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Preliminary Results of Integrated Pig-Fish and Duck-Fish Production Tests

EMMANUEL M. CRUZ
Freshwater Aquaculture Center
Central Luzon State University
Muñoz, Nueva Ecija, Philippines
AND
ZIAD H. SHEHADEH
ICLARM
MCC P.O. Box 1501, Makati
Metro Manila, Philippines

Abstract

Pig-fish and duck-fish production trials are described using 40 or 60 pigs/ha and 750 or 1,250 ducks/ha of pond surface, with total fish stocking densities of 10,000 or 20,000/ha (85% *Sarotherodon niloticus,* 14% *Cyprinus carpio* and 1% *Ophicephalus striatus).* The highest net yields were obtained with the 60 pig/20,000 fish and 750 ducks/20,000 fish combinations: 1,950 kg/ha and 1,690 kg/ha, respectively, from 90-day culture periods. Comparisons with control ponds receiving inorganic fertilization and measurements of water quality parameters (pH, dissolved oxygen and ammonia) are included.

Introduction

The rising cost of high protein fish feed and inorganic fertilizer, as well as the general concern for energy conservation, have brought about increased interest in the utilization of animal manures in aquaculture and in the traditional systems which integrate animal husbandry with aquaculture.

Recent experiments have demonstrated that considerable fish production can be obtained when animal manures are properly applied to fish polyculture systems. Moav et al. (1977) reported a daily gain of 35 kg/ha (8t/ha/240d) from a fish polyculture system (silver carp, common carp, grass carp and tilapia) receiving liquified cowshed manure. Polyculture of carps, channel catfish and largemouth bass, with wastes from 66 pigs/ha as the only source of nutrients, yielded 4 t/ha/yr (Buck et al. 1978). A daily yield of 32 kg/ha (7.6t/ha/240d) was achieved in ponds receiving only duck droppings (Wohlfarth 1978) and supplementary addition of chicken droppings under conditions of intensive fish culture increased fish yield by 21% and decreased the feed conversion rate by 0.4 units (Rappaport and Sarig 1978). Similar findings reported in earlier literature were reviewed by Woynarovich (1979).

Much of this information is germane to temperate and/or subtropical climates. Although integrated animal-fish farming has a long history in Southeast Asia, production methods are not well documented, if at all, and formal experimentation is only just beginning. Furthermore, the classic polyculture systems used are based on Chinese or Indian carps, which are either not marketable or fetch low prices in some countries like the Philippines.

In the case of the Philippines (Central Luzon), where average farm size is less than 3 ha (Sevilleja & McCoy 1979), integrated animal-fish farming could be an appropriate means for increasing returns from a limited land area and reducing risk by diversifying crops. However, before a development effort can be mounted to popularize animal-fish farming, available production methods need to be adapted to the prevailing tropical climate and locally marketable fish species, and the economic viability of the system needs to be ascertained.

Accordingly, a research project was initiated in 1977 at the Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU), to 1) design a fish polyculture system that would provide the highest economic return, giving manure as the only nutrient source, 2) determine the maximum pig or duck stocking rate per unit area of freshwater fish pond, and 3) clarify the economics of the developed production system(s). This paper presents the preliminary findings from the first 180 d of a series of production tests.

Methodology

A special facility was constructed consisting of 12 ponds each of 1,000 m^2 area for the pig-fish tests and 12 ponds each of 400 m^2 for the duck-fish tests with the animal pens on top of the dikes (Figure 1).

The tests were run for 180 d, which corresponds to the pig rearing period from weaned piglet to market size (finished) pig. The ducks were grown as layers and kept in the pens for the same period of time. Two fish production tests of 90 d each were conducted during this period, as the preferred tilapia market size in Central Luzon (60 g) can be attained or surpassed in 90 d at the FAC.

The factorial experimental design consisted of two animal stocking rates of 40 and 60 pigs/ha; 750 and 1,250 ducks/ha. Fish production in conjunction with each animal stocking rate was tested at stocking densities of 10,000 and 20,000 fish/ha with manure as the only input. Two control ponds received only inorganic fertilizer (N:P:K, 16:20:0) at the rate of 50 kg/ha every 15 d. Each combination was duplicated during the first 90-d fish production period and replicated three times during the second 90-d period.

Weaned piglets (Large White-Landrace cross) weighing 18 to 20 kg each, and Pekin ducks of 500 to 700 g were fed and managed according to standard procedures recommended for the Philippines (PCARR 1976, 1977). Manure from pig pens was washed into the ponds via narrow concrete canals, while duck droppings were collected and broadcast on the ponds. In both cases, manure was dispensed to the ponds daily at 8:00 to 10:00 am. The ducks were allowed to graze on the ponds daily and nylon screens inside the ponds protected the dikes from their foraging activities.

The fish species and densities used were:

Sarotherodon niloticus (Nile tilapia)	8,500/ha	17,000/ha
Cyprinus carpio (common carp)	1,400	2,800
Ophicephalus striatus (Snakehead or mudfish) a tilapia predator	100	200
	10,000/ha	20,000/ha

The growth of fish, pigs and ducks was monitored every other week. Dissolved oxygen and water temperature were recorded with an oxygen/temperature meter (Yellow Springs Instruments; YSI 54 AR) at 6:30 am on alternate days. Early morning ammonia-ammonium concentration was determined weekly with a specific ion meter (Orion, Model 47A) and an ammonia electrode (Orion, 95-10). All readings were taken at a depth of 0.5 m in three locations along the long axis of the ponds and a mean value calculated. Fish were harvested at the end of each culture period by draining the ponds and fish recovery rates, production and other pertinent growth data recorded.

Results

A. PIG-FISH TESTS

1. First 90-d Test Period (Table 1, Figure 2)

Net fish yields increased with pig stocking rates and fish density to a maximum of 958 kg/ha (10.7 kg/ha/d), with tilapia and carp mean weights of 43 and 80 g, respectively, from the 60 pigs-20,000 fish/ha combination. Control ponds receiving inorganic fertilizer produced a maximum of 560 kg/ha (6.2 kg/ha/d) which is roughly equivalent to the yield from ponds with 40 pigs and between 10,000 and 20,000 fish/ha, and to 58% of the yield from the 60-20,000 combination.

