The ICLARM-CLSU integrated animal-fish farming project: final report

Kevin D. Hopkins
Emmanuel M. Cruz

FRESHWATER AQUACULTURE CENTER - CENTRAL LUZON STATE UNIVERSITY

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

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Muñoz, Nueva Ecija, Philippines

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MUÑOZ, NUEVA ECIJA, PHILIPPINES

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Cover: Aerial view of the CLSU Freshwater Aquaculture Center facilities. ICLARM-CLSU project ponds are in the foreground.

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Preface

Although integrated farming has a long history in Southeast Asia, production methods have not been well documented. The methods and potential benefits of combining livestock and fish culture operations need to be better defined before large-scale development efforts are mounted to popularize this form of agriculture and often, available production methods need to be refined and adapted to the prevailing economic circumstances. With these points in mind, ICLARM and the Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU) began a cooperative research project in 1978 with the ultimate objective of designing a technology for integrated farming appropriate to rural development in the Philippines.

A special 2-hectare facility was constructed at the FAC during 1978 and a series of experiments was conducted over the following three years, terminating at the end of 1981. The project was supported by CLSU, ICLARM and the Rockefeller Foundation.

Preliminary results have been reported previously in this series (ICLARM Technical Reports 2). The present report encompasses all the project results and includes a large amount of raw and summarized data collected over the 3-year experimental period. Some additional papers dealing with specific aspects have also resulted from the project. A list is provided in Appendix E of all project-related papers.

As documented in this final report, the project went a long way towards packaging an integrated-farming technology although, as the authors point out, some complex problems remain, the solutions to which remain elusive. It is hoped that the encouraging results of this initial research effort will be of value to policymakers, planners, agriculturists and aquaculturists and that it will provide a stimulus for further documentation and research on other, similar traditional aquaculture systems.

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Abstract

The International Center for Living Aquatic Resources Management and Central Luzon State University Integrated Animal-Fish Farming Project spanned four years, 1978 to 1981 at Nueva Ecija, Philippines. Eighteen major experiments were conducted with pig-fish, duck-fish, and chicken-fish systems. The livestock were grown in houses on the pond dikes and their manure was added daily to ponds that were 400 or 1,000 m^2 in size. Most of the experiments were factorial designs with livestock numbers and fish stocking densities as the main variables. The fish were a polyculture of Nile tilapia *(Oreochromis niloticus)* and *Cyprinus carpio* with predators, *Channa striata* or *Clarias batrachus*, used in certain experiments to control tilapia recruitment.

Mean net fish yields greater than 15 kg/ha/day of market-size tilapia and 4 kg/ha/day of carp were attained with manure loads of approximately 100 kg dry matter/ha/day with pig manure and with chicken manure. Higher manure loads reduced yields. Duck-fish experiments had lower yields than those of pig- or chicken-fish experiments.

In addition to fish growth and yields, water chemistry, plankton populations, and livestock and fish parasites were monitored. On average, dissolved oxygen was above 200% saturation in the afternoon and dropped below 1 mg/l in the early morning in systems receiving high manure loads. Total ammonia sometimes exceeded 2 mg/l in chicken-fish experiments. The plankton populations were highly variable even between ponds treated identically. No parasites zoonotic to men were found in the livestock or the fish.

Preliminary economic analyses showed that livestock-fish systems can be highly profitable and can contribute to increasing rural incomes in addition to utilizing protein in feed stocks more efficiently than livestock systems alone.

1. Introduction

An animal-fish system is simply a fishpond into which animal manures are regularly added. This addition of manures is usually frequent, often daily. In most systems, an effort is made to build the livestock units as close as possible to the fishponds to minimize the costs of transporting the manure. The manure can be consumed directly by the fish but its main benefit is to supply nutrients for phytoplankton and to act as a substrate for heterotrophs [bacteria and meiofauna which are eaten by the fish (Schroeder 1980)]. These systems have long been used in temperate climates, particularly China, but their use in the tropics is not as well developed (Wohlfarth and Schroeder 1979; Pullin and Shehadeh 1980).

In January 1978, the International Center for Living Aquatic Resources Management (ICLARM) entered into a cooperative agreement with Central Luzon State University (CLSU), Muñoz, Nueva Ecija, Philippines to establish an Integrated Animal-Fish Farming Project at CLSU's Freshwater Aquaculture Center (FAC). The purpose of the Project was to systematically develop and document integrated animal-fish systems under tropical conditions. The initial experiments concentrated on developing guidelines for manure loading rates which would maximize fish production without unreasonable risk of fish kill. Pigs and ducks were selected as the manure sources because the available literature was most extensive for animal-fish systems using these animals. Later, chickens were substituted for the ducks when problems of duck marketing arose. In these initial experiments two densities of a polyculture of Nile tilapia *(Oreochromis niloticus)*, as the main cultured crop; *Cyprinus carpio*, as a bottom stirrer to prevent weed growth; and the predator, *Channa (Ophicephalus) striata* were compared.

After the initial experiments were completed, the basic systems were modified by changing the length of the culture periods, predator levels, stocking rates and species composition. Water chemistry, plankton and economics of the systems were also studied.

Two very extensive tabulations of both raw data and summaries are presented in Appendices B and C, which we hope will be useful to persons studying the dynamics of detritus usage in fishponds and will lead to a better understanding of these highly productive systems.

2. Experimental Design

When the Project was established, the primary interests were the aquacultural aspects of the systems. The livestock portion was considered a necessary evil by the Project biologists (primarily aquaculturists) which was needed to supply a regular source of manure. Given this bias, and the extensive literature available on pig, chicken and duck rearing, it was decided to use accepted Philippine design and management practices for the livestock units without modification (PCARR 1976a, 1976b, 1977). This strategy would allow more rapid dissemination and adoption of Project-developed technologies because new livestock-culture practices would not be involved.

The Project area was approximately 2 ha and included twelve 0.1-ha earthen ponds, twelve 0.04-ha earthen ponds, four brood ponds and six animal houses located on the pond dikes (Fig. 2.1). The ponds had average depths of 0.7-0.9 m. The pig houses were constructed with concrete slab floors, concrete hollow-block pen walls, and galvanized iron roofs. Each pig house was subdivided into pens and each pen was connected via a concrete channel and plastic pipe to a single pond. The poultry houses were similar to the pig houses but the walls were made of wire to increase ventilation. Shutters were lowered over the walls during storms or cold weather. When ducks were being grown, the poultry houses were divided into pens with a walkway for the ducks from each pen to a pond. When the Project shifted to chicken raising, the partitions were removed and broiler cages were placed in the poultry houses.

The Project facilities were designed so that the pig and duck manure flowed directly into the ponds during the daily pen washing. Chicken manure was removed from the collecting trays three times a week and dumped into the ponds. Also, the ducks defecated directly into the ponds during their foraging. The amount of manure was regulated by controlling the number and size of the animals.

The duration of experiments was based on animal growth rates. Pigs and Peking ducks take about six months to reach market size, while chickens require 45-49 days. Tilapia attain the market size of 60 g in Central Luzon (Guerrero and Guerrero 1975) in 90 days or less based on expected growth rates of 1-2 g/day. Thus, two independent fish cycles are possible within one pig or duck production period, while two chicken cycles correspond to one fish production cycle.

Fig. 2.2A depicts the initial pig and duck experiments of the Project. The animals grew steadily until harvest at day 180 while the fish were harvested at day 90, the pond was restocked and the

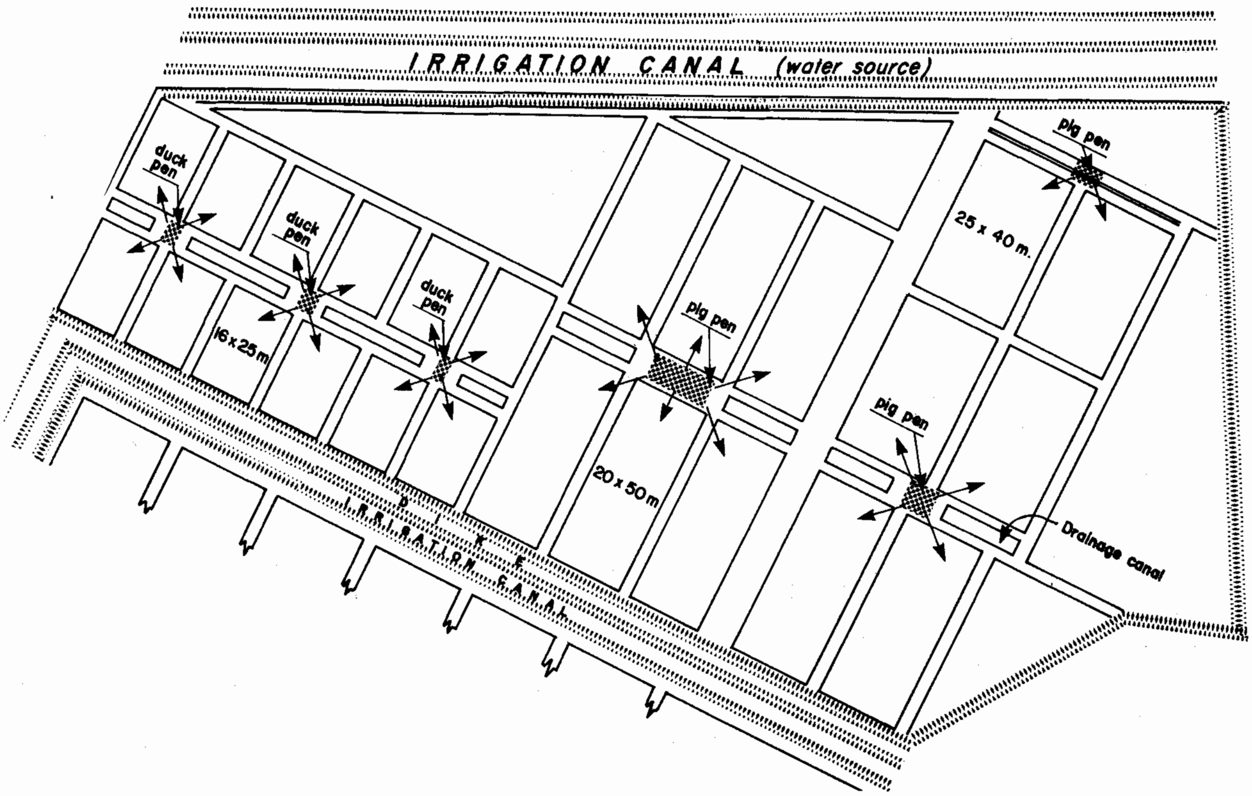

Fig. 2.1. Plan of the Project site at the Freshwater Aquaculture Center, Central Luzon State University, Muñoz, Nueva Ecija.

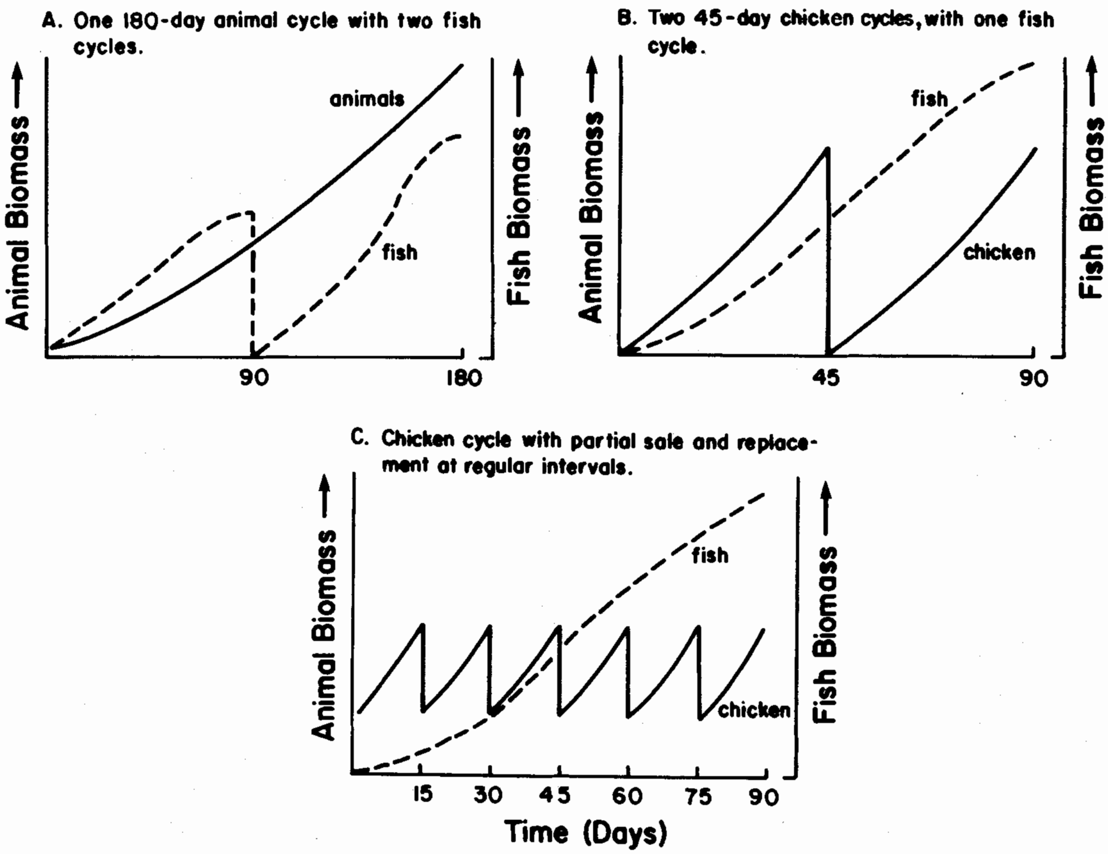

Fig. 2.2. Livestock and fish production cycles used in Project experiments.

second fish harvest was at day 180. During the first 90 days the manure output was lower than the second 90 days and thus the fish yields tended to be lower during the first cycle. Fig. 2.2B shows two chicken cycles with one fish cycle. It was apparent that the drastic drop in manure output at day 45 would probably restrict fish growth so an alternative chicken management cycle was used (Fig. 2.2C). In this system, one third of the flock was sold and replaced with chicks at regular intervals throughout the whole fish cycle. This lessened the magnitude of the fluctuations in manure output (see Chapter 3).

Below are brief descriptions of the experiments conducted during the Project. In general, factorial designs were used and results analyzed using analysis of variance and/or regression techniques. Detailed description of the experimental methods are presented in the appropriate places in the following chapters and/or Appendix A. Similarly, detailed stocking and harvest summaries are contained in Appendix B. Treatments were always duplicated or triplicated (see results in following chapters and appendices).

EXPERIMENT 1. FIRST 90-DAY PIG-FISH YIELD TRIALS, AUGUST TO NOVEMBER 1978

Inorganic fertilizer or manure from 40 and 60 pigs/ha was added to 1,000-m^2 ponds for 90 days. Inorganic fertilizer was added at the recommended rate of 50 kg of 16-20-0 (N-P-K) biweekly (PCARR 1976c). Pig size initially averaged about 19 kg and reached 55 kg at the completion of the experiment. Fish stocking densities of 10,000 and 20,000 fish/ha were used. Eighty-five percent of the fish were *Oreochromis niloticus*, 14% were *Cyprinus carpio*, and 1% was *Channa striata*. The ratios of this polyculture system were used as a standard in all other experiments (except where otherwise stated).

EXPERIMENT 2. SECOND 90-DAY PIG-FISH YIELD TRIALS, DECEMBER 1978 TO MARCH 1979

After completion of Experiment 1, the ponds were refilled and stocked. The pigs used in Experiment 1 were then grown to market size (approximately 100 kg). Fish stocking densities were the same as Experiment 1. There was considerable turnover in Project personnel during this experiment and the data collection was incomplete.

EXPERIMENT 3. THIRD 90-DAY PIG-FISH YIELD TRIALS, JUNE TO SEPTEMBER 1979

This experiment was the same as Experiment 1 except that the number of pigs was increased to 80 and 100 pigs/ha. Pig size averaged 11 kg initially and reached approximately 40 kg at the end.

EXPERIMENT 4. FOURTH 90-DAY PIG-FISH YIELD TRIALS, OCTOBER 1979 TO JANUARY 1980

The pigs from Experiment 3 were grown to marketable size after the ponds had been refilled and stocked. As recruitment control had been incomplete in Experiments 1 to 3, *Channa striata* levels were increased to 300 fish/ha.

EXPERIMENT 5. SIX-MONTH PIG-FISH YIELD TRIALS, FEBRUARY TO AUGUST 1980

Although the previous paired 90-day pig-fish experiments (1 to 4) had produced market-size fish, a single 6-month cycle was tested because only one-half the number of fingerlings was required and the higher average fish biomass could possibly utilize the food resources more efficiently. Manure from 100 pigs/ha was added to 1,000-m^2 ponds stocked with approximately 10,000 and 20,000 fish/ha for 6 months. *Channa striata* were stocked into 50% of the ponds. In the other ponds, recruitment control was attempted by selective harvest of fingerlings. During biweekly growth sampling, the fingerlings captured were removed while the initial stock was returned to the ponds.

EXPERIMENT 6. 120 AND 140 PIGS/HA YIELD TRIALS, JANUARY TO MARCH 1980

During the 90-day yield trials (Experiments 1 to 4), the manure loading rate at which fish growth would decrease and/or fish kills occur was not reached. However, the recommended maximum animal density in the pig houses was reached in Experiment 4. Therefore, to simulate higher manure loading levels, it was decided to haul manure from a nearby piggery and load it into 400-m^2 ponds at the rates equivalent to 120 and 140 pigs/ha from the 2nd 90-day pig-growth period: a very high loading level. Proximate analyses of the manure from the chosen piggery were comparable to analyses from the Project pigs. Measured manure output during Experiment 4 was multiplied by the appropriate factor to compute the daily manure loading. Fish were stocked at only 20,000/ha because the previous experiments showed that 10,000 fish/ha was less profitable than 20,000 fish/ha. The latter density was thereafter used as the standard stocking rate. After four sampling periods which showed the fish to be growing slower than in Experiment 4, this experiment was terminated on day 58. In addition to the slower growth, the severe logistical problems encountered in obtaining and hauling a consistent supply of manure from a piggery which was not under Project control, led to this early termination.

EXPERIMENT 7. ZERO TREATMENT I, AUGUST TO NOVEMBER 1980

This experiment was to provide the data needed to determine the Y-intercept of graphs relating nutrient input to fish yield: i.e., a control to determine the natural productivity of the ponds without fertilization/manuring. Fish were stocked at 20,000 fish/ha and no nutrients were added to the pond. Unfortunately, one week before scheduled harvest, a severe typhoon flooded the research ponds. Therefore, only the growth data collected during the experiment are available and not the final yields.

EXPERIMENT 8. FIRST DUCK-FISH YIELD TRIALS, SEPTEMBER TO DECEMBER 1978

Manure from 1,000 and 1,500 Peking ducks/ha was added to 400-m^2 ponds, until October 25, 1978 at which time a typhoon caused heavy duck mortality. The remaining ducks were distributed such that rates of 750 and 1,250/ha were maintained until the end of the experiment. Stocking densities were 10,000 and 20,000 fish/ha.

EXPERIMENT 9. SECOND DUCK-FISH YIELD TRIALS, JANUARY TO APRIL 1979

After refilling and restocking the ponds, the ducks used in Experiment 8 were grown for an additional 3.5 months and the manure added to the ponds. Duck densities were 750 and 1,250/ha. Fish stocking rates were 10,000 and 20,000/ha. After this experiment, the Project encountered considerable difficulties in marketing the ducks locally (Peking ducks are eaten primarily by the Chinese community in the Philippines which is concentrated in Manila). It was decided to discontinue the duck-fish experiments in favor of chicken (broiler)-fish experiments.

EXPERIMENT 10. BROILER-FISH INTEGRATION 1, MARCH TO JUNE 1980

All the manure from 1,000, 3,000 or 5,000 broilers/ha was added to 400-m^2 ponds thrice weekly. The broiler flocks were composed of three size groups (see Chapter 3). The fish stocking level was approximately 20,000 fish/ha.

EXPERIMENT 11. BROILER-FISH INTEGRATION II,
NOVEMBER 1980 TO FEBRUARY 1981

The manure from 250, 500, 750 or 1,000 broilers/ha was added to 400-m^2 ponds. Twenty thousand fish/ha were stocked.

EXPERIMENT 12. BROILER-FISH INTEGRATION III,
APRIL TO JULY 1981

The manure from 7,500 or 10,000 broilers/ha was added to 400-m^2 ponds for approximately 4 weeks. The size of the flock then decreased to zero within a month because chicks were unavailable for replacement of marketed birds. The experiment was continued to determine the residual effect of manure added during the initial weeks.

EXPERIMENT 13. POLYCULTURE WITH A FILTER FEEDER *(CHANOS CHANOS)*,
JANUARY TO APRIL 1981

During the earlier experiments, high concentrations of both phyto- and zooplankton were measured. In an attempt to use the plankton more efficiently, milkfish *(Chanos chanos)* were added to the system. The basic 20,000 fish/ha stocking rate was supplemented with milkfish at the rates of 750, 1,500, and 2,250/ha. The manure loading rate was 100 pigs/ha. Pig size was approximately 62 kg initially and increased to 100 kg. In both this experiment and Experiment 15, much of the data were lost when a record book which had been placed on a pig pen wall was eaten by the pigs.

EXPERIMENT 14. RECRUITMENT CONTROL I,
NOVEMBER 1980 TO APRIL 1981

The typhoon which disrupted Experiment 7 also flooded a newly-stocked pig-fish experiment. The pigs increased in weight to about 27 kg during the renovation period. As the pigs would reach market size in only 5 months, it was decided that postfingerling tilapia and carp should be stocked so that this experiment could be compared to the 6-month pig-fish cycles. In the first 6-month pig-fish experiment (Experiment 5), both the predation system and the selective harvest of fingerlings proved to be somewhat ineffective during the later parts of the experiment. Therefore, another predator, *Clarias batrachus*, was added and the selective harvest procedures were modified in this experiment. Also, the basic stocking density was increased to 30,000 fish/ha (28,500 tilapia, 1,500 carp). This increase was an attempt to produce higher yields and to produce a smaller tilapia than the 200-g fish produced in Experiment 5. Large tilapia had proved difficult to market locally.

EXPERIMENT 15. *OREOCHROMIS NILOTICUS* FRY PRODUCTION,
DECEMBER 1980 TO JANUARY 1981

This short experiment was conducted in the interim between pond renovation after the October 1980 typhoon and the start of Experiment 13. The 1,000-m^2 ponds were stocked with 200, 400, 600, 800, and 1,000 kg/ha of tilapia breeders. Manure from 100 pigs/ha (initial weight 35 kg, final weight 62 kg) was added to the ponds. The purpose of this experiment was to determine the potential of manured ponds for fry and fingerling production in the absence of predators.

EXPERIMENT 16. ZERO TREATMENT II,
JULY TO OCTOBER 1981

This experiment was a repeat of Experiment 7 which was disrupted by a typhoon.

EXPERIMENT 17. OXYGEN-DYNAMICS IN BROILER-FISH INTEGRATION, JANUARY TO FEBRUARY 1981

In an effort to obtain a better understanding of oxygen dynamics in chicken-fish systems (Experiment 10), the experiment was repeated and dissolved oxygen (DO) profiles were constructed once a week for each 8 ponds. These 24-hour profiles were based on hourly DO readings taken at four locations at 10-cm depth intervals, from the surface to the bottom. This experiment lasted one month.

EXPERIMENT 18. BROILER-FISH INTEGRATION IV, SEPTEMBER TO DECEMBER 1981

This was a second attempt to add manure from 7,500 or 10,000 chickens/ha to 400-m^2 ponds.

In addition to the fish, water quality parameters, including dissolved oxygen, nitrates, ammonia, phosphates, alkalinity, conductivity, pH and Secchi disk visibility were routinely measured during the experiments. Also, plankton samples were collected, identified, and plankton concentrations computed.

3. Animal Husbandry and Manure Output

PIGS

Large white-Landrace hybrid weanlings were purchased from commercial sources and transported to the Project site. Initial weight varied from an average of 11.9-19 kg. The animals were fed a commercial starter ration while less than an average weight of 17 kg, then a grower ration to 60 kg, and a finisher ration to market-size (80-105 kg). Feed compositions are listed in Table 3.1. The feeding rate was adjusted such that the pigs would consume all of the ration in two 1-hour feeding sessions per day. This represented about 3.5-7% body weight/day. Additionally, when the pigs reached a weight of approximately 25 kg the commercial rations were supplemented with fresh-cut paragrass *(Brachiaria mutica)* at the rate of 1% body weight/day. Sometimes fresh ipil-ipil *(Leucaena* sp.) leaves were substituted for the grass.

Animals were vaccinated against hog cholera and dewormed regularly. In case of disease, the sick animals were injected with broad-spectrum antibiotics and antibiotics added to the feed. In case of severe illness, the sick animals were isolated and returned to their growing pens only when the disease was under control. Animals infected with scabies were swabbed with used crankcase or gear oil.

