THE RESOURCES AGENCY OF CALIFORNIA
Department of Fish and Game

THE GRASS CARP[1/]

RONALD J. PELZMAN
Inland Fisheries Branch

SUMMARY

In response to a proposal to introduce grass carp, Ctenopharyngodon idella, into California, the life history is briefly reviewed and the desirability of an introduction is evaluated.

Grass carp, also known as white amur, one of the largest members of the carp or minnow family, may reach 100 lb. They are native to those rivers of China and Siberia which drain into the Pacific Ocean. They have been introduced for pond culture into a number of countries, and experimentally for aquatic plant control into the United States. Grass carp can withstand water temperatures from 32 to over 90 F, and oxygen concentrations as low as 0.5 ppm. Spawning occurs from April to mid-August at water temperatures above 68 F. A current of 2 to 5 ft/sec and a rising water level in excess of 4 ft within a 12-hr period are required for spawning. A 16-lb female was reported to contain some 100,000 eggs. Grass carp generally do not reproduce in ponds, and must be induced to do so by injections of fish pituitary extracts. The digestive tract of grass carp is extremely short for a principally herbivorous fish, and about half of its food passes through undigested. Young grass carp feed primarily on zooplankton, while adults are omnivorous, with plant material constituting the bulk of the diet. Grass carp have demonstrated their ability to control aquatic weeds when stocked in sufficient numbers.

It is recommended that the grass carp not be introduced into California waters, and that it remain on the prohibited list of animals which may not be introduced into or possessed in California. If they were stocked into California irrigation systems, they would probably find their way into game fish waters. It is likely that they would survive in many of these waters and reproduce in some. Their impact on game fishes, by direct and indirect competition, would almost certainly be detrimental. If they became established in California's larger rivers, they might become an even greater "pest" than the carp, Cyprinus carpio.

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INTRODUCTION

The grass carp, also known as the white amur, has been suggested for possible introduction into California irrigation systems for the control of aquatic *weeds.* This report briefly reviews its life history, and evaluates the desirability of its introduction.

LIFE HISTORY

The grass carp, one of the largest of the Cyprinidae, has an elongated body with a relatively large head and mouth (Sneed, 1971). Unlike the carp, grass carp lack barbels (Stevenson, 1965). The upper surface of the body is greenish-brown, while the sides and undersurface are silvery (Cross, 1969; Sneed, 1971).

Grass carp may attain lengths to 4 ft (Sneed, 1971), and weights to 100 lb (Cross, 1969; *Sneed,* 1971).

Cross (1959) reported that grass carp take between five and nine years to become sexually mature. Lin (1935) found that the majority of grass carp in the West River, China, were about four years old, and that none of the mature fish were less than three years old. Hora and Pillay (1962) reported that one-year-old grass carp weighed from 0.5 to 1.4 lb and were from 5.9 to 11.8 inches long. They found that two-year-old fish weighed from 4.0 to 5.1 lb, and averaged 23.6 inches in length. Stevenson (1965) found that grass carp in experimental ponds in Arkansas weighed 0.01 lb and were 3.1 inches in length at 6 months of age. Twelve-month-old grass carp weighed 0.8 lb and were 11.0 inches in length, while 18-month-old fish weighed 4.0 lb and were 19.7 inches long. The rate of growth of grass carp is two to three times that of carp (Greenfield, 1970).

The grass carp is native to those rivers of China and Siberia (where it is called the white amur), which run into the Pacific Ocean (Cross, 1969; Greenfield, 1970; Sneed, 1971). It has been introduced, for pond culture, into Taiwan, Malaysia, Japan, Vietnam, Thailand, Hong Kong, Ceylon, and India, as well as, Great Britain, Israel, eastern Europe, Germany, and Holland (Stevenson, 1965; Cross, 1969; Greenfield, 1970). In the United States, the grass carp has been introduced into five state-owned lakes in Alabama, reared at the Marion Fish Hatchery, Alabama, planted in an irrigation pond at Tuscon, Arizona, and kept in artificial ponds in Arkansas (Greenfield, 1970).

Grass carp can withstand water temperatures from 32 F to over 90 F (Stevenson, 1965), tolerate salinities as high as 10% (Doroshev, 1963), and withstand oxygen concentrations as low as 0.5 ppm (Yeh, 1959).