The growth rate of tilapia (Figures 3, A & B) increased with pig stocking rates and decreased as fish density increased. A maximum final mean weight of 73 g was obtained with the 60-10,000 combination. Individual mean weights from other combinations were 54 g or less. Tilapia growth levelled off at a mean weight of 35 g in the 40-20,000 combination indicating that maximum carrying capacity was reached at the given fish stocking densities and pig biomass (manure delivery). Growth also levelled off in control ponds at mean

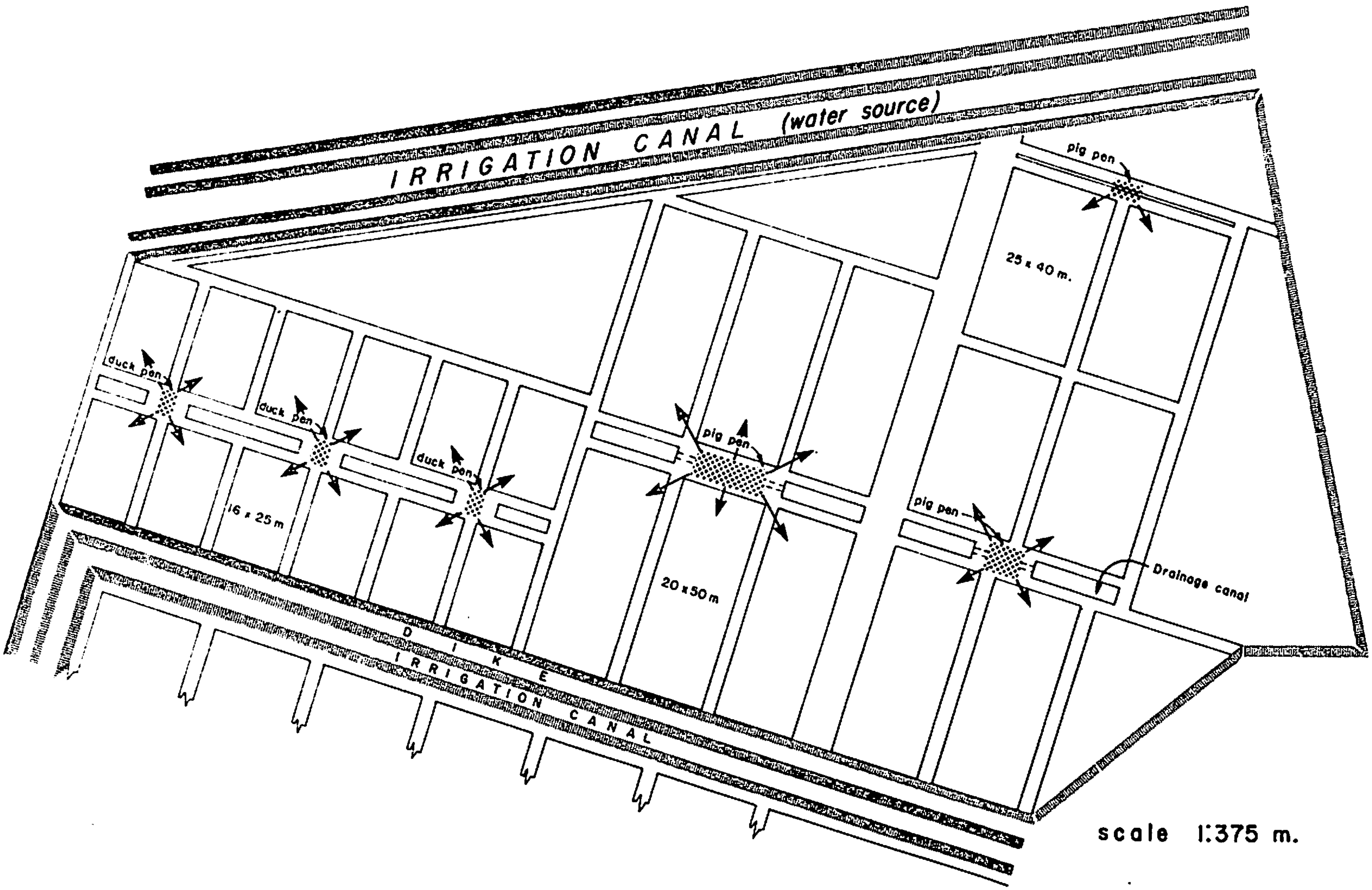

Figure 1. Layout of the experimental facility showing the relationship of animal pens to fish ponds. Arrows indicate waste delivery.

weights of 52 and 33 g at the low and high fish densities respectively after 60 d and began to decrease towards the end of the culture period.

Final individual mean weight of carp was also highest (149 g) in the 60-10,000 combination (it was not possible to follow carp growth because the fish evaded sampling nets successfully). Carp yields from the 60-10,000 and 60-20,000 combinations were identical, indicating that the carrying capacity for carp at the given fish and pig stocking rates was reached.

Although the 60-20,000 combination gave the highest fish yield, the 60-10,000 combination could prove more profitable if significantly higher prices can be obtained for larger fish. Another point worth noting from the comparison of yields from control ponds and those receiving manure from 40 pigs is that a 40-15,000 combination would result in savings equal to the price of 300 kg of 16:20:0 fertilizer over 90 d.

Initial and final individual mean weights of pigs for the 90-d period were about 20 and 52 kg, respectively (Table 3).

2. Second 90-d Test Period (Table 2, Figure 2)

Since this test series was initiated with pigs of about 56 kg mean weight (Table 3) carried over from the first test period, as compared to 20 kg mean weight in the latter, both fish growth rates and net yields were expected to be higher due to increased manure delivery.

As can be noted from Table 2 and Figure 2, net yields again increased with pig and fish stocking rates to a

Table 1. Fish production *(Sarotherodon niloticus, Cyprinus carpio* and *Ophicephalus striatus)* in pig-manured ponds during the first 90-day test period (September-November 1978). Production figures represent means of duplicate ponds.

