AGRI-FACTS
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Biological Weed Control in Alberta Using Triploid Grass Carp

Heavy, dense stands of submerged aquatic vegetation are a major problem in many Alberta pond and dugout environments. Controlling this vegetation using the weed-eating grass carp may be one answer to this problem.

The problems are particularly acute in the shallow, warm water environments of farm ponds during the summer months. Extensive weed growth frequently clogs intake pumps and filter systems, interferes with recreational activities, and causes water quality to deteriorate.

Water quality problems occur in the late summer and continue into the winter as dense weed growth decomposes. This decomposition leads to oxygen depletion and nutrient release, which stimulates microscopic algae that contribute to obnoxious tastes and odours.

Grass carp are an alternative to traditional weed control methods

Traditional methods of controlling excessive aquatic weed growth include mechanical harvesting (chaining, raking, weed cutters, hand harvesting) or the application of chemicals. Mechanical methods are often labour-intensive and costly. Chemical treatments are also expensive and can directly or indirectly harm other aquatic life and water quality.

Regional health authorities and agencies directly involved with the livestock industry have recently identified the quality of on-farm domestic and livestock dugout water supplies as a concern. When you consider that the majority of farm dugouts have multiple functions, the concern becomes significant. The same dugout may be used for domestic water, livestock watering and commercial or recreational pond fishery.

Biological control programs may provide promising alternatives to traditional methods of weed control. Species of insects, snails, fish and even aquatic mammals like sea manatees have been investigated world-wide for their potential as agents in controlling aquatic weeds. One of the most extensively studied biological control organisms is the weed-eating (herbivorous) fish known as the grass carp or Silver Amur.

Species description

The grass carp, one of the largest members of the minnow family, is indigenous to large coastal rivers in Siberia (Amur River) and China that flow into the Pacific Ocean between latitudes 51° North and 23° North. The carp are also extensively cultured in China, Malaysia, Singapore, Borneo, Indonesia, Thailand, Taiwan, Hong Kong and the Philippines.

In some countries, the grass carp is an integral part of fish culture, and fish flesh forms an important source of protein for human consumption. In North America, the grass carp is currently licenced to control aquatic vegetation in irrigation canals, reservoirs, recreation lakes and farm ponds in Mexico and 37 American states.

Grass carp can be readily distinguished from the closely related common carp and some native species that may look like grass carp, such as suckers (see Figure 1). The back of the grass carp is dark grey, and the sides of the body are light with slightly gold sheen. The belly is scaled and dusky, yellowish green to silver white in colour. Fins are either greenish-grey or buff in colour. The fish has moderate to large scales with a dark brown base. Body shape is oblong with a rounded belly and broad head. Teeth have been replaced by specialized structures called pharyngeal teeth located in the back of the throat. These are used for tearing and grinding plant matter.

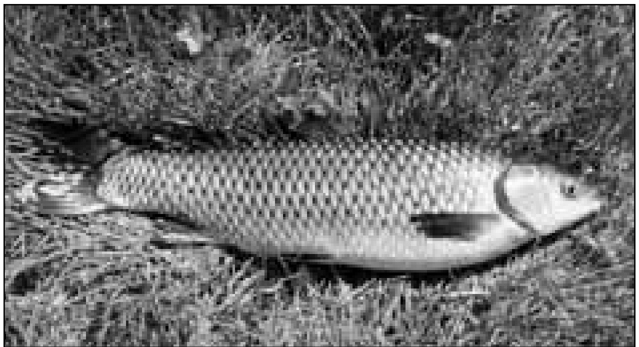

Figure 1. Triploid grass carp

By contrast, European or common carp have a laterally compressed, robust body (deep bodied from the back of the fish to the belly). Colouration is usually olive-green on the back of adult fish and yellowish on the belly area. Tail fins often have a reddish hue. Common carp are easily distinguished by the presence of barbels (whiskers) located at the corners of the mouth. It should be noted that common carp are benthic (bottom) foraging fish that muddy the water during feeding, whereas the grass carp "clip" vegetation near the base or at mid-water level.