Lin (1935) found that grass carp spawn in the center of large rivers with flows of 12,000 to 20,000 ft/hr, usually below extensive rapids. Nikolskii (1956) reported that a current between 2 and 5 ft/sec is required for spawning. According to Lin (1935), water temperatures from 79 F to 86 F are required. Nikolskii (1956) found that water temperatures must be above 68 F. Spawning takes place after a sudden rise in the river, usually after heavy rains (Greenfield, 1970). Lin (1935) stated that a rise in excess of 4 ft within a 12-hr period is *necessary* for spawning. Spawning during periods of high turbidity appears to reduce predation on the semipelagic eggs (Greenfield, 1970).

Grass carp make a spawning migration, usually in large shoals, and spawning occurs from April to mid-August (Greenfield, 1970).

Lin (1935) reported that a 16-lb female grass carp contained some 100,000 eggs, but believed that all of the eggs would not be spawned at one time. He also found that hatching took place 34 hr *after* fertilization, while Tang, Hwang, and Liu (1963) reported that hatching occurred 24 to 30 hr after fertilization. Shortly after hatching, the larvae swim actively and begin feeding on zooplankton, and to a lesser extent on phytoplankton (Greenfield, 1970).

With the exception of reported pond spawnings in Japan (Anonymous, 1961) and in Taiwan (Tang, 1960), grass carp have not reproduced in pond situations outside their natural habitat (Greenfield, 1970). Spawning has been induced in ponds by injections of fish pituitary extracts (Alikunhi, Sukumaran, and Parameswaran, 1963; Tang, Hwang, and Liu, 1963).

The digestive tract of the grass carp is extremely short for a principally herbivorous fish. At temperatures from 82 to 86 F, food passes completely through the fish in 8 hr according to Hickling (1966). Digestion is incomplete, and about half of the food material passes through undigested (Hickling, 1966). Opponents of the grass carp claim that this fecal material adds to the problem of overfertilization, however, it cannot be considered to be merely waste material, since it provides food for organisms farther down the food chain (Sneed, 1971). Stroganov (1963) reported that the feces of grass carp promoted vigorous growth of plankton. Due to the incomplete digestion, the grass carp must consume large quantities of food. Under favorable conditions, the grass carp will eat more than its own weight of plant material in a day (Cross, 1969). This explains its effectiveness in controlling acuatic vegetation.

Young grass carp begin feeding on zooplankton and phytoplankton shortly after emerging from the egg (Cross, 1969). The animal constituent of the diet is replaced by vegetation before they reach two inches in length (Cross, 1969). This change does not occur rapidly, and there is some doubt as to whether it is ever complete (Cross, 1969). The omnivorousness of grass carp was noted by a number of researchers. Lin (1935) found them to eat grass, leaves, and water plants, as well as small fish, earthworms, silkworm pupae, flesh of freshwater mussels, beef, insects, and even decayed cloth and shoes. Stevenson (1965) reported that fingerlings fed heavily on Daphnia, chopped earthworms, and chironomid larvae. Cross (1969) reported that in his laboratory, grass carp about 9 inches in length ate Daphnia, tubifex worms, and Asellus as well as vegetation. Nikolskii (1954; 1956) reported that the young of grass carp fed on crustaceans, rotifers, and chironomid larvae. Stevenson (1965) suggested that more study is needed to determine whether the grass carp will remain a strict herbivore when stocked in ponds containing a variety of foods. He believed that pond culture conditions in *Asia* may have obscured a possible preference by grass carp for food other than plant life.

Nair (1968) cited numbrous references attesting to the ability of the grass carp to control the growth of aquatic plants. Avault (1965) tested the herbivorous capability of 12- to 16-inch grass carp by introducing one fish into each of 10 experimental pools, each of which had been planted with 12 species of aquatic plants. He estimated this to represent 685 grass carp per surface acre. Within