Pigs/ha	Species	Stocking fish/ha	Individual mean weight (g) Initial	Final	Gain (g)	Average daily gain (g)/fish	Recovery %	Yield (kg/ha) in 90 d
0 (control)[1]	*S. niloticus*	8,500	6.7	48.7	42.0	0.5	90.4	376.1
	C. carpio	1,400	12.2	119.2	107.0	1.2	100.0	176.1
	O. striatus	100	1.0	165.8	165.8	1.8	45.0	7.5
	Total	10,000				3.5		559.7
0 (control)[1]	*S. niloticus*	17,000	3.8	26.7	22.9	0.3	78.5	357.0
	C. carpio	2,800	3.4	22.7	19.3	0.2	100.0	78.6
	O. striatus	200	1.0	97.5	96.5	1.1	65.0	10.5
	Total	20,000				1.6		446.1
40	*S. niloticus*	8,500	4.0	53.6	49.6	0.6	72.8	329.0
	C. carpio	1,400	3.2	109.4	106.2	1.2	100.0	155.0
	O. striatus	100	1.0	161.9	160.9	1.8	45.0	7.1
	Total	10,000				3.6		491.1
40	*S. niloticus*	17,000	4.5	35.1	30.6	0.3	92.5	552.4
	C. carpio	2,800	4.6	46.0	41.4	0.5	90.5	116.7
	O. striatus	200	1.0	167.7	166.7	1.9	80.0	13.4
	Total	20,000				2.7		682.5
60	*S. niloticus*	8,500	4.9	73.2	68.3	0.8	87.3	542.0
	C. carpio	1,400	4.7	149.3	144.6	1.6	100.0	209.5
	O. striatus	100	1.0	200.0	199.0	2.2	25.0	4.9
	Total	10,000				4.6		756.4
60	*S. niloticus*	17,000	2.5	43.1	40.6	0.5	72.2	742.0
	C. carpio	2,800	3.0	80.1	77.1	0.9	97.0	195.7
	O. striatus	200	1.0	186.1	185.1	2.1	90.0	20.5
	Total	20,000				3.5		958.2

[1]Inorganic fertilizer NPK (16-20-0) applied @ 50 kg/ha/15 days.

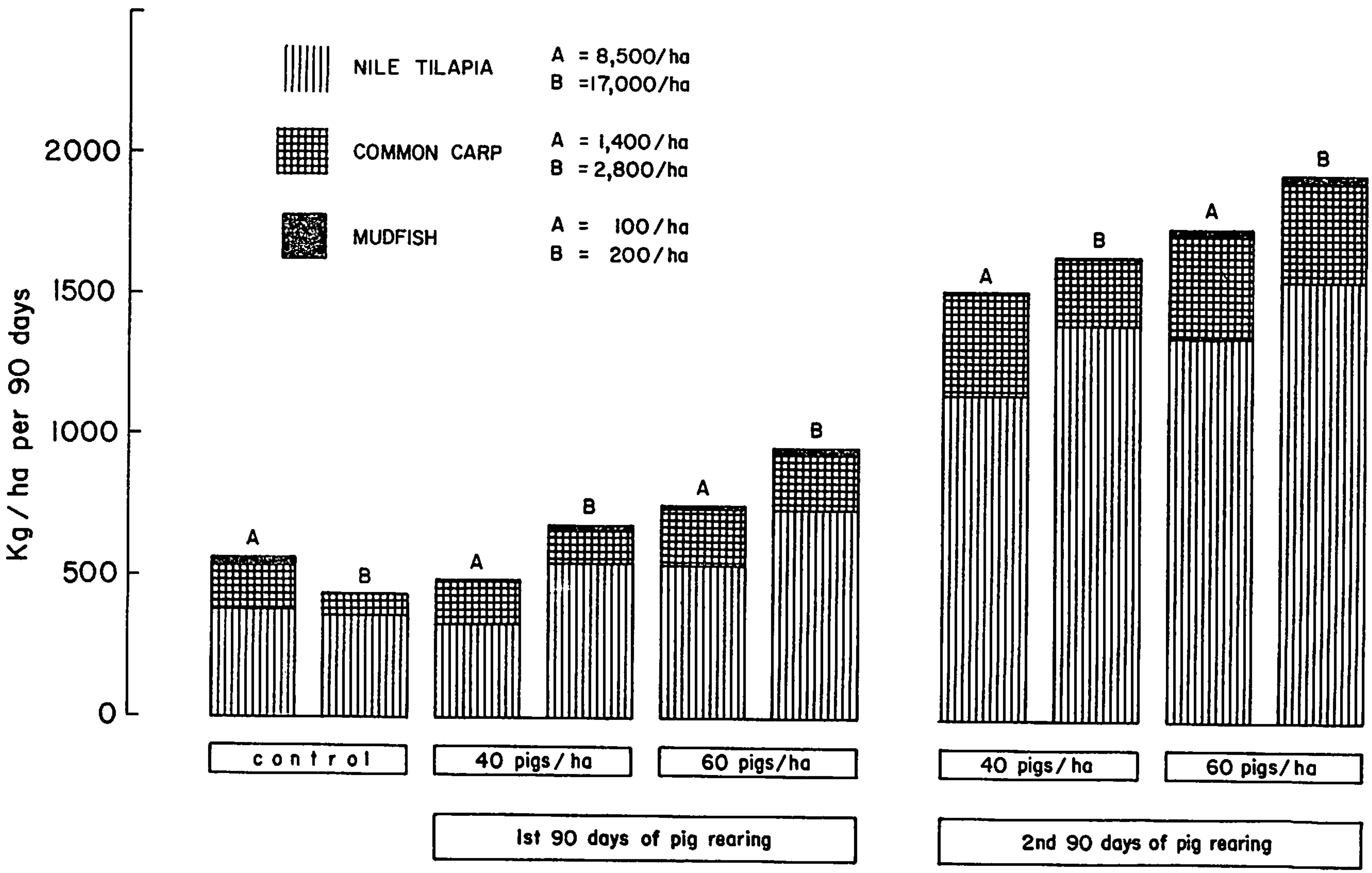

Figure 2. Individual and cumulative net yields of nile tilapia *(Sarotherodon niloticus)*, common carp *(Cyprinus carpio)* and mudfish *(Ophicephalus striatus)* cultured together for 90-day periods in ponds receiving pig manure. The columns represent the means from duplicate ponds over the 1st 90 days and triplicate ponds over the 2nd 90 days.

maximum of 1,950 kg/ha (22 kg/ha/d), with tilapia and carp mean weights of 119 and 181 g, respectively, from the 60-20,000 combination.