Sucker species are either blackish or grayish on the back, with silver sides and bellies (white sucker) or dark-olive slate on the back and sides with white bellies (longnose sucker). Scales of these fish are smaller that the grass or European carp. Unlike the carp species, suckers have large lipped mouths located well below the head.

Grass carp in Alberta

Grass carp were first introduced into southern Alberta (49 - 50° north latitude) in 1987 to research their use in the biological control of aquatic vegetation in irrigation canals. Later research was conducted on the control of aquatic vegetation in farm ponds (dugouts) and golf course environments.

Aquatic weed control

Grass carp have proven to be effective in controlling a large number of different aquatic weeds, including Chara (stonewort), water plantain, sago pondweed, Canada waterweed, and filamentous algae.

A common pond species called white water buttercup is least preferred by the fish and may only be uprooted when other, more palatable aquatic species are depleted. It appears that the young new buttercup growth is consumed by grass carp. The young growth of pond cattails, sedges and rushes may be eaten and ultimately controlled, over time, as older plants die back.

Fish growth and survival

The amount of vegetation consumed by grass carp is related to fish size, fish numbers, water temperatures, weed density and species composition, as well as the length of time the fish have been in the ponds. Smaller fish (25 -
40 cm) will consume more feed (35 - 50 per cent body weight per day) than larger fish (45 cm), 20 to 30 per cent body weight per day.

Dugout studies conducted more than two years in Southern Alberta found average weed control in areas with grass carp to be 73 - 80 per cent. In some ponds, because of fewer palatable aquatic plants, weed control was as low as 20 per cent. Fish survival over the summer months was high in both years of the study, with averages of all dugouts at 91 per cent in 1994 and 97 per cent in 1995. When fish were transferred to aerated overwintering dugouts, survival ranged from 82 to 100 per cent.

According to scientific literature and various tests conducted by many researchers, the amount of food consumed by grass carp is directly related to temperature. For example, at a water temperature of 13°C, grass carp can consume 5 per cent of their body weight per day while at temperatures of 18 to 25°C, grass carp consume 24 per cent of their body weight.

Alberta studies suggest that grass carp have optimal feeding temperatures of 18°C or higher, with moderate feeding activity between 13°C and 18°C and limited feeding below 13°C. In southern Alberta, grass carp in farm dugouts did feed on artificial rations (fish feed) during temperatures as low as 7°C.

Water temperatures in southern Alberta dugouts were within active feeding ranges for four months of the year (77 days of optimal >18°C and 43 days of sub-optimal between 13 - 18°C). In comparison, northern dugouts (Peace River) had active feeding temperatures for three and a half months of the year (46 days of optimal >18°C and 60 days of sub-optimal, between 13 - 18°C). This difference suggests that a cooler environment in the northern part of the Province will result in lower aquatic weed consumption rates by grass carp. However, it must be noted that pond water temperatures are also controlled by pond depth, wind exposure and water source.

Stocking triploid grass carp with other species (polyculture)

In China and other Asian countries, fish culturists commonly stock grass carp in ponds with other species that have different feeding requirements. For example, silver carp consume microscopic algae; bighead carp, microscopic algae and small invertebrates; black carp, mainly snails and clams; and common carp and tilapia consume invertebrates, plant materials and decomposed animal and plant matter.

This polyculture practice makes the best conversion of food items to fish flesh and provides an ecological balance in the pond. This same practice may be applied in Alberta where landowners introduce grass carp and trout species into the same environment.

Complete removal of aquatic plants by grass carp will reduce trout growth and eventually lead to mortality. Trout depend on the aquatic invertebrates. Grass carp may compete with trout indirectly by eliminating the invertebrate food/cover or directly by feeding on invertebrates in the absence of suitable aquatic plants.