Table 3.1. Guaranteed analysis of pig feeds from feed bag labels.

Component[1]		Percent composition[2] Starter ration	Grower ration	Finisher ration
Crude Protein	(NLT)	18	16	13
Crude Fat	(NLT)	4	4	4
Crude Fiber	(NMT)	8	10	3
Ash	(NMT)	8	8	3
Moisture	(NMT)	13	13	13

[1]NLT = not less than, NMT = not more than. These feeds are also supplemented with vitamins and minerals.
[2]Percent of dry matter (except for % moisture).

Note: 80% of feed samples met or exceeded the manufacturer's specification for crude protein, 100% samples for fat, 0% for ash, 100% for moisture, and 0% for fiber.

The growth rates exhibited by the pigs were highly variable (Fig. 3.1). Even though the pigs used in Experiments 1 and 2 were initially 60% larger than the pigs in Experiments 3 and 4, the latter pigs attained the same final weight in a comparable period of time. The slower growth rates exhibited in the early experiments might well be the result of "runts" being included in the experimental animal population. Even though healthy-looking weanlings were selected by Project personnel for purchase, the weanling producers are known to include older "runts" in groups of young weanlings. In later experiments, whole litters from small farms were purchased to minimize this problem.

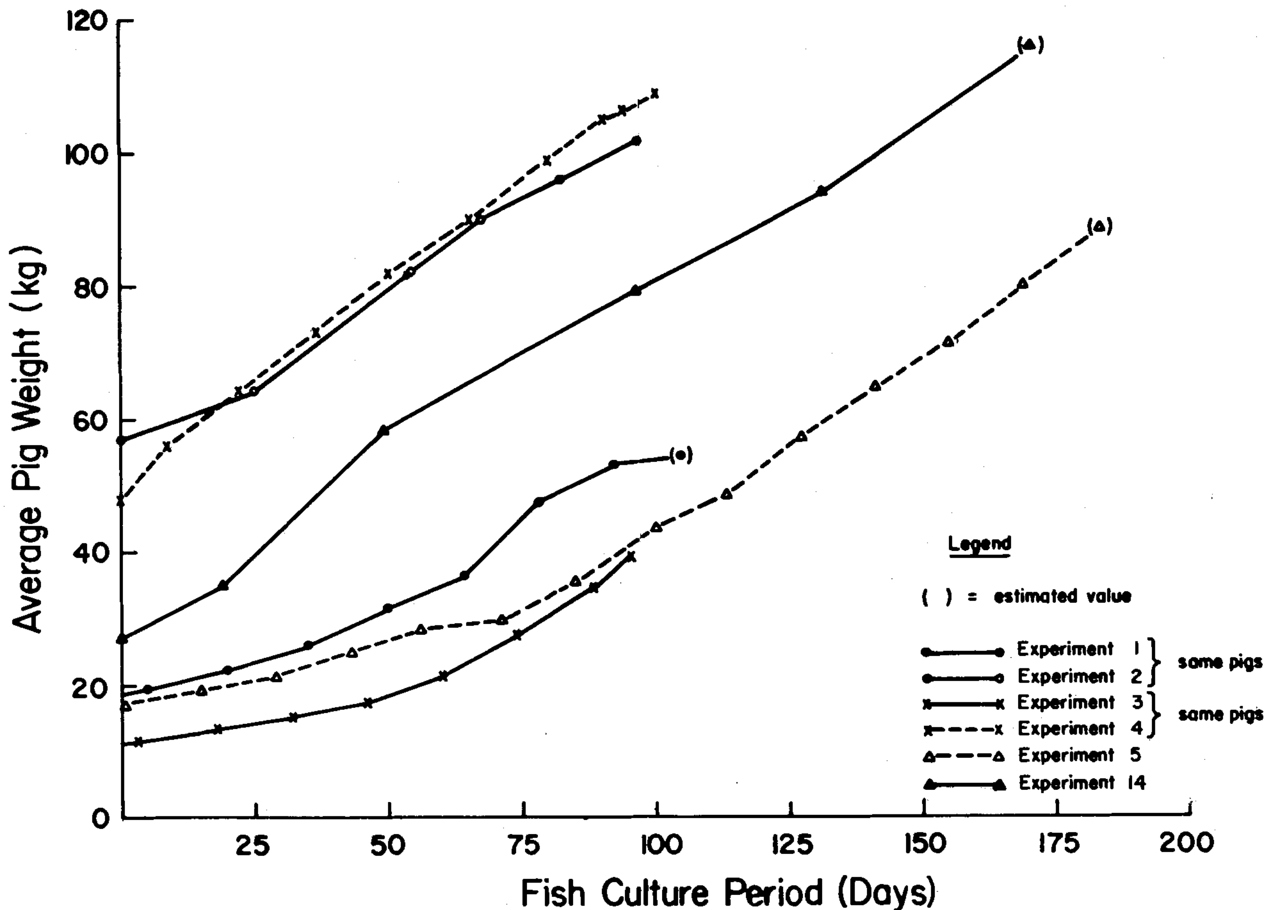

Fig. 3.1. Average pig weights during pig-fish experiments. For details of numbered experiments, refer to the text.

Feed-conversion ratios (FCR) averaged 4.23 for Experiment 3 and 5.51 for Experiment 4 (a weighted average of 5.08). In Experiments 5 and 14, the FCR decreased to 4.52 and 4.30, respectively. This was possibly a result of the change in weanling purchase policies.

Manure output was determined weekly during Experiments 3 and 4 by closing the outlet from the pens to the ponds for a 24-hour period and collecting all of the manure (mixed with urine) voided during the period. Manure output (as a percentage of total live weight (TLW)) appeared to be a function of both animal size and feed type (Fig. 3.2). A logarithmic relationship describes the relationship of animal size to manure output when a grower ration is fed while a linear relationship is more appropriate when finisher ration is used. The correlation coefficients for these two relationships are highly significant ($\alpha = 0.01$). No relationship between animal size and manure output was indicated (with a linear equation, $R = 0.17$) with starter ration. Therefore, the mean manure output with starter of 5.1% TLW per day was used in our analyses. Fig. 3.3 shows the relationship of animal size/manure output.

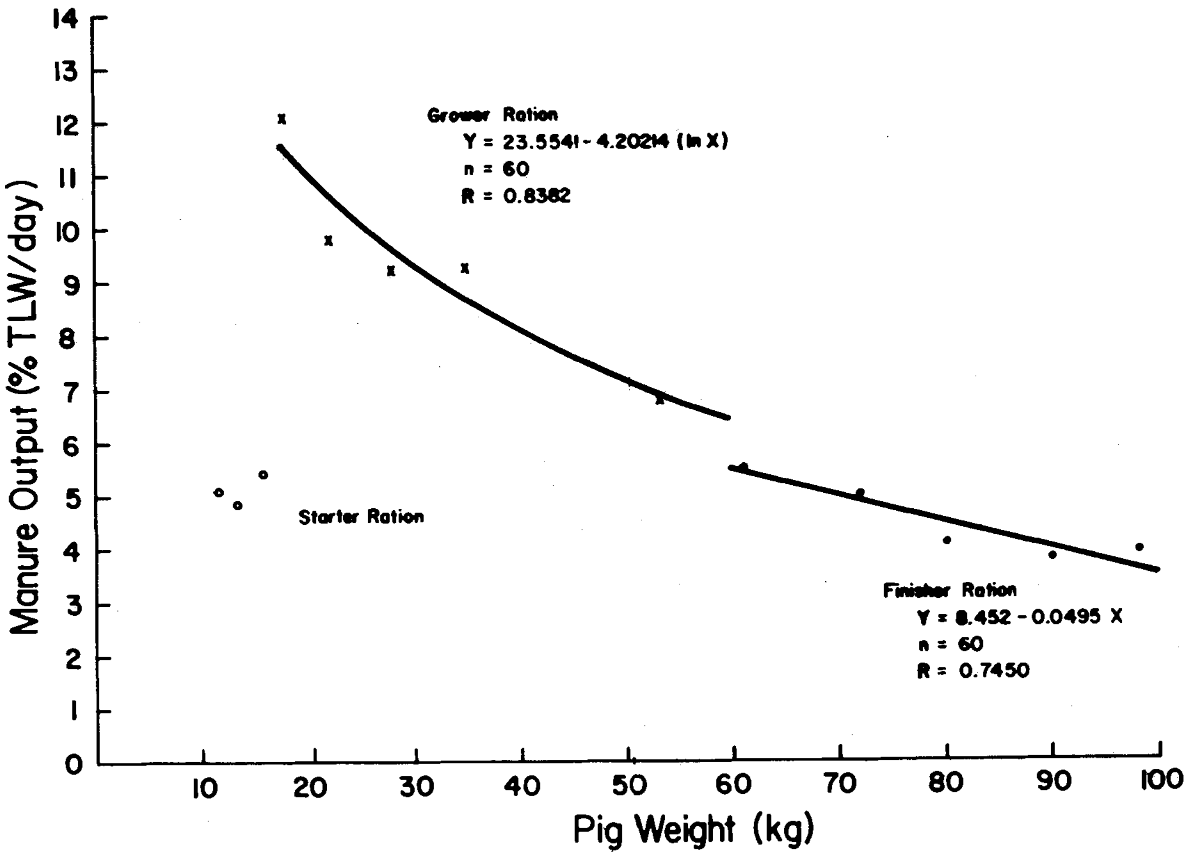

Fig. 3.2. Relationships between pig size and manure output for large white-Landrace cross pigs used in integrated pig-fish culture experiments: each data point used in computing these relationships was a mean of the individual measured outputs of 8 or 10 pigs; the plotted points are grand means of 12 such data points. (TLW = total live weight)

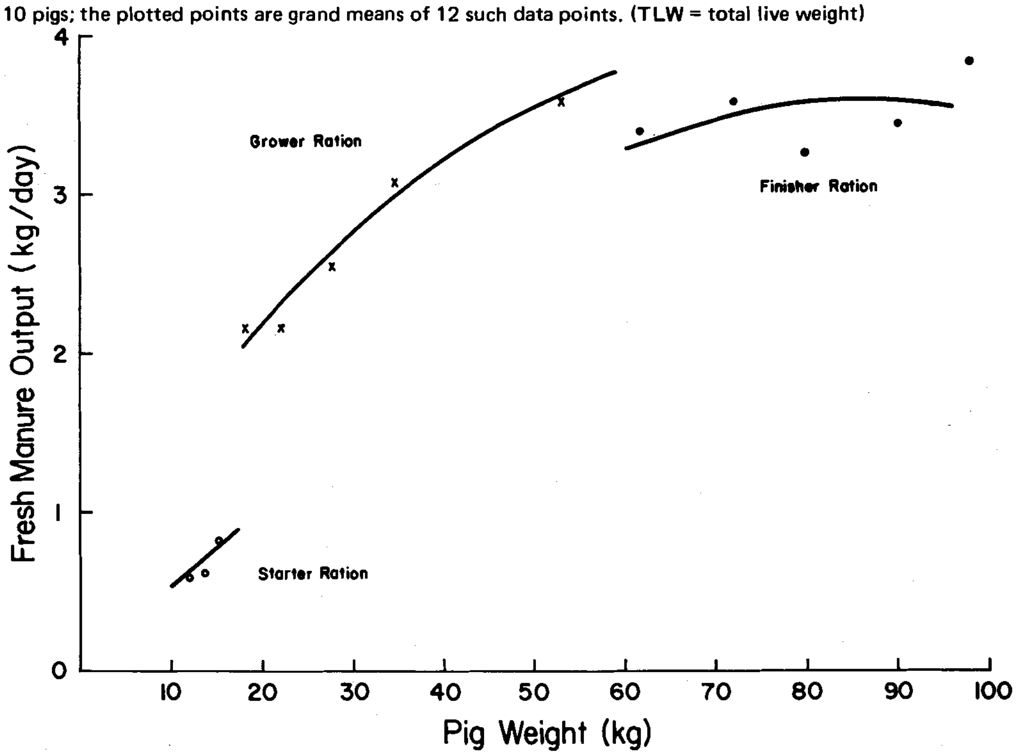

Fig. 3.3. Relationships between pig weight and manure output for large white-Landrace cross pigs used in integrated pig-fish culture experiments: the curves were computed by regression analysis from raw data; each plotted point is a mean of 12 observations each of which was obtained from measurements on 8 or 10 individual pigs.

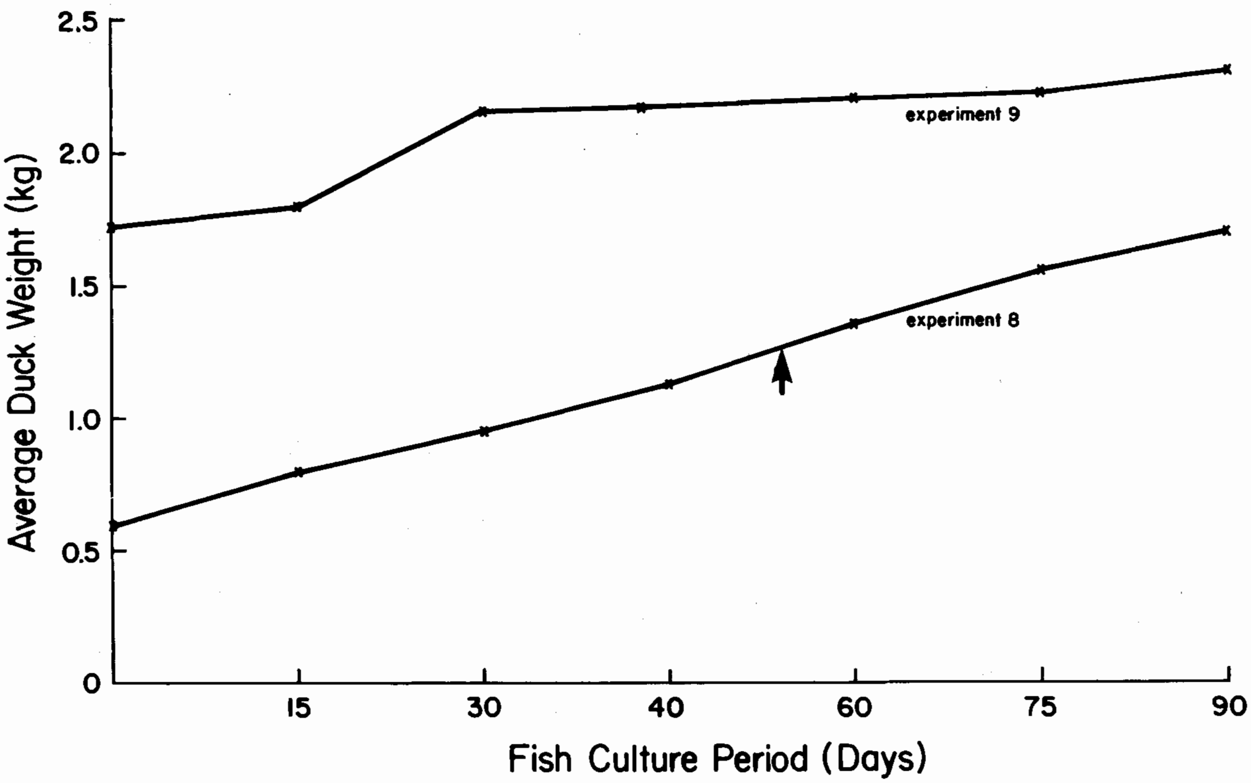

Fig. 3.4. Average duck weights during duck-fish integrated culture experiments. Arrow indicates occurrence of typhoon which reduced duck densities. Details in text.

Proximate analyses of thoroughly-mixed composite samples were made weekly. Moisture content averaged 77% for manure from pigs fed starter ration, 73.6% for grower ration-fed animals, and 68.7% for finisher-fed animals. Although the difference between values for grower and finisher-fed animals was highly significant ($F = 31.89$ with $df = 165$), the grower ration was fed during the rainy season while the finisher ration was used during the dry season. Therefore the average moisture content of 70.1% is probably a good overall estimate. Nitrogen composed an average of 1.9% of the total solids (TTS) and did not vary significantly during the experiment. Percentage of ash increased from 6.99% TTS with starter-fed pigs to 7.74% TTS with grower-fed pigs and 12.44% TTS for finisher-fed pigs. The difference between the last two values is highly significant ($F = 8.01$ with $df = 146$). Lipid levels (ether extract) were significantly higher for animals fed starter ration than for animals fed the other rations (7.8% TTS vs. 15.7-18.2% TTS). The 24-hour BOD averaged 12 mg O_2/g fresh manure and the fiber content was 21.2% TTS. All of these values correspond closely to published values for pig manures (Azevedo and Stout 1974; Taiganides 1977).

DUCKS

Day-old Peking ducklings, obtained from a commercial producer, were confined to the duck houses for one month and thereafter allowed access to the ponds (and dikes in Experiment 8) during the day. A broiler-starter ration was fed for the first two weeks after which a broiler-finisher ration was fed until harvest. Feeding was *ad libitum*. The growth rate of the ducks is shown in Fig. 3.4.

No reliable duck manure data were collected during the two duck-fish experiments. At a later date, manure was collected from a flock of native laying-ducks which were being fed a mixture of pig feed and rough rice (in addition to their foraging in a fishpond) to obtain approximate data. Manure output was 11% TLW per day, containing 69% moisture, 1.47% TTS nitrogen, and 20% TTS fiber.

CHICKENS

Day-old broiler chicks were purchased from commercial suppliers and raised in three-tiered cages using recommended Philippine practices (PCARR 1976a). The chicks were held at densities of up to 30 chicks/m^2. After two weeks, the birds were transferred to "grow-out" cages. The maximum density in the "grow-out" cages was approximately 11 birds/m^2. The birds were fed a commercial starter ration (21% crude protein, 4% crude fat, 8% crude fiber, and 8% ash) *ad libitum* until market size. Market size of 1.1-1.4 kg was attained in about 49 days with an average FCR of 2.57.

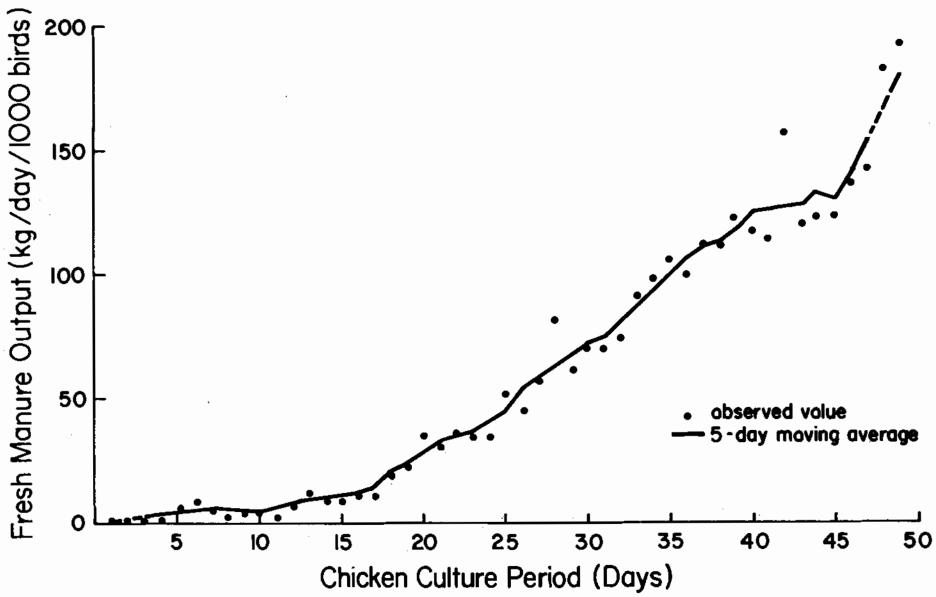

Fig. 3.5. Fresh manure output from even-aged broiler chickens used in integrated chicken-fish culture experiments.

The chicken flock was managed such that there were always three sizes of birds present. This was done by marketing one-third of the flock and replacing them with an equal number of chicks. This stocking and harvesting was done at intervals of two or three weeks throughout the experiments. These uneven cycles were caused by chicks being available only on Saturdays while the culture period was seven (2 + 2 + 3) weeks.

Manure from one age group of chickens was collected daily for a complete culture period of 49 days. Fig. 3.5 shows the relationship of chicken age to fresh manure output. A simple linear or curvilinear equation could not satisfactorily explain the observed relationship so 5-day moving averages were used in our analyses. Proximate analyses of manure were made throughout the culture period. Percent dry matter appears to be a function of daily manure output. The probable reason for this is that small amounts of feces can dry more quickly than the larger lumps. Dry matter varied from 35.0% to 79.4% of fresh manure weight. The following equation shows this relationship:

$$\begin{aligned} Y &= 87.7857 - 11.931 (\ln X) \\ R &= 0.967 \\ n &= 6 \end{aligned} \qquad (3.1)$$

where Y = percent dry matter, X = manure output per 1,000 birds of a given age per day, R = correlation coefficient and n = number of samples. The correlation coefficient is significant at the 0.01 level. Nitrogen varied from 3.2 to 5% TTS with a weighted average (based on relative amounts of manure) of 3.5% TTS. Lipids averaged 10.9% TTS, ash was 9.8% TTS, and fiber was 18.2% TTS.

Using the relationship presented in Equation 3.1, the 5-day moving averages shown in Fig. 3.5, and the daily number of birds in each size (age) group, we computed the chicken manure output (dry matter basis) during the fish culture cycles (Fig. 3.6). The uneven cycles are readily apparent. Manure output varied from 11 to 31 kg dry matter/day for 1,000 birds of mixed sizes. If the same number of birds was raised on an even-age basis, manure output would vary from 1 to 45 kg dry matter/day. It must be stressed that the total output of manure is the same for even-aged rearing and for the "2 to 3 week" replacement cycle.

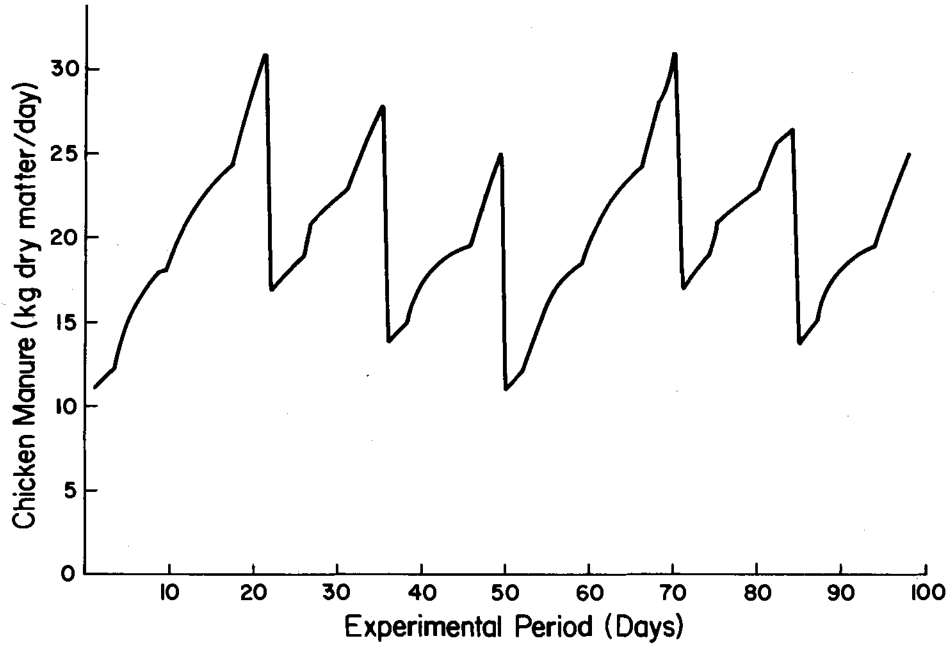

Fig. 3.6. Daily manure output (dry matter) for a flock of 1,000 mixed-size broiler chickens used in integrated chicken-fish culture experiments.

MANURE OUTPUT AND COMPOSITION

After a thorough review of the manure output and proximate analysis data and a review of published values, the set of values which were used in further analyses was selected (Table 3.2). Whenever possible, values from the Project were used.

The daily manure output of the pigs varied according to ration and animal size and the relationships illustrated in Fig. 3.2 were used in later analyses. The total solids, nitrogen, and crude fiber values used were from Project data. The phosphate, potash, and BOD_5 values were extracted from Taiganides (1977) as these parameters were not measured on the Project. The measured nitrogen content was lower than Taiganides' table values (% TTS basis) but the measured total solids were greater. If expressed on a total liveweight basis, the measured nitrogen value and Taiganides' value

Table 3.2. Summary of selected manure output and proximate analysis values which were used in analyses in following chapters.

