A Finishing System for Large Tilapia

Work Plan 7, Study 3

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Introduction

Pond carrying capacity is largely determined by management practices. Earlier work on semi-intensive culture of Nile tilapia *(Oreochromis niloticus)* using manure or inorganic fertilizers indicated that carrying capacity might reach 2,000 to 3,000 kg/ha (Diana et al. 1991a, b; Knud-Hansen et al. 1991). As stocking density is increased in fertilized ponds, carrying capacity remains largely the same and density-dependent growth occurs (Diana et al. 1991b). Thus, the ultimate size of fish at harvest is largely related to density stocked in fertilized ponds, while biomass at harvest is more consistent regardless of stocking density. Maximum size at harvest for these fertilized ponds is approximately 250 g for fish grown five months.

Increasing the size at harvest of tilapia requires more intensive management, which largely involves supplemental feeding. CRSP experiments with supplemental feeding indicated that tilapia can reach 500 g in 5 months when feed and fertilizer are provided in combination (Diana et al. 1994, 1995). Such experiments were done at fish densities of 3 fish per m^2, which would cause density-related declines in growth for fish in fertilized ponds. However, the addition of supplemental feed increased the growth rate of fish stocked at high density, and resulted in a higher carrying capacity for the pond. The limit on such feeding and density increases would occur when conditions in the ponds reach limiting levels due to increased oxygen demand, build up of metabolites, or other factors which produce poor water quality. Such a limit to tilapia production was demonstrated for Honduran ponds at 3 fish/m^2 (Green 1992), while Diana et al. (1994) found no decline in water quality for tilapia stocked at 3 fish/m^2 in Thai ponds, and Diana and Lin (1996) found no decline in water quality even up to 9 fish/m^2. In the latter studies, concomitant fertilization probably helped maintain reasonable water quality.

Another possible system to grow large tilapia under intensive culture would be to grow tilapia in submerged cages within tilapia ponds. In such a system, waste feed, feces, and excretory products of the caged tilapia would increase nutrient levels for the tilapia at large in the pond, possibly resulting in their rapid growth as well. The limits to such a system would be how many fish caged fish a pond could support, and how many fish could be supported in each cage. The purpose of this experiment was to determine if tilapia could be grown to large sizes in cages submersed within ponds used for tilapia culture. This is a logical extension of earlier work on polyculture of *Clarias* in cages with tilapia in ponds (Lin and Diana, 1995), and would allow both a finishing system and grow out system with limited infrastructure.

The objective of this study was to evaluate caging densities and pond loading rates for tilapia caged and fed intensively in ponds with smaller

Table 1. The biomass, number, and mean size of tilapia stocked and harvested from each pond and cage.

Pond	Cage	At Stocking			At Harvest		
		Number	Biomass	Mean Size	Number	Biomass	Mean Size
L1		626	1.6	2.6	496	87.0	175.4
	L16	16	6.4	400.0	17	15.4	905.9
	L16	16	6.4	400.0	16	13.9	868.8
	L32	32	11.4	356.3	23	19.5	847.8
	L32	32	11.7	365.6	20	16.0	800.0
	L64	64	22.0	343.8	48	40.4	841.7
	L64	64	22.3	348.4	11	7.7	700.0
L2		626	1.8	2.9	522	57.8	110.7
	L16	16	5.1	318.8	7	3.9	557.1
	L16	16	5.3	331.3	5	3.2	640.0
	L32	32	11.7	365.6	2	1.4	700.0
	L32	32	11.5	359.4	3	1.8	600.0
	L64	64	22.3	348.4	19	13.1	689.5
	L64	64	22.2	346.9	3	1.8	600.0
L3		626	1.7	2.7	543	79.1	145.7
	L16	16	6.0	375.0	15	11.1	740.0
	L16	16	7.1	443.8	16	11.7	731.3
	L32	32	10.3	321.9	30	20.0	666.7
	L32	32	11.1	346.9	30	19.4	646.7
	L64	64	22.5	351.6	26	16.6	638.5
	L64	64	23.3	364.1	45	29.3	651.1
H1		626	1.8	2.9	530	80.4	151.7
	H16	16	6.5	406.3	9	5.2	577.8
	H32	32	11.3	353.1	3	1.5	500.0
	H64	64	20.0	312.5	43	25.4	590.7
	H64	64	21.7	339.1	24	12.0	500.0
	H128	128	41.6	325.0	29	16.0	551.7
	H256	256	88.7	346.5	63	32.4	514.3
H2		626	1.6	2.6	578	97.6	168.9
	H16	16	5.9	368.8	15	11.7	780.0
	H32	32	11.4	356.3	13	8.9	684.6
	H64	64	22.5	351.6	63	56.1	890.5
	H64	64	21.9	342.2	20	13.5	675.0
	H128	128	45.1	352.3	48	37.7	785.4
	H256	256	87.4	341.4	34	25.9	761.8
H3		626	1.8	2.9	559	84.6	151.3
	H16	16	6.8	425.0	6	4.4	733.3
	H32	32	10.5	328.1	8	4.9	612.5
	H64	64	22.8	356.3	11	7.0	636.4
	H64	64	21.5	335.9	7	4.0	571.4
	H128	128	43.0	335.9	33	19.3	584.8
	H256	256	85.6	334.4	23	15.8	687.0