So, if you wish to maintain a viable trout population, keep a moderate density of aquatic plants in the dugout. Stock lower numbers of grass carp, and do not eradicate all the plants.

Both stocked trout and grass carp populations may be maintained on artificial rations (pellets) if fed sparingly and infrequently. Trout are more aggressive feeders and will frequently remove surface food before grass carp. Overall, there should be no major constraints to maintaining both fish species in polyculture situations.

The effect of grass carp as an exotic species

When introduced into new environments, exotic species such as grass carp have the potential to introduce diseases into the native fish population. All grass carp introduced or propagated in Alberta have been tested for important parasite, bacterial and viral diseases. Mature fish (brood) and their young are maintained in quarantine environments, with annual disease testing of fingerlings before being introduced into outdoor pond environments. To date, all tests have found no important diseases in the grass carp populations in Alberta.

Concern is expressed over unwanted reproduction of grass carp should they escape into natural lakes and rivers. The potential to displace native fish does exist through the removal of aquatic weeds as natural feeding and breeding habitat. In the native environment of the Amur river basin, grass carp spawn and reproduce under very exacting water temperature and flow conditions. In North America, natural spawning has only been reported in the large river systems of the southeastern U.S. and Mexico. However, natural spawning has not been observed in the colder climate regions of Europe and Canada.

So that escaped fish cannot reproduce, grass carp used in Alberta are sterilized before being used in weed control programs. All grass carp used in the province are sterile and unable to reproduce.

The fish are sterilized by subjecting the fertilized eggs to pressures of 8000 psi for one and one half minutes. The "pressure shock" treatment creates a developing fish with chromosomes in three sets (triploid) instead of the normal two (diploid). The result is a normal fish in all respects except that it cannot reproduce. In other words, the triploid grass carp is "functionally sterile." In addition, each individual fish is tested and confirmed as triploid by close examination of blood cells using a Coulter Counter.

Stocking triploid grass carp for aquatic weed control

Five primary attributes should be considered before stocking triploid grass carp for aquatic vegetation control. These attributes are as follows:

1. pond water temperature,
2. aquatic vegetation density and distribution,
3. grass carp feeding preferences for aquatic plants,
4. weed management objectives and
5. desired time to achieve objectives.

A model developed by Bergersen and Swanson for grass carp applications in Colorado has been selected and modified for application in Alberta (see Table 1).

Aquatic weed growth in ponds is controlled by many factors. Weed growth begins after ice-out in the spring, when water temperatures rise and nutrients become more available.

Some aquatic weeds may appear when water temperatures are below the optimum feeding temperature for the grass carp, while other species become abundant later in the summer. Pond depth as well as the depth and area of the shoreline zone will ultimately determine the amount of sunlight to reach the pond bottom where aquatic weed growth begins.

Wind action and water clarity are also influencing factors. In addition, the weed species composition also changes from pond to pond as well as throughout the season in individual ponds. Changing water temperatures may also contribute to the type and density of weeds consumed by grass carp. These factors make it difficult to prescribe the precise number of fish required to achieve a specific level of weed control.

