GRASS CARP RESEARCH AND PUBLIC POLICY IN ENGLAND

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INTRODUCTION

Clearly, this paper will deal with United Kingdon experience only, for while some of the discussion and controversy which has surrounded the grass carp in other countries is apparent, firsthand knowledge of their situations is obviously unavailable. However, from what has been published the situation in the United States and indeed other countries, has been rather similar to that in the UK; grass carp have had their protagonists, more or less cautions, and their antagonists. Some of the latter have been very outspoken, which is not necessarily a bad thing, but occasionally their case has been served badly by wild overstatements and sometimes sheer mis statements. A classic example was a popular article attacking grass carp as an undesirable exotic but the characteristics of the fish described were obviously those of the common carp (Cyprinus carpio L.).

EXOTIC SPECIES

Being islands, the UK has a comparatively limited fauna, including freshwater fish. Generally, also, there is public recognition that exotics can be undesirable or even dangerous; the risk of rabies reaching England from continental Europe via smuggled dogs and cats has received wide publicity. Perhaps stemming from this awareness there has been little public pressure in favor of introducing exotic freshwater fish during the last two decades or so. Occasionally the angling press will carry an article or print a letter in favor of black bass (Micropterus salmoides Lacepede) but these raise little support. Also, there have been well publicized problems with exotic animals: the coypu (Myocastor coypus Kerr), the mink (Mustella vison L.) and the grey squirrel (Sciurus carolinensis Gmelin).

The only exotic freshwater fish which has been successfully introduced into the UK in recent times has been the pike-perch, or zander, (Stizostedion lucioperca L.). This was imported from Germany by the Duke of Bedfore in 1878 (Buckland 1883), but it remained localized until 1963 when it was introduced into the Great Ouse system in East Anglia. From here its spread has been rapid, but the effect on fisheries is difficult to determine; as always the decision between "good" and "bad" in freshwater fisheries involves a value judgment in which objective standards are impossible to apply. It appears that the effect zander have had in England "depends on whether or not you like them" (Dr. R.S.J. Linfield, Regional Biologist, Anglian Water Authority, Personal Communication).

RESEARCH PROGRAMS AND POLICY

It was against this generally conservative background that grass carp (Ctenopharyngodon idella Val.) were imported for experimental work in the UK. In about 1963 the then Chief Officer of Salmon and Freshwater Fisheries, the late F.T.K. Pentelow, was persuaded by the late C.F. Hickling that grass carp might be useful in helping with aquatic weed control. At that time, and it is the same today, the only legislation controlling the importation of freshwater fish was the Diseases of Fish Act, 1937, under which the Ministry of Agriculture, Fisheries and Food (MAFF) could grant licenses. Initially, a license was granted to the Central Electricity Generating Board to import some 15,000 fingerling grass carp from the Far East, which were stocked into the cooling lagoon of a thermal power station on the north-west coast of England where weeds were impeding the circulation of water. Unfortunately, the experiment was not successful for the fish did not survive. The reason was thought possible due to predation by the resident brown trout population of the effect of brackish water, or perhaps both.

Some fish from the consignment, however, were kept in the laboratory where they grew and were eventually given to MAFF. These were the fish wer used in our first experiment in a pond in southeast England (Pentelow and Stott 1965). This trial had a very simple objective; to determine if the fish would in fact eat weeds under our climatic conditions and it was quite successful. Great care was taken in the selection of the site, the pond was spring-fed and the stream flowing from it discharged directly into an estuary where the water quality was so poor as to make the survival of any escapees very doubtful. Naturally, the outflow was screened. The pond was on private ground, well concealed and overlooked by a private house whose occupants, when told of the experiment, readily agreed to keep an eye open for unauthorized intruders.