Parameter	Pig	Duck	Chicken
Daily manure output[1]	3.5 - 11.5% TLW	11.7% TLW	24 - 106 kg/1,000 birds
Total solids (TTS)	29.9%	43.0%	35.0 - 79.4%
Nitrogen (N)	1.9% TTS	2.3% TTS	3.5% TTS
Phosphate	0.017% TLW	3.3% TTS	4.6% TTS
Potash (K_2O)	0.010% TLW	1.4% TTS	2.1% TTS
Crude fiber	21.2% TTS	20.0% TTS	18.5% TTS
BOD_5	0.22% TLW	9.2% TTS	21.4% TTS

[1]TLW = total live weight.

were comparable (0.026 to 0.051% TLW and 0.039% TLW, respectively).

Data from Woynarovich (1979) were the main source of information on Peking ducks. Using his duck growth data from a 7-week period and the stated manure output of 6 kg per duck, a daily manure output of 11.7% TLW was computed. Dry matter, nitrogen, phosphate, and potash values also came from Woynarovich (1979). Crude fiber values were Project data on laying ducks while the BOD_5 was based on data in Loehr and Schulte (1971).

The manure output of chickens was a function of size and the relationships in Figs. 3.4 and 3.5 were used for later analyses. Dry matter varied according to the amount of manure excreted (Equation 3.1). Nitrogen and crude fiber values were Project data while phosphate, potash and BOD_5 values were from Taiganides (1977).

SUMMARY

Table 3.3 presents a summary of experiments and ponds grouped according to average daily manure input computed from the preceding relationships. It must be emphasized that all the wastes from the animals were placed in the ponds. If only solid matter (i.e., feces without urine) were used, results would have been different.

Table 3.3. Average daily manure input during the experiments.

Animal type	Manure load (kg dry matter per ha/day)	Experiment no. (pond no.)[1]
Pig	31 – 40	1 (2, 3, 6, 9) ; 3 (2, 4, 6, 8)
	41 – 50	1 (10) ; 2 (2, 3, 5, 6, 9, 11) ; 3 (1, 3, 9)
	51 – 60	1 (4, 7, 12) ; 3 (5, 7, 10, 11)
	61 – 70	2 (1, 4, 7, 8, 10, 12) ; 3 (12)
	81 – 90	4 (2, 4, 6, 8, 9, 11)
	101 – 110	4 (1, 3, 5, 7, 10, 12)
	131 – 140	6 (13, 14, 20)
	151 – 160	6 (19)
Duck	51 – 60	8 (13, 15, 16, 18, 20, 23)
	76 – 85	8 (14, 17, 19, 21, 22, 24) ; 9 (13, 15, 16, 18, 20, 23)
	131 – 140	9 (14, 17, 19, 21, 22, 24)
Chicken	5	11 (14, 21)
	10	11 (17, 19)
	15	11 (15, 22)
	20	10 (15, 19, 22) ; 11 (13, 20)
	61	10 (16, 21, 23)
	97	12 (14, 21)
	101	10 (13, 14, 20)
	131	12 (15, 20)
	151	18 (18, 22)
	202	18 (16, 17)
Inorganic fertilizer		1 (1, 5, 8, 11)

[1] 1 (2) indicates experiment 1, pond 2.

4. Fish Yields

The net yields from the animal-fish systems were examined separately and an attempt was then made to relate the systems to each other. In the analyses, data from any pond in which less than 50% of the tilapia survived were rejected. This was necessary because, during the early experiments, ponds were sometimes stocked before the poison* used in pond preparation was completely dissipated. The data are presented in Appendix B.

CONTROLS

Experiment 16 and part of Experiment 1 were the control experiments. In Experiment 16, no nutrients were added to old ponds (i.e., ponds which had been previously used for animal-fish experiments). In Experiment 1, inorganic fertilizer was added at recommended rates to new ponds. Experiment 1 was a "control" in the sense that use of inorganic fertilizer is standard practice. The yields were, as expected, low (Table 4.1). There appeared to be a residual effect from previous experiments in Experiment 16 as the total net yields were equivalent to those attained with inorganic fertilizers in new ponds. This residual effect could have been caused by an increase in nutrient loads in the sediments, and/or the presence of algal cells in ponds which had been incompletely dried.

Table 4.1. Mean net fish yields from control ponds.

Experiment no.[1]	Stocking rate[2] (fish/ha)	Culture period (days)	Mean net yield (kg/ha/day)		
			Tilapia	Carp	Total[3]
1	10,000	96	3.5	1.6	6.4
1	20,000	106	2.3	0.7	3.3
16	20,000	90	6.1	0.6	6.7

[1]Inorganic fertilizer was used in Experiment 1 with new ponds. In Experiment 16, no nutrients were added, but old ponds were used.
[2]Approximately 85% tilapia, 14% carp, 1% *Channa striata.*
[3]Includes *Channa striata* and *O. niloticus* fingerlings.

PIG-FISH SYSTEMS

The primary variables which were manipulated during the pig-fish experiments were manure load, stocking density, and length of the culture period. As mentioned, there appeared to be a residual effect in ponds which had been previously used. The manure loads in Experiments 1, 2 and 3 overlapped and a plot of the yields from these experiments illustrates the higher yield in old ponds (Fig. 4.1). The residual effect confused the analyses and Experiment 1 was not included in further analysis in this section.

The pig-fish system usually had two 90-day fish culture cycles in each pig-production cycle. The mean fish yields attained using this arrangement of culture cycles are shown in Table 4.2. Two fish stocking rates and several manure loading rates were used. Stocking 20,000 fish/ha produced a higher yield of tilapia than 10,000 fish/ha although the average size of fish was smaller with 20,000 fish/ha (Appendix B). A more detailed presentation of yields attained with 20,000 fish/ha is shown in Figs. 4.2 and 4.3 for tilapia and carp, respectively. The tilapia yields were highly variable at low manure loads. As the manure loads increased, the average yield increased and variability appeared to decrease. At very high manure loads, average yield began to decrease and variability to increase. The relationship between manure loading and yield can be described mathematically by the parabolas presented with the data in Fig. 4.2.

*Gusathion A (Bayer), an organophosphate, was added to partially drained ponds at 0.15 mg/l to eradicate any stray fish. Dissipation usually required one week (depending on weather conditions).

Table 4.2. Mean fish yields (net) in pig-fish systems during short (58 to 104 day) culture periods.

Stocking rate[1] (fish/ha)	Manure load (kg dry matter/ha/day)	Mean net yield (kg/ha/day) Tilapia	Carp	Tilapia recruits	Total[2]
10,000	31 – 40	8.2	1.0	5.9	15.4
	41 – 50	11.5	3.3	1.5	16.3
	51 – 60	8.8	1.5	7.2	17.8
	61 – 70	14.9	3.9	0	18.9
	81 – 90	10.7	2.7	0	13.6
	101 – 110	11.3	3.3	0	14.8
20,000	31 – 40	13.1	1.7	2.1	17.3
	41 – 50	14.0	1.4	0.1	15.7
	51 – 60	13.6	2.3	7.1	23.3
	61 – 70	16.2	3.1	0.3	19.9
	81 – 90	15.4	3.7	0.1	19.4
	101 – 110	19.2	4.5	0.3	24.2
	131 – 140	16.2	4.4	0.2	21.1
	151 – 160	13.3	3.9	0.2	17.6

[1] Approximately 85% tilapia, 14% carp, and the remainder *Channa striata*.
[2] Also includes *Channa striata*.

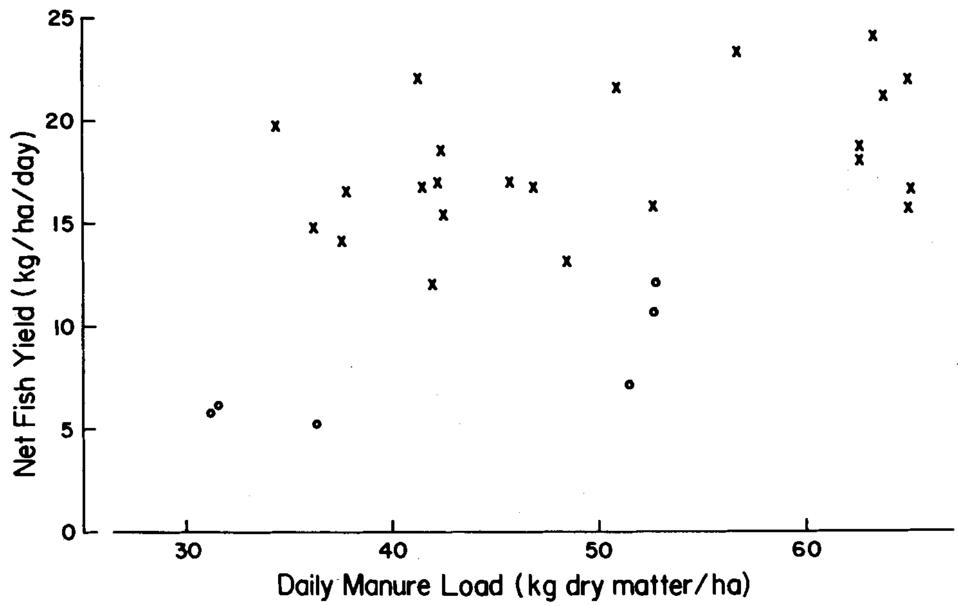

Fig. 4.1. Residual effects of pond-manuring illustrated by differences in net fish yields from 'old' (X) and 'new' (O) ponds used in integrated pig-fish culture experiments.

The carp data were much more difficult to analyze because stocking rates and size at stocking varied due to fingerling shortages. Preliminary indications were that a multiple regression equation, including initial size and number in addition to manure loads, may provide acceptable estimates of carp yields. This equation will require further refinement.

An alternative to two 90-day fish culture cycles in each pig production cycle was one 180-day fish culture cycle. This alternative cut fingerling costs, labor and water requirements. Also, it was hoped that the higher average biomass would lead to more efficient utilization of the available food resources and produce larger fish. A major constraint to the longer cycle was the probability of

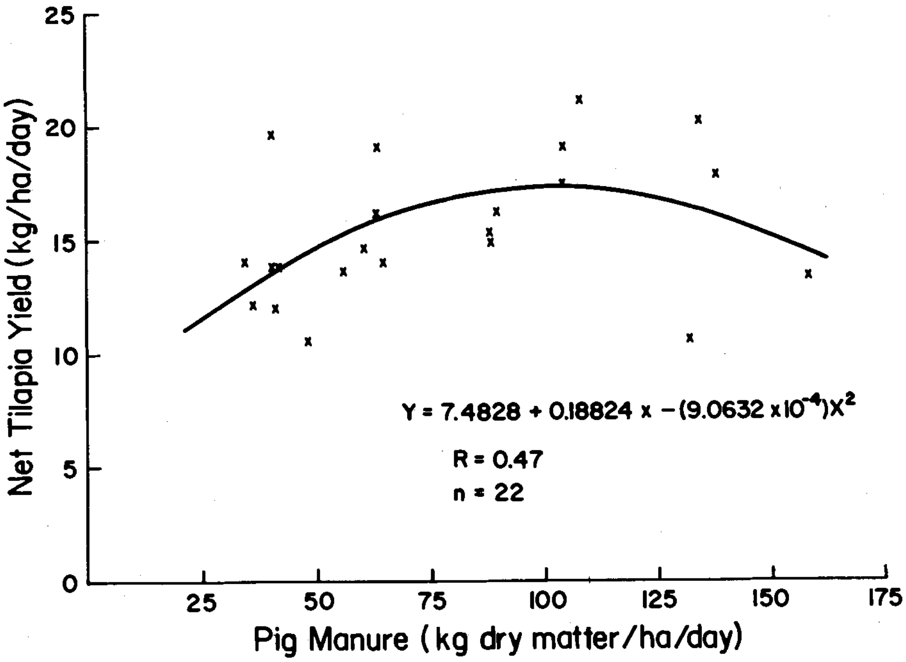

Fig. 4.2. Net yield of tilapia *(Oreochromis niloticus)* stocked at 17,000/ha in pig-manured ponds during short growout experiments (58-107 days).

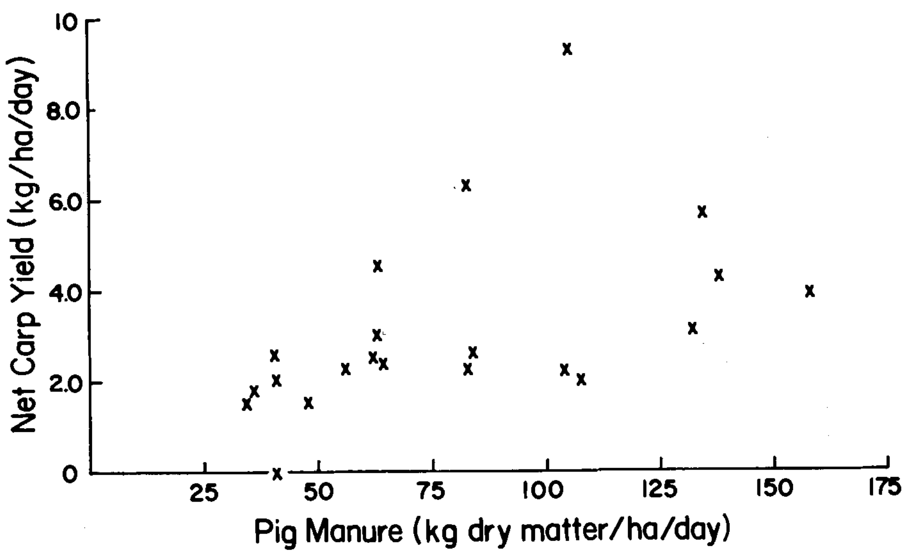

Fig. 4.3. Net yield of common carp *(Cyprinus carpio)* stocked at 1,180 to 2,300/ha with tilapia in pig-manured ponds during short growout experiments (58-107 days).

overpopulation with subsequent stunting by the tilapia. Two recruitment control mechanisms were tried. The first was based on the predator levels which were refined in Experiments 4 and 6 (see below); the second entailed partial harvest of recruits during the biweekly growth sampling. Stocking levels of fish were 10,000, 20,000 and 30,000 fish/ha.

The results are summarized in Table 4.3. Concern about potential overpopulation by tilapia was valid. It was only at a stocking density of 31,300 fish/ha, including predators, that recruitment was checked. However, if the recruits were included, very high net yields of 33.5 kg/ha/day (12,228 kg/ha/annum) were attained at 20,000 fish/ha without predators.

To compare the single 180-day cycle with the two 90-day cycles, the yields for each 90-day period were added together. For manure, an average load during the first 90-day cycle of 51-60

Table 4.3. Net fish yields attained in ponds receiving pig manure for 155 to 185 days. Average manure load was 80 to 90 kg dry matter/ha/day. Data from Experiments 5 and 14.

Recruitment control	Stocking rate (fish/ha)	Mean net yield (kg/ha/day)			
		Tilapia	Carp	Tilapia recruits	Total[1]
Partial harvest	10,000	8.4	2.3	18.2	28.8
	20,000	13.0	2.1	18.4	33.5
	30,000	15.5	2.0	10.1	27.9
Predator	10,300	11.1	2.4	10.1	23.9
	20,400	15.6	3.0	11.5	30.6
	31,300	19.1	1.6	1.3	23.0

[1]Also includes *Channa striata.*

Table 4.4. Net fish yield using two 90-day fish culture cycles with pig manure loads equivalent to those used in single 180-day cycles. Data from Table 4.2.

Stocking rate (fish/ha)	Manure load (kg dry matter/ha/day)	Mean net yield (kg/ha/day)			
		Tilapia	Carp	Tilapia recruits	Total[1]
10,000	51 – 60	8.8	1.5	7.2	17.8
	101 – 110	11.3	3.3	0	14.8
	$\overline{X}$ = 76 – 85	10.1	2.4	3.6	16.3
20,000	51 – 60	13.6	2.3	7.1	23.3
	101 – 110	19.2	4.5	0.3	24.2
	$\overline{X}$ = 76 – 85	16.4	3.4	3.7	23.8

[1]Also includes *Channa striata.*

kg/ha/day and during the second 90-day cycle of 101-110 kg/ha/day was used. The net yields for two 90-day cycles at these manure loads are shown in Table 4.4. At stocking densities of 10,000 and 20,000 fish/ha, there was no significant difference in the yields of market-size fish between a single 180-day cycle and two 90-day cycles. However, the 180-day cycle provided a large supply of recruits in addition to the potential benefits listed earlier. Also, the highest yields of market-size fish were obtained with 30,000 fish/ha and a 180-day cycle. Although a stocking rate of 30,000 fish/ha was not used in two 90-day cycles, it is doubtful that market-size fish could be attained in the first 90-day cycle at this density.

The systems above were based on growing a group of weanlings to market size. If a relatively even supply of manure was available, (e.g., when several size groups are grown simultaneously), loading the ponds at an average rate of 101-110 kg/ha/day for the whole culture period(s) would probably have maximized yields.

DUCK-FISH SYSTEMS

In experiments 8 and 9, ducks were used as the manure source. Experiment 8 was conducted in newly constructed ponds and Experiment 9 used the same ponds after the completion of Experiment 8. Net yields are shown in Table 4.5 and Fig. 4.4. New ponds gave lower yields than "old" ponds and stocking of 20,000 fish/ha produced more fish than 10,000 fish/ha. Also, increasing the average manure load from 82 to 136 kg dry matter/ha/day had no significant effect on yield. In this situation of rather limited data, the most than can be said is that a mean duck manure input of 82 kg dry matter/ha/day will yield an average of 11.9 and 15 kg/ha/day at stocking rates of 10,000 and 20,000 fish/ha, respectively.

CHICKEN-FISH SYSTEMS

The fish yields in experiments that used chicken manure as the nutrient source are summarized in Table 4.6 and Figs. 4.5 and 4.6. These yields followed the pattern shown by the pig-fish data of highly variable results at low manure levels. As the manure load increased, the yield increased and variability appeared to decrease. With further increasing manure loads, yields decreased. Tilapia

Table 4.5. Mean fish yields from ponds receiving duck manure.

Stocking rate (fish/ha)	Manure load (mean, kg dry matter/ha/day)	Mean net yield (kg/ha/day)		
		Tilapia	Carp	Total[1]
Experiment 8				
10,000	55	3.7	1.9	7.5
	80	4.8	1.7	6.9
20,000	54	4.4	2.2	6.6
	85	6.5	2.9	9.5
Experiment 9				
10,000	82	8.6	2.8	11.9
	136	8.2	2.5	11.4
20,000	81	12.9	1.9	15.0
	136	11.4	2.5	14.2

[1]Also includes *O. niloticus* recruits and *Channa striata.*

yields were maximized with a manure input of approximately 100-110 kg dry matter/ha/day, equivalent to 5,000 to 5,500 chickens/ha. Carp yields were maximized at 50-60 kg dry matter/ha/day indicating that carp were less tolerant than the tilapia to conditions at higher manure loadings.

The yields attained from Experiment 12, in which the bulk of the manure was added early in the experiment, were the same as yields attained in experiments with more "even" manure delivery. This phenomenon requires further investigation.

N, PHOSPHATE, BOD_5 AND FIBER IN THE MANURE

Nitrogen, phosphate, BOD_5, and fiber content values for each manure type were calculated and yield was then plotted as a function of each of these components (Figs. 4.7-4.10). The N and

Table 4.6. Mean fish yield from ponds receiving chicken manure.

Manure load (kg dry matter/ha/day)	Number of chickens[1]	Mean net yield (kg/ha/day) Tilapia	Carp	Tilapia recruits	Total[2]
5	250	8.5	2.1	0	10.8
10	500	8.5	2.7	0	11.4
15	750	6.3	2.5	0.4	9.3
20	1,000	11.1	3.5	3.5	18.2
61	3,000	14.8	5.2	0.5	20.6
97	7,500 →0	16.8	2.4	0	19.2
101	5,000	16.4	3.0	8.8	28.7
131	10,000 →0	14.8	2.4	0	17.2
151	7,500	12.8	0.4[3]	0	13.2
202	10,000	11.8	0.3[3]	0	12.1

[1]Number/ha, 7,500 →0 and 10,000 →0 (decreasing to zero) occurred in Experiment 12.
[2]Also includes *Channa striata.*
[3]Carp recovery rate was very low, 20 to 22%.

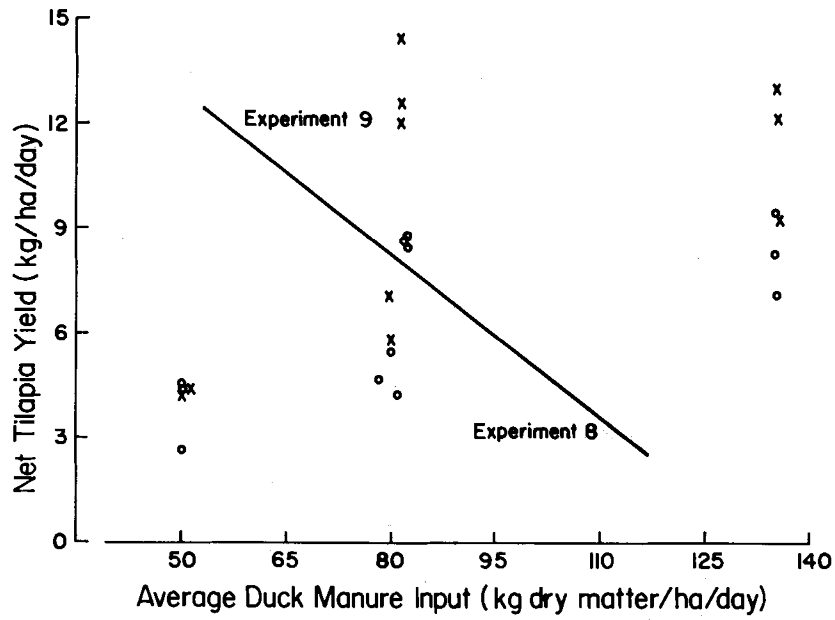

Fig. 4.4. Net yield of tilapia *(Oreochromis niloticus)* stocked at 8,500 (O) and 17,000/ha (X) in duck-manured ponds.

phosphate values were used because they are major nutrients for the phytoplankton. BOD_5 was selected as a general indicator of potential bacterial production and fiber was included as an indicator of bacterial substrate. The variability of these parameters was very great at lower manure loads and decreased somewhat as manure loads and yields increased. The data suggested that phosphate and BOD_5 may be more "important" than the N or fiber in determining tilapia yield but further analysis will have to be conducted to refine the relationships.

MILKFISH

In an effort to utilize more effectively the very dense plankton populations, particularly at higher manure loads, it was decided to stock another plankton feeder into the ponds. The silver

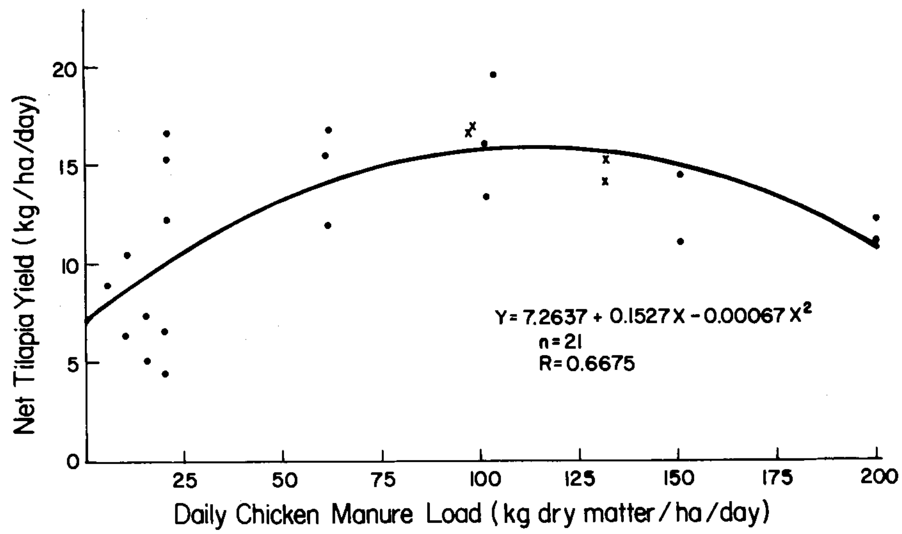

Fig. 4.5. Net yield of tilapia *(Oreochromis niloticus)* stocked at 17,000/ha in chicken-manured ponds. 'X' points represent decreasing manure load due to unavailability of chickens (Experiment 12) not used in regression.