Table 1. Grass carp stocking model

Obtaining the standard density of fish for your pond size	**Measure the length and width of your pond** in metres. **Multiply length x width, then divide this number by 10,000** (since there are 10,000 square metres in one hectare). This figure gives you the number of hectares. Then, **multiply this number by 400** (since the standard stocking rate is 400 - 25 cm sized grass carp per hectare of water).			Standard number of fish
Water temperature units (dependent on pond location in Alberta)	high medium/high medium medium/low low	South – Medicine Hat to Calgary Northeast – Provost to St. Paul Central – Hanna to Stettler Northwest – Leduc to Athabasca Peace – Valleyview to Fort Vermillion	1.00 1.25 1.30 1.35 1.40	⇦ select factor multiply with above number and enter at right ⇨
Aquatic plant density	low medium high	sparse, few patches, limited vegetation routine plant growth on bottom to top heavy stands emerging through water	0.40 0.60 1.00	⇦ select factor multiply with above number and enter at right ⇨
Aquatic plant distribution	low medium high	shoreline only, less than 1/3 of pond area plants throughout, less then 1/2 of pond area plant abundant, greater then 1/2 of pond area	0.40 0.80 1.00	⇦ select factor multiply with above number and enter at right ⇨
Aquatic plant types – feeding preference of grass carp	low medium high	rushes, cattails, watermilfoil, water buttercup coontail, filamentous algae, reed grass chara, duckweed, pondweed, water plantain	1.30 1.10 1.00	⇦ select factor multiply with above number and enter at right ⇨
Per cent of aquatic vegetation needing to remain	20 - 25% 10 - 20% 0 - 10%	ideal cover for fish, wildlife habitat swimming, minimal cover for fish water storage, aesthetics, fish farming	0.75 0.85 1.00	⇦ select factor multiply with above number and enter at right ⇨
Time necessary to achieve aquatic weed control	3 - 4 years 2 - 3 years 1 year	recreational fishery, wildlife habitat water storage, decoration, aesthetics water storage, fish farming	0.80 0.90 1.00	⇦ select factor multiply with above number and enter at right ⇨
Size of grass carp being stocked*	7.6 - 15 cm 20 - 30 cm 36 - 50 cm 50+ cm	3 - 6 inches in length 8 - 12 inches in length 14 - 2- inches in length 20 plus inches in length	1.5 1.0 0.7 0.6	⇦ select factor multiply with above number and enter at right ⇨
Total number of Triploid Grass Carp required for stocking your pond				

* This model takes into consideration the fact that small grass carp consume vegetation at a faster rate than larger fish and that they also suffer greater mortality due to predators.

Seasonal stocking considerations

Specific stocking periods are recommended for grass carp. If stocking is planned in the spring, the fish should be stocked 4 to 6 weeks after ice-out, preferably after water temperatures reach 10°C or higher. This time allows the grass carp to become acclimatized to the pond and provides an opportunity for them to feed on early growth stages (young shoots, buds etc.) of new aquatic weed growth.

It is possible to stock in the mid to late summer period, providing water temperatures are high and sufficient natural or supplementary feed is available. To ensure successful overwintering survival, fish should be in good body condition by fall. When water temperatures are lower than 10°C in the fall, stocking is not recommended.

After stocking with grass carp, aquatic vegetation growth should be monitored for one to two years. At the end of the second year, adjustments to increase fish numbers can be made, depending on the amount and type of aquatic vegetation remaining.

As the grass carp age, their feeding efficiency will decline, and some will die. Therefore, it may be necessary to restock your pond. This might take place every four to five years to maintain the desired level of weed control. A variety of carp size classes in the pond will also take advantage of the changing vegetation preferences and feeding rates of your fish.

Alternate methods of control

Mechanical (harvest by hand or machine) or chemical control can be applied prior to or after grass carp have been introduced into the pond. This control may be necessary if some of the least preferred (e.g. white water buttercup) species persist or if the pond has an excessive density of aquatic weed growth. After using mechanical or chemical methods, grass carp can be used to control regrowth.

Contact the Aquaculture Section, Alberta Agriculture, Food and Rural Development for more information on mechanical or chemical control of aquatic vegetation.

Artificial feeding programs

Under certain circumstances, grass carp may require supplementary feeding. Vegetation may be depleted early in the growing season if the pond is overstocked or if it contains highly palatable aquatic weed species.

Grass carp will readily consume vegetation like grass clippings, clover, fresh cut alfalfa and most soft-tissued weed species such as dandelions. In fact, the name “grass carp” comes from the fish’s unique ability to consume terrestrial grasses. The fish will eat clippings from golf courses or similar turf areas, although use caution when feeding grass clippings as they may contain pesticides quite toxic to fish.