Tilapia growth rates (Figure 3C) followed the same pattern as in the first test period. A maximum mean weight of 166 g was obtained from the 40-10,000 combination, as compared to 120 g from 60-20,000 combination. Tilapia growth did not level off in any of the test combinations indicating that the manure delivery rate did not limit growth as in the case of the 40-20,000 combination in the first 90-d period. However, at fish densities of 10,000/ha, tilapia growth did not increase with increased pig stocking rate. This indicates that at 60 pigs/ha, more food was produced than could be utilized by the fish biomass.

Carp yield was highest (370 kg/ha) in the 60-pig combinations but was essentially the same at both fish densities, indicating that the carrying capacity for carp was reached with 60 pigs.

Initial and final individual mean weights of pigs during the second 90-d culture period were 57 and 102 kg, respectively (Table 3).

3. Water Quality

Early morning (6:30 A.M.) water temperature was 25 to 29°C (minimum-maximum) during the first 90-d test period (September to November) and 21 to 27°C during the second period (January to March). pH varied between 7.5 and 9 in control ponds and pig-fish ponds during the first period and between 8 and 9 in pig-fish ponds during the second period. There were no discernible differences in pH between the various pig-fish combinations during either test period.

Special attention was paid to dissolved oxygen concentrations in pond water as an indicator of manure overloading, particularly during the second test period when water temperature was lower and manure loading higher than in the first period. Early morning dissolved oxygen (Figure 4) varied between 3 and 8 ppm in control ponds. Fish density and pig stocking rates did not affect oxygen concentrations in either test period. Concentrations in pig-fish ponds during the first period began to decrease steadily from control values on the 66th day but remained above 3 ppm. During the second

Table 2. Fish production (*Sarotherodon niloticus, Cyprinus carpio* and *Ophicephalus striatus*) in pig-manured ponds during the second 90-day test period (January-March 1979). Production figures represent means of triplicate ponds.

Pigs/ha	Species	Stocking fish/ha	Individual mean weight (g) Initial	Individual mean weight (g) Final	Gain (g)	Average daily gain (g)/fish	Recovery %	Yield (kg/ha) in 90 d
40	*S. niloticus*	8,500	3.7	166.1	162.4	1.8	83	1,156
	C. carpio	1,400	71.4	344.7	273.3	3.0	73	356
	O. striatus	100	103.6	263.0	159.4	1.8	27	8
	Total	10,000				6.6		1,520
40	*S. niloticus*	17,000	2.8	92.0	89.2	1.0	90	1,408
	C. carpio	2,800	71.4	166.5	95.2	1.1	52	253
	O. striatus	200	103.6	238.3	134.8	1.5	25	11
	Total	20,000				3.6		1,672
60	*S. niloticus*	8,500	3.2	160.5	157.2	1.7	100	1,364
	C. carpio	1,400	71.4	358.8	287.4	3.2	75	373
	O. striatus	100	103.6	217.8	114.2	1.3	50	11
	Total	10,000				6.2		1,748
60	*S. niloticus*	17,000	3.9	119.9	115.9	1.3	78	1,576
	C. carpio	2,800	71.4	181.1	109.7	1.2	71	353
	O striatus	200	103.6	305.3	201.7	2.2	35	21
	Total	20,000				4.7		1,950