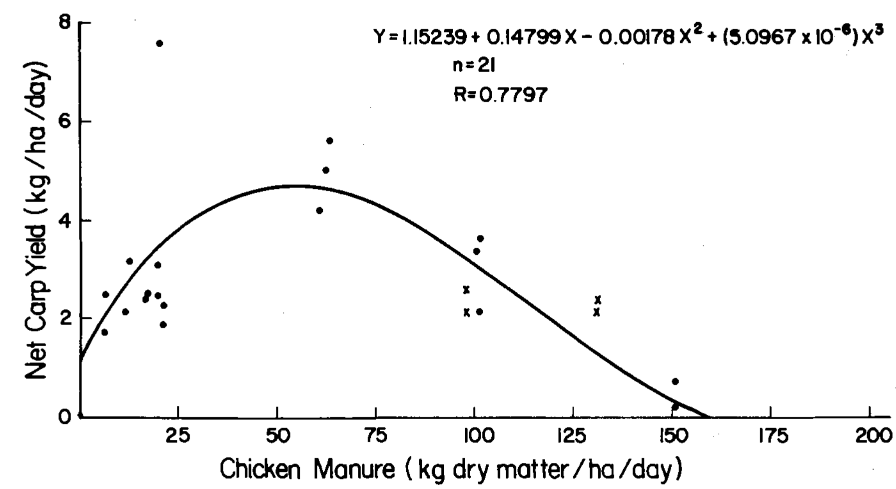

Fig. 4.6. Net yield of common carp *(Cyprinus carpio)* from chicken-manured ponds containing tilapia. 'X' points represent decreasing manure load due to unavailability of chickens (Experiment 12) not used in regression.

carp, *Hypophthalmichthys molitrix*, was considered, but it was almost unknown and probably unmarketable in the Philippines, so the more familiar milkfish, *Chanos chanos*, was used. However, survival rates for the milkfish were very low.

PREDATION

The initial pig-fish experiments included the predator, *Channa striata*, to control tilapia recruitment. It was stocked at the rate of 1% of the total fish number. It was found that a total fish density of 10,000/ha produced an average yield of recruits of 661 kg/ha while only 211 kg/ha were produced at a stocking density of 20,000 fish/ha. This indicated that a simple ratio of predators to prey "parents" was not effective in predicting or controlling recruitment. The predator level was then increased to 300 predators/ha regardless of the stocking density of other fish (Experiment 4). Recruitment was controlled at this predator level. An analysis of predator-prey relationships, comparing these data with other published work, has been prepared (Hopkins et al. 1982). We also used *Clarias batrachus* as a predator with limited success (Experiment 14).

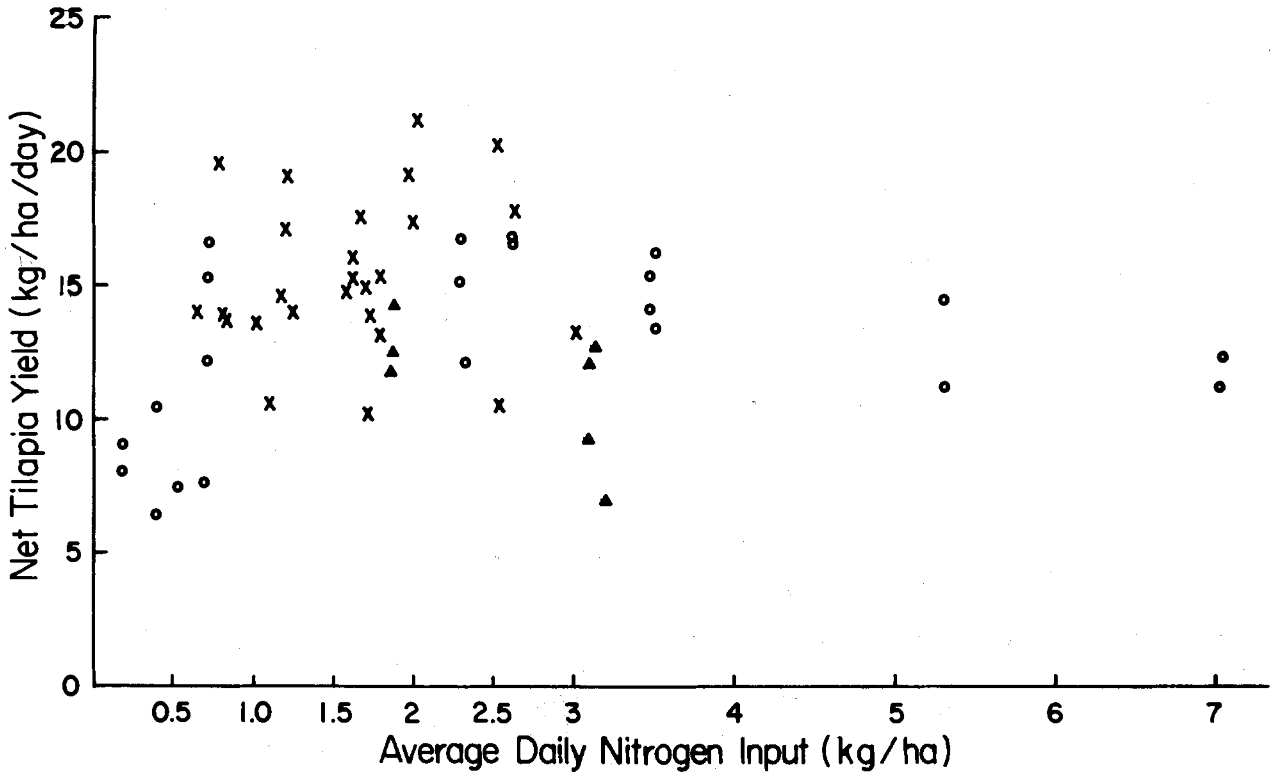

Fig. 4.7. Relationship between net yield of marketable tilapia *(Oreochromis niloticus)* stocked at 20,000/ha and nitrogen input from manure of pigs (X), chickens (O) and ducks (Δ) (culture periods, 58-107 days).

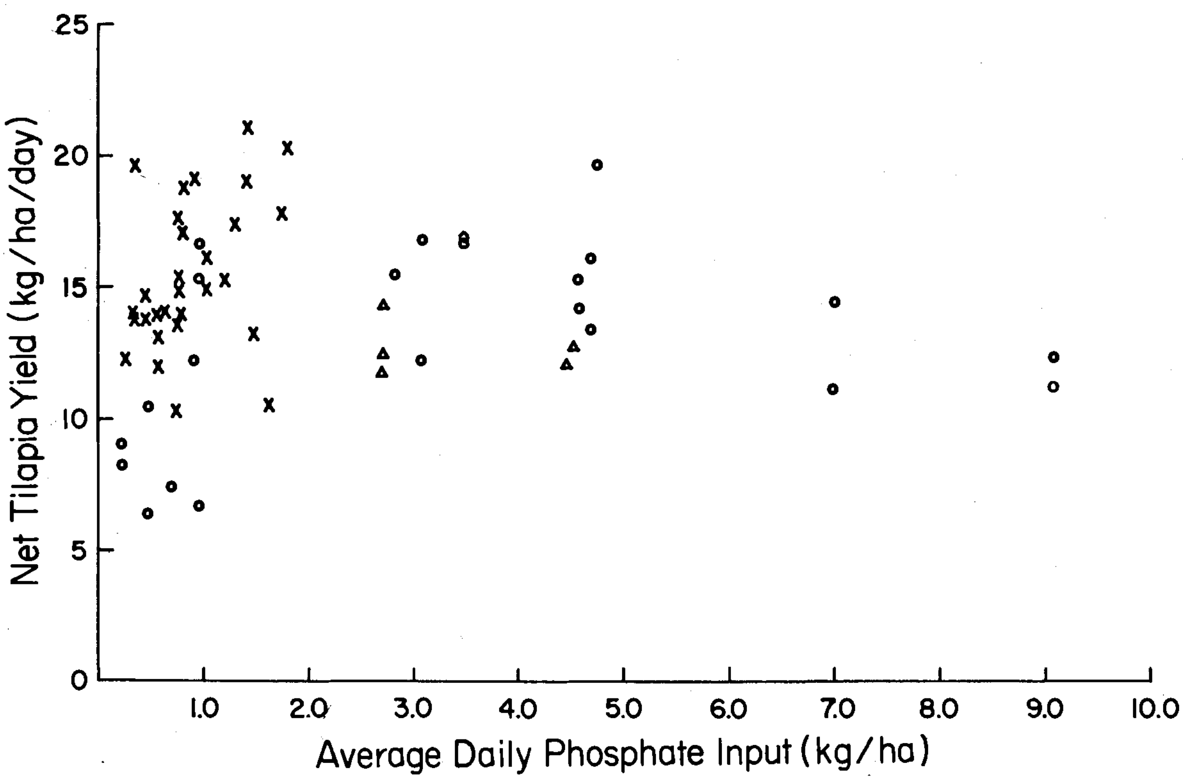

Fig. 4.8. Relationship between net yield of marketable tilapia *(Oreochromis niloticus)* stocked at 20,000/ha and phosphate input from manure of pigs (X), chickens (O) and ducks (Δ) (culture periods, 58-107 days).

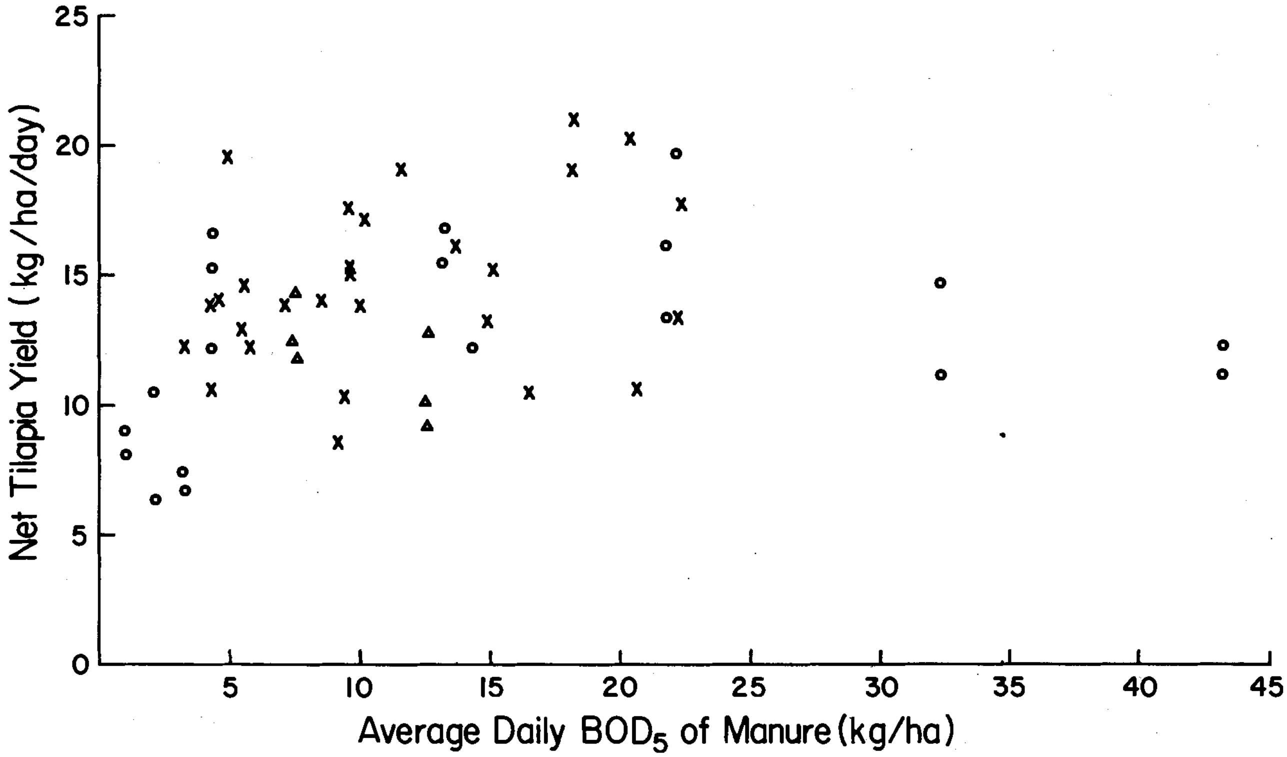

Fig. 4.9. Relationship between net yield of marketable tilapia *(Oreochromis niloticus)* stocked at 20,000/ha and BOD_5 of pig (X), chicken (O) and duck (Δ) manures (culture periods, 58-107 days).

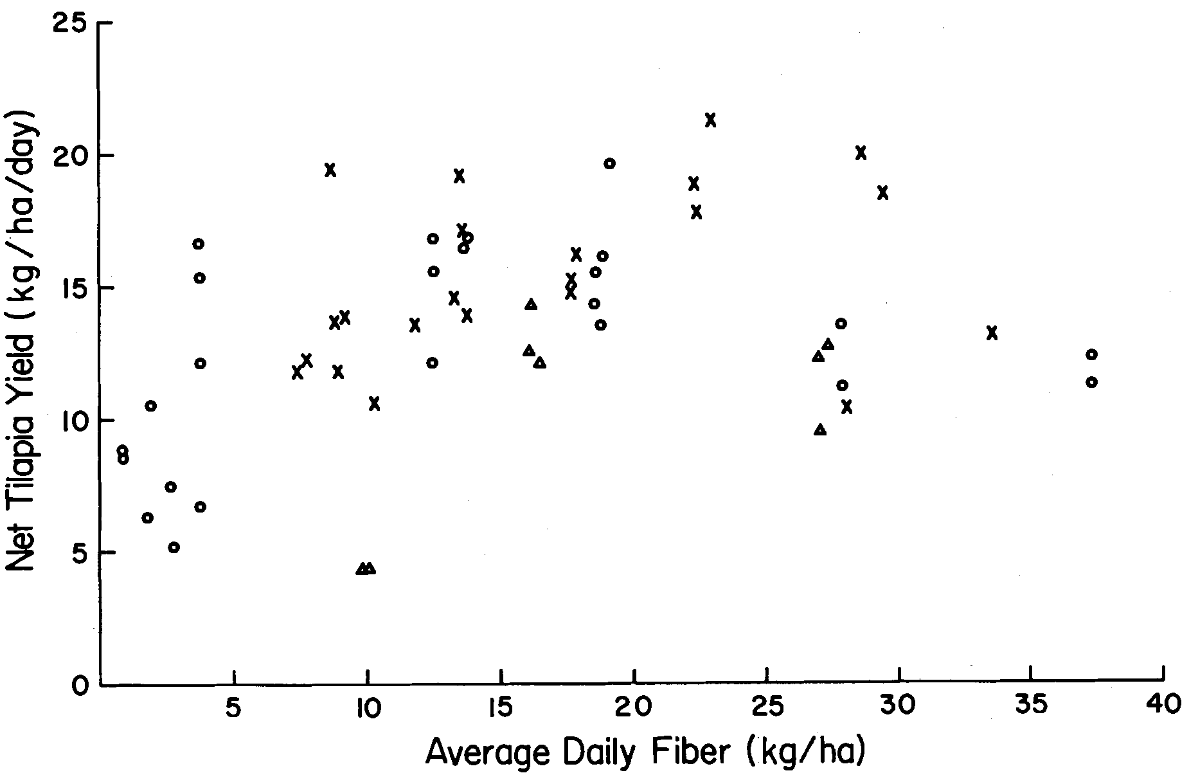

Fig. 4.10. Relationship between net yield of marketable tilapia *(Oreochromis niloticus)* stocked at 20,000/ha and fiber input in pig (X), chicken (O) and duck (Δ) manures (culture periods, 58-107 days).

FINGERLING PRODUCTION

Recruits produced during yield experiments were usually used to restock new experiments. Experiment 15 was an attempt to determine the potential for fingerling production in integrated livestock-fish systems (Table 4.7). Survival rates at high broodfish stocking densities were unexplainably low and many small fry and fingerlings escaped through the drains. However, based on the average of results from Ponds 3 and 8, an integrated livestock-fish system could produce at least 125,000 two-gram fingerlings per ha per 50-day cycle (2,500/ha/day). As expected, higher densities of broodstock yielded smaller fingerlings probably because of competition/predation among the fry themselves and between the fry and the broodfish.

Table 4.7. Tilapia fingerling production from ponds receiving piggery wastes at the rate of 100 pigs/ha during approximately 50 days.

	Broodstock weight[a]		Fingerlings harvested[b]		
Pond	Stocking (kg)	Harvest (kg)	Mean wt (g)	Total wt (kg)	Estimated number
3	200	262	2.5	409	173,000
8	400	580	1.66	137	83,000
6	600	700	0.86	33	38,000
1	800	338	0.47	140	298,000
2	1,000	412	1.1	56	50,000

[a]At stocking, all fish were at least 45 to 50 g; some were 150 to 200 g.
[b]Small fry and fingerlings escaped through the drains except in pond no. 1 in which attempts were made to catch the small fish.

5. Fish Survival and Growth

The two major determinants of fish yield are survival and growth. In an aquaculture system with relatively short culture periods, most fish mortality can be attributed to stocking stress, since most dead fish are seen shortly after stocking. Mortality will be minimal if high quality fingerlings are carefully stocked into well prepared ponds.

Fish growth during an aquaculture experiment is usually analyzed with a simple plot of length or weight at time (Fig. 5.1). If the initial sizes are the same and the number of treatments is small, some conclusions can be made. However, when the number of treatments increases or initial sizes vary as in all these experiments, the utility of this simple plot diminishes. A frequently utilized alternative expresses average growth during the culture period on a gram/day basis. Tables 5.1 and 5.2 present summaries of fish growth in the present experiments using this method. Additional data are contained in Appendix B. As expected, lower stocking densities gave higher growth rates. Slow growth was observed at low manure loads, and growth rate increased as manure loads increased until, at very high manure loads, growth decreased.

The problem with using mean growth over the whole period is that fish growth is highly dependent upon the size of the fish. In absolute terms, 10-g fish grow much slower than 100-g fish, although relative growth is faster for the smaller fish. In order to include fish size in growth analyses, growth was analyzed using a modification of a method by Pauly and Ingles (1981).

Pauly and Ingles' method is based on a multiple regression of the form:

$$\bar{G} = a + b_1X_1 + b_2X_2 + \ldots b_nX_n \qquad (5.1)$$

where $\bar{G}$ = average daily growth in length during the sampling period, X_1 = mean fish length during the sampling period, and variables $X_2 - X_n$ are factors which affect growth, while the a and $b_1 - b_n$ are coefficients from the regression equation. As shown in Pauly and Ingles (1981), the parameters L_∞ and K of the von Bertalanffy Growth Formula (VBGF) of the form $L_t = L_\infty (1-e^{-K(t-t_o)})$ can be estimated from this regression by equations analogous to those of Gulland and Holt (1959) i.e.,

$$K = -b_1 \tag{5.2}$$

and

$$L_\infty = (a + b_2X_2 + \ldots b_nX_n)/-b_1 \tag{5.3}$$

where L_∞ is asymptotic length and K is the growth coefficient.

Ponds were seined at approximately 2-3 week intervals during the experiments. The captured fish were individually measured and weighed in bulk. The length data from these samples and some lengths at harvest are presented in Appendix C along with data on manure inputs and environmental parameters during the sample period. Some preliminary analyses of growth using these data were made. Nine independent variables were selected for inclusion in the analyses (Table 5.3). These variables were evaluated in step-wise regressions using the Statistical Package for Social Sciences (Nie et al. 1975). Mean length was included in all regressions while the other variables were included in the final regression only if the F-value from their contribution to the coefficient of multiple determination was greater than 3. Tables 5.4 and 5.5 present the regressions for fish growth in ponds receiving pig and chicken manure, respectively. The models were used directly to estimate fish growth (G) over short periods by substituting the following term for mean length:

$$X_1 = (L_i + (T/2)\,\bar{G}) \tag{5.4}$$

where X_1 = mean length, L_i = initial length, T = number of days in the period and $\bar{G}$ = average growth (increment) per day.

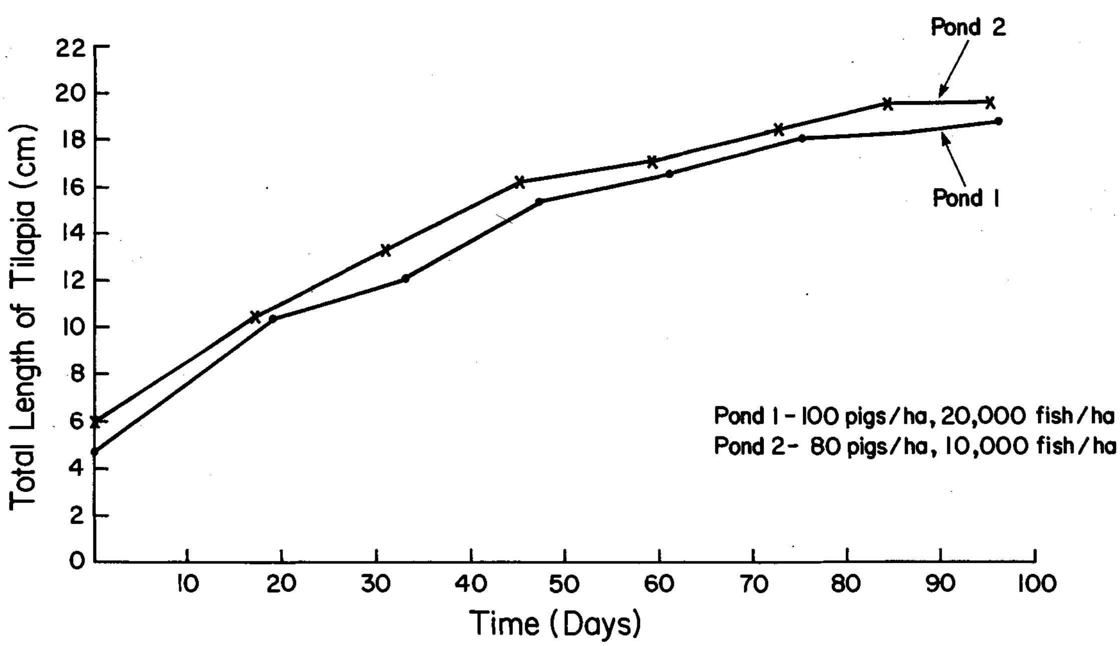

Fig. 5.1. Examples of typical tilapia growth from the integrated pig-fish culture experiments (Experiment 4).

Table 5.1. Mean tilapia stocking and harvest weights and growth in integrated pig-fish systems.

Culture period[1]	Stocking rate[2] (fish/ha)	Manure load (kg dry matter/ha/day)	Mean stocking weight (g)	Mean harvest weight (g)	Mean growth rate (g/day)
Short	10,000	31 – 40	5	81	0.77
		41 – 50	3	152	1.62
		51 – 60	4	99	0.94
		61 – 70	3	160	1.75
		81 – 90	4	138	1.44
		101 – 110	4	141	1.45
	20,000	31 – 40	4	62	0.60
		41 – 50	3	89	0.91
		51 – 60	3	69	0.68
		61 – 70	4	111	1.15
		81 – 90	4	105	1.05
		101 – 110	4	112	1.16
		131 – 140	8	72	1.09
		151 – 160	13	60	0.81
Long	10,000	85 – 95	3	237	1.27
	20,000	85 – 95	3	188	1.03
	30,000	80 – 82	26	178	0.94

[1]Short = 58 to 104 days, long = 155 to 185 days.
[2]Approximately 85% tilapia, 14% carp and the remainder *Channa striata* and/or *Clarias batrachus*.

Table 5.2. Mean tilapia stocking and harvest weights and growth in integrated poultry-fish systems. Culture period was 89 to 106 days.

Poultry type	Stocking rate[1] (fish/ha)	Manure load (kg dry matter/ha/day)	Mean stocking weight (g)	Mean harvest weight (g)	Mean growth rate (g/day)
Ducks	10,000	51 – 60	2	69	0.65
		76 – 85	2	95	0.90
		131 – 141	2	110	1.08
	20,000	51 – 60	2	48	0.45
		76 – 85	2	79	0.78
		131 – 141	2	87	0.85
Chickens[2]	20,000	5	9	84	0.74
		10	10	79	0.70
		15	10	77	0.67
		20	6	97	0.98
		61	2	137	1.49
		101	3	106	1.10
		151	9	81	0.84
		202	10	80	0.83

[1]Approximately 85% tilapia, 14% carp, and the remainder *Channa striata*.
[2]Experiment 12 not included.

Table 5.3. Variables used in growth analyses.

Variable	Units
Dependent variable	
Average growth rate	cm/day
Independent variables	
Mean length	cm
ln (tilapia density)	*ln* (number/ha)
ln (average tilapia weight)[a]	*ln* (g)
ln (avg. manure input during sample period)	*ln* (kg/ha/day)
ln (residual manure)[b]	*ln* (kg/ha/day)
ln (recruits)	*ln* (kg/ha)
ln (carp biomass)	*ln* (kg/ha)
Pond size	m^2
Pond age[c]	–

[a]Estimated by using mean length and the length-weight relationship presented in Appendix F. As weights were not normally distributed, some bias may result from this method.
[b]Manure added in the last 45 days but not including manure added during the sample period itself.
[c]New = 0, old = 1.

Table 5.4. Stepwise regression analysis of fish growth using pig-fish data in Appendix C.