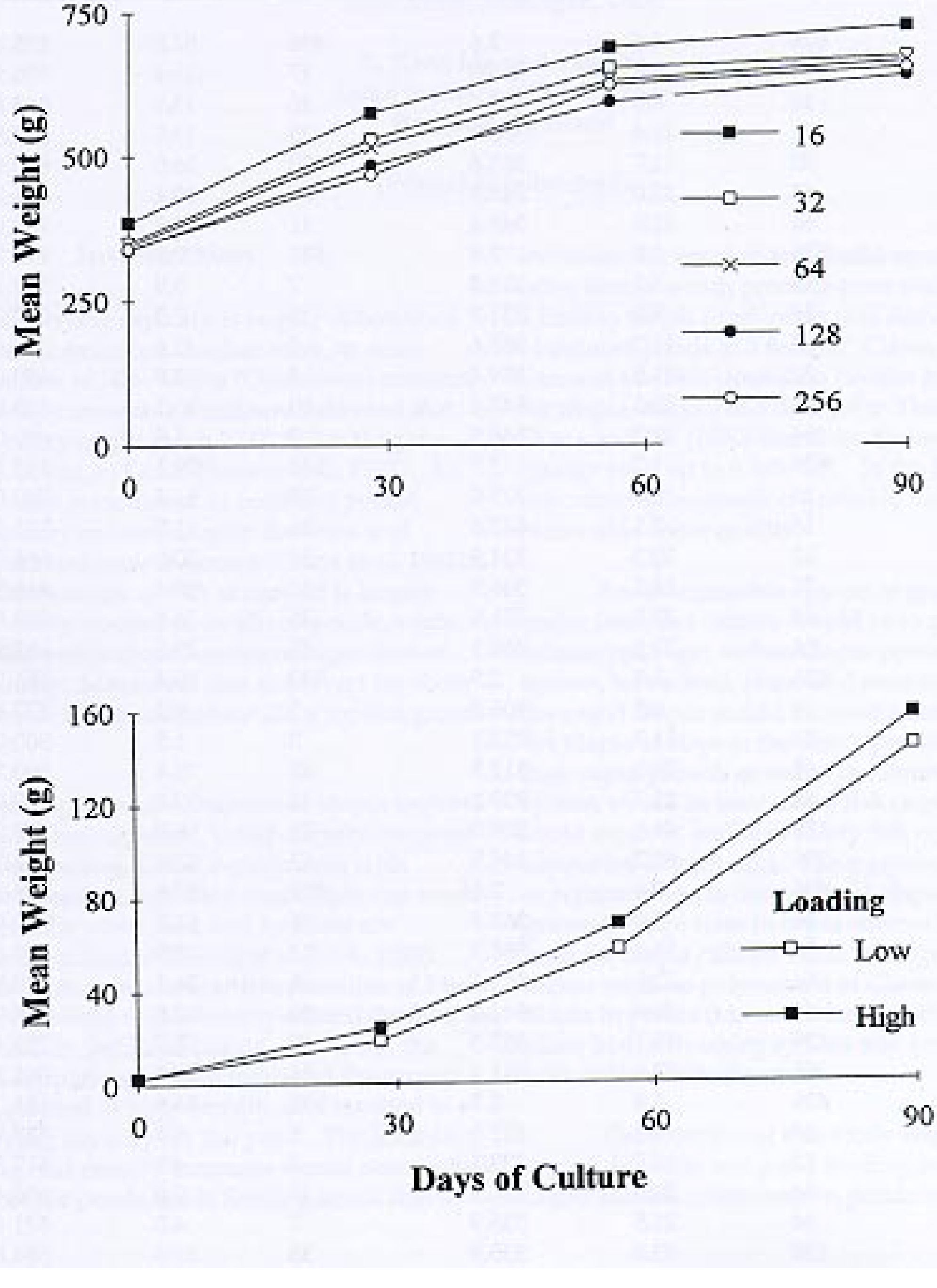

Figure 1. Changes in mean weight during culture for tilapia in cages at different densities (upper) and in ponds with different cage loading rates (lower).