2 to 3 weeks complete control was attained of naiad, Naas guadalupensis; pondweed, Potamogeton diversifolius; waterweed, Elodea densa; muskgrass, Chara sp., duckweed, Spirodela polyrhiza; needlerush, Eleocharis acicularis; eelgrass, Vallisneria americana; and Pithophora sp. After the elimination of these weeds, there was a 2- to 3-week interim during which the fish discontinued feeding. During the following 2 weeks, however, the fish ate, and finally eliminated from the pools, alligatorweed, Alternanthera philoxeroides; parrotfeather, Myriophyllum brasiliense; Eurasian milfoil, M. spicatum; and water hyacinth, Eichhornia crassipes. Stevenson (1965) placed six grass carp averaging 2.0 lb into a quarter-acre pond (equal to planting 24 fish per surface acre), which was heavily populated with muskgrass, naiad, and smartweed. In two months, the aquatic plants were reduced, but not eliminated; however, the fish were supplied with commercial feed during this period. Forty 2-inch fingerlings were introduced into a 2-acre pond on a Tucson, Arizona, golf course. After the first year, the fish were very effective in keeping the pond free of undesirable plant growth (Greenfield, 1970). According to Greenfield, a single grass carp which was introduced into a weed-choked, half-acre pond caused a noticeable reduction in weed intensity. Kuronuma and Nakamura (1957) found that aquatic weeds could be controlled in farm ponds in one year by planting the ponds with about 12 grass carp per surface acre. Sills (1970) reported that fingerling grass carp 3 to 4 inches long, when stocked into heavily vegetated ponds at rates of 100, 150, and 250 fish per surface acre, were unable to control the established growths. Sills (1970) stocked 2,000 grass carp weighing from 0.25 to 0.5 lb into a 20-acre pond that had a five-year history of excessive growths of naiad and pondweed. He reported that all rooted aquatic vegetation disappeared within six weeks, and that there was none present during the remainder of the year.

At an experimental pond in London, England, Stott and Orr (1970) estimated that 1,499 grass carp consumed 13.4 tons of waterweed and 8.4 tons of parrotfeather from April 23 to September 17, 1968. Parker (1969) discussed feeding experiments at Ealacca in which it was estimated that 150 fish ate 9.5 tons of grass in two months.

Stevenson (1965) reported that grass carp brought to the Fish Farming Experimental Station, Stuttgart, Arkansas, were infested with Ichthyophthirius multifiliis and Lernaea cyprinacea. Grass carp brought into Hungary from China were infected with Achromobacter sp., Pseudomonas sp., and Aeromonas punctata (Szakolczai and Molnar, 1966). Considerable mortality resulting from Ichthyophthirius multifiliis occurred in fish brought to the Salmon and Freshwater Fisheries Laboratory, London, from Hong Kong and Taiwan (Cross, 1969).

The flesh of the grass carp has an excellent flavor and texture, but has a great many floating rib bones (Sneed, 1971). It is well known as a food fish in the Far East (Pentelow and Stott, 1965).

Grass carp usually jump when seined (Sneed, 1971). According to Martin (1970), visitors from countries in which the grass carp is found have reported that hatchery personnel there have been killed by collisions with large grass carp during seining operations.

Anglers have taken grass carp on spinners, spoons, streamer flies, dry flies, dead and live minnows, liver, worms, algae, and even grass (Sneed, 1971). According to Sneed (1971) they are extremely wary and are strong swimmers, but will jump only occasionally after being hooked. If they do jump they are in a class with tarpon.

CONCLUSIONS AND RECOMMENDATIONS

Grass carp can effectively control aquatic weeds. However, they would almost inevitably spread to California's game fish waters if they were brought in for weed control purposes. The hardy grass carp could create problems comparable to and possibly worse than those caused by the common carp, which is generally considered to have been an undesirable introduction.

Grass carp eat animal food as well as aquatic vegetation, and could therefore compete directly with game fishes which utilize small invertebrates in or around aquatic vegetation, particularly the young of the warmwater species.

The grass carp is capable of eating great quantities of plant material; however, a possible preference for other foods may have been obscured under pond culture conditions (Stevenson, 1965).

Large populations of grass carp pulling up roots and rhizomes would probably keep many waters in a turbid state and thereby interfere with the reproduction and feeding of sight-feeding game fishes as now occurs widely as a result of feeding activities of the common carp.

Young grass carp would compete directly with young game fishes, which also feed primarily on invertebrates.

The grass carp might also cause problems in some waters by returning a great deal of undigested material to the water.

Grass carp could probably establish thriving wild populations in the larger California rivers. They tolerate higher salinities than most freshwater species, and might have a profound effect in the Sacramento-San Joaquin Delta.

For these reasons, it is recommended that grass carp not be introduced into California, and that its possession remain prohibited in California except for display in public aquariums, as now required by Section 671(e) 9(c) of Title 14, California Administrative Code.

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