I. Independent variables included in equation

Variable	b (coefficients)	Multiple R	Simple R	F value
Mean length	–.00802	.51846	–.51846	21.496
Pond age	.06797	.58394	.10202	32.411
ln (tilapia density)	–.02565	.60189	–.10046	9.355
ln (recruits)	–.00540	.61053	–.43694	11.937
ln (manure residual)	–.01369	.62028	–.49387	12.883
ln (daily manure input)	.02530	.62969	–.21827	8.297
Constant	.35749			

II. Analysis of variance

	Degrees of freedom	Sum of squares	Mean square	F value
Regression	6	1.22994	.20499	46.648
Residual	426	1.87201	.00439	

Equation 5.1 was then rearranged to:

$$G + [(T/2)b_1G] = a + b_1L_i + b_2X_2 + \ldots b_nX_n \qquad (5.5)$$

For longer periods, it was necessary to estimate the VBGF parameters and use the VBGF to estimate length at time. The value of K for the pig-fish data was 2.93 on a yearly basis while for the chicken-fish data, K (per year) was 4.06. L_∞ varied according to the values of the other parameters. These equations did not contain any variables which would cause the downturn in growth observed at high manure levels because, due to cross-correlations, we were unable to enter variables which could cause the downturn. However, this methodology shows considerable promise as a means to predict growth under varying conditions and to identify factors which have a significant effect on growth (or are closely correlated to factors which affect growth).

Table 5.5. Stepwise regression analysis of fish growth using chicken-fish data in Appendix C.

I. Independent variables included in equation

Variable	b (coefficients)	Multiple R	Simple R	F value
Mean length	–.01112	.55246	–.55246	21.171
ln (daily manure input)	.02229	.63149	.35704	14.367
ln (recruits)	–.01185	.64981	–.24278	11.798
ln (tilapia density)	–.05504	.69458	–.32788	11.747
Constant	.69907			

II. Analysis of variance

	Degrees of freedom	Sum of squares	Mean square	F value
Regression	4	.41019	.10255	23.537
Residual	101	.44005	.00436	

6. Water and Soil Chemistry

In order to simplify analyses of the role of water quality, only data from 90-day experiments were considered. More detailed data can be found in Appendix C. The most important water quality parameters were temperature, dissolved oxygen (DO), ammonia and pH. Additionally, alkalinity, conductivity, nitrate, nitrite and phosphate were determined.

The Project pond-water supply came from the 8,420-ha Pantabangan Reservoir, about 30 km from the Project, via open irrigation canals. There was little control over the quality of the incoming water other than closing the inlet gates if the presence of toxic substances was suspected. Unfortunately, when canal water levels were low, people would occasionally use pesticides to catch fish in the canals. We usually placed test fish into the canal before allowing water to enter the Project site.

Table 6.1 presents the concentrations of five parameters measured at the start of several experiments. The large variability may be the result of runoff from cultivated areas. The initial alkalinity values were all considerably higher than the 20 mg/l considered necessary for substantial phytoplankton production (Boyd 1979).

The concentrations of the five parameters at the end of the 90-day experiments are presented in Table 6.2. As expected, increasing manure loads increased the alkalinity, conductivity and phosphate. These increases were most apparent in the ponds receiving pig manure (Fig. 6.1). No correlations between manure levels and nitrate or nitrite concentrations were apparent.

AMMONIA AND pH

Table 6.3 presents the ranges and means of NH_3 - NH_4^+ concentrations and pH at mid-morning. As the pH tended to remain in the 7 to 8 range, the ionized form, NH_4^+, predominated. This form is considered to be less toxic (in the short term) than the unionized form, NH_3. The chicken-fish experiments showed the highest NH_3 - NH_4^+ levels. The maximum value in Table 6.3 is 2.4 mg/l. In Experiment 12 which was not included in Table 6.3 because manure loading was stopped before the end of the experiment, levels in excess of 6 mg/l were measured within two weeks of maximum manure loading (200 kg dry matter/ha/day). At high pH, the percentage of unionized NH_3 increased so toxicity increased. Also, low DO increased ammonia toxicity. Fortunately, low dissolved oxygen levels occurred in the early morning when the pH was lower. As the day progressed, photosynthesis increased oxygen levels and caused shifts in the alkalinity system so

Table 6.1. Water quality parameters measured at the start of experimental periods.

Parameter	Mean	Standard deviation	Range	Number experiments sampled
Alkalinity[1]	97	42	41 – 155	7
Conductivity[2]	231	–	–	1
Nitrate[1]	0.10	0.03	0.03 – 0.10	3
Nitrite[1]	0.14	0.27	<0.01 – 0.55	4
Phosphate[1]	0.21	0.26	<0.01 – 0.61	6

[1]mg/l.
[2]μmho/cm.

Table 6.2. Mean water quality parameters measured at the end of 90-day experiments.

Animal type	Manure load (kg dry matter/ha/day)	Alkalinity (mg/l $CaCO_3$)	Nitrate (mg/l)	Nitrite (mg/l)	Phosphate (mg/l)	Conductivity (μmho/cm)
Pig	31 – 40	121	0.14	0.01	0.13	264
	41 – 50	124	0.03	0.01	0.14	245
	51 – 60	125	0.04	0.01	0.06	276
	61 – 70	148	0.05	0.01	0.40	250
	81 – 90	154	0.11	0.01	0.55	346
	91 – 100	196	0.08	0.01	0.81	410
	101 – 110	183	0.11	0.02	0.68	389
Duck	81 – 90	146	0.06			
	131 – 140	159	0.09			
Chicken	5 – 6		0.10	0.01		
	10 – 11		0.09	0.01		
	15 – 16		0.13	0.02		
	20 – 21	160	0.13	0.01	0.11	
	60 – 61	174	0.06	0.03	0.04	
	101 – 103	137	0.11	0.01	0.04	

the pH rose. An example of pH increases during the day is shown in Fig. 6.2. A shift of 1.6 pH units as shown in the figure could possibly change enough NH_4^+ to NH_3 to cause mortality. This is suspected to be the cause of poor carp survival at high chicken-manure levels.

DISSOLVED OXYGEN

Dissolved oxygen (DO) was probably the single most important water quality parameter and the most difficult parameter to measure and describe adequately. The DO usually varied from the top to the bottom of the pond. Also, it fluctuated diurnally and the amplitude of the fluctuations tended to increase as the manure loads increased. It was only in later experiments, starting with Experiments 5 and 6, that a chart recorder and automatic stirrer for the oxygen probe became available. We were then able to monitor diurnal DO fluctuation.

Initially, we measured DO at dawn or shortly thereafter at a point 30-cm deep which we subjectively decided to be representative of the whole pond. In Experiment 17, DO depth profiles were constructed at 10-cm intervals at 4 locations in each pond. One of the 4 locations included the regular sampling station. With these profiles, it was possible to check the accuracy of the regular

Table 6.3. Range and mean of early morning ammonia-ammonium concentrations and pH in ponds receiving animal manures during the experimental periods.

Animal type	Manure input (kg dry matter/ha/day)	$NH_3 - NH_4^+$ (mg/l) Range	$NH_3 - NH_4^+$ (mg/l) Mean	pH Range	pH Mean
Pig	31 – 40	0 – 0.225	0.063	6.8 – 8.2	7.6
	41 – 50	0 – 0.500	0.153	6.6 – 9.6	8.1
	51 – 60	0 – 0.215	0.060	6.7 – 8.8	7.6
	61 – 70	0 – 0.585	0.214	6.8 – 8.4	7.6
	81 – 90	0 – 0.80	0.121	7.0 – 9.0	8.0
	91 – 100	0 – 0.270	0.122	7.2 – 8.7	8.0
	101 – 110	0 – 0.86	0.131	7.2 – 9.0	7.9
	131 – 140	0 – 0.265	0.096	6.9 – 8.6	7.7
	151 – 160	0 – 0.465	0.110	7.3 – 8.4	7.8
Duck	81 – 90	0.112 – 0.545	0.238	6.4 – 8.8	7.7
	131 – 140	0.115 – 0.651	0.256	6.7 – 9.0	7.7
Chicken	5 – 6	0.023 – 0.50	0.209	7.0 – 8.6	7.6
	10 – 11	0.029 – 0.640	0.223	6.9 – 8.1	7.4
	15 – 16	0.013 – 0.500	0.200	6.8 – 8.1	7.4
	20 – 21	0.012 – 0.660	0.138	6.8 – 9.1	7.5
	60 – 61	0.010 – 2.380	0.151	6.8 – 9.1	7.8
	101 – 103	0.019 – 2.400	0.143	7.3 – 8.9	7.8

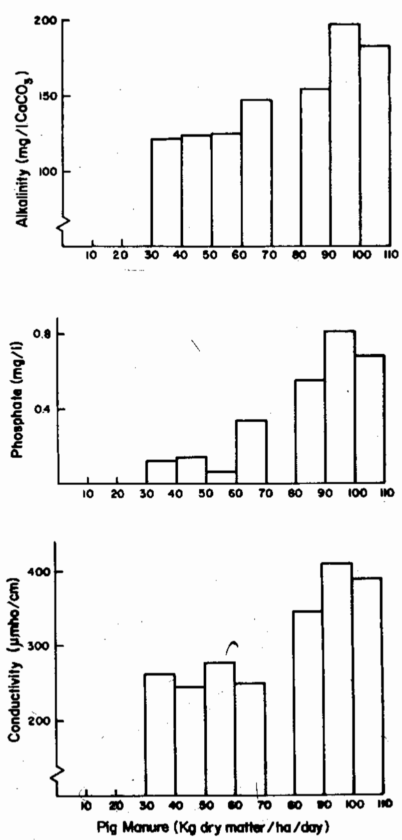

Fig. 6.1. The effects of pig manure loading levels on pond water final alkalinity, phosphate content and conductivity.

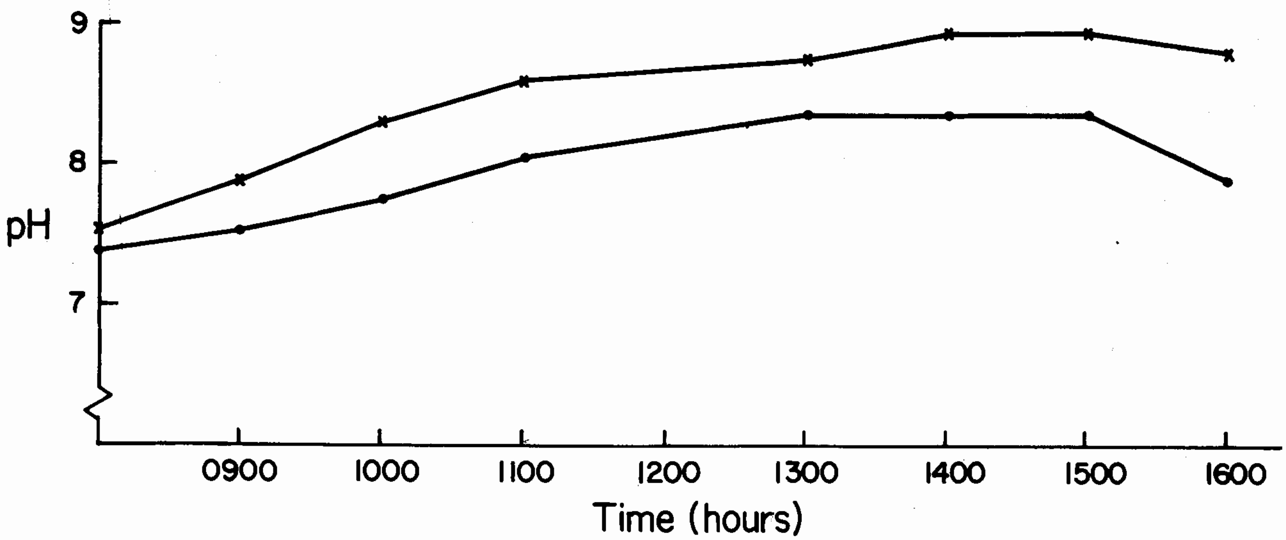

Fig. 6.2. Fluctuations in pH over the period 0800-1600 hours in two 0.04-ha ponds receiving manure from the equivalent of 140 pigs/ha. (For details see Experiment 6).

sampling station in approximating the average DO in the whole pond. Fig. 6.3 shows the equation for the linear correlation of the DO values obtained at the regular sampling station and an average DO value computed from the depth profiles. Stratified samples were taken from the available data in an effort to have 20 observations in each DO interval of 1 mg/l. The frequency distribution is also shown in Fig. 6.3. It was found that the regular sampling station yielded reliable estimates of average DO as evidenced by the very high correlation coefficient (R) of 0.9786. The accuracy was very good in the range of 4 to 8 mg/l but the regular sampling station tended to overestimate the DO at very low levels and underestimate at high levels.

The simplest way to determine the effect of manure inputs on the DO was to correlate average early morning DO over the whole experimental period with average daily manure input over the same period. Figs. 6.4-6.6 show this relationship for pig-fish, duck-fish and chicken-fish systems, respectively. At higher manure loads, average early morning DO was usually less than 1 mg/l and averages of less than 0.4 mg/l were encountered. Although predictive equations, such as those developed by Boyd et al. (1978), could be developed using our data, the very high observed variability would reduce their utility.

As fish yields at the highest manure loads were reduced and DO was very low at these loads, we hypothesize that DO was limiting but we did not have equipment for supplemental aeration to test the hypothesis.

Early morning dissolved oxygen concentrations are usually used as an indicator of oxygen availability in pond systems. Although such values indicate how low the DO fell, they do not indicate the length of the low DO period. Fig. 6.7 illustrates this "problem" with early morning DO in our experiments. Using overnight chart recordings of DO, it was possible to plot the number of hours DO was below arbitrary limits (0.5 mg/l in part A and 3 mg/l in B) and early morning DO. With an early morning DO of 0.1 mg/l the length of time DO was below 0.5 mg/l varied from about 1.5 to 8.75 hours. A fish under conditions of 0.5 mg/l DO for 8.75 hours will certainly be under more stress than one under those conditions for only 1.5 hours. Given the limitations of early morning DO, a more appropriate indicator for oxygen stress appeared to be an average nighttime DO or number of hours DO was below a critical value. To obtain these values required oxygen meters and recorders for each pond being monitored or research assistants who work all-night. We tried both options with only limited success because of logistics, lack of electricity and fatigue.

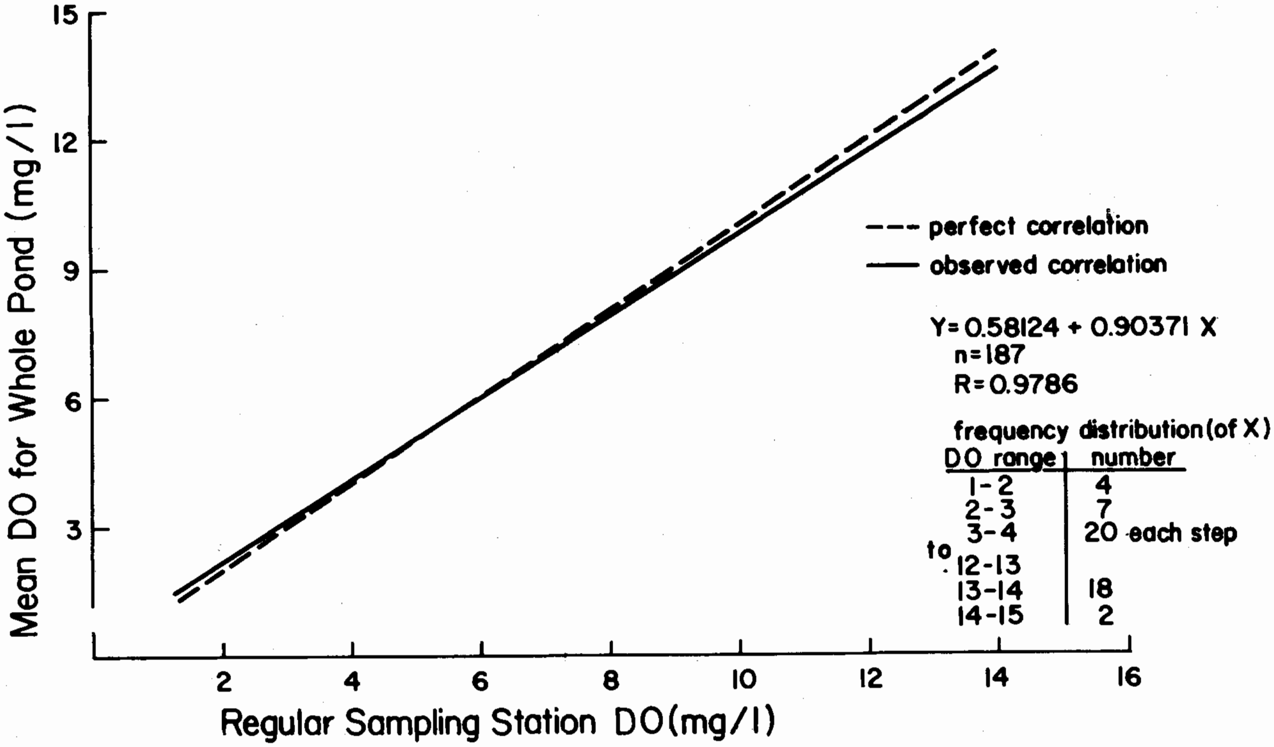

Fig. 6.3. Relationship between dissolved oxygen (DO) measurements at a regular sampling station (30-cm deep) in a manured pond and the average dissolved oxygen for the whole pond based on dissolved oxygen/depth profiles. Data from Experiment 17 (see text).

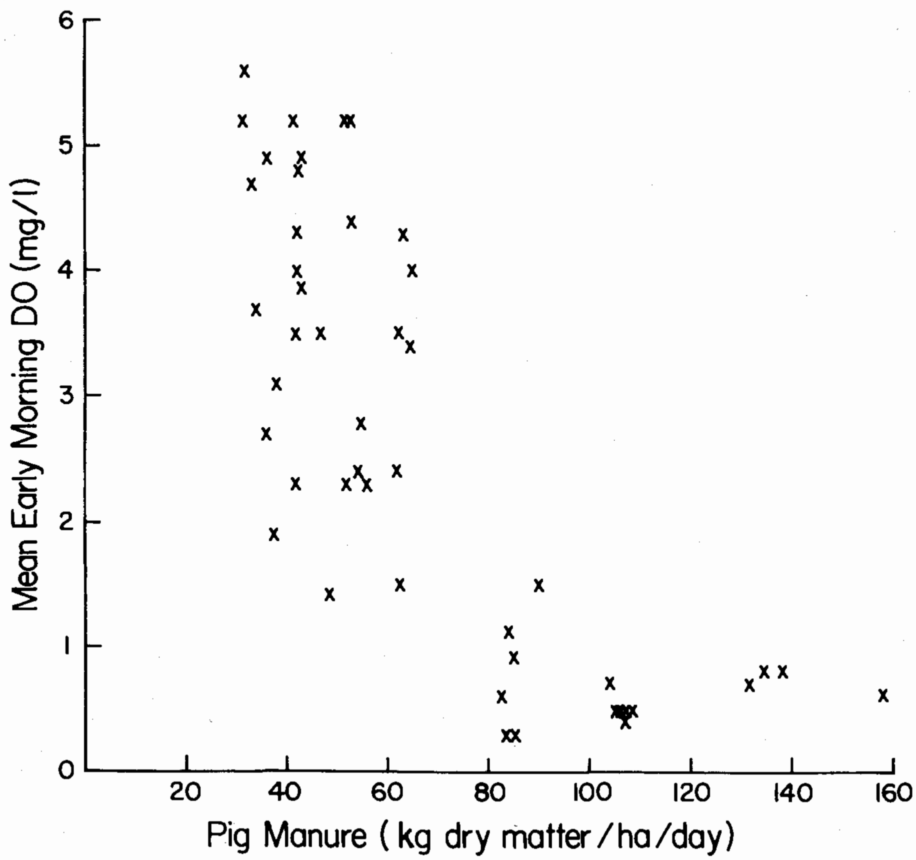

Fig. 6.4. Relationship between average daily pig manure inputs and average early morning dissolved oxygen over 58- to 104-day culture periods in pig-fish integrated culture experiments.

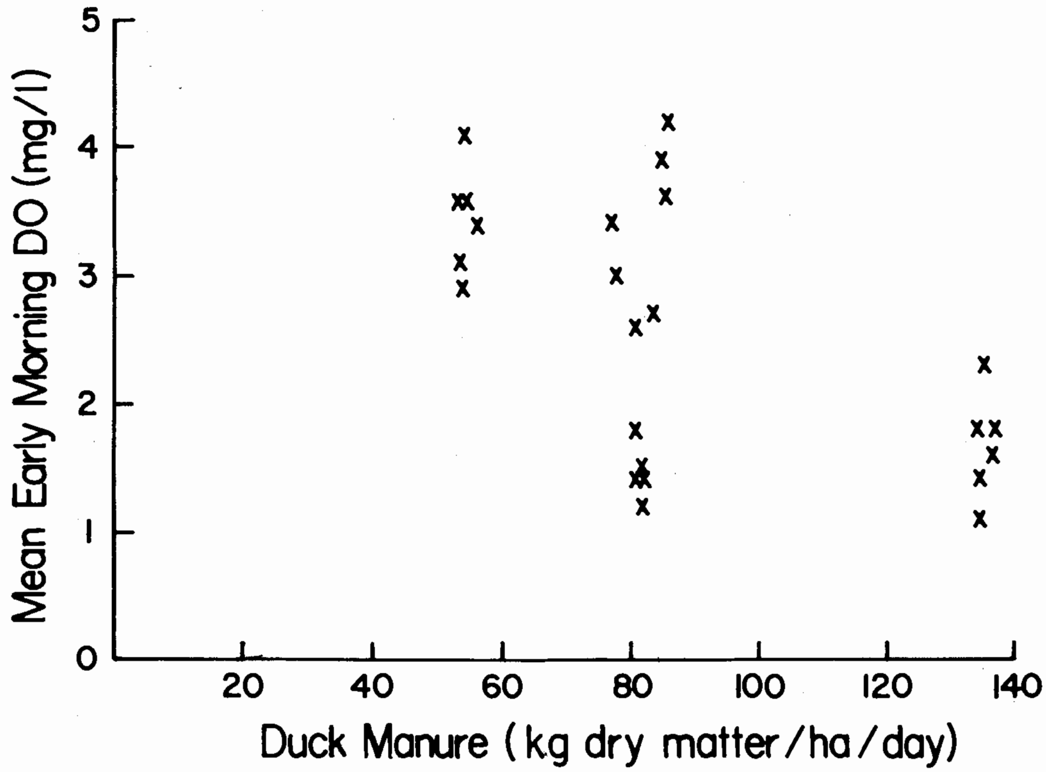

Fig. 6.5. Relationship between average daily duck manure inputs and average early morning dissolved oxygen over 58- to 107-day culture periods in duck-fish integrated culture experiments.

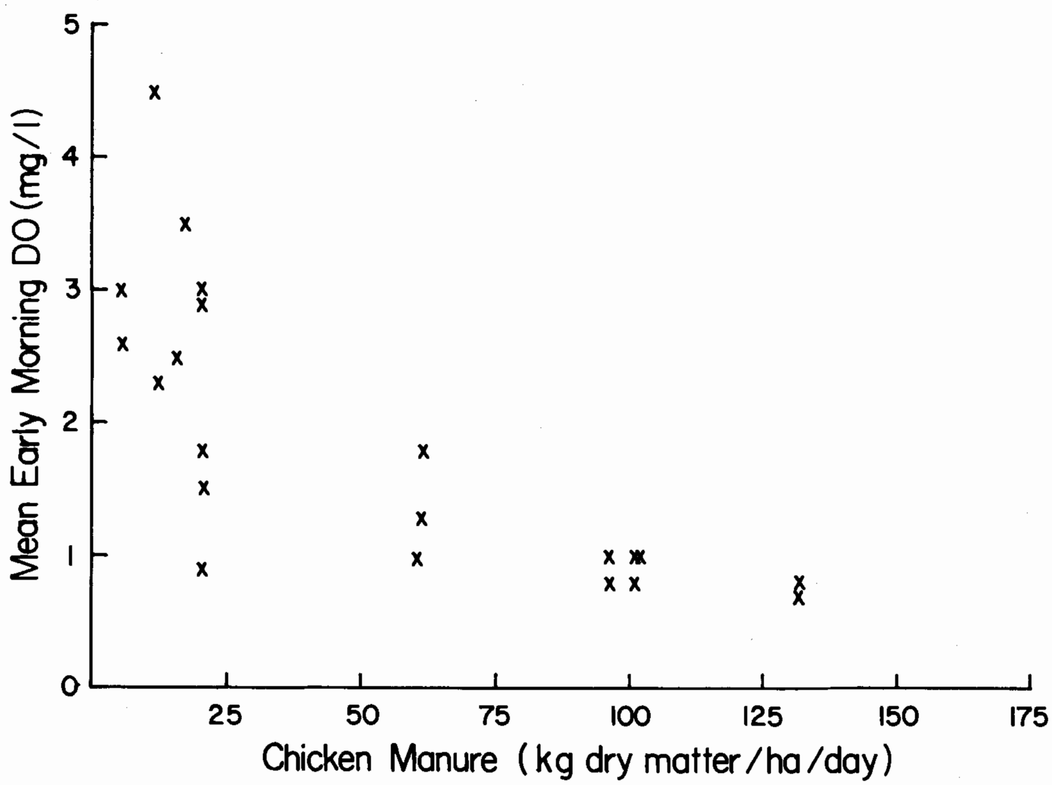

Fig. 6.6. Relationship between average daily chicken manure inputs and average early morning dissolved oxygen over 89- to 101-day culture periods in chicken-fish integrated culture experiments.

