INTENSIVE CULTURE OF WHITE AMUR IN CAGES

TOMMIE G. CRAWFORD, Department of Biological Sciences, Arkansas State University, State University, AR 72467

JOHN K. BEADLES, Department of Biological Sciences, Arkansas State University, State University, AR 72467

Abstract: From 3 May 1979 through 9 November 1979, cage culturing of fingerling white amur, *Ctenopharyngodon idella* was conducted utilizing alfalfa pellets, catfish pellets, alfalfa and bermuda grass hay or aquatic vegetation as feeds. Feed utilizations, feed conversion ratios and growth rates were analyzed. Feed conversion ratios ranged from 10:1 to 30:1. Fish fed the catfish pellets or hay yielded poor growth. Those fed the alfalfa pellets were larger and achieved the expected stocker size. Mortality was a problem throughout the study period. Handling stress, agonistic behavior, and bacterial and fungal infections appeared to have been the causative agents.

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Cage culture of fish refers to the raising of fish in enclosed containers (cages) suspended in a body of water. Cage culture began in Asia in the early 20th Century (Hickling 1962). Since then, its use has spread to other regions of the world. In the United States, cage culture has dealt chiefly with the rearing of catfish (Collins 1970, Schmittou 1970, Holmes et al. 1974, and Hill 1975). To avoid predation, it has been demonstrated that cage culture can be used to grow fingerling fish to a stocker size. This has been reported for channel catfish *(Ictalurus punctatus)* by Hatcher (1971) and Hess (1976), striped bass *(Morone saxatilis)* by Powell (1973) and largemouth bass *(micropterus salmoides)* by Snow and Wright (1976).

White amur, because of development of hatchery techniques which can supply large numbers of fish (Bailey and Boyd 1970), has become important in some areas as a means of controlling excessive aquatic vegetation in reservoirs (Avault 1965, Avault et al. 1968, Sills 1970, Sneed 1971, and Bailey 1975). Cage culture of the white amur could be beneficial in several ways:

1. The white amur could be raised in cages near the release area. This would eliminate hauling large poundages and allow the release of a larger, acclimated fish.
2. Predation on fingerling fish could be reduced.
3. A reduction in labor at harvest time could be possible as no seining would be required.
4. Extra pond space in hatcheries would be made available for other fish species, as fingerling white amur could be reared in cages away from the hatchery environment.

The purpose of this study was to determine if white amur could be raised to stocker size (227 to 340 g) in cages in 1 growing season, utilizing 4 different feed sources. Growth, survival and condition of fish fed different feeds were compared.

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METHODS

The study was conducted in Lake Frierson, an Arkansas Game and Fish Commission lake, in northeast Arkansas. The study site was located approximately 95 m north of an earthen dam in water ranging from 3.6 to 4.2 m in depth.

Eight cages were utilized for the study. Six of the cages were 1 m x 1 m x 2.4 m, while two were 1 m x 1 m x 1 m. The cages were constructed of cypress frames and were enclosed by asphalt coated hardware cloth of 1 cm^2 mesh. The cages were anchored in a row of trees by a 1.5 cm diameter steel cable.

Fish were stocked in the cages on 3 May 1979 at a stocking density of 187 fish per m^3. At stocking the fish had a mean weight of 31.8 g/fish in the 6 large cages and 36.3 g/fish in the 2 small cages.

Fish in 2 of the large cages were fed a floating, pelleted catfish ration (30% protein, ConAgra, Inc.). The fish in the second pair of larger cages were supplied a diet of alfalfa pellets (15% protein). Fish in the final 2 large cages were fed a diet of alfalfa and bermuda grass hay (10% protein). The fish in the 2 small cages were supplied diets of freshly harvested aquatic vegetation. Fish in 1 small cage were supplied coontail *(Ceratophyllum demersum,* 11% protein), while fish in the second small cage were initially fed water smartweed, *(Polygonum punctatum)* and later aquatic primrose *(Jussiaea repens,* 6% protein).

The catfish ration was fed by use of automatic feeders at a rate of 1 percent of body weight, every 3 hours, during a 15-hour period each day. The alfalfa pellets were fed by use of demand feeders. Hay and aquatic vegetation were fed by hand twice daily in amounts to ensure that fish had all they would consume. Fish were offered feed from 5 May 1979 until the completion of the study on 9 November 1979.