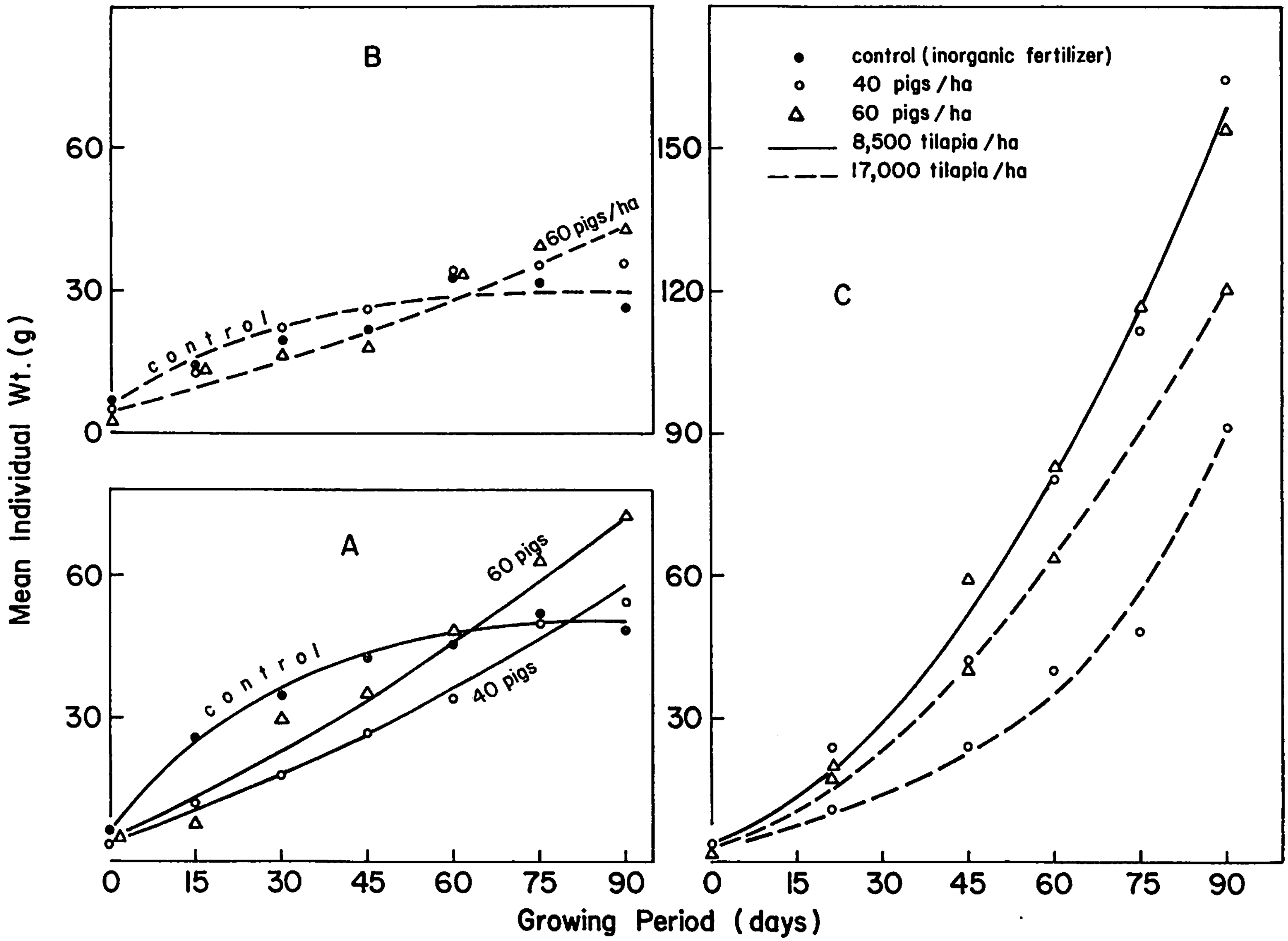

Figure 3. Growth rates of *Sarotherodon niloticus* at two stocking densities in ponds receiving pig manure: A–mean individual weights of fish stocked at 8,500/ha in duplicate 0.1-ha ponds receiving manure from 40 and 60 pigs/ha during the 1st 90 days of a pig production cycle and inorganic fertilizer (NPK:16:20:0) for comparison. B–as A but with 17,000 fish/ha comparing 60 pigs/ha and inorganic fertilization. C–as A and B but with triplicate ponds during the 2nd 90 days of the pig production cycle with no inorganic fertilization for comparison.

Table 3. Change in individual mean weights of pigs during the two 90-day test periods.

Combination (pig-fish/ha)	Initial	2	4	6	8	10	12
				Time (wk)			
A. First test period							
40-10,000	19.77	23.95	27.30	32.72	37.50	48.57	53.97
40-20,000	18.67	22.10	26.06	32.92	36.30	47.42	51.80
60-10,000	18.54	22.09	25.46	30.28	34.46	44.08	49.94
60-20,000	19.68	22.35	25.11	30.40	39.08	50.65	56.61
B. Second test period							
40-10,000	61.25	68.66	79.66	85.91	94.58	99.33	105.75
40-20,000	50.60	58.98	69.33	78.66	87.66	93.66	100.91
60-10,000	55.15	63.27	71.99	81.72	89.05	97.16	103.88
60-20,000	60.02	66.18	72.91	82.35	87.88	92.86	97.02

period, oxygen values declined steadily, after 1 mo, from 5 to 1.2 ppm (Figure 4). Ammonia-ammonium concentrations in the second test period increased gradually from 0.22 to 0.35 ppm in all combinations except the 60-20,000 set where a final concentration of 0.78 ppm was recorded.

B. DUCK-FISH TESTS

1. First 90-d Test Period (Table 4, Figure 5)

The results of this test were not as clearcut as the equivalent pig-fish tests because a substantial amount of duck manure was deposited on the dikes and did not reach the ponds, and due to the influence of a typhoon on duck health and growth. The manure problem was eliminated in the second test period with a fence which excluded access to the dikes.

The same general trends noted in the pig-fish tests were nevertheless evident. Yields tended to increase with duck and fish stocking rates to a maximum of 980 kg/ha (10.9 kg/ha/d), with tilapia and carp mean weights of 60 and 96 g, respectively, from the 1,250 ducks-20,000 fish combination. Fish yield from the 750-10,000 combination matched production from control ponds with the same fish density.

2. Second 90-d Test Period (Table 5, Figure 5)

Maximum fish yield of about 1,690 kg/ha (18.8 kg/ha/d), with mean tilapia and carp weights of 98 and 213 g, respectively, was obtained in this test series from the 750-20,000 combination. Yields from ponds with duck stocking rates of 1,250/ha gave lower yields than those with 750 ducks/ha at both fish densities.

The growth curves of tilapia (Figure 6) demonstrate depressed growth at the higher duck stocking rate. Carp production, however, was highest (402 kg/ha) from the 1,250-20,000 combination despite prevailing low oxygen concentrations.

3. Water Quality

Early morning water temperature was 23 to 28°C and 21 to 28°C during the first and second test periods, respectively. pH was 7 to 8 in both periods. Early morning dissolved oxygen declined steadily during both test periods but remained above 2 ppm throughout the first period. During the second period, however, oxygen values were below 2 ppm most of the time, declining to less than 1 ppm towards the end of the period. Ammonia-ammonium concentrations in the second test period increased gradually from 0.19 to 0.30 ppm in all combinations except the 1,250-20,000 set in which concentrations rose to 0.52 ppm.

Tentative Conclusions

In spite of the preliminary nature of the data, some tentative conclusions can be reached:

A. PIG-FISH TESTS

1. The results clearly indicate that 60 pigs-20,000 hectare provide the highest net yield of fish. As indicated in the text, maximum yield may not correspond with

