) predation by largemouth bass.

Common carp frequently escaped from ponds during periods of high water. In one pond an estimated 50 percent of the population was lost. Carp were caught readily by fishing, but most fishermen were encouraged to return the fish to the ponds. Very few fish were removed by fishing from most ponds.

Experiments have shown that natural mortality of common carp was approximately 20 to 30 percent annually. Ponds in which control of algae was obtained remained algae-free for about three or four years. At the end of this time most of the carp had died and restocking was necessary.

Fingerling carp are highly susceptible to predation by largemouth bass. In three ponds the mortalities were 95 percent within one month, 77 percent within 12 months, and 87 percent within 29 months. Stocking with larger carp, 20 to 40 cm in length, resulted in better survival in two bluegill brood ponds. After 84 days one pond was drained and 18 of the 20 carp were recovered. The second pond was drained 99 days after stocking and all the 20 carp were recovered.

A bass-bluegill pond was stocked with 15 to 25 cm carp at a rate of 62 per ha. Eight months later the pond was drained and 82 of 87 carp stocked were recovered. Of the 392 bass in the pond at the time of draining, 51 were 35 to 45 cm in length. However, even a 45 cm largemouth bass can swallow only 18 cm or smaller Carassius auratus, and common carp have greater body depths than C. auratus.

The fish population of the above pond was analyzed to determine the effect of carp on the bluegill population. Since common carp are forage fish, any effect on the population would show as competition between carp and bluegills. On draining, 439 kg of bluegills per ha were recovered. This was one of the highest weights of bluegills produced at this station in a bass-bluegill pond. Thus there was no apparent competition between the 439 kg of bluegills per ha and the 133 kg of carp per ha. In other ponds also similar results were obtained. Weights of carp used for weed control did not measurably reduce growth of bluegills or interfere with the pond balance.

4.2.2 Pool experiments

Common carp, approximately 15 cm long, when stocked at the rate of 1,693 per ha in plastic-lined pools gave good control of Pithophora sp. and E. acicularis within three months. Partial control was obtained on N. guadalupensis and P. diversifolius. These two weeds were reduced as much as 50 percent within three months. No appreciable control of Chara sp., E. densa, A. philoxeroides, M. brasiliense, M. spicatum, and V. americana was obtained.

Control over E. acicularis appeared to be the result of uprooting by the carp rather than actual ingestion of the weed, even though it was present in their stomachs. E. acicularis has a rather short root system and is apparently uprooted easily since it could be seen floating in pools.

In one plastic pool test where carp were stocked at a rate of 1,693 per ha the water remained clear in 12 pools, became dingy in 14, developed a phytoplankton bloom in four and was muddy in 10 pools. The eight control ponds that received no carp were clear but in four of the pools higher plants were densely tangled with filamentous algae. They did not occur around higher plants in pools with carp.

Feeding activities of common carp left small holes or pock marks in the bottom of many pools. These marks were observed in over 90 percent of all pools where some reduction of weed abundance occurred. The pock marks were about 3 to 7 cm deep and wide. In some pools the holes were so numerous that a honeycomb effect was achieved. It was also noted at draining that in most pools the weeds were covered with silt. Moreover, in weed preference studies in aquaria, carp were frequently observed to work over the bottom by sucking up and spitting out the substratum.

Weed preferences were observed in pools and in tests conducted in aquaria. Filamentous algae were preferred. Chara sp. and higher plants were fed on in aquaria but appeared to be eaten only because little else was available.

4.3 Tilapia

4.3.1 Pond experiments

T. melanopleura, 18 to 13 cm in total length, when stocked in April and May at 2,470 to 4,940 per ha in established bass-bluegill ponds, appreciably reduced or controlled the following weeds within three to four months: Pithophora sp., Spirogyra sp., E. acicularis, E. densa, Hydrochloa sp., U. biflora, Rhizoclonium sp., M. brasiliense, S. polyrhiza, P. nodosus, Chara sp., Micranthemum umbrosum, and N. guadalupensis. Under the same stocking conditions T. melanopleura failed to control B. schreberi and Nymphaea sp. In some ponds in which the water remained clear the weeds reappeared the following year.