Following this experiment, a limited number of fingerlings were imported by MAFF in 1965 for more trials. These came in by air from the Far East, but great difficulties were experienced in keeping the fish alive. Several consignments were received but they were invariably in poor condition on arrival and often infected with Ichthyophthirius multifiliis and Gyrodactylus sp. Consequently it was only when fish became more readily available in Europe (Krupauer 1971) that a sufficient stock was obtained enabling more work to be carried out. Two thousand one- and two-summer fish were brought in by road from Hungary in 1976 but these were more than could be accommodated in the Ministry's London laboratory and it was necessary to place the fish in water which were not directly under MAFF supervision. Luckily England is well provided with "stately homes", large country houses situated in private parkland and almost invariably with lakes well supervised by resident staff. These have been very useful for grass carp work. Part of the first Hungarian consignment was stocked in a pond at Woburn Abbey with the interested consent of His Grace the Duke of Bedford, the great grandson of the Duke who introduced zander years earlier.

These fish were subsequently used in the first real experiments which were to examine the relationship between stocking rates and degree of weed control obtained (Stott and Robson 1970). From this point it became apparent that the fish might have a real role to play on controlling aquatic weeds in the UK and this related directly to MAFF's responsibility for and interest in land drainage of agricultural areas throughout the country - an extremely important function in relation to our production. Although the grass carp work remained under the control of MAFF, and was carried out by it, Salmon and Freshwater Fisheries Laboratory, the then recently formed Aquatic Weed Section of the Agricultural Research Council's Weed Research Organization became involved in collaborative research and, of course, MAFF's Land Drainage Division was kept informed of progress.

Although, as explained above, the importation of freshwater fish could be controlled by MAFF only under the Diseases of Fish Act, 1937, the river authorities (local government bodies controlling fisheries, and responsible for pollution control), local land drainage and other water functions (in river basin areas) had received powers under the Salmon and Freshwater Fisheries Act, 1972, enabling them to prohibit the introduction of fish into their areas for whatever reason. By this time, through publications and papers presented at scientific meetings whether published (Stott 1967) or not, the work on "the grass-eating carp" was becoming widely known. The popular media, newspapers, radio and television, all seemed to be quite fascinated by the idea behind the work and considerable interest was aroused. This was undoubtedly welcome, but it led to scores of letters sometimes wanting more information, which was gratifying, but more often making requests for supplies of fish which could not be met. Neither MAFF nor the local river authorities wanted the fish to become widespread. We had to explain to the enquirers that MAFF was discouraging the spread of grass carp until our investigations were completed. This was invariably accepted as logical and proper; indeed the appreciation by the public of the need for a thorough examination of the potential of grass carp and the ecological effects of its grazing has been a great help to the Laboratory.

From the scientific viewpoint, however, it was by no means certain how thorough an ecological study could be made with the limited resources available, but it seemed sensible to concentrate, at least initially, on the effect grass carp grazing might have on indigenous fish species. The really big issue, the possibility that the fish might breed in our water, and spread to become a nuisance which would be impossible to eradicate and expensive to control was, of course, not open to experimentation but by the early '70's from the increasing amount of published work on the fish, particularly in the USSR and Eastern Europe, it was becoming clear that breeding did not readily occur outside the native range and this was very interesting from our point of view. Remarks such as artificial reproduction being "the main and decisive link in their economic development and exploitation" (Vinogradov et al. 1965), were encouraging.

The progress of our work carried out on the effect grass carp grazing might have on other fish species was rather disappointingly slow. Suitable sites, having an adequate population and variety of indigenous species, were difficult to find, for at that time security both from point of grass carp escaping and human interference was given high priority. The earlier work on stocking rates had been done in ponds surrounded by a specially erected barbed wire fence as very little was known about the fish. Some work was, however, successfully completed and bream (*Abramis brama* L.) were shown to grow better in the presence of grass carp than by themselves and survive no worse. There were reports in the literature of similar results with several species (Opuszynski 1968, 1971). Work at sites using fish other than bream was less successful; a series of divided pond experiments taught us little except that grass carp could and would easily leap over the nets we had used to keep populations apart.