Table 6.4. Mean maximum dissolved oxygen measured during mid- to late afternoon in integrated livestock-fish ponds.

Livestock type	Manure load[a] (kg dry matter/ha/day)	Number of samples	Mean dissolved oxygen (mg/l)
Pigs	61 – 70	1	15.0
	71 – 80	4	15.9
	81 – 90	3	16.4
	91 – 100	3	15.3
	101 – 110	10	16.7
Chickens	11 – 30	4	13.1
	51 – 70	5	15.8
	71 – 90	1	14.4
	91 – 110	1	16.8
	111 – 130	2	17.0

[a]Manure applied on preceding day.

Table 6.5. Organic matter in pond soils.

Sample	pH	% Ash	% Organic matter
A[1]	6.94	89.8	10.2
B[2]	–	89.6	10.4
C[3]	–	95.7	4.3

[1]A: at start of experiments.
[2]B: after the completion of Experiment 1 using pig manure.
[3]C: after the completion of Experiment 12 using chicken manure.

Maximum DO was determined during Experiments 4, 5 and 10 using a chart recorder and oxygen meter. The results are presented in Table 6.4. Mean maximum DO was above 200% saturation while concentrations above 20 mg/l were occasionally encountered.

Manure build-up, except for a mound of fibrous material about 5-10 m in diameter and 10-cm deep directly under the manure delivery pipes, was negligible. Soil samples were analyzed for organic matter on three occasions (Table 6.5). No increases were noted. This lack of manure build-up is in contrast to integrated livestock-fish systems in China where build-ups do occur. Probably the year-round high temperatures at the research site, which are conducive to bacterial decomposition and rapid turnover of all except the fibrous matter, are the cause.

The pond-bottom respiration was measured six times in pig-fish ponds receiving manure at a loading rate of 100 pigs/ha. The respiration ranged from 21 to 80 mg $O_2/m^2/hr$ with a mean of 49 mg $O_2/m^2/hr$ (standard deviation 21.3 mg $O_2/m^2/hr$).

7. Plankton

Plankton sampling and identification were carried out in some experiments. Attempts were made to collect samples weekly or bi-weekly. Additional samples were collected during unusual events, such as a very dense plankton bloom. A total of 143 plankton samples was collected as shown in Table 1 of Appendix G.

The plankton were identified to genera whenever possible and unit counts were made (see Appendix A for further details). To quantify the diversity, a Shannon-Weaver index and an evenness index were computed for the zooplankton and phytoplankton data separately. The equation for the

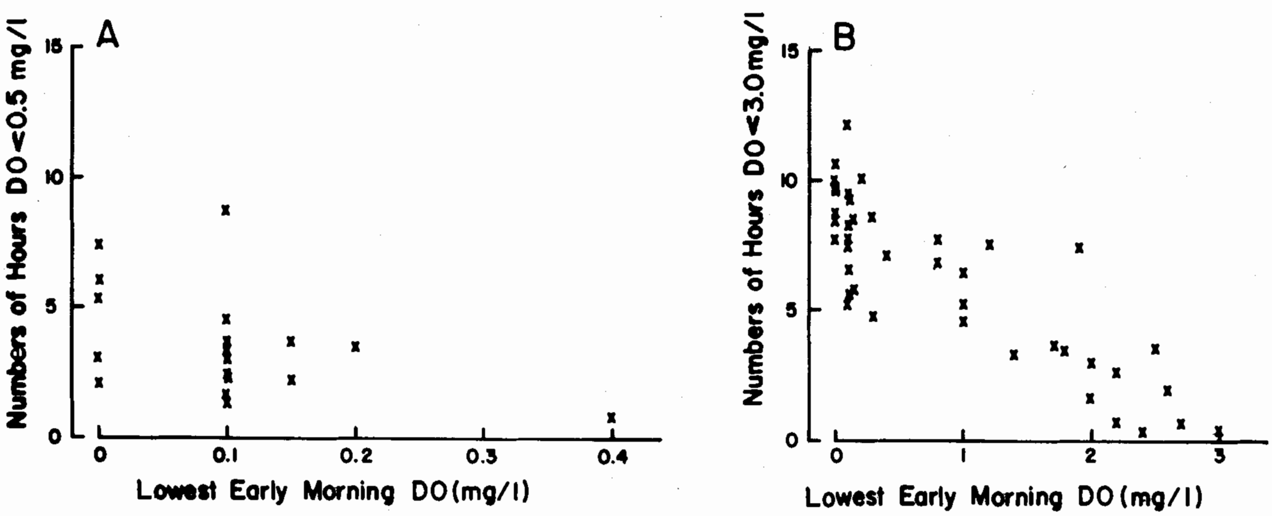

Fig. 6.7. Relationships between lowest early morning dissolved oxygen and the number of hours for which dissolved oxygen was below arbitrary levels in manured ponds. (For details, see text).

Shannon-Weaver index ($\bar{H}$) is:

$$\bar{H} = -\Sigma (n/N) \, ln \, (n/N)$$

where n = number of units in each genus/group and N = total number of units (Odum 1971). The evenness index (e) is:

$$e = \bar{H}/ln \, S$$

where S is the number of species. These indices are constructed such that the higher the value, the more diverse the plankton population.

In Tables 2-17 of Appendix G are presented data on phytoplankton and zooplankton density, occurrence and dominance by genera/group, and diversity for both pig-fish and chicken-fish systems. The following characteristics were observed:

1) Major differences were found between ponds treated identically; species composition and densities could change in only a few days. To identify trends, we grouped data by treatments, weekly for chicken-fish systems and bi-weekly for pig-fish systems.

2) No relationship between increasing pig manure load and plankton densities was apparent (Appendix G, Tables 2 and 5). However, there was a very distinct trend that, at fairly constant manure loads, plankton densities decreased as the experiments progressed. Perhaps the increasing biomass of fish cropping the plankton populations was responsible.

3) The most common and dominant phytoplankton genera in pig-fish systems were: Chlorophyta—*Pediastrum, Scenedesmus, Coelastrum,* and *Chlorella;* Cyanophyta—*Microcystis, Lyngbya,* and *Oscillatoria;* Chrysophyta and Euglenophyta—*Euglena, Phacus* and *Trachelomonas* (Appendix G, Table 3). The most common and dominant zooplankton genera were: Rotifera—*Brachionus, Trichocerca, Asplanchna, Filinia* and *Philodina;* Cladocera—*Moina* and *Diaphanosoma;* Copepoda—*Cyclops,* unidentified copepodites, nauplii, and harpacticoids (Appendix G, Table 6).

4) No trends of the diversity and evenness indices were apparent in the pig-fish data (Appendix G, Tables 4 and 7) or chicken-fish data (Appendix G, Tables 12 and 17).

5) There appeared to be a positive correlation between chicken-manure load and plankton density (Appendix G, Tables 8 and 13). The trend was particularly obvious when Experiment 11

(manure loads 5 to 20 kg/ha/day) was separated from Experiments 10 and 12. Experiments 10 and 12 were conducted during the dry season while Experiment 11 was conducted during the rainy season.

6) The most common and dominant phytoplankton genera in chicken-fish ponds were essentially the same as found in pig-fish ponds except for these few additions: *Closterium*, *Cosmarium* and *Merismopedia* (Appendix G, Tables 7.9 to 7.11). The only major difference in the zooplankton populations was that *Philodina* was not found in chicken-fish ponds (Appendix G, Tables 7.14 to 7.16).

In addition to collecting plankton samples, we regularly determined primary productivity using the light-dark bottle method. Figures 7.1 and 7.2 show the relationship between primary productivity and pig manure and chicken manure input, respectively. The data used were from Appendix C. A slight positive correlation seemed to exist but the variance was very high.

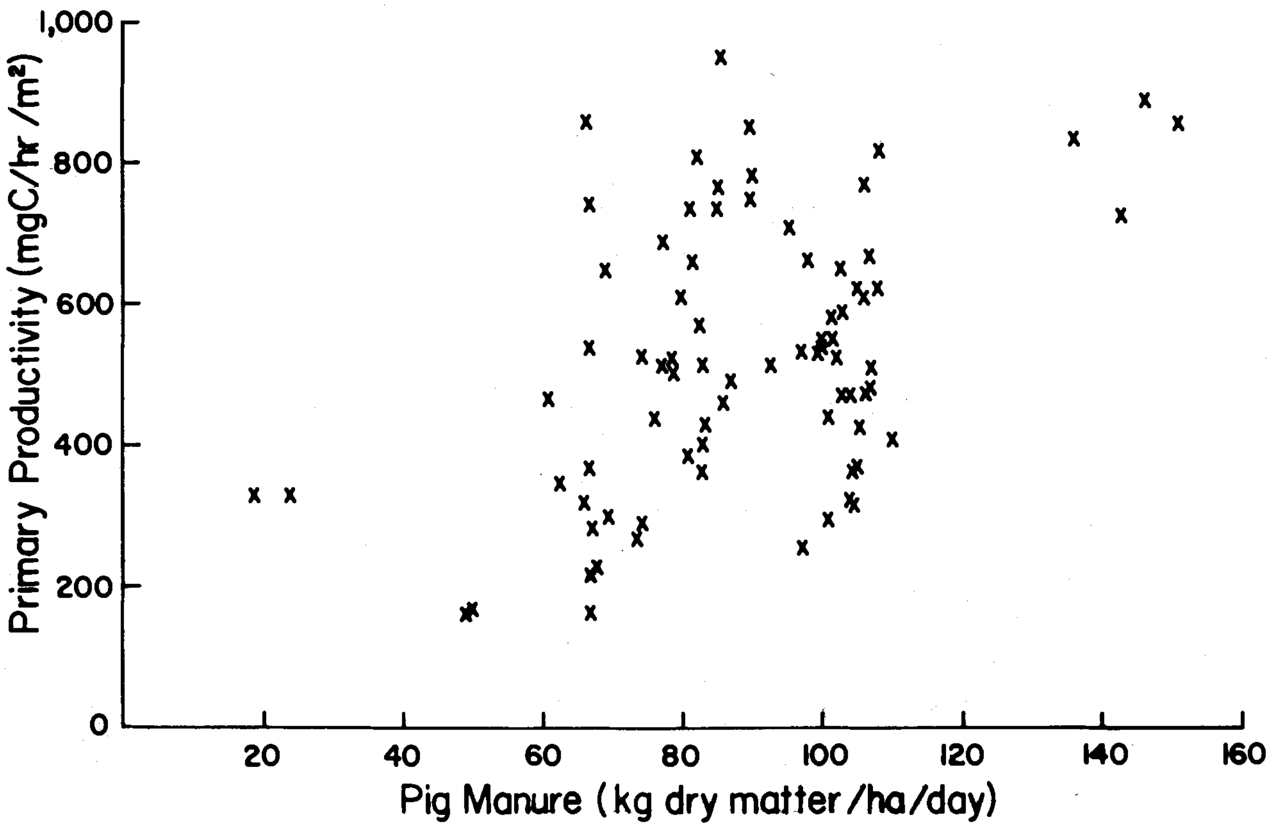

Fig. 7.1. Relationship between primary productivity and pig manure load in pig-fish integrated culture experiments.

8. Parasites

Whenever untreated manures are used to feed and fertilize fishponds, the possibilities of parasites and disease must be considered, including the health of the fish under the stressful conditions of such ponds. Although a detailed experimental approach is needed to define accurately the possible public health risks of animal-fish systems, the lack of supporting infrastructure at CLSU precluded this approach in the present research. However, the animals and fish were monitored regularly for parasites.

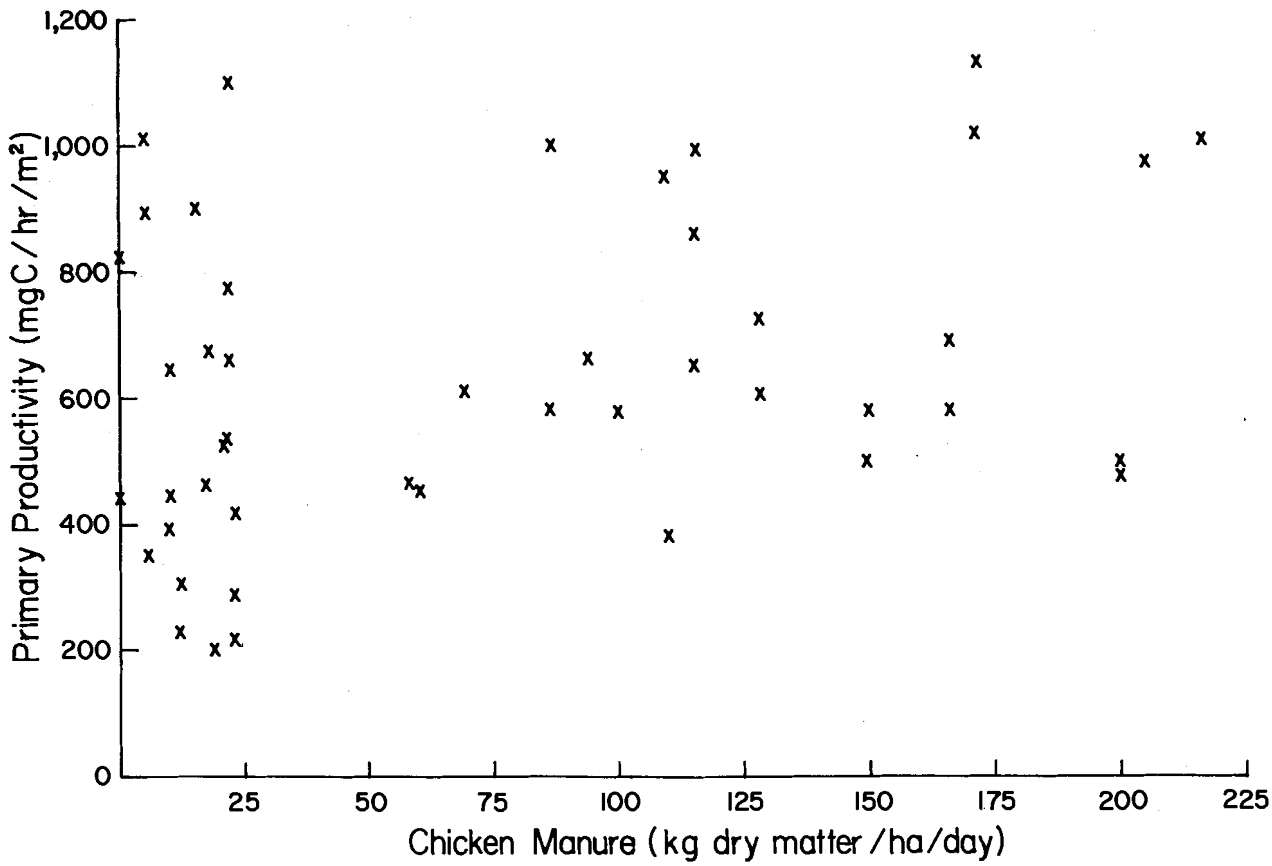

Fig. 7.2. Relationship between primary productivity and chicken manure load in chicken-fish integrated culture experiments.

Samples of animal fecal material and fish were collected routinely during pig-fish Experiments 3, 4, 5, 6, 13 and 14 and chicken-fish Experiment 10. The feces were examined directly and after concentration by flotation and sedimentation techniques. The fish samples were subjected to thorough post-mortems and careful attention was focused on finding parasites which are zoonotic to humans. Also, after Experiment 4, two pigs were slaughtered and partially dissected. Attention was given to finding the cysts of parasites in the muscles as well as gastrointestinal parasites.

Direct examination of manure consisted of placing a small amount of freshly voided fecal material on a slide with a few drops of saline solution. The mixture was spread over the slide and a cover slip put in place. The sample was examined microscopically under low and high power and parasites were identified (Soulsby 1968) and abundance noted.

The flotation and sedimentation techniques used were from Coles (1980). In the sedimentation method, a sample of feces was diluted with water, allowed to settle, and the sediments examined. In the flotation method, a fecal sample was added to a supersaturated sugar solution and the material trapped in the surface layer was examined.

Fish were examined individually by taking samples from gills, skin scrapings, fins, muscles, the whole gastrointestinal tract and its contents, and the body cavity. Initially, the fish were examined externally and then the opercula were removed. A portion of the gills was cut from the gill arches and the filaments were separated. Samples of the filaments were placed in a petri dish and flooded with a physiological saline solution. The filaments were examined using a stereoscopic microscope. Whenever a parasite was found, it was separated from the gill filament, transferred to a slide and examined by compound microscope. In the case of monogenetic trematodes, careful attention was given to avoid damaging the anchors and hooklets as they are very important in identification.

Skin scrapings, fins and muscle were cut/excised from the fish and directly examined using a compound microscope. Muscle samples were obtained from the dorsal third of the body near the backbone and were teased apart before examination. The gastrointestinal tract was separated into its components. The intestines were cut open lengthwise while the other organs were teased apart. Examination was made using a stereoscopic microscope.

RESULTS

Although the livestock were monitored for parasites during seven experiments, it was only during Experiment 3 that parasites were found. Shortly after the pigs had arrived on the Project, 19 of 108 pigs were found to have light to moderate (1-5 parasites per microscope field under a low power objective) infestations of *Balantidium*, a protozoan parasite. The animals responded well to the broad-spectrum antibiotic; the parasite was eradicated. No other parasites were found in the animals or their manures. It must be stressed, however, that all of the Project animals underwent regular treatments with broad-spectrum anthelminthics and that the animals were confined with little chance for infection. These conditions often do not exist on small farms.

The fish parasite densities are presented in Table 8.1. It is interesting to note that only three genera of parasites were found. The monogenetic trematode, *Cichlidogyrus*, was found in the tilapia. The occurrence of this parasite in Philippine tilapia was previously noted by Duncan (1973). The carps were also found to have a monogenetic trematode tentatively identified to be *Dactylogyrus*. The snakehead had a nematode believed to be a *Camallanus* species. A few milkfish, *Chanos chanos*, and catfish, *Clarias batrachus*, were also examined during Experiments 13 and 14 but no parasites were visible.

The data in Table 8.1 show the species preferences of the three parasites. The monogenetic trematode infestations of tilapia were probably insignificant but the trematode densities in the carp became relatively high in three of the experiments. It is assumed that the nematodes were adversely affecting growth of the *Channa striata* but these fish were being used for recruitment control of tilapia so slower growth would be of no consequence. No trends between parasite density and manure load were discernible.

9. Preliminary Economics

The basic methodologies used in economic analyses of these integrated livestock-fish systems were:

1. To determine the relationship between fish yield and manure load. This relationship is called a production function.
2. To calculate the capital cost and operating cost for several pond sizes, using accepted design parameters (see Table 9.1 for example).
3. To determine the relationship between pond size and capital cost and operating cost for excavated ponds and levee ponds with either gravity or pumped water systems, using regression techniques (Table 9.2).
4. To determine the combination of pond size and manure load which maximizes operating profit from the fishpond, using an iterative (trial and error) computational method. Although less elegant than using the concepts of marginal revenue and marginal cost, this trial and error method was easily performed on a programmable calculator (Hewlett-Packard model HP-41c). This method had five steps. First, a given pond size and number of livestock were selected. Second, the livestock number was converted to manure load and was entered into the production function equation to compute estimated net fish yields. Third, the initial fish weights were added to the net fish yields and the totals were multiplied by the fish prices (₱8-10*/kg for tilapia, and ₱5/kg for carp) to

*₱7.40 = $1.00 (1979).

Table 8.1. Fish parasite densities in five pig-fish experiments and one chicken-fish experiment (Experiment 14).

Experiment number	3 and 4	5	6	10	14
OREOCHROMIS NILOTICUS					
Number of fish examined	180	453	80	109	70
Percent infected	0	48	19	26	7
Cichlidogyrus density[a]					
Mode	–	00–1[c]	1–2	00–1	00–1
Maximum	–	2	1–2	3–4	0–1
CYPRINUS CARPIO					
Number of fish examined	90	134	34	49	30
Percent infected	78	88	100	8	10
Dactylogyrus density[a]					
Mode	–	00–1	–	000–1	1
Mean	7	–	5	–	–
Maximum	15	2–3	>8	0–3	1
CHANNA STRIATA					
Number of fish examined	42	8	0	0	5
Percent infected	57	100	–	–	80
Nematode density[b]					
Mature					
Mean	4	4	–	–	4[d]
Maximum	6	6	–	–	8
Immature					
Mean	1	1	–	–	–
Maximum	2	2	–	–	–

[a]Individual parasites per gill filament.
[b]Number of parasites per fish; probably *Camallanus* sp.
[c]With this density rating system, the number of parasites per gill filament ranges between the two numbers given. For example, 0–3 indicates that the number of parasites varies from 0 to 3 per filament. The 00 rating indicates most gill filaments have no parasites while a 000 indicates that almost all the gill filaments are free of parasites.
[d]Although no immature forms were noted, the mature female nematodes were gravid with large numbers of encapsulated embryonic forms.

compute total revenue. Fourth, the pond size was entered into the cost function equation to estimate operating cost. The value of the manure was then added to the operating cost. Fifth, operating cost was subtracted from total revenue to arrive at operating profit. This 5-step procedure was repeated with other numbers of livestock until the maximum operating profit for the given pond size was determined. Also, by holding the number of livestock constant while varying the pond size, it was possible to determine the maximum profit with a given number of livestock.

5. To compute the animal density (or manure load) which would maximize internal rate of return (IRR) into perpetuity from the fishpond using an iterative routine based on the following simplified formula:

$$IRR = \frac{TR - TOC}{TCC + AWC}$$

Table 9.1. Capital and operating costs in Philippine pesos for an eight-month production cycle of a 10,000-m^2 excavated fishpond receiving piggery wastes. ₱7.40 = $1.00. Extracted from Hopkins et al. (1981).

Capital costs	
a) Land clearing at ₱3,000/ha	3,000.00
b) Dikes	38,360.00
c) Drain pipe	2,600.00
d) Water inlet structure	150.00
e) Storage building	3,200.00
f) Engineering fee, 6% of a) to e)	2,840.00
g) Pump	9,350.00
h) Buckets	3,920.00
i) Seine	2,772.00
j) Wheelbarrow	200.00
	66,392.00
Operating costs	
k) Land rent	1,104.00
l) Irrigation fee at ₱390/ha/yr	260.00
m) Fingerlings at ₱0.15 each, 3-5 g each	6,000.00
n) Labor	555.00
o) Poison	21.00
p) Fuel	3,670.00
q) Maintenance	2,107.00
r) Equipment depreciation	2,565.00
	16,282.00

Table 9.2. Equations for the computation of total capital cost (TCC) and total operating cost (TOC) in Philippine pesos for an 8-month production cycle for various pond sizes. ₱7.40 = US$1.00. Extracted from Hopkins et al. (1981).

Pond type	Water system	Applicable pond size (m^2)	Equation number	Equation[1]
Excavated	Gravity	100 – 7,575	1	$\ln$ TCC = 4.4102 + 0.7163 $\ln$ X
		7,576 – 50,000	2	TCC = 28497 + 2.7657 X
		100 – 1,500	3	$\ln$ TOC = 2.7471 + 0.6952 $\ln$ X
		1,501 – 50,000	4	TOC = 989 + 1.0145 X
Excavated	Pump	500 – 8,750	5	$\ln$ TCC = 6.3324 + 0.5167 $\ln$ X
		8,751 – 50,000	6	TCC = 28908 + 3.6938 X
		500 – 1,200	7	$\ln$ TOC = 3.2777 + 0.6866 $\ln$ X
		1,201 – 50,000	8	TOC = 1680 + 1.4592 X
Levee	Gravity	100 – 1,525	9	$\ln$ TCC = 5.4568 + 0.6497 $\ln$ X
		1,526 – 50,000	10	$\ln$ TCC = 6.2819 + 0.5371 $\ln$ X
		100 – 2,600	11	$\ln$ TOC = 3.0293 + 0.6856 $\ln$ X
		2,601 – 50,000	12	TOC = 1899 + 1.013 X
Levee	Pump	500 – 8,725	13	$\ln$ TCC = 6.9539 + 0.4793 $\ln$ X
		8,726 – 50,000	14	TCC = 49213 + 3.6533 X
		500 – 1,450	15	$\ln$ TOC = 3.7882 + 0.6315 $\ln$ X
		1,451 – 50,000	16	TOC = 2255 + 1.4679 X

[1] X = size of pond in m^2, $r > 0.99$.

where TR = total revenue, TOC = total operating cost, TCC = total capital costs, and AWC = an estimate of average working capital. IRR is determined for the length of the culture period and should be corrected to an annual basis. This formula was sufficient for our purposes because the depreciation and maintenance costs included in TOC were sufficient to maintain the condition of the fish culture facilities indefinitely.