Sampling of the fish began on 15 May 1979 and continued weekly until 9 August 1979 when it was discontinued in an attempt to determine if sampling stress was causing mortality. The sampling method involved weighing and measuring a random sample of 25 fish per large cage and 10 fish from each small cage.

Aquaria studies were conducted in an attempt to determine if agonistic behavior was occurring and affecting mortality rates.

In an attempt to maintain the original stocking density, fingerling fish were added to all cages on 8 June 1979 and 28 August 1979, and to 1 catfish ration cage on 5 October 1979.

Water quality measurements were taken biweekly at the cage site and at 2 control sites. Measurements included: temperature and D.O. at 0.5 m intervals, light penetration, and hydrogen ion concentration (pH) from both the limnetic and hypolimnetic zones.

At the termination of the study, the cages were pulled ashore. The fish were removed, weighed and measured.

Arithmetic means for fish weight and weight gains were computed for fish fed each diet, as well as for physicochemical water quality determinations. Data were analyzed by computer using Minitab (Ryan et al. 1976). Specific statistical tests employed were: CORR, which computed linear correlations for weight gains of fish fed different feed sources; POOL, which computed T-ratios to test for significant differences between mean weight gains of fish fed different feed sources; and AOVO, which computed analysis of variance for mean gains of fish fed different feed sources. Weight gain data were analyzed for the first 14 weeks (when weekly sampling was occurring), while water quality data were analyzed for the entire study period.

RESULTS

Fish fed catfish ration and hay grew poorly and fish supplied the aquatic vegetation diets lost weight (Table 1). Several fish fed the aquatic vegetation diets were noted to possess deformations of the spine. Fish fed alfalfa pellets achieved the expected stocker size (Table 1).

Table 1. Survival and growth of white amur grown in cages utilizing catfish pellets, alfalfa pellets, hay or aquatic vegetation as feed sources.

	Catfish Pellets	Alfalfa Pellets	Hay	Aquatic Vegetation
Number of Fish Stocked	1767	1540	1350	501
Number of Fish Recovered	866	675	562	262
Percent Survival	49	44	42	52
Mean weight at Stocking (g/fish)	31.8	31.8	31.8	36.3
Mean Weight at Harvest (g/fish)	47.1	265.5	45.4	26.0
Mean Weight Gain (g/fish)	16.7	234.3	14.4	-10.3
Mean Weekly Weight Gain (g/fish/week)	0.6	8.9	0.5	-0.4

Statistical analysis of mean weight gains for the first 14 weeks of the study indicated no significant difference ($P > 0.05$) between fish fed different feed sources.

Once weekly sampling was discontinued, a difference in weight gain was noted between fish using different feed sources. Mean weekly weight gains ranged from -0.4 g for fish fed aquatic vegetation to 8.9 g for fish fed alfalfa pellets (Table 1).

Initial growth was slow or non-existant and was followed by sporadic gains and losses (Fig. 1). This pattern of growth continued until weekly sampling was discontinued on 9 August 1979. Accelerated growth was then noted in fish fed alfalfa pellets, maintenance levels were observed in fish fed catfish pellets, and hay, and weight loss continued in fish fed aquatic vegetation (Fig. 1).

Feed conversion ratios were high, ranging from approximately 10:1 for alfalfa pellets to approximately 30:1 for hay (Table 2). A feed conversion ratio could not be computed for the aquatic vegetation, due to the weight loss which occurred among fish.

Mortality was a significant problem throughout the study (Table 1, Figs. 2 & 3). A total of 5158 fish were stocked during the course of the study, and only 2365 fish were removed at the close of the study. Fish began to die 1 week after stocking. Dead fish examined had missing scales and suffered from fungal infections of *Saprolegnia* and *Achyla*. Treatments were initiated which involved dipping fish in a 25 ppm formalin solution each time they were handled. Fungi was not noted on fish again during the remainder of the study.