FOOD PREFERENCE

Emerging from earlier work on weed control an interest was developed on the food preferences of the fish and this was continued at the Weed Research Organization. There was a certain amount of information available in the literature (Stroganov 1963; Verigin et al. 1963; Zolatova 1966; Krupauer 1967; Fischer 1968; Edwards 1974) and it seemed clear that the fish, particularly when small and at lower ambient temperatures, preferred soft vegetation to hard fibrous plants and that some plants seemed to be avoided. Our own work (Stott and Robson, unpublished data) confirmed this. Thus it was possible that the usefulness of grass carp might have practical limitations and that through selective grazing the fish might actually increase weed biomass in a mixed stand of weeds by removing the competition of the preferred species and thus allowing other plants to increase. This liklihood would be greater at the lower stocking rates designed to reduce the plant biomass to, say, 25 - 50% of its potential. Indeed it has recently been suggested that aiming to stock to achieve a 50% reduction of plant growth potential may be very difficult or even impossible (Fowler and Robson, in preparation).

REPRODUCTION PROBLEMS

In addition to fears that weed control by grass carp might be very difficult to manage, the problem of the fish reproducing naturally still caused concern. Experiments were reported on monosexual culture (Stanley et al. 1975; Stanley 1976a) and this could be a possible approach. However, with more publications giving details on natural breeding outside the normal range of the fish (Inaba et al. 1957; Aliev 1965; Motendov 1969; Vinogradov and Zolotova 1974; Mitrofanov 1975) it began to seem less and less probable that the grass carp would spawn naturally in the UK. Certainly water temperature in some rivers (e.g. R. Trent) receiving a number of heated effluents from power stations might occasionally become high enough, but water velocities are too low to keep the pelagic eggs in suspension for a distance of the order of 200 km which is apparently desirable (Stanley 1976b) and sudden rises in water level, which are apparently necessary to initiate spawning, could only be caused by rain which inevitably decreases water temperature. The rather outside chance that power station cooling water discharges might themselves be suitable spawning sites in other, more swiftly flowing rivers was discounted when it was shown that at temperatures below 20 C the eggs either failed to hatch or, if the did hatch, the embryos were deformed and non viable (Stott and Cross 1973).

WEED CONTROL

Another aspect of the work in the UK needs mentioning. It was never assumed that the grass carp would be the complete answer to our weed control problems and conventional methods would still be needed in some circumstances even if biological control became a practicality. Weed cutting would barely affect the fish but clearly the tolerance of the fish to herbicides was important. The fish is quite tolerant and Tooby et al. (in preparation) have shown that it is in no danger from the herbicides cleared for use in the UK when used at the recommended dosages (Table 1) although its appetite may be temporarily reduced (Table 2) at some concentrations.

CONTROL COSTS

Despite the potential value of grass carp for weed control its usefulness would be limited if it proved to be very expensive and this aspect has been given some attention. For UK conditions it has been assumed that a 50% reduction in weed growth potential is acceptable and can be achieved and maintained by a fish density of between 125-200 kg/ha. From data on fish growth and an assumed constant annual mortality of 50%, the changes in the biomass of a cohort of 12,500 one-summer grass carp, mean weight 10 g, is such that (assuming no limitation due to food shortage, etc.) an initial stocking of 125 kg will control 17 hectares/year (Table 3). Currently 125 kg of one-summer fish imported from Yugoslavia (the only country able to satisfy the recently imposed UK health certificate requirements) cost 1,750 ($3150), making the cost of control 103 ($185) per hectare per year excluding labor. This sum compares very favorably with the aquatic herbicides cleared for use in water in the UK but it is more than the cost of cutting (Table 4). The grass carp costs in this model are believed to be overestimated because the growth data were taken from fish in suboptimal conditions and also large grass carp may well exhibit lower mortality rates than the one assumed. In addition, almost half the cost of the fish was due to transportation and associated costs which could be reduced significantly if the fish were to be artificially bred in the UK. The model is a very simple one, however, and labor charges need to be incorporated in the estimates, nevertheless the indications are that biological control could be economically attractive.