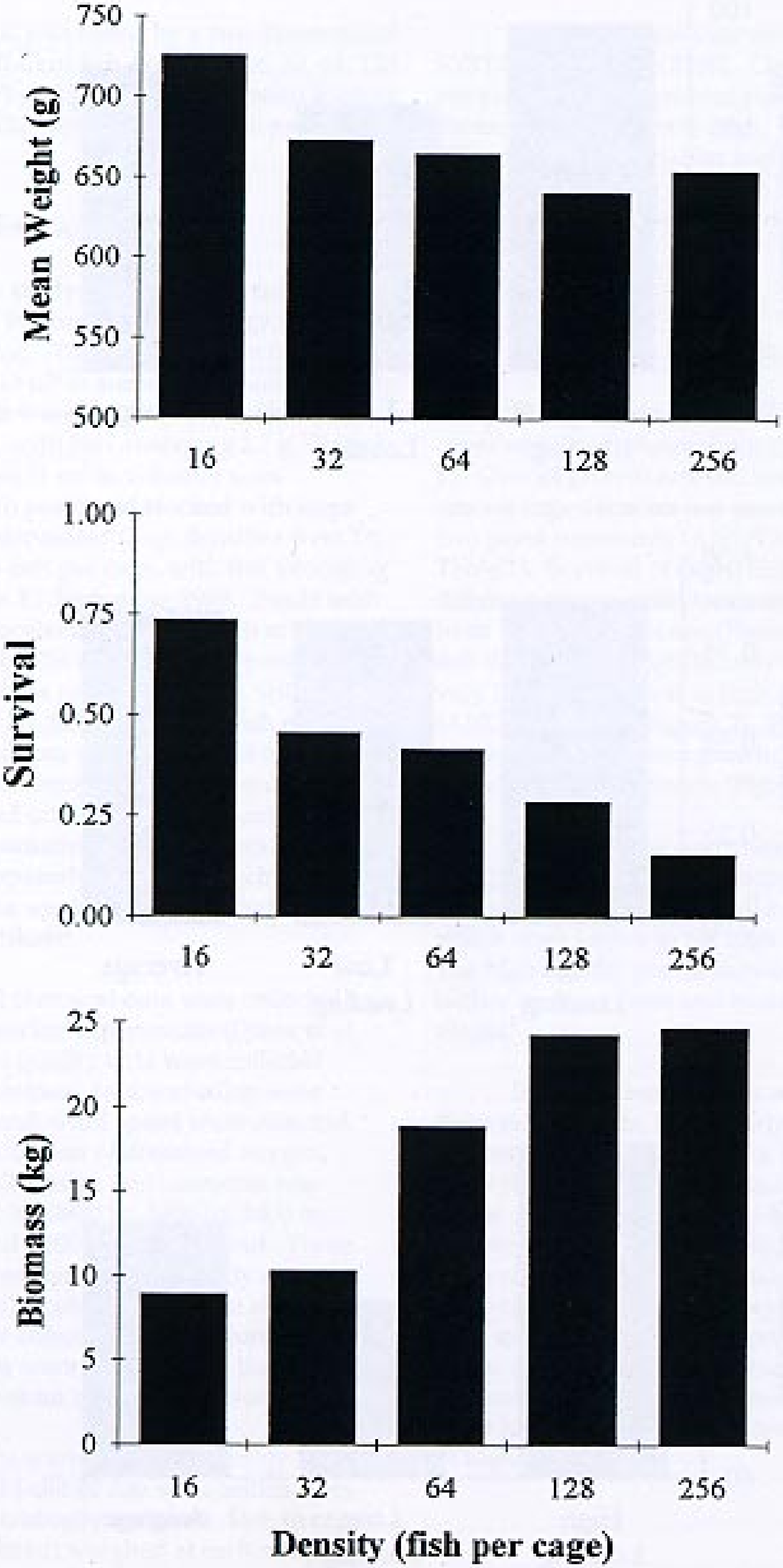

Figure 2. Final weight (upper), survival (middle), and biomass (lower) at each density for fish in cages at different densities.