As water temperatures warmed and cages were restocked on 8 June 1979, mortalities increased dramatically. Examinations revealed that fish were suffering from an acute case of MAS (Motile *Aeromonas* septicemia). Fish were heavily infected with *Aeromonas hydrophila*, the causative organism and exhibited symptoms described by Lewis and

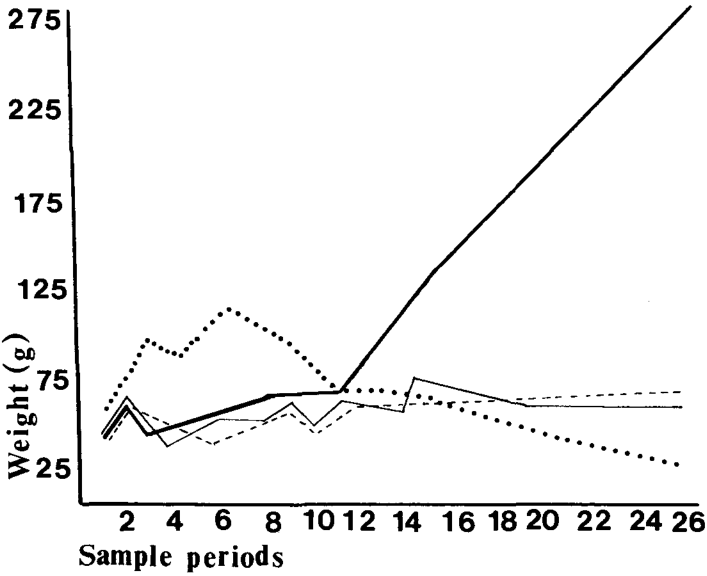

Fig. 1. Weekly growth rates of fish fed catfish pellets (---), fish fed alfalfa pellets (__), fish fed hay (__) and fish fed aquatic vegetation (••••).

Plumb (1979). Oral treatments of 3.5 g of Terramycin (oxytetracycline) per 45 kg of fish proved unsuccessful as did subsequent oral treatments of 5.0 g per 45 kg of fish. Treatment included mixing pelleted feeds (catfish and alfalfa pellets) with cooking oil and then coating the feed with the drug. Fish being fed aquatic vegetation and hay received no treatment because of the difficulty in administering the drug.

Mortality leveled off until 28 August 1979, when, after restocking, mortality sharply increased (Figs. 2 & 3). Examinations revealed that fish were again suffering from MAS. Treatments of 5.0 g of Terramycin (oxytetracycline) per 45 kg of fish were administered to fish being fed with catfish and alfalfa pellets and mortalities decreased more rapidly than during the earlier infection.

Studies conducted in aquaria revealed agonistic behavior occurring between fish. This usually involved acclimated fish chasing and nipping fins of newly stocked fish, and was especially prevalent when smaller fish were introduced with the acclimated fish.

Water quality characteristics varied seasonally or with daily weather conditions and virtually no differences were noted between the cage site and the control sites.

The only noted effect upon the surrounding environment was the attraction of native biota to the cage site. Large numbers of aquatic insects were noted emerging near the cage site, and were often observed resting upon the cages. Throughout the study bluegill, *(Lepomis macrochirus)*, longear sunfish *(Lepomis megalotis)* and redear sunfish *(Lepomis microlophus)* appeared to be attracted to the cages where they fed on the above aquatic insects or pelleted feed that was split or thrown into the water by automatic feeders. Other native fishes observed near the cage site included largemouth bass *(Micropterus salmoides)*, blue catfish *(Ictalurus furcatus)* and yellow bullheads *(Ictalurus natalis)*.

Table 2. Feed conversion data for white amur grown in cages utilizing catfish pellets, alfalfa pellets, hay or aquatic vegetation as feed sources.

	Catfish Pellets	Alfalfa Pellets	Hay	Aquatic Vegetation
Weight of Fish Stocked (kg)	48.6	51.3	44.0	16.3
Weight of Fish Harvested (kg)	88.6	91.8	44.0	6.8
Weight of Mortalities (kg)	26.0	55.0	15.0	7.9
Net Weight Gain (including mortalities, kg)	65.0	95.5	15.0	-1.6
Feed Consumed (kg)	1022	977	453	194
Feed Conversion (Feed Consumed/ Net Weight Gain)	15.7:1	10.2:1	30.2:1	[1]

[1]Due to negative weight gains no calculation was made for this feed source.