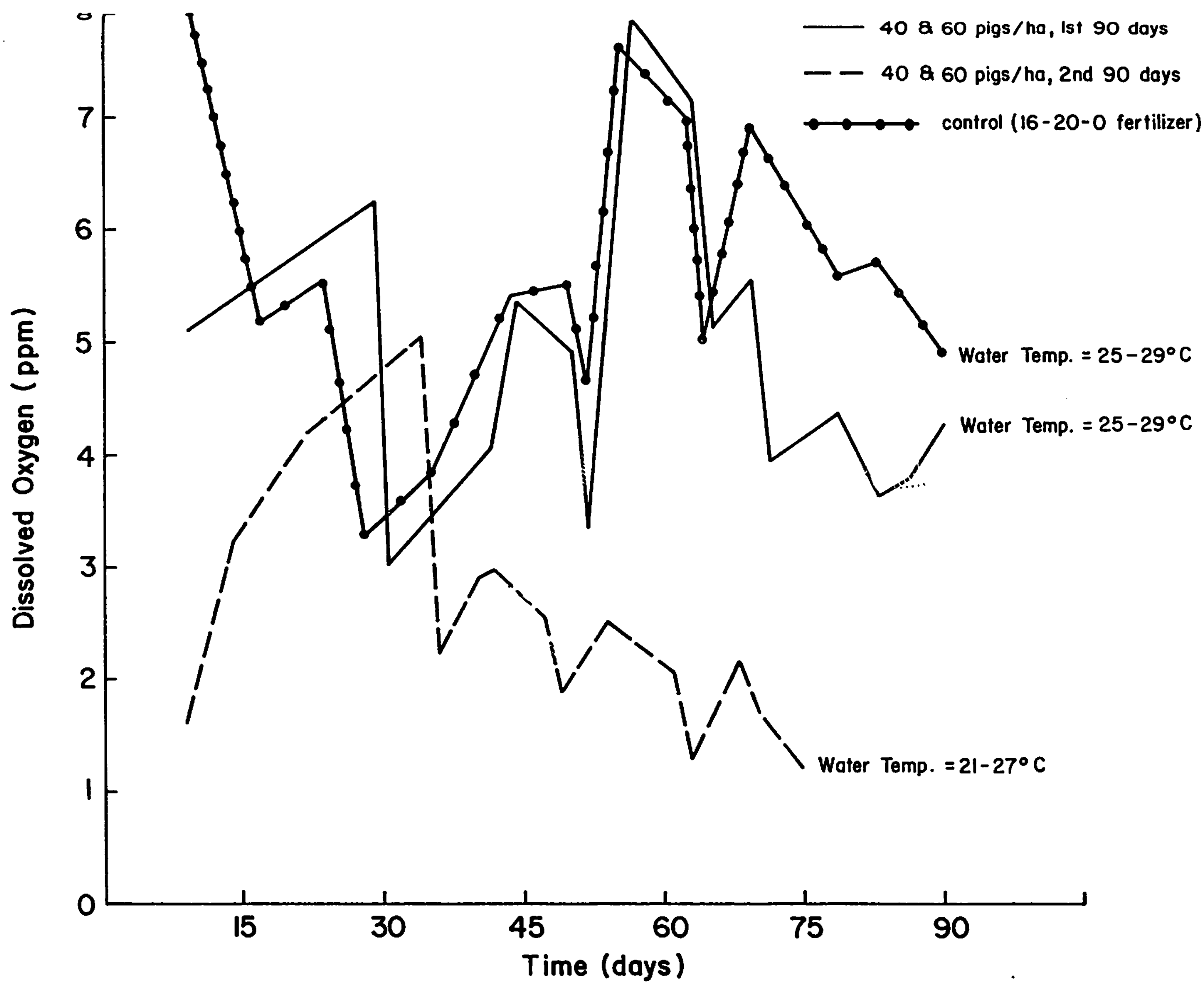

Figure 4. Early morning (6:30 A.M.) dissolved oxygen in ponds receiving pig manure during two consecutive 90-day periods. Data represent mean values from duplicate ponds for the 1st 90 days; controls and triplicate ponds for the 2nd 90 days.

maximum economic return. Much will depend on size-related market price for fish. If a premium is paid for larger fish, then stocking rates must be reduced with a resulting decrease in total net yield. At present, mixed sizes of tilapia are marketed in Central Luzon at a wholesale price of ₱*6/kg while carp fetches about 3 to ₱4/kg. This may change in the future.

2. Assuming for the moment that maximum production and profitability are synonymous, annual fish production with the 60-20,000 combination will depend on the management method used. For example, if pigs are grown from 20 to 100 kg over the pond, then a net yield of 958 + 1,950 = 2,908 kg/ha can be achieved in one pig rearing cycle of 180 d. To this can be added the fish yield (958 kg/ha) from another 90-d period with new pigs to make a total production of 3,866 kg/ha in 270 d. It is evident from our data, however, that fish production during the first 90 d of pig rearing is low due to inadequate manure production, and that doubling the pig biomass during this period would double the fish yield resulting in annual fish production of 1,950 x 3 = 5,850 kg/ha in 270 d.

If adjustment of pig biomass is not feasible, an alternative would be to increase fish production during the initial 90 d with supplemental feed (rice bran).

*US$1.00 = ₱ (Philippine pesos) 7.33.

3. Since dissolved oxygen concentrations were about one ppm during the end of the second 90-d pig rearing period at 60 pigs-20,000 fish/ha, it appears likely that a further increase of pig stocking rate will either reduce fish production or cause fish mortality during the last 90 d of the pig rearing period.

B. DUCK-FISH TESTS

Following the same argument outlined above, and assuming Pekin ducks are raised as layers, then the recommended maximum duck-fish stocking rate is 750-20,000. Maximum net fish yield, after ducks have become regular layers, would be 1,690 kg/ha/90 d, or 5,070 kg/ha in 270 d.

C. FISH COMPOSITION

The above recommendations are based on a fish composition of 85% nile tilapia, 14% common carp and 1% mudfish. This composition was used because fry of these fish can be produced or obtained by farmers in the Philippines fairly easily. However, this system is unstable because it does not include efficient filter feeders. There is particular need to add a nannoplankton

Table 4. Fish production (*Sarotherodon niloticus*, *Cyprinus carpio* and *Ophicephalus striatus*) in duck-manured ponds during the first 90-day test period (October-December 1978). Figures represent means of duplicate ponds.