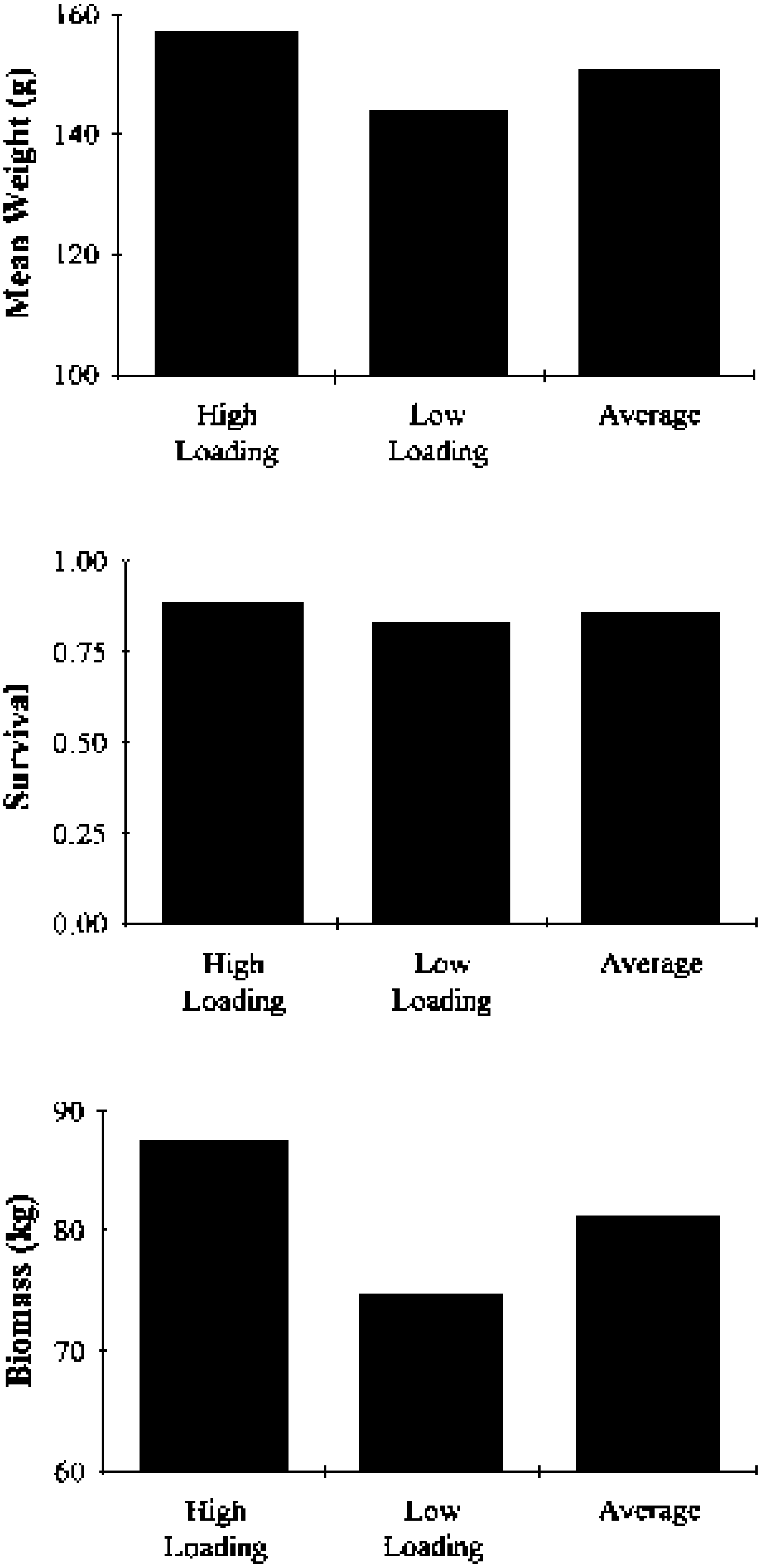

Figure 3. Final weight (upper), survival (middle), and biomass (lower) at each density for fish in ponds with different cage loading rates.

tilapia at large. This was tested by a two dimensional test: cages with different fish densities (16, 32, 64, 128, and 256 fish per m^3) and ponds with different loading rates of caged fish (224 and 560 caged fish per pond).