In a 7.3 ha lake 13 to 18 cm T. melanopleura were stocked in April at 617 per ha and effectively reduced a heavy infestation of N. guadalupensis that had been a problem for more than six years. Seining in August revealed numerous intermediate sunfishes with small tilapia present in lesser numbers. In other ponds where weeds were controlled, small tilapia were also abundant (10 to 30 per 15 m quadrant seine haul). This and the presence of tilapia spawning beds were indications of good survival. In ponds that contained many large bass, survival of tilapia and weed control were usually poor.

Stocking with young-of-the year T. melanopleura did not prove successful since too little time was available for weed control. In Alabama this species of tilapia usually begins spawning in May, and 8 to 10 cm young are not available until August. Stocking in August did not allow enough time for weed control before cold weather killed the fish.

Generally, the best means for controlling aquatic weeds in ponds in the United States is with fertilization. However, in many experimental ponds, the weed growth was so heavy or water flow through ponds so great that fertilization was impractical. In these cases use of T. melanopleura appears feasible. Once weeds are reduced or controlled, the ponds may be fertilized to encourage phytoplankton blooms to shade out remaining weeds. On the other hand T. melanopleura may give only temporary control of weeds unless restocked each spring in temperate climates. In this case a herbivorous fish that can overwinter in ponds is needed.

T. melanopleura stocked in farm ponds for weed control experiments has had no adverse effects on the fish population. When stocked in established bass-bluegill populations at the rate of 1,235 per ha, almost no young-of-the year fish became large enough to utilize plant material. Either some repressive factor present prevented the fish from spawning, or bass and bluegill eliminated the young fish shortly after hatching. In newly stocked ponds brood tilapia often produced larger numbers of young, when spawning took place before bluegill spawning. However, if bluegills spawned first, the tilapia produced few young. Stocking 2,470 or 4,940 tilapia per ha had no adverse effects on pond balance.

T. melanopleura have not interfered with growth of other fish species when stocked in large impoundments that contained established populations of largemouth bass and bluegill (Byrd and Crance, 1965). They reported that tilapias did not contribute a significant amount to the average total catch during a 14 year study because they were stocked only once in most lakes and did not overwinter. They found, however, that the stocking of 10 to 13 cm tilapias at the rate of 2,470 per ha in two lakes provided an average catch of 58 kg per ha during a four month period with no significant effects on the other species in the population.

Results with T. nilotica and T. mossambica for weed control have been less encouraging than those with T. melanopleura. T. nilotica has controlled Pithophora sp., and N. guadalupensis in ponds when stocked at 2,470 to 4,940 per ha, but showed little promise for controlling most higher plants. T. mossambica has also been effective in controlling Pithophora sp. in ponds, but has not been effective in controlling higher plants. For example, in two experimental ponds containing 7,410 T. mossambica per ha with no other fish species present, Chara sp., and E. acicularis invaded and covered 50 to 70 percent of the pond bottom by fall draining.

4.3.2 **Pool experiments**

Ten to 15 cm long T. melanopleura, T. nilotica, T. mossambica and T. heudeloti were stocked in plastic-lined pools at rates of 3,384, 5,076, and 6,768 per ha. At rates of 5,076 and 6,768 per ha T. melanopleura gave excellent control of the following weeds within 80 to 90 days: N. guadalupensis, P. diversifolius, E. densa, Chara sp., S. polyrhiza, U. biflora, E. acicularis and Pithophora sp. However, no apparent reduction was obtained in E. crassipes, A. philoxeroides, M. brasiliense, M. spicatum and V. americana. These weeds were eaten but not until other weeds were eliminated. Six months after T. melanopleura was removed from the pools some weeds reappeared. Morever, viable akinetes of Pithophora sp. were recovered from tilapia faeces and germinated in water.

Both T. nilotica and T. mossambica were effective in controlling Pithophora sp. T. mossambica failed to reduce higher plants, whereas T. nilotica reduced N. guadalupensis, P. diversifolius, and E. acicularis in some pools but failed to reduce these weeds in other pools. T. heudeloti fed on higher plants in pools, but no extensive reduction was obtained.