DISCUSSION

The poor relative condition, extremely poor growth rate and the high mortality of fish obtained in the study indicated that diets utilized, with the possible exception of the alfalfa pellets, were deficient in some aspect.

The presence of spinal deformations among fish fed diets of aquatic vegetation strongly indicated the deficiency of one or more essential vitamins. Dupree (1966) and Halver (1970) noted that such abnormalities are frequently present in fingerling fish receiving a diet deficient in thiamine and ascorbic acid.

Poor yields were obtained on the floating catfish ration possibly because the fish were unable to utilize a diet containing large amounts of animal protein. Poor growth on catfish ration was also noted by Shireman et al. (1978) when white amur were raised under intensive culture conditions.

Fish did not perform well on the alfalfa and bermuda grass hay apparently due to the unpalatability of the hay used. It was observed that fish would only consume the leafy portion of the hay. The majority of the hay was coarse, with a high stem content.

The increased growth rates in fish fed alfalfa pellets, after weekly sampling was discontinued (Fig. 1), indicated that the lack of growth early in the study was due at least in part to sampling stress. Several factors contributed to the mortality problem experienced in this study. Considered foremost of these was stress placed upon fish by handling and sampling. During sampling activities, fish could be observed striking the sides of the cages. This could result in injury to the fish and allow bacteria to become established.

Restocking cages (in order to keep stocking densities constant) resulted in marked increases in mortality (Fig. 2). This was possibly due to stress associated with handling the

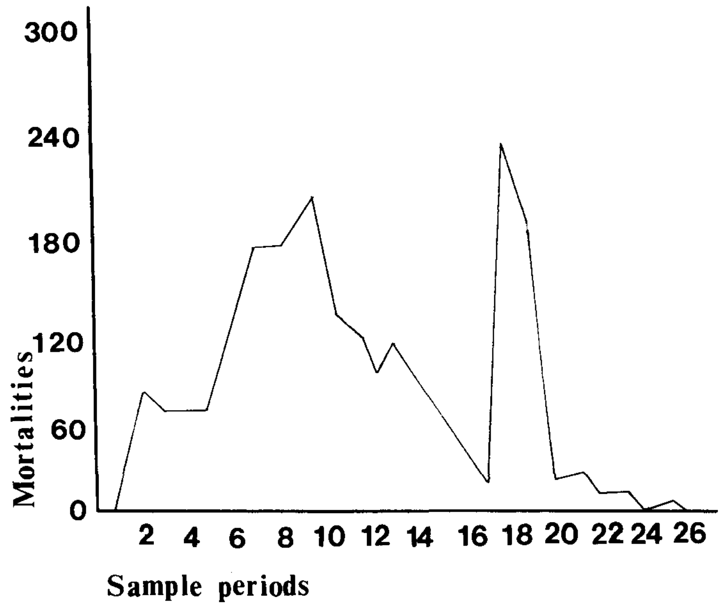

Fig. 2. Weekly sumation of total mortalities.

fish, as well as agonistic behavior on the part of acclimated fish toward newly stocked fish. Studies conducted in aquaria supported this observation. Konikoff and Lewis (1974) noted similar behavior in caged catfish.

Relatively high temperatures at stocking could have caused fish to experience difficulty in acclimating to the water of Lake Frierson, and therefore contributed to the mortality problem. The temperature of 22° C when fish were stocked on 3 May 1979 was well above the 13° C suggested by Schmittou (1969) as the maximum temperature for cage stocking.

Although feed conversion values for this study were quite high, the alfalfa pellet value was similar to the 10:1 value obtained when white amur were fed *Spirogyra* (Stanley and Jones 1976), and all values were less than the 42:1 noted for white amur fed filamentous algae (Prikhod'ko and Lupacheva 1967).

Feed conversion values would not have been affected by the loss of feed into the lake. The catfish ration was a floating feed and any lost to the lake would have been due to the action of the automatic feeders. The quantity of feed lost in such manner was small and would have had little effect upon the feed conversion ratio. The alfalfa pellets used were too large to fall through the mesh of the cage. Similarly, the small quantity of hay lost through decomposition in the bottom of the cages would not have altered feed conversion ratios.