6. To prepare budgets for representative livestock operations and compare profit and IRR for these operations.

7. To integrate a fish culture operation with the livestock operation based on the optimum criteria already established; to prepare a budget for the whole integrated operation and determine profit and IRR.

We also conducted taste tests to determine the palatability of fish raised on an integrated farm and evaluated integrated farming systems in terms of their efficiency of resource utilization, particularly nitrogen (protein) pathways.

It must be emphasized that all the analyses presented below were on Philippine systems and refer to prevailing costs at the time of the study. Integrated farming-system economics are highly location-specific and the comparisons made here, particularly the ranking of profitability of duck-fish, pig-fish and chicken-fish systems, should not be taken as general rules.

PIG-FISH SYSTEMS

We have produced preliminary economic analyses of pig-fish systems (Hopkins et al. 1981; Sevilleja 1982) which present the optimum numbers of pigs and pond sizes which maximize operating profit and IRR from the fish operation; and hypothetical case studies of fishponds integrated with three different types of piggeries—backyard, growing-operation only, and a combined breeding and growing operation, respectively. A summary of the conclusions of those papers follows:

1. Farmers with a large amount of manure available and a limited area for ponds can maximize operating profit and IRR when manure is applied at the rate equivalent to 100 pigs/ha. Any excess manure should be disposed of in other ways.

2. When the number of pigs, rather than pond area is limited, manure should be used more efficiently. Operating profit is maximized at 53 pigs/ha for ponds with gravity water systems and 67 pigs/ha for ponds with pumped water systems. IRR is maximized at 80 ± 10 pigs/ha.

3. The magnitudes of the operating profit and IRR are highly sensitive to the scale of the operation (Fig. 9.1). Because of economies of scale, operating profit and IRR increase as pond size increases up to about 3 ha after which they stabilize.

4. A backyard piggery is profitable, IRR = 22%, if labor costs are excluded. This is a reasonable assumption for family labor since the labor tasks are of short duration. A small combined breeding and growing operation yields about 19% IRR, but a growing operation only is a losing venture.

5. Integrating fish culture with the piggeries increases return on investment substantially for all three piggery operations (Table 9.3). Perhaps more important than the effect on IRR is the increase on income, particularly for the backyard farm.

DUCK-FISH SYSTEMS

Most duck rearing in the Philippines is done on small farms to supplement family income (BAEcon 1976). The ducks are usually grown for their eggs which are made into delicacies.[a] There are two duck-rearing methods adopted by farmers, pasture method and confinement method. In the pasture method, ducks are allowed to graze in newly harvested rice fields. When a field has

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[a] "Balut"—fertilized eggs which are allowed to develop almost to hatching before boiling; "itlog na pula"—hard-boiled salted eggs colored red and "penoy"—hard-boiled eggs.

Table 9.3. Annual costs and returns in Philippine pesos of three types of integrated pig-fish farming systems, Nueva Ecija, Philippines, 1980 (₱7.60 = US$1.00). From Sevilleja (1982) with slight modifications.[1]

	Growing[2]	Backyard[3]	Breeding and growing[4]
I. Piggery			
Capital costs	62,000	2,282	95,000
Operating costs	158,300	5,077	170,570
Total returns	134,080	6,060	189,651
Net income	(24,220)	983	19,081
Avg. working capital	52,769	2,113	7,107
IRR (%)	–	22.4	18.7
II. Fishpond			
Capital costs	47,802	5,403	52,791
Operating costs	18,923	1,649	25,329
Total returns	44,730	4,788	68,904
Net income	25,807	3,139	43,575
Avg. working capital	3,155	344	4,222
IRR (%)	50.6	54.6	76.4
III. Integrated			
Capital costs	109,802	7,685	147,791
Operating costs	177,223	6,726	195,899
Total returns	78,810	10,848	258,555
Net income	1,587	4,122	62,656
Avg. working capital	55,924	2,457	11,329
IRR (%)	1.0	40.6	39.4

[1]Period was changed to annual basis from 8- to 10-month cycles in Sevilleja (1982). Average working capital was estimated and included in computation of IRR. Capital costs were reestimated.
[2]80 pigs and 1-ha pond. [3]6 pigs and 0.12-ha pond. [4]162 pigs of varying sizes and 1.3-ha pond.

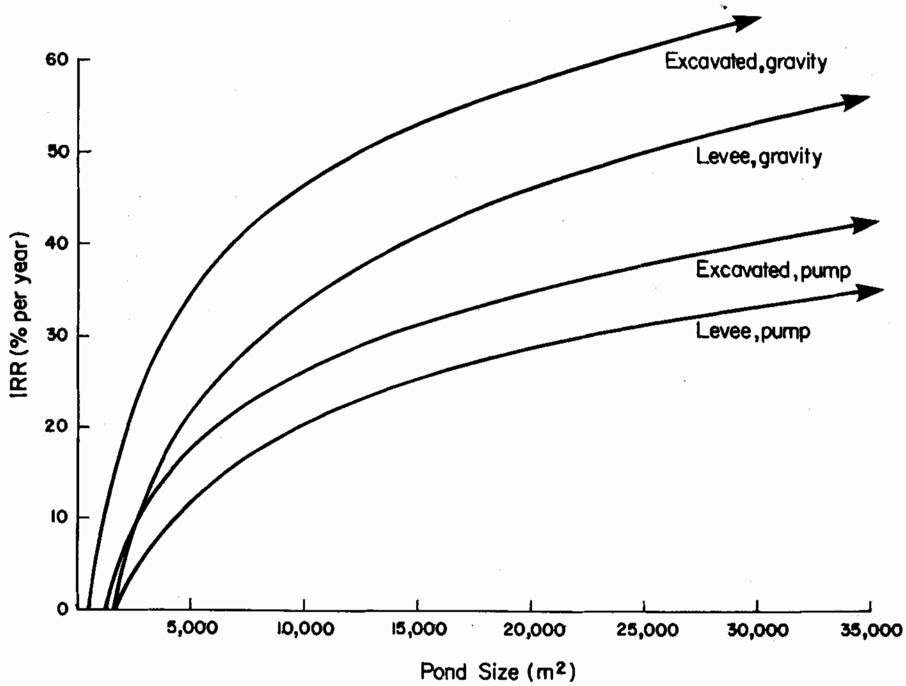


Fig. 9.1. Internal rate of return (IRR) into perpetuity as a function of pond size for four pond-type/water-system combinations receiving manure from 80 pigs/ha.

been completely grazed, the ducks are moved to other fields. When pasture is unavailable, the ducks are enclosed and fed a maintenance diet of rice supplemented with feed concentrates. In the confinement method, ducks are kept in cages or pens throughout their life. They are usually fed rice and snails. This method is commonly practiced in areas where the main feed components, especially snails, are readily available. As only the confinement method is amenable to integration with fish culture, we consider only that method.

Integrating fish culture with ducks reared in confinement can be easily done by building a fishpond adjacent to the duck house. The ducks are allowed access to the pond to forage. Any manure in the duck house is collected and thrown in the pond.

Basic data and information on duck rearing were based on Asuncion (1979) with costs and values updated to 1980 prices. The average farm which raised ducks in confinement had 517 ducks totalling 775 kg. Stock comprised over 90%of the initial capital costs (Table 9.4). Costs and returns are presented in Table 9.5.

Daily fresh manure output from 775 kg of ducks was estimated to be 91 kg or 11.7% of total live weight. This was equivalent to 39 kg dry matter per day (see Chapter 3). The limited yield data from the Project's duck-fish experiments did not allow the computation of a production function relating yields to input loading. Therefore, the maximum net yield of 12.9 kg/day of tilapia and 1.9 kg/day of carp attained with 82 kg dry duck manure/ha/day was used as the "recommended" manure loading rate. Using this loading rate, a 4,760-m^2 pond was needed to accommodate the daily duck manure output.

A summary budget for a 4,760-m^2 excavated pond using a gravity water system is presented in Table 9.6. IRR of the fish operation is much less than the IRR of the duck operation. Therefore, if it is possible to expand the duck operations, the farmer should invest in the expansion of the duck operation instead of integrating with fish culture. If however, the duck-egg market will not allow further expansion or if the farmer wishes to reduce risk by diversification, the fish operation is a good investment because its IRR is considerably higher than the current return on certificate of deposit (15%). The IRR for an integrated duck-fish operation is about 40% per annum (Table 9.7).

Our analyses did not consider the potential for reduced feeding costs by allowing the ducks to forage on the pond because we did not have enough data to estimate the savings. Again, the change in *income* from integration is probably of more significance than IRR maximization for farmers.

CHICKEN-FISH SYSTEMS

The analyses of chicken-fish systems were restricted to integrating fish culture with cage rearing of broilers following the same procedures used on the Project. However, the methodologies used in the analyses can be easily adapted for a layer operation.

Chicken manure can be readily sold in the Philippines as fertilizer for fishponds or agricultural crops. Thus, in contrast with pig and duck manure, it was essential to assign a cost to chicken manure used in the fish culture component of an integrated chicken-fish farm. Therefore, maximizing fish output will not always maximize profits.

The chicken farms were classified into two categories: those farms having large numbers of chickens and only a small area for ponds; and those farms with limited number of chickens relative to the potential pond size. In the first category, we computed the number of birds (manure loading rate) which would maximize operating profit and IRR for a given pond size. In the second category, we computed the pond size which would maximize operating profit and IRR for a given number of chickens. A third possibility of limited capital was not analyzed.

The numbers of chickens which would maximize operating profit for given sizes of pond are shown in Table 9.8. The manure loading rates which yielded maximum operating profit fluctuated around 4,400 chickens/ha of pond. IRR for a given pond size was maximized at essentially the same loading rates.

Table 9.4. Average capital investment of backyard duck egg production method in Nueva Ecija, 1980. (Confinement method - 517 birds)

Item	Cost (₱)
Stock	10,340
Building/laying house	409
Water trough	63
Feed trough	80
Trays	9
Lighting facilities	54
Screen/fence	136
Total	11,091

Table 9.5. Annual costs and returns of confinement rearing of 517 ducks in Nueva Ecija, 1980.

Item	Cost (₱)
I. Operating costs	
Variable costs	
Labor	4,257
Feeds:	
Palay (unmilled rice)	27,080
Concentrate	152
Snails	24,709
Stock replacement	1,500
Mortality	1,414
Drugs	24
Electricity	122
Repairs and maintenance	31
Interest on loans	642
Fixed costs	
Rent (land)	281
Depreciation	183
Land tax	7
Total costs	60,402
II. Returns	
Egg sales	65,968
Stock sales	463
Others[1]	3,919
Total returns	70,350
III. Net returns	9,948
Avg. working capital[2]	6,000
IV. IRR (%)	58.2

[1]Include eggs and stock consumed at home and given away.
[2]Estimated at about 10 percent of total costs.

Table 9.6. Annual summary budget for a 4,760-m^2 excavated fishpond stocked with 20,000 fish/ha. Water flow is by gravity and nutrient source is 39 kg dry duck manure/day.

Item		Amount (₱)
Capital cost[1]		35,448.00
Operating cost[2]		8,727.00
Total revenue		20,435.00
Tilapia[3]	17,793.00	
Carp[4]	2,642.00	
Net income		11,708.00
Average operating capital		1,455.00
IRR (%)		31.7

[1]Based on equation in Table 9.2.
[2]Based on equation in Table 9.2 corrected to an annual basis.
[3]Assumes 5-g initial weight, 17,000 tilapia/ha, 3 stockings per annum, net yield of 12.9 kg/ha/day and 270 culture days, mortality is minimal, price = ₱10/kg.
[4]Assumes 5-g initial weight, 2,800 carp/ha, 3 stockings per annum, net yield of 1.9 kg/ha/day and 270 culture days, mortality is minimal, price = ₱5/kg.

Table 9.7. Annual summary budget for a duck-fish farm with 517 ducks and a 4,760-m^2 fishpond, Nueva Ecija, Philippines, 1980.

	Amount (₱)		
	Component		
Item	Ducks	fishpond	Integrated
Capital costs	11,091	35,448	46,539
Operating costs	60,402	8,727	69,129
Total returns	70,350	20,435	90,785
Net income	9,948	11,708	21,656
Av. working capital	6,000	1,455	7,455
IRR (%)	58.2	31.7	40.1

Table 9.8. Number of chickens and chicken density which maximize gross profit from a given size fishpond.

Given pond size (m^2)	Number of chickens	Chicken density (no./ha pond)	Operating profit (₱)	IRR[1] (%)
500	225	4,500	774	8.8
750	325	4,333	1,519	15.4
1,000	450	4,500	2,331	19.3
1,500	650	4,333	4,074	25.2
2,500	1,125	4,500	7,966	34.2
5,000	2,200	4,400	17,661	46.0
7,500	3,325	4,433	27,360	53.2
10,000	4,400	4,400	37,051	62.6
20,000	8,900	4,500	75,842	84.6
30,000	13,500	4,500	114,618	95.5
40,000	17,800	4,450	153,415	101.9

[1]Per annum, stocking density = 20,000 fish per ha, 3.5 crops per year.

Table 9.9. Pond size and chicken density required to maximize internal rate of return (IRR) for ponds receiving manure from a given number of chickens.

Given number of chickens	Pond size (m^2)	Chicken density (no./ha pond)	Operating profit (₱/annum)	IRR[1] (%)
100	40,000	< 250	–	–
500	40,000	< 250	–	–
750	40,000	< 250	–	–
900	30,000	300	41,080	34.4
1,000	17,500	570	29,173	35.7
3,000	14,000	2,140	42,944	60.3
5,000	19,000	2,630	64,076	74.2
7,500	25,000	3,000	88,788	84.8
10,000	30,000	3,000	110,142	91.9

[1]Per annum, stocking density = 20,000 fish per ha, 3.5 crops per year.

When the number of chickens was limited, the densities which maximized IRR increased as pond size increased (Table 9.9). With a low number of chickens, our mathematical model "selected" values below 250 chickens/ha as optimum. However, we have not tested levels lower than 250 chickens/ha and there was considerable variability at these low loading rates. It is suggested that rates less than 500 chickens/ha should not be used. Yields are not predictable at lower loading rates.

The relationships in Tables 9.8 and 9.9 are difficult to visualize from the tables alone. Three examples are provided. In Fig. 9.2 we first plotted the chicken density which maximizes IRR for given numbers of chickens (the curve). We then overlayed a line at 4,400 chickens/ha which was the density which maximized IRR for a given pond size. Higher densities reduced yields.

If possible, the farmer should operate such that he uses all his available land and a chicken density of 4,400 chickens/ha or all of his available chickens (manure) and a pond size which would "give" a density on the lower curve. Sometimes the coordination of available land and chickens would yield a density which lies between the curve and the line. The farmer should then use the available land and manure to maximize his IRR.

Examples:

1. A farmer has 6,000 chickens and 0.5 ha of land available for a fishpond. As the maximum profit and IRR for a 0.5-ha pond are attained with 4,400 chickens/ha (upper line, Fig. 9.2), he

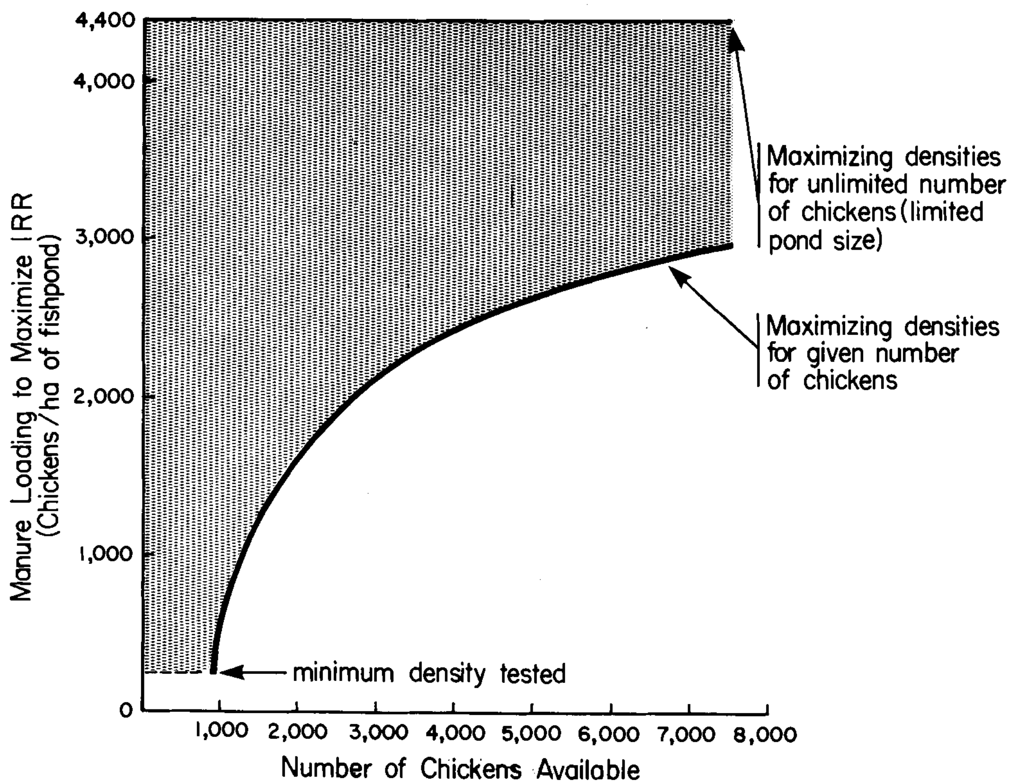


Fig. 9.2. Chicken densities which maximize internal rate of return (IRR) from the fishpond.

should add the manure from 2,200 chickens to the pond and sell the rest of the manure.

2. A farmer has 3,000 chickens and 5 ha of land available for ponds. Since the number of chickens available is limited, the lower curve in Fig. 9.2 should be followed. To maximize IRR for the 3,000 chickens, a density of 2,140 chickens/ha should be used. Therefore, the farmer should use a 14,000-m^2 pond.

3. A farmer has 2,000 chickens and 6,000 m^2 available for pond. At 4,400 chickens/ha, he would need 2,640 chickens. On the other hand, using the curve for a limited number of chickens, he should use a pond of 1.4 ha. He has neither 2,640 chickens nor 1.4 ha. In this situation, the farmer would maximize his IRR using all of his available land and manure.

In the above analyses, we were concerned with integrating a fish-culture operation with an existing chicken farm. Therefore, only the IRR for the fish-culture operation was computed. When starting an integrated chicken-fish farm (i.e., a farm in which the chicken operation does not yet exist), the IRR on the investment for the whole integrated chicken-fish farm needs to be maximized.

The capital investment and a simple cost and return analysis for a 1,000-chicken broiler operation are shown in Tables 9.10 and 9.11, respectively. Estimated IRR was relatively low, 13.3% per annum.

The iterative program which computed operative profit and IRR for the fish operation was modified to include the costs and returns of the chicken operation (based on a per chick basis) in order to compute the operating profit and IRR for the whole integrated chicken-fish farm operation. When building a new integrated chicken-fish farm, the suitable area for fishponds will probably be the main limiting factor. The numbers of chickens required to maximize IRR of the integrated chicken-fish operation for given sizes of pond have been computed (Table 9.12). As pond size increases, the manure loading rate should decrease. The reason for this is that the fish operation is more profitable at large pond sizes than the chicken operation. Therefore, the manure loading rate should be minimized at large pond sizes in order to minimize "losses" from the chickens and to maximize IRR.

If the number of chickens is the limiting factor, the analyses indicate that larger ponds have higher IRR. However, as pond sizes above two to three ha are difficult to manage, we do not

Table 9.10. Capital investment for a 1,000 caged-chicken broiler farm in CLSU, Muñoz, Nueva Ecija, Philippines, 1981.

Item	Amount (₱)
Building[1]	12,370.00
Chicken cages[2]	15,560.00
Total	27,930.00

[1]Assumes ratio of building floor area to area within 3-tiered cage is 0.69 and the cost/m^2 of floor area equals ₱250. Seven years useful life.

[2]3-tiered cages complete with lights, feeders, and water troughs. Assumes 1/3 of flock is chicks. Densities are 30 chicks/m^2 and 11 larger birds/m^2 within the cage; cost/m^2 inside cage = ₱217. Five years useful life.

Table 9.11. Cost and return analysis for a 1,000 caged-chicken broiler farm in CLSU, Muñoz, Nueva Ecija, Philippines, 1981.

	Amount (₱)	
Fixed cost		
Cage depreciation	3,112.00	
Building depreciation	1,767.00	4,879.00
Variable cost[1]		
Chicks, 7,000 at ₱3.35 each	23,450.00	
Feeds[2]	48,510.00	
Labor[3]	2,170.00	
Drugs and medicine	4,550.00	
Electricity[4]	1,890.00	
Delivery cost[5]	910.00	
Miscellaneous[6]	350.00	81,830.00
Total cost		86,709.00
Revenues		
Chickens[7]	90,580.00	
Chicken manure and feed sacks[8]	630.00	91,210.00
Net income		4,501.00
IRR (%)		13.3

[1]Assumes 7 crops per year.
[2]Average feed conversion = 2.57:1; average size of harvested birds = 1.15 kg; average size of mortalities = 0.57 kg; cost of feed = ₱2.56/kg; 1 US$ = ₱8.
[3]₱2.63/hour.
[4]1 watt/chick, 24 hrs/day for 15 days, ₱0.75/kw.
[5]Labor and fuel at ₱40/300 chickens in 10 km radius.
[6]Includes electric bulbs, record books, brooms, etc.
[7]Harvest size 1.15 kg, 90% survival. Price = ₱12.50/kg.
[8]Chicken manure price = ₱3/50 kg sack with 60% dry matter, 0.0205 kg dry matter/day/bird; sack price = ₱1/bag.

Table 9.12. Number of chickens (chicken density) which maximize IRR for the integrated chicken-fish system given pond size.[1]

Pond size (m^2)	Number of chickens	Chicken density (no./ha)	Net income	IRR (%)
500	225	4,500	1,782	11.9
750	325	4,333	2,974	14.2
1,000	425	4,250	4,230	15.9
1,500	600	4,000	6,728	18.4
2,500	800	3,200	11,077	21.9
5,000	1,400	2,800	22,243	25.9
7,500	1,900	2,533	32,392	27.9
10,000	2,500	2,500	43,444	30.1
20,000	3,750	1,875	75,253	34.6
30,000	5,000	1,667	106,203	36.6
40,000	6,000	1,500	133,707	37.7

[1] Assumes 3.5 ninety-day fish culture cycles per year and 7 forty nine-day chicken cycles per year.

recommend ponds larger than these sizes. Also, a minimum manure loading rate of 250 to 500 chickens/ha of pond is recommended (see above).

PIGS, DUCKS OR CHICKENS?

The following comparison from project results and related analyses is not to be taken as a definitive ranking of integrated farming systems. It merely illustrates the options under Philippine conditions at the time of the Project.

The most obvious way to compare the different livestock-fish systems is to compare maximum IRRs. However, since maximum IRRs of the integrated systems were computed only for chicken-fish systems, our tentative conclusions were based on relative magnitude of the IRRs of the separate livestock and fish-culture components.

Duck raising is more profitable than a backyard piggery or a combined breeding and growing pig farm. Both pig operations are more profitable than a broiler chicken operation. The maximum fish yields attained with the different systems are not greatly different. Therefore, using maximum IRR as the criteria, duck-fish systems would rank first followed by pig-fish systems and lastly chicken-fish systems. However, duck raising is site-specific requiring a large market in which to sell the relatively high-priced duck eggs.

A major concern when trying to develop a "new" agricultural or aquacultural method into a viable industry is the capital intensity of the method. This is particularly important if the method is to have any effect on small-scale farms. All of our analyses indicate that a pond must be at least 1,000 m^2 to 1,500 m^2 in size in order to be profitable. Example budgets for livestock-fish systems with a small pond, 1,200 m^2, were computed (Table 9.13). Animal levels were selected to yield at least 15% IRR per annum (or the single "recommended" level in case of the ducks). The investment costs (capital + working capital) vary from about ₱17,200 to ₱23,100. These costs could be reduced considerably if free labor was provided.

TASTE TESTS

Two taste-test experiments were conducted, one for fish raised in pig-fish ponds and the other in duck-fish ponds. Fish grown in ponds fertilized with inorganic fertilizer were used as the controls.

Fish from the experimental ponds were randomly selected and harvested. The fish were prepared by removing the gills, internal organs, scales and fins. The cleaned fish were cooked by steaming. One fish from each treatment (manure level or inorganic fertilizer) was placed in each platter. The fish were coded so the taste panel could not identify them.