Fresh cut plants can be broadcast daily over the pond surface. However, avoid spreading more than the grass carp will eat. Grass carp will also readily consume artificial fish feed (fish pellets). However, minimal feeding of fish feed is recommended (a half litre container per day). Fish pellets may contribute to “fishy” water taste and also provide feed for numerous minnow fish species that often inhabit the same pond.

Protecting grass carp from predation

Predatory fish and specific birds prey upon stocked fish in all ponds. If your pond is irrigation-fed, the Northern Pike is likely to be the predator of most concern. Netting (seining) or angling to control this species should be done before stocking fish. Protective screening on water inlet delivery systems will also prevent unwanted fish introductions.

Great blue herons, seagulls, mergansers, kingfishers and cormorants are the most important bird predators on fish in small ponds. Fish smaller than 30 cm (12 in) are very vulnerable to fish and bird predations.

Try protecting stocked fish with overhead predator netting, flagged baler twine placed one meter apart, or some form of water surface cover such as floating plywood or styrofoam sheets. After fish reach 38 cm (15 in), they become less susceptible to predation. *Overview of Techniques for Reducing Bird Predation at Aquaculture Facilities* describes and illustrates techniques for controlling avian predators in stocked fish ponds (see the references at the end of this factsheet).

Temperature and oxygen considerations

Grass carp have been successfully overwintering in farm ponds in Southern Alberta for the past several years. They are tolerant to cold and warm water conditions, providing they are gradually acclimatized to changes in water temperatures.

Their upper temperature range of 30°C or higher exceeds normal peak water temperatures (24 - 25°C) in most Alberta ponds. Compared to most native species, the carp are also tolerant of lower oxygen values, 2 to 3 mg/l compared to 5 to 6 mg/l for most trout species.

However, ponds less than three meters (10 ft) deep and heavily infested with aquatic plant growth may have summer night-time values or late winter values that may approach 0 mg/l dissolved oxygen. In shallow ponds, use some form of artificial aeration to maintain appropriate oxygen levels during the high temperatures of summer and throughout ice-covered winter periods.

Deeper ponds may also benefit from aeration. Recent studies have indicated an improvement in water quality and fish health in aerated pond environments.

Pond licencing and inspection

Grass carp are listed as a permitted species to stock in the province under the *Alberta Fisheries Act* (1997). Pond owners may obtain a "Recreational Fish Culture" application form (a $10 yearly fee) on-line at: www.agric.gov.ab.ca by searching for "Fish Culture License." You can also call 780-427-5083

Triploid grass carp, Arctic char, brook trout, brown trout, rainbow trout and tiger trout are allowed as species acceptable for stocking in private farm ponds. A "Recreational Fish Culture" licence holder can buy grass carp, char and trout species noted above, but may not traffic or sell fish. Grass carp may now be stocked in the formerly Restricted Area of Alberta.

Once stocked into a licenced pond, grass carp may not be legally moved to other locations.

Ecological role of aquatic weeds

You need to understand the importance of aquatic plants in ponds before starting an aquatic weed control or eradication program. Aquatic vegetation may be considered a nuisance in some instances and beneficial in others.

If the pond is overgrown, with heavy dense weeds that are troublesome or unsightly to the user, then they are likely considered a nuisance. However, aquatic vegetation can be beneficial. It provides the following:

- material (substrate) for food for insect communities
- cover and spawning material for fish
- food as well as shelter for waterfowl and other wildlife.

Pond substrate and shoreline stability is provided by some rooted aquatic vegetation. By maintaining sparse-to-moderate levels of aquatic vegetation on the lake bottom, you can still have the benefits of vegetation in lakes. Maintaining this level of vegetation will reduce detrimental affects to both biological and recreational values. The stocking formula provided in this factsheet will help you determine the fish numbers needed to achieve the desired levels of control.

Helpful references

Overview of Techniques for Reducing Bird Predation at Aquaculture Facilities. Curtis, K.S., W.C. Pitt, and M.R. Conover. 1996. The Jack Berryman Institute Publication 12, Utah State University, Logan, 20pp.

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