There was no evidence that fish in any of the cages were supplementing diets by feeding on natural food organisms. The pathological examinations conducted did not reveal any food items other than the feeds given.

Of the 4 diets offered, alfalfa pellets were best utilized. Only fish on this diet passed fecal material when handled, indicating active feeding. Other obvious indications of utilization were the superior gains obtained on this diet. This feed source appeared to have acceptable palatability.

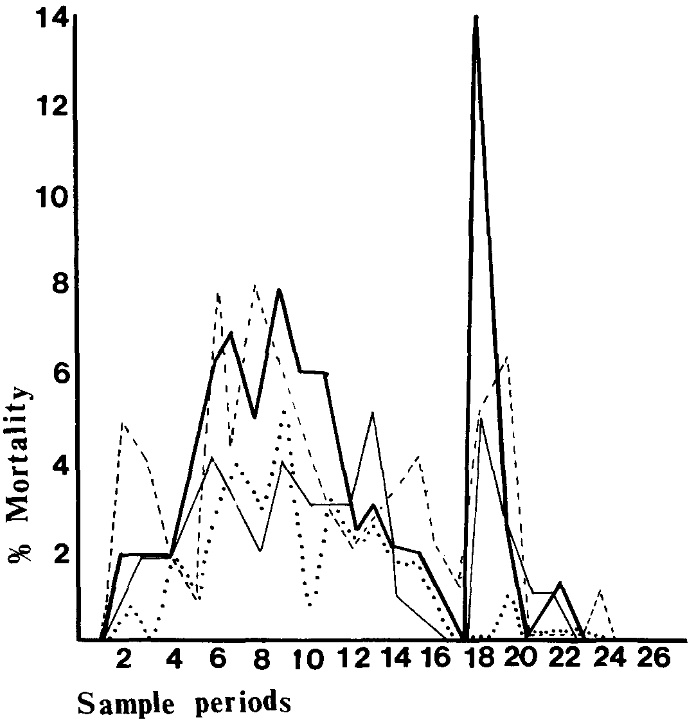

Fig. 3. Weekly mortalities of fish fed catfish pellets (---), fish fed alfalfa pellets (__), fish fed hay (__) and fish fed aquatic vegetation (•••).

Water quality was not affected by the cage culture operation. No significant differences occurred in water quality due to the tremendous dilution of waste products and dissolved feed which occurred in the water of the reservoir. Similar findings were reported by Murrell (1973) and Loyacano and Burch (1977), when much larger biomasses of channel catfish were raised in cages.

The loss of small amounts of feed by the automatic feeders, along with an increase in natural food organisms (due either to the presence of metabolic waste and/or the presence of the surface area of the cages), were responsible for the attraction of native fishes.

This study demonstrated that stocker size white amur can be raised in cages utilizing alfalfa pellets as a feed source. However, many problems emerged and future cage culture of this fish should utilize some methods different from those in this study.

Foremost among methods which should not be used are frequent sampling and handling of fish. As much effort as possible should be made to ensure that fish in cages are not excited. Restocking of cages should be done sparingly, and with fish of the same size as those already in the cages. This could eliminate the apparent agonistic behavior that occurred during this study.

Operations involving cage culture of the white amur need to be started in early April before water temperatures warm and should utilize new plastic meshes as cage materials to diminish the effect of abrasiveness of cage materials on fish.

LITERATURE CITED

AVAULT, J. W. 1965. Preliminary studies with grass carp for aquatic weed control. Prog. Fish Cult. 27:207-209.

AVAULT, J. W., R. O. SMITHERMAN, and E. W. SHELL. 1968. Evaluation of eight species of fish for aquatic weed control. FAO Fisheries Report 44. VII E-3:109-122.

BAILEY, W. M. 1975. Operational experiences with the white amur in weed control in Arkansas. Pages 75-78 *in* Proc. of a symposium on water quality management through biological control. Dept. of Environmental Engineering Sciences. Univ. of Florida, Gainesville, Fla.