RESEARCH POLICY

It is clear that there is a limit to the amount of useful information which can be gained from the small-scale investigations which have so far been carried out in the UK and, in view of the possible benefits which biological control might bring to weed control, it has been recommended that the grass carp trials should be increased and extended (Stott 1977). A steering committee has recently been established by MAFF through which water authorities (the successors to the river authorities mentioned above) are cooperating with MAFF and the Weed Research Organization in carrying out larger field trials to provide more information and experience with the fish. A shortage of grass carp is holding up the rapid implementation of these plans and a source of new supplies which can meet our health requirements is being sought. It is realized that larger trials hold some risks, for well-meaning but ill-advised anglers may try to take fish and put them in open waters but the chances of damage are not great if breeding does not take place. The next few years are going to be very interesting.

SUMMARY

The current position with regard to grass carp in the UK can be summarized:

1. The fish seems to be potentially useful for water weed control and could be used in conjunction with the aquatic herbicides currently used.

2. The ecological impact of the fish is poorly understood, but since the chances of natural breeding taking place is believed to be low, the risk of permanent damage is virtually nil.

3. The economics look promising but better data on natural growth and mortality rates are needed.

4. More information is needed on the food preferneces of the fish under natural conditions.

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Table 1. Toxicity, 96 hr. L.C.$_{50}$ values, for various aquatic herbicides to grass carp[1/].

Active Ingredient	Herbicide Trade Name	% Composition	96 hr. L.C.$_{50}$ (mg/1)	Max. Concn. of active ingredient (or formulation) in water 1 m deep if recommended rate is applied to surface (mg/1).
Dalapon		85	30,000	3.0 (3.5)
2,4-D Amine Salt		50	1,350	0.4 (0.8)
Diquat	Aquacide	13.5	1,400	2.0 (14.8)
Terbutryne	Clarosan	100 tech.	6.2	0.1
Glyphosate	Roundup	36	14	0.8 (0.5)
Dichlobenil	Casoron	100 tech.	9.5	1.0

1/ Data from: Tooby, T.E. et al. (in preparation).

Table 2. Reduction in amount of *Elodea canadensis* eaten by grass carp in water containing aquatic herbicides.[1]

Herbicide	Recommended dosage (active ingredient) (mg/1)	Reduced feeding observed at; (mg/1)	Food intake depression
Dichlobenil	1.0	1.6	80
Diquat	2.0	18.2	70
Cyanatryn	0.2	1.75	70

[1] Data from: Lucey, J. et al. (in preparation).

Table 3. Change in biomass of a cohort of 12,500 one-summer fish in a one hectare water body, assuming no limitation on growth.

Time	Age of Fish	No.	Mean wt. (g)	Biomass (kg)	Biomass ÷ 4
1st Spring	0+	12,500	10	125	—
2nd Spring	1+	6,250	78	488	122
3rd Spring	2+	3,125	230	719	180
4th Spring	3+	1,563	470	735	184
5th Spring	4+	781	820	640	160
6th Spring	5+	391	1,300	508	127
7th Spring	6+	195	1,800	351	88
8th Spring	7+	98	2,300	225	56

Table 4. Costs, including labor, of an annual herbicided treatment, and biannual mechanical cutting, of aquatic weeds in a standard channel 1 km long, 10 m wide and 1 m deep.

Herbicide (mg/1)	Cost $
"Clarosan" (1% terbu tryne)	
Recommended dose 0.05	229 - 257
Max. permitted dose 0.01	445 - 502
"Casoron GSR" (22% dichlobenil)	
Recommended dose 1.0	504
"Aquacide" (2,4-D Amine salt)	
Recommended dose 1.0	310 - 324
Max. permitted dose 2.0	581 - 610
Manufacturer's max recommended dose 8.0	2,212 - 2,324
Mechanical cutting including weed removal	131