Ducks/ha	Species	Stocking fish/ha	Individual mean weight (g) Initial	Final	Gain (g)	Average daily gain (g)/fish	Recovery %	Yield (kg/ha) in 90 d
750	*S. niloticus*	8,500	1.8	69.0	67.2	0.8	76.6	395.0
	C. carpio	1,400	2.3	165.0	162.7	1.8	100.0	196.8
	O. striatus	100	1.0	150.0	149.0	1.7	87.5	9.4
	Total	10,000				4.3		601.2
750	*S. niloticus*	17,000	2.1	61.9	59.8	.7	59.9	489.5
	C. carpio	2,800	2.3	61.2	58.9	.7	95.5	225.3
	O. striatus	200	1.0	135.0	134.0	1.5	37.5	16.0
	Total	20,000				2.9		730.8
1,250	*S. niloticus*	8,500	2.0	71.5	69.5	.8	85.0	502.0
	C. carpio	1,400	2.3	134.3	132.0	1.5	83.9	166.2
	O. striatus	100	1.0	179.9	178.9	2.0	91.7	16.3
	Total	10,000				4.3		684.5
1,250	*S. niloticus*	17,000	2.1	59.7	57.6	.6	61.0	679.0
	C. carpio	2,800	2.3	95.7	93.4	1.0	92.0	290.8
	O. striatus	200	1.0	96.9	95.9	1.1	43.7	9.8
	Total	20,000				2.7		979.6

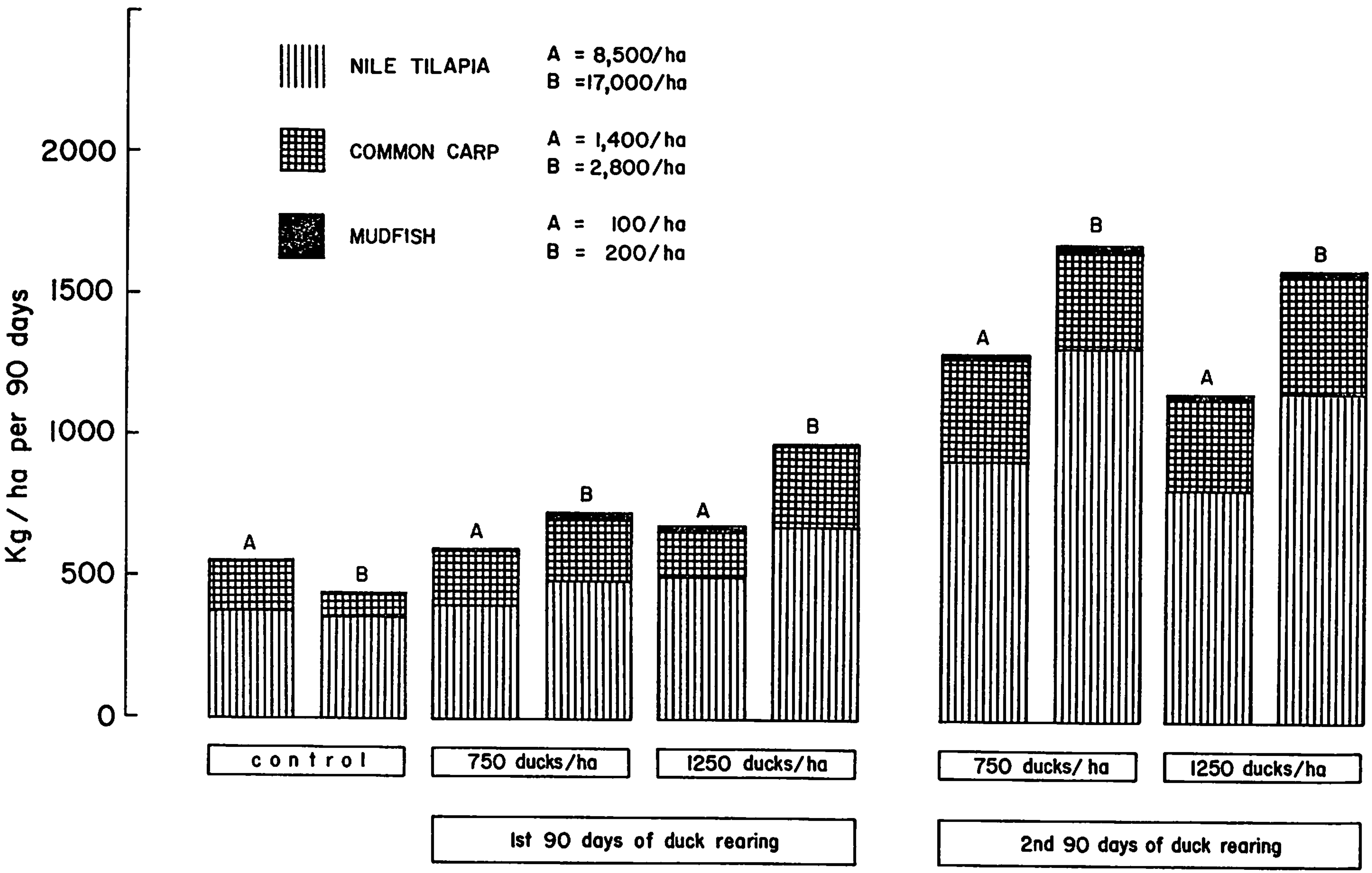

Figure 5. Individual and cumulative net yields of nile tilapia *(Sarotherodon niloticus)*, common carp *(Cyprinus carpio)* and mudfish *(Ophicephalus striatus)* cultured together for 90-day periods in ponds receiving duck manure. The columns represent the means from duplicate ponds over the 1st 90 days and triplicate ponds over the 2nd 90 days.