BAILEY, W. M., and R. L. BOYD. 1970. A preliminary report on spawning and rearing of grass carp *(Ctenopharygodon idella)* in Arkansas. Proc. Ann. Conf. S.E. Assoc. Game & Fish Comm. 24:560-569.

COLLINS, R. A. 1970. Cage culture of catfish in reservoir lakes. Proc. Ann. Conf. S.E. Assoc. Game & Fish Comm. 24:489-496.

DUPREE, H. K. 1966. Vitamins essential for growth of channel catfish. Bureau of Sport Fisheries and Wildlife. Tech. papers, 7.

HALVER, J. E. 1970. Nutrition in marine aquaculture. Pages 75-102 *in* W. J. McNeil, ed. Marine Agriculture. Oregon State Univ. Press, Corvalis.

HATCHER, R. M. 1971. Cage culture of channel catfish. Conf. Proceedings: Producing and marketing catfish in the Tennessee Valley. Tennessee Valley Authority Bulletin Y-38. 96pp.

HESS, T. B. 1976. Cage culture of channel catfish for supplemental stocking. Final report project F-26-3. Georgia Dept. of Natural Resources, Game and Fish Division. Atlanta. 9 pp.

HICKLING, C. F. 1962. Fish culture. Faber and Faber, London. 295pp.

HILL, T. K. 1975. Comparisons of albino and normal channel catfish grown in cages in a pond. Proc. Ann. Conf. S.E. Assoc. Game & Fish Comm. 28:231-239.

HOLMES, D. W., V. M. DOUGLAS, and R. T. LACKEY. 1974. Pond and cage culture of channel catfish in Virginia. J. Tenn. Acad. Sci. 49:74-78.

KONIKOFF, M. and W. M. LEWIS. 1974. Variation in weight of cage reared channel catfish. Prog. Fish Cult. 36:138-144.

LEWIS, D. H. and J. A. PLUMB. 1979. Bacterial diseases *in* J. A. Plumb, ed., Principle diseases of farm raised catfish, Alabama Agr. Exp. Stn., Southern Cooperative Series No. 225. 96pp.

LOYACANO, H. A. JR. and M. M. BURCH. 1977. Effects of cage culture of catfish upon water quality in reservoirs. Georgia J. Sci. 35:5-11.

MURRELL, J. L. 1973. The intensive culture of channel catfish, *Ictalurus punctatus* (Raf.), in the intake and discharge canals of a steam electric generating station, Trinidad, Texas. M.S. thesis. Texas A & M Univ., College Station. 103pp.

POWELL, M. R. 1973. Cage and raceway culture of striped bass in brackish water in Alabama. Proc. Ann. Conf. S.E. Assoc. Game & Fish Comm. 26:345-356.

PRIKHOD'KO, V. A. and L. I. LUPACHEVA. 1967. The diet of white amur. Ryba Khoz., 3:58-60, Moscow. [in Russian].

RYAN, T. A., B. L. JOINER, and B. F. RYAN. 1976. Minitab student handbook. Duxbury Press. North Suitaute, Mass. 341pp.

SCHMITTOU, H. R. 1969. Cage culture of channel catfish. Pages 72-74 *in* Proc. 1969 Fish Farming Conf. Texas Agr. Ext. Ser. Texas A & M Univ., College Station.

SCHMITTOU, H. R. 1970. The culture of channel catfish, *Ictalurus punctatus* (Raf.), in cages suspended in ponds. Proc. Ann. Conf. S.E. Assoc. Game & Fish Comm. 23:226-244.

SHIREMAN, J. V., D. E. COLLE, and R. W. ROTTMAN. 1978. Growth of grass carp fed natural and prepared diets under intensive culture. J. Fish Biol. 12:457-463.

SILLS, J. B. 1970. A review of herbivorous fish for weed control. Prog. Fish Cult. 32:158-161.

SNEED, K. E. 1971. The white amur, a controversial biological control. Am. Fish. Farmer. 2:6-9.

SNOW, J. R. and C. F. WRIGHT. 1976. Rearing largemouth bass fingerlings in cages. Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies. 29:74-81.

STANLEY, J. G. and J. B. JONES. 1976. Feeding algae to fish. Aquaculture. 7:219-223.