Materials and Methods

Data for this study were collected from 6 ponds at the Asian Institute of Technology, northwest of Bangkok, Thailand. The ponds used in the experiment were 313 m^2 in surface area and normally filled to 1 m. Ponds were stocked with 2 fish/m^2 on 22 September 1993, with fish averaging 2.7 g. Prior to pond stocking, cages (1 m^3 in volume) were submersed into each pond and stocked with large tilapia at different densities. Cage densities were 16, 32, 64, 128, and 256 fish per cage, with fish averaging 346 g at stocking on 15 September 1993. Ponds with low loading rates received 6 cages, 2 each at densities of 16, 32, and 64 fish (224 caged fish per pond). Ponds with high loading rates received 6 cages, with 1 cage each at densities of 16, 32, 128, and 256 fish per cage and 2 cages at 64 fish per cage (560 caged fish per pond). Fish in cages were fed to satiation daily, with satiation determined on a weekly basis using floating feed. The average satiation rates for cages at a given density were subsequently applied to each cage for the remainder of the week. In addition to feeding, ponds were not fertilized.

Physical and chemical data were collected in a similar manner to earlier experiments (Diana et al. 1991a, 1994). Water quality data were collected biweekly. Meteorological data, including solar radiation, rainfall, and wind speed were collected daily. Vertical distribution of dissolved oxygen, temperature, pH, alkalinity, and ammonia was determined at 0600 hr, 0900 hr, 1400 hr, 1600 hr, 1800 hr, 2300 hr, and 0600 hr in each pond. These diurnal analyses were repeated biweekly on water from the top (25 cm), middle, and 25 cm above the bottom of the water column. Temperature and oxygen differentials were calculated as the difference between top and bottom measurements at 1600 hr.

Fish in ponds were sampled monthly for average weight. At least 40 fish were seined from each pond and individually weighed. Fish in cages were counted and batch weighed at each sampling.

Statistical analyses were conducted using SYSTAT (Wilkinson 1990). Overall growth (g/day), net yield (kg), and percent survival were calculated for each pond and each cage. Treatment effects on fish or chemical variables were tested with the monthly data set by ANOVA and Tukey's multiple range test. Differences were considered significant at an alpha of 0.05.

Results

Fish weight increased in a linear fashion in cages and ponds throughout the experiment (Figure 1). Overall growth rate did not differ significantly among cage densities nor among fish at large in the two pond treatments (ANOVA, $p < 0.05$, Figure 1, Table 1). Survival of caged fish was not significantly different among pond treatments nor among densities from 16-64 fish per cage (Figure 2). However, higher fish densities did significantly affect survival, with very low fish survival at high fish densities in cages (ANOVA, $P<0.05$, Figure 2). Pond loading rates did not significantly affect growth, survival, or yield of fish at large in the ponds (Figure 3).

Most physical and chemical variables showed no significant differences among pond treatments. Exceptions were chlorophyll *a* and total phosphorus, which were higher in the high density treatments. The high density ponds showed no ill effects of the higher stocking rates and loading rates due to caged tilapia.

Significant mortalities occurred in cages in these experiments, particularly at densities in cages greater than 64 per m^3. Many of these ponds lost more than 80% of their original fish stock (Table 1). While dates of mortalities are available, these cannot be correlated to dissolved oxygen or other characteristics of the ponds at those dates, since the latter data were only collected every two weeks, and many dates with mortalities did not coincide with the dates of water quality collections. Thus, while the water quality overall did not deteriorate in these ponds, it must have reached limiting levels in the cages stocked at high densities.

Discussion

Growth did not differ among cages, indicating that density dependent growth was not a problem in these cages. However, this is a misleading statement because mortality differed dramatically among cages, so the density stocked was not held constant between treatments throughout the experiment. However, within a density of 16-64 fish per cage, there was no density dependent growth or survival.

Growth was rapid in all ponds, and reached rates near usual levels for fertilized ponds. Final size was less than normal dues to the short time period over which the experiments were conducted (90 days), but comparable to growth observed after 90 days of culture (Diana et al. 1991a, 1991b).

The application of this study to tilapia management is fairly obvious. Most rapid growth and highest survival in cages occurred at 16 to 64 fish per cage. The optimal finishing system at present appears to be with tilapia at 64 fish per cage. Water quality did not deteriorate in the high loading rate ponds, at least to the point of killing the tilapia at large in those ponds or in terms of affecting their growth rates. Therefore, it is still unclear how many cages or caged fish could be added to such a pond without water quality deterioration. In fact, since many fish died in the high loading ponds, it is not even clear whether those ponds would have reached deleterious conditions if the fish had remained alive at those caging numbers. Further experiments would be necessary to answer such questions.

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