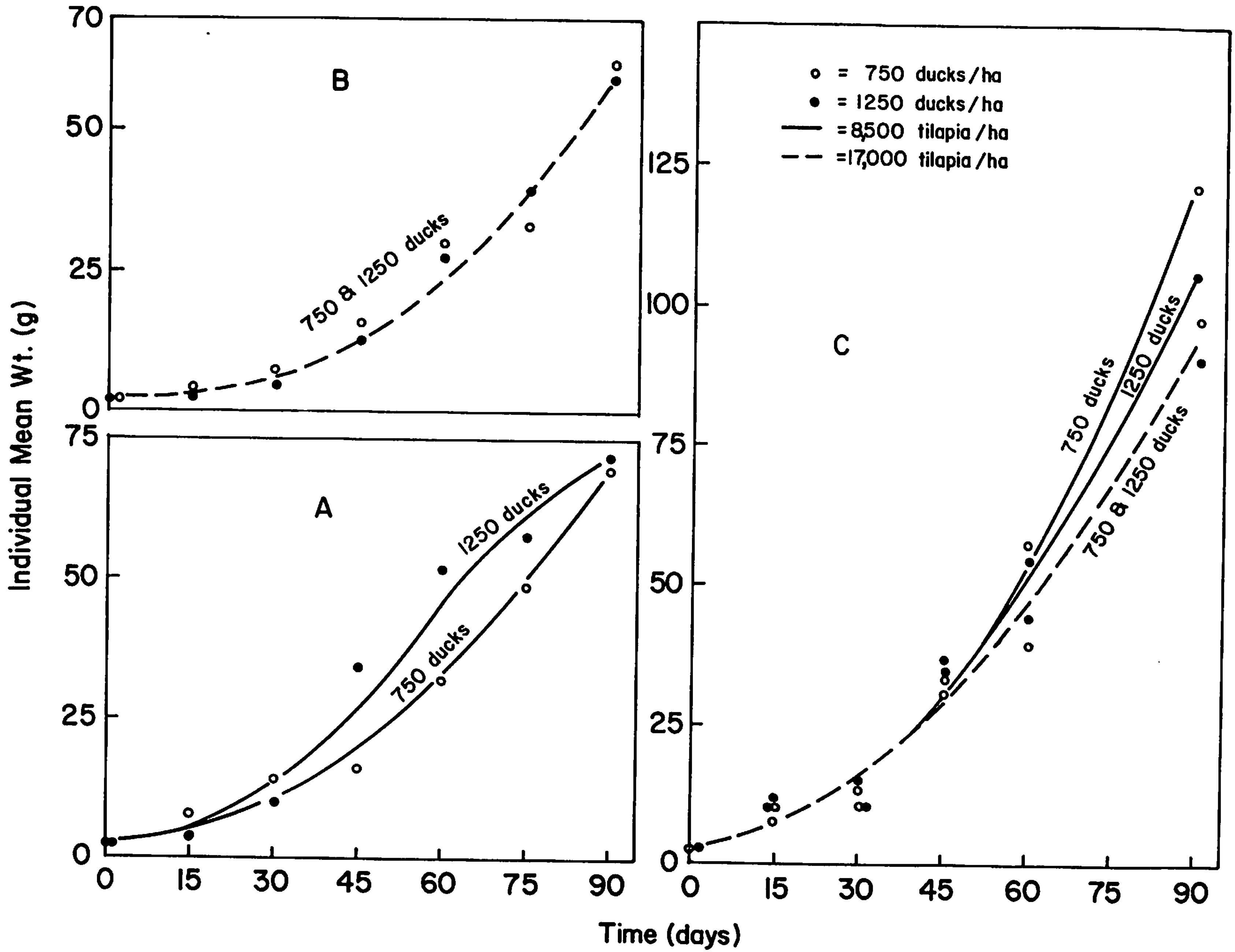

Figure 6. Growth rates of *Sarotherodon niloticus* stocked at two densities in ponds receiving duck manure: A—mean individual weights of fish stocked at 8,500/ha in duplicate 0.04 ha ponds receiving manure from 750 and 1,250 ducks/ha during the 1st 90 days of a duck production cycle. B—as A but with 17,000 fish/ha. C—as A and B but using triplicate ponds receiving manure during the 2nd 90 days of a duck production cycle.

Table 5. Fish production *(Sarotherodon niloticus, Cyprinus carpio* and *Ophicephalus striatus)* in duck-manured ponds during the second 90-day test period (January-March 1979). Figures represent means of triplicate ponds.

Ducks/ha	Species	Stocking fish/ha	Individual mean weight (g) Initial	Final	Gain (g)	Average daily gain (g)/fish	Recovery %	Yield (kg/ha) in 90 d
750	*S. niloticus*	8,500	2.0	121.6	119.6	1.3	90.5	920.3
	C. carpio	1,400	54.5	378.2	323.7	3.6	75.0	368.8
	O. striatus	100	33.7	276.7	243.0	2.7	46.7	15.2
	Total	10,000				7.6		1,304.3
750	*S. niloticus*	17,000	2.0	97.6	95.6	1.1	81.8	1,323.3
	C. carpio	2,800	51.0	213.0	162.0	1.8	61.6	345.8
	O. striatus	200	34.7	232.7	198.0	2.2	37.5	20.5
	Total	20,000				5.1		1,689.6
1,250	*S. niloticus*	8,500	2.0	106.9	104.9	1.2	88.8	824.5
	C. carpio	1,400	56.7	299.7	243.0	2.7	66.7	323.8
	O. striatus	100	39.0	300.0	261.0	2.9	8.3	15.0
	Total	10,000				6.8		1,163.3
1,250	*S. niloticus*	17,000	2.0	90.4	88.4	1.0	79.3	1,174.5
	C. carpio	2,800	48.3	273.3	225.0	2.5	63.7	402.0
	O. striatus	200	40.0	211.0	171.0	1.9	50.0	21.5
	Total	20,000				5.4		1,598.0

feeding fish, like the silver carp *(Hypophthalmichthys molitrix)*, to control phytoplankton populations (especially in the duck ponds). The addition of such fish to the system can be expected to increase net yield and reduce oxygen stress. Since silver carp is not marketable in the Philippines, milkfish *(Chanos chanos)* will be added to the system in future tests.

Experiments will also be conducted to test the feasibility of replacing most of the common carp with *Sarotherodon aureus* which is mostly a bottom feeder and would fetch a higher price than carp.

D. FISH GROWING PERIOD

Stocking and draining of fish ponds every 90 d is not practical. It wastes labor, growing time and water. Furthermore, animal wastes cannot be turned into the pond during drainage and harvest operations. The fish growing period should at least match the animal rearing period. Optimally, ponds should be drained only once per year.

E. ENVIRONMENTAL IMPACT

Future tests in this project will include measurements of BOD_5 and nitrogen and phosphorous concentrations in water drained from fish ponds in order to assess the pollution hazard from this effluent. Consideration will also be given to setting aside a small pond area as a receptacle for animal manure during harvest/restocking operations. Such a pond could be stocked with air-breathing fish, such as *Clarias* spp. or *Ophicephalus striatus.*

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