T. melanopleura showed less selectivity in feeding (on weeds) than C. idella. Weeds eaten in order of preference were: (i) N. guadalupensis, (ii) P. diversifolius and Chara sp., (iii) E. acicularis, (iv) C. demersum, (v) E. densa, (vi) B. rotundifolia, (vii) M. spicatum, (viii) V. americana, (ix) M. brasiliense, (x) E. crassipes, and (xi) A. philoxeroides.

4.4 Other species of fish

Ictalurus punctatus reduced or eliminated Pithophora sp. in ponds when stocked at the rate of 2,470 per ha, but not when stocked at 494 per ha. When stocked in pools at 1,692 per ha, they fed only slightly on higher plants. The weeds appeared to be eaten only when little else was available.

Carassius auratus controlled Pithophora sp. when stocked in pools at 1,692 per ha but did not reduce the abundance of higher plants.

5 SUMMARY AND CONCLUSIONS

The ideal herbivorous fish for aquatic weed control should meet the following requirements: (i) control a wide variety of weeds, (ii) not interfere with other fish species, (iii) be hardy and easy to handle, (iv) be economical to use, and (v) add to the fishery.

5.1 Ctenopharyngodon idella

(i) C. idella 25 to 40 cm long, when stocked at 49 to 99 per ha controlled a wide variety of weeds. Stocking rates should be determined according to the species and abundance of weeds. The lowest stocking rate at which weeds are still controlled is recommended.

(ii) This fish is currently being evaluated for its effect on bass-bluegill populations. Other studies (section 2.1) indicate that C. idella has not interfered with other fish species.

(iii) C. idella is hardy; it can withstand cold water, low oxygen and frequent handling.

(iv) This species will grow rapidly and efficiently on a wide variety of foods. Since only small numbers are needed for weed control in ponds, it should be inexpensive to use. Spawning, once a limiting factor in the use of this species, has been induced by hormone injections (Tang, et al., 1963; Alikunhi et al., 1963; Alikunhi and Sukumaran, 1964; Lin, 1965)

(v) C. idella should add to the fishery of a pond both by its weight and by reducing weeds.

Perhaps the only real limiting factor for use of C. idella in the United States is that it is an exotic fish and its escape and possible establishment in our river systems must be considered. Only through long experimentation and investigation can the advantages and disadvantages of the introduction be evaluated. This problem might be solved by use of mono-sex culture.

5.2 Cyprinus carpio

(i) Common carp controlled few species of weeds when stocked in bass-bluegill ponds at 124 per ha, but its control of Pithophora sp.alone merits its use, since this branched alga is a major problem in the southeastern United States.

(ii) This fish has not interfered with other species of fish when stocked at 124 per ha.

(iii) Common carp are hardy, easy to handle and overwinter easily.

(iv) There are commercial dealers in the United States selling carp for weed control at 10 to 50 cents a piece depending on size. The cost varies from $12.50 to $61.75 per ha for their use in algae control.

(v) Common carp add little to the catch in ponds but do have considerable angler appeal, especially when individual fish reach 4.5 to 5.4 kg in size.

5.3 Tilapia

(i) T. melanopleura when stocked at 2,470 to 4,940 per ha controlled a variety of weeds. Best control was obtained in ponds where survival was high and the fish spawned. After tilapia reduced weed abundance, fertilization was effective in further control.

(ii) T. melanopleura has not interfered with other fish species in large impoundments or in farm ponds.

(iii) T. melanopleura rarely overwinter in Alabama. They begin dying when the water temperature reaches 12°C.

(iv) Consequently, at this station they have been overwintered each year in troughs in a heated building for the following year's research. The expense of overwintering the fish is the major limiting factor for use of tilapia in most of the United States. They have been overwintered in springs, but survival has often been poor.

(v) T. melanopleura when stocked at 2,470 to 4,940 per ha have not appreciably added to the fishery. However, late summer fishing, when other fishing declines, has often been good. The sunfish-like characteristics of this exotic fish contribute to its angler appeal.

T. mossambica and T. nilotica controlled some aquatic weeds, but T. melanopleura was more efficient than these two species which do not merit further consideration. T. heudeloti fed on aquatic weeds but not appreciably.

5.4 Other species of fish

Carassius auratus and Ictalurus punctatus when stocked at rates low enough to prevent interference with other fish species had little potential for controlling weeds.

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