Table 9.13. Budgets for integrated livestock-fish systems with 1,200-m^2 ponds. Animal numbers selected to yield at least 15% IRR per annum.

Item	Amount (₱)		
	Pig-fish[1]	Duck-fish[1]	Chicken-fish[2]
Number of animals	6	130	275
Capital cost			
Livestock component	2,282	2,796	7,673
Fish component[3]	13,211	13,211	13,211
Total	15,493	16,007	20,884
Operating cost (per annum)			
Livestock component	5,250[4]	15,227	23,845
Fish component[3]	3,234	3,234	3,880
Total	8,484	18,461	27,725
Average working capital[5]			
Livestock component	2,200	1,512	1,703
Fish component	539	539	554
Total	2,739	2,051	2,257
Revenues[6]			
Livestock component	6,060	17,735	25,083
Fish component	5,286	5,152	6,175
Total	11,346	22,887	31,258
Net income	2,862	5,073	3,533
IRR (%)	16	28	15

[1]3 ninety-day fish cycles per annum.
[2]3.5 ninety-day fish cycles per annum.
[3]Based on Table 9.2.
[4]Labor costs included.
[5]A crude estimate based on operating cost and length of culture cycles.
[6]Tilapia at ₱10/kg; carp at ₱5/kg.

Each taste panel was composed of six persons selected to include males and females, laborers and scientists and different cultures (Malay and Caucasian). The panelists were asked to evaluate the taste of the fish on the basis of the following scores:

10 – Excellent	5 – Slightly fair
9 – Very good	4 – Slightly poor
8 – Good	3 – Poor
7 – Slightly good	2 – Very poor
6 – Fair	1 – Extremely poor

The results are shown in Tables 9.14 and 9.15. In both tests, fish reared in manured ponds received higher ratings than those reared in ponds receiving inorganic fertilizer. Further, high manure levels gave higher ratings than lower manure levels. This palatability of fish grown in manured ponds is further supported by our observations made during the sale of fish produced on the Project. Buyers would line up on our pond dikes to buy the fish as the fish were harvested. The buyers were

Table 9.14. Taste tests of Nile tilapia reared in ponds fertilized with inorganic fertilizer and pig manure.

Panelist	Score: Inorganic fertilizer input (16-20-0)	Manure input (pigs/ha) 40	60
1	8	5	7
2	6	3	8
3	10	9	9
4	4	10	10
5	8	7	9
6	3	9	6
Total	39	43	49

Table 9.15. Taste tests of Nile tilapia reared in ponds fertilized with inorganic fertilizer and duck manure.

Panelist	Score: Inorganic fertilizer input (16-20-0)	Manure input (ducks/ha) 750	1,250
1	5	9	9
2	6	6	10
3	7	9	10
4	6	9	9
5	6	8	7
6	6	8	8
Total	36	43	53

Table 9.16. Crude protein input and output for 6-month period in an integrated pig-fish farm with 10 pigs and a 1,000-m^2 pond stocked with 20,000 fish/ha.

Item	Amount (kg)	Percent dry matter	Percent nitrogen[a]	Crude protein (kg)
Inputs				
Starter ration	228	90	3.51	45
Grower ration	1,914	90	2.14	231
Finisher ration	2,193	90	2.08	257
Total input				533
Outputs (net)				
Pigs (whole)	912			
carcass	684[b]	50.7[c]	4.42[c]	93
Tilapia (whole)[d]	338			
carcass	287[e]	77.4[f]	12.3[f]	50
Carp (whole)	63			
carcass	54[e]	75.6[g]	11.8[g]	10
Total output				153

[a]Dry matter basis.
[b]Average dressout percentage = 75 (Lawrie 1979).
[c]Based on Paul and Southgate (1978).
[d]Includes small tilapia (recruits). They are eaten in the Philippines.
[e]Estimated average dressout (gut, gills and scale removed) of 85%.
[f]Winfree and Stickney (1981).
[g]Sidwell et al. (1974).

well aware of the nutrient source for the ponds. It is often suggested to hold the fish grown in manure ponds overnight or for a few days in "clean" water to allow them to "clean" themselves out. The Project initially did this but stopped when the buyers wanted to take the fish directly from the pond. Immediate sale minimized both labor and weight loss during holding (10 to 15% in 14 hours). The fish should be removed from the pond alive and rinsed before sale. The only complaints received about bad tasting fish occurred when the fish had died in the pond mud during harvest or were inadequately rinsed before sale.

PROTEIN UTILIZATION

In the literature of scarcity, the incongruity of feeding large amounts of protein feed stocks to livestock instead of to humans appears frequently. The fact that most people prefer eating meat to eating feed stocks is often overlooked. Integrating fish culture with livestock rearing would blunt some of the criticisms by producing more palatable protein from the same amount of feed stocks. Table 9.16 presents a crude protein budget for a pig-fish system based on Experiments 3 and 4. The protein efficiency of the pig operation was only 17%. Integrating fish culture with the pig operation increased protein efficiency to 29%.

10. Summary

During the four-year research of the CLSU/ICLARM Integrated Animal-Fish Farming Project, 18 major experiments were conducted which showed the potential for producing high yields of tilapia and carp while disposing of livestock manures. A brief summary of the findings follows:

1. Manure output by pigs was a function of both animal size and ration type. The manure output could be estimated by two equations:

$$\text{Grower ration} \quad Y = 23.5541 - 4.20214\ (\mathit{ln}\ X)$$
$$\text{Finisher ration} \quad Y = 8.452 - 0.04957\ X$$

where Y = daily fresh manure output as a percentage of pig weight and X = pig weight in kilograms. Different output levels would be expected if different feed brands or compositions are used.

2. At very low manure loads, fish yields tended to be low. As manure loads increased, average fish yield increased but variability was also high. As the loads increased further, average fish yield increased towards a maximum but variability decreased. If manure load increased still higher, average yield then decreased and variability increased. A probable explanation is that at very low manure levels, nutrients are limited and only a small response is possible. When the amount of nutrients increased, productivity increased and natural variability of these systems allowed both high and low yields to be attained. At still higher manure loads, there were so many nutrients available that high yields were almost always attained. The maximum yield was probably dependent on the innate growth capability of the fish, not external factors. In our system stocked with 20,000 fish/ha, yields of 15-20 kg/ha/day of marketable tilapia and 5-8 kg/ha/day of carp were achieved. At very high manure loads, growth decreased, probably due to low dissolved oxygen.

3. A new pond gave lower yields than older ponds. A residual effect from manuring may have existed, or ponds previously manured may have already contained bacteria and plankton species which grew well under conditions encountered in manured ponds.

4. Increasing the fish stocking density from 10,000 to 20,000 and then to 30,000 fish/ha ($\approx$ 85% tilapia, 15% carp) increased fish yields.

5. Allowing tilapia recruitment to occur increased yield substantially by increasing the number of fish. If the recruits could be utilized (e.g., for restocking, animal feed, or sale if the market accepts small fish), average total yields in excess of 28 kg/ha/day could be attained (10,200 kg/ha/annum).

6. Maximum yields attained with chicken and pig manures were similar. Manure loads at maximum yield were approximately 100 kg dry matter/ha/day for both chickens and pigs. At low manure loads, chicken manure was more effective than pig manure. Yields with duck manure were somewhat lower.

7. Predator-prey ratios as commonly used in aquaculture were ineffective in controlling recruitment if stocking densities varied greatly.

8. At least 2,500 two-gram fingerlings could be produced per ha per day from ponds receiving piggery wastes.

9. Growth of individual fish was faster at lower stocking densities. Mean growth rates above 1.5 g/day/fish were attained.

10. Multivariate equations based on a modification of the "Gulland and Holt Plot" of the form

$$b = a + b_1 X_1 + b_2 X_2 + \ldots b_n X_n$$

where b = average daily growth during period, X_1 = average fish length during period and $X_2 \rightarrow X_n$ are factors which affect growth, appeared to have good potential in predicting growth.

11. Increasing manure loads increased alkalinity, conductivity and phosphate concentrations in the ponds. Total ammonia concentrations greater than 2 mg/l were occasionally measured at high manure loads. However, the relatively high alkalinity, > 100 mg/l $CaCO_3$, kept the mean pH at 8.1 or below, so most of the ammonia stayed in the less toxic, ionized, NH_4^+ form.

12. Early morning dissolved oxygen was inversely related to manure load with concentrations below 1 mg/l routinely measured at high manure loads. Mean mid-afternoon DO was above 200% saturation at high manure loads.

13. From overnight oxygen monitoring, it was shown that early morning DO inadequately described the oxygen regime in the ponds because it showed only how low the DO dropped, not for how long it was low.

14. Heavy build-up of organic matter in the fishponds did not occur, indicating that the manure decomposition was almost complete.

15. Major differences in plankton species composition and abundance were found even between ponds treated identically. Also composition and abundance often changed within a few days.

16. No relationship between increasing pig manure load and plankton densities was apparent. However, increasing chicken manure loads appeared to increase plankton density.

17. The most common phytoplankters in pig-fish ponds were *Pediastrum, Scenedesmus, Coelastrum, Chlorella, Microcystis, Lyngbya, Oscillatoria, Euglena, Phacus* and *Trachelomonas*. The most common zooplankters were *Brachionus, Trichocerca, Asplanchna, Filinia, Philodina, Moina, Diaphanosoma* and various copepods. Chicken-fish ponds had essentially the same plankters with addition of *Closterium, Cosmarium* and *Merismopedia*. *Philodina* was not found in the chicken-fish ponds.

18. No parasites zoonotic to livestock or humans were found during regular examination of fish grown in Project ponds. However, the livestock were also kept "parasite-free", a condition which cannot be expected on many small farms. Only three fish parasites were encountered: *Cichlidogyrus* in the tilapia; *Dactylogyrus* in the carp, and a nematode (probably *Camallanus* sp.) in *Channa striata*.

19. The farmer with a large number of livestock will maximize his operating profit and internal rate of return from ponds with 100 pigs/ha or 4,400 chickens/ha of pond. When the number of livestock is limited, operating profit and internal rate of return are maximized at lower animal densities.

20. Both operating profit and internal rate of return are highly dependent on pond size. Ponds much below 1,000 m^2 are not profitable while returns in excess of 70% and 90% per annum are possible with large pig-fish ponds and chicken-fish ponds, respectively.

21. The integration of fish culture with pig or poultry rearing significantly increased the operating profit and IRR over that possible with the livestock operation alone. The fish component of a duck-fish farm was less profitable (IRR basis) than the duck component but the contribution to net income was very important.

22. Taste tests and observations made during sales of Project fish showed that fish grown in manured ponds were preferred to those grown in ponds fertilized with inorganic fertilizer.

23. The integration of fish culture with pig rearing increased the crude protein efficiency (crude protein output/crude protein input) from 17 to 29%.

There are still many areas needing further clarification. The main areas are:

1. How much of the fish yield can be attributed to feeding on phytoplankton; how much is

from direct feeding on the manure; and how much is from feeding on detritivores (bacteria, worms, etc.)?

2. What causes the downturn in growth and yields at high manure levels? If the cause is low dissolved oxygen, will supplemental aeration increase yields?

3. If the livestock are grown under less hygienic conditions than those used on the Project, will parasites zoonotic to humans be transmitted to the fish? What are the risks of bacterial and viral infections in eating fish from integrated farms?

4. Is it possible to model reliably the very complex processes in ponds receiving livestock wastes and predict yields under varying environmental conditions?

Acknowledgements

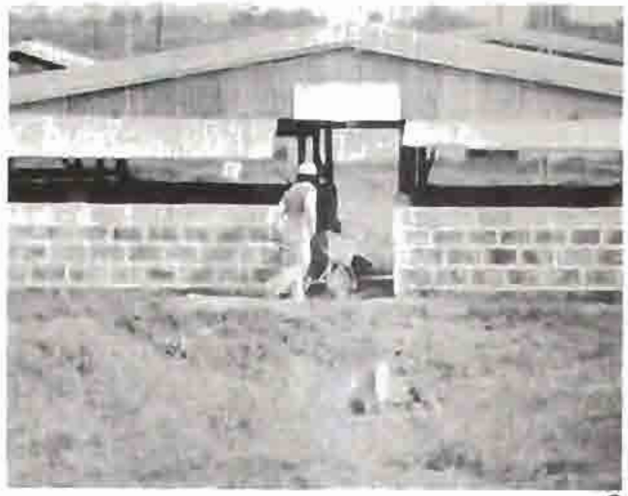
This project was made possible through the efforts of many people, too numerous to list individually. We wish to especially acknowledge Dr. Roger S.V. Pullin for his many suggestions and ideas and because he had the unenviable task of reviewing and correcting the drafts of this report.

Although any project of the scale attained by the Animal-Fish project is the result of a team effort by everyone involved (i.e., senior scientists, technicians, accounting clerks, laborers), the success of this project was due in large part to the outstanding efforts of the laborers. They worked very hard under often unpleasant conditions.

Lastly, we would like to thank the Philippine Bureau of Animal Industry for providing pigs for the last pig-fish experiment.

The CLSU/ICLARM Integrated Farming Project in Pictures

1



2

1. Experimental ponds (foreground) at the Freshwater Aquaculture Center of the Central Luzon State University. Animal houses can be seen on the dikes.
2. Pig houses were constructed on the dikes between ponds. Each pond received the waste from one pig pen.
3. Weanling pigs, 10-15 kg each, were raised according to recommended Philippine practices and fed a commercial ration at 3-5% body weight/day.
4. Pens were washed daily with water pumped from the ponds, such that untreated manure flowed directly into the ponds.
5. The tilapia *(Oreochromis niloticus)* reached market size, less than 60 g, in 90 days in these experiments.

3

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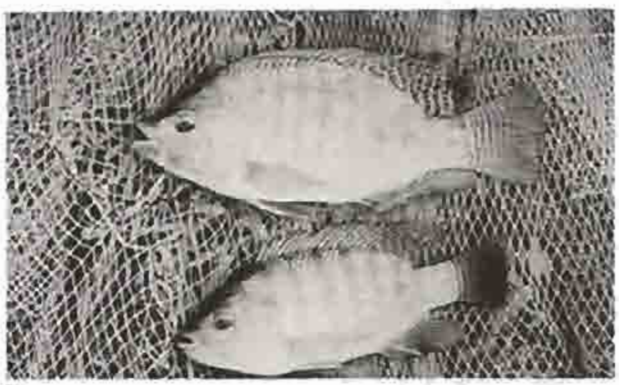
4

6

7

6. Fish were measured regularly and monitored for parasites.
7. Experimental livestock were kept "parasite free".
8. *Oreochromis niloticus* [male (upper) and female (lower)] comprised 85% of fish stocked in each pond.
9. Common carp *(Cyprinus carpio)* comprised 14% of the fish stocked.
10. Snakehead or mudfish *(Channa striata)* made up the remaining 1% of fish stocked in most experiments.



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11. Fish were harvested by seining and then draining the ponds.
12. Laboratory at the Freshwater Aquaculture Center, Central Luzon State University. Water quality parameters were monitored regularly.
13. Poultry houses were constructed on pond dikes.
14. Peking ducks were grown for 180 days (two fish-production cycles). They were given access to the ponds during daytime.
15. Chickens were raised in cages. Mixed-sized flocks were used, with the largest third of the flock harvested and replaced by chicks every two to three weeks.

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16-17. For economic analysis, a period of two months was added to the production cycle to account for time spent in harvesting and pond maintenance.

18. Yields equivalent to nearly 7 t/ha/yr of market-sized tilapia were obtained with predator recruitment control.

19. When no predatory snakehead were included in experimental stocking, yields were higher—equivalent to over 10 t/ha/yr—due to spawning and recruitment during the cycle.

20. A tasting panel found that the fish grown in manured ponds were preferable to those grown in ponds using inorganic fertilizer.

18

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19

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Appendix A
Analytical Methods and Equipment Used

WATER ANALYSIS

Alkalinity (total) – Mixed bromo-cresol green-methyl red indicator method (APHA:AWWA:WPCF 1971, pp. 54-55) using 0.02N HC1.

Ammonia-Ammonium – Orion model 95010 ammonia electrode used with Orion Model 407A specific ion meter.

Conductivity – Hach model 16300 portable conductivity meter.

Nitrate – Phenoldisulfonic acid method (APHA:AWWA:WPCF 1971, pp. 234-237) using a Bausch and Lomb Spectronic 21 spectrophotometer.

Nitrite – Sulfuric acid method (APHA:AWWA:WPCF 1971, pp. 240-243) using a Bausch and Lomb Spectronic 21 spectrophotometer.

Orthophosphate – Ascorbic acid method (Lind 1979, pp. 64-65) using Spectronic 21 spectrophotometer.

pH – Orion model 91-02 combination pH electrode with Orion model 407A specific ion meter.

Oxygen (dissolved) – Polarographic sensors with Clark-type membranes with built-in thermistors for temperature measurement and compensation. For measurements at one point in time, Yellow Springs Instruments (YSI) model 5739 dissolved oxygen probe with YSI model 54A oxygen meter at approximately 30 cm below water surface. For continuous measurements, a YSI model 5795A submersible stirrer and a chart recorder were used in combination with the probe and meter. If oxygen concentrations approached or exceeded 20 mg/l, water samples were collected and DO determined using the standard Winkler method (APHA:AWWA:WPCF 1971, pp. 477-478 w/o azide). The probe accuracies were regularly checked using the Winkler method and a standard calorimeter thermometer.

Temperature – Early morning water temperature was measured using the thermistor in the YSI model 5739 dissolved oxygen probe with a YSI model 54A oxygen meter at a depth of 30 cm. Maximum and minimum water temperatures were measured using a Tyler maximum and minimum registering thermometer.

Visibility – 20 cm diameter Secchi disk.

PLANKTON

A composite sample totalling approximately 30 l was collected from several points in the pond using buckets. A 4- to 10-l subsample was taken and filtered through a No. 150 mesh (106 μm) sieve.The filtrate was then filtered again through a No. 400 (38 μm) sieve. The residues were washed from the sieves into separate bottles and 10% formalin added to the bottles. Sample volume was measured and a 1-ml subsample was placed in a Sedgewick-Rafter cell which was calibrated using a stage micrometer and examined at 100x (10x object and 10x ocular) using a Whipple disk. Plankton were identified using Prescott (1970), Pantastico (1977), Edmondson (1959), Mamaril (1978). Field counts were made using plankton units.

Primary productivity was measured using the light-dark bottle method. Bottle were placed vertically at 1-11 cm depth, 13-23 cm, 26-36 cm, 40-50 cm. The bottles were placed in the water at 1100 hours and removed at 1300 hours. Oxygen concentrations were determined using a YSI model 5720 BOD bottle probe and a YSI model 54A oxygen meter. If DO exceeded 20 mg/l, the Winkler method was used.

FEEDS, MANURES AND SOILS

Ash – Oven-dried sample at 550°C for at least 4 hours.

Fiber (Crude) – Digestion with mild acid and alkaline solutions in a Labconco crude fiber condenser (AOAC 1970, pp. 129-131).

Lipids – Direct ether extraction using Lab-line soxhlet-type extraction rack (AOAC 1970 p. 128).

Nitrogen – Kjeldahl method (AOAC 1970, p. 123).

Organic matter – Dry matter minus ash.

Phosphorus (Total) – Neutral NH_4F-Soluble phosphorus as in Swingle (1969).

Water – Oven-drying of sample at 105°C for 24 hours (manures and soils) or 6 hours (feeds).

All these analyses (except water) were made with approximately 2 gram triplicated samples (rarely duplicated only).

Oxygen demand (Biochemical) – 24-hour BOD using distilled water enriched with a phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride. DO was measured using a YSI model 5720 BOD bottle probe and YSI model 54A oxygen meter. BOD bottles were incubated at room temperature.

WEATHER

Evaporation (total) — Measured daily 0800 with an evaporation pan (mm).
Humidity (relative) — Dry and wet bulb thermometer at 0800 and 1400 hours (%).
Radiation — Daily 0800 using roof-mounted Lambda Instrument Corp. model LI-200S pyranometer, sensor and LI 500/200m integrator (langleys).
Rainfall — Daily 0800 to 0800 using a standard rain gauge and rain recorder (mm).
Temperature (air) — Maximum-minimum registering thermometer at 0800 and 1700 hours (°C).
Wind (speed and direction) — Wind vane at 0.3 m above ground and cumulative wind dial (km/day).

The weather data are from the CLSU/PAGASA Agromat Station which is approximately 1 km from the Project pond area.

FISH SAMPLING

The fish were sampled at stocking, regularly throughout the experimental periods, and at harvest. Random samples of 50-100 *O. niloticus* and *C. carpio* were taken at stocking. The total length and weight of each fish were determined. All of the *Channa striata* stocked were measured. Additionally bulk weights and counts were made for each species.

Sampling to determine growth rates was usually conducted biweekly. Ponds were seined and, as a general rule, at least 40-50 of the captured tilapia and all of the captured carp and *Channa striata* were weighed and measured.

Fish harvest was effected by first lowering the water level, seining to remove most of the large fish, and draining the pond completely in order to collect the remaining fish. The tilapia were sorted into "original stock" and recruits. Bulk weights of both tilapia groups, the carp and *Channa striata* were taken. The larger fish were individually counted while a subsample of the recruits was weighed and counted. Approximately 5-10% samples of each species were individually weighed and measured. All sampling during later experiments measured only total lengths of sampled fish because length-weight relationships allowed estimation of individual weights.

Appendix B

Fish Stocking and Harvest Summaries

The table on the following pages contains the stocking and harvest data for every completed experiment. Also included is a summary of the nutrient inputs and the more important water quality data. The following is a listing and explanation of each category in the table. An entry in parentheses indicates an estimate.

Category	Explanation
Experiment Number (Exp. No.)	– See chapter 2 for experiment descriptions
Pond Number (Pond No.)	– Ponds 1-12 are 1,000 m^2 while Ponds 13-24 are 400 m^2
Animal Type	– Pig, chicken, duck, IF (inorganic fertilizer) or none
Days	– Length of culture period in days. If dates are desired, the start of the first sampling period (Appendix C) usually corresponds to stocking and the end of the last period to harvest.
DO	– Average early morning dissolved oxygen (mg/l)
Temperature (Temp.)	– Average early morning water temperature (°C)
N_i	– The number stocked (#/ha)
$\bar{W}_i$	– Average weight at stocking (g)
W_i	– Total biomass stocked (kg/ha)
N_h	– The number harvested (#/ha)
% S	– Percent survival
W_h	– Total biomass harvested (kg/ha)
$\bar{W}_h$	– Average weight at harvest (g)
Y	– Net yield (kg/ha)
Y/d	– Daily net yield (kg/ha/day)
R_s	– Recruits captured and removed during sampling (kg/ha)
R_h	– Recruits captured at harvest (kg/ha)
ΣR	– Total recruits (kg/ha). In Experiment 2, no data regarding fingerlings were contained in the records so zero was entered into this table.
Manure	– Cumulative total of manure added to pond during experiment (kg dry matter/ha). This can be converted to nitrogen, phosphate, potash, fiber, or biochemical oxygen demand by multiplying by the appropriate constant (Table 3.2). The nutrient input levels for inorganic fertilizer were 0.53 kg N/day and 0.67 kg PO_4/day.

						Oreochromis niloticus												*Cyprinus carpio*						
Exp. no.	Pond no.	Animal type	Days	DO	Temp.	N_i	$\bar{W}_i$	W_i	N_h	%S	W_h	$\bar{W}_h$	Y	Y/d	R_s	R_h	ΣR	N_i	$\bar{W}_i$	W_i	N_h	%S	W_h	$\bar{W}_h$
1	1	IF	97	5.4	27.1	8500	5.9	5	8180	96	428	52	378	3.9	–	99	99	1400	19.7	27.5	1540	> 100	239	155
1	5	IF	96	5.4	27.1	8500	7.5	6	7160	84	323	45	296	3.1	–	101	101	1400	4.7	6.6	1360	97	113	83
1	8	IF	101	5.2	27.0	17000	2.3	39	3830	23	63	17	24	0.2	–	0	0	2800	2.6	7.3	3330	> 100	62	19
1	11	IF	106	5.6	27.0	17000	6.4	108	13350	79	357	27	249	2.4	–	3	3	2800	4.2	11.8	3570	> 100	95	27
1	6	Pig	101	4.9	27.0	8500	6.5	55	6190	73	329	53	274	2.7	–	109	109	1400	4.1	5.7	1380	99	141	102
1	9	Pig	98	4.7	26.8	8500	1.6	14	2820	33	153	54	139	1.4	–	0	0	1400	2.4	3.4	1450	> 100	170	117
1	2	Pig	99	5.2	27.2	17000	5.6	95	15420	91	556	36	461	4.7	–	15	15	2800	5.8	16.3	2410	86	109	45
1	3	Pig	99	5.6	27.0	17000	3.5	60	15230	90	543	34	484	4.9	–	0	0	2800	3.4	9.4	2660	95	125	47
1	4	Pig	96	5.2	27.2	8500	5.0	43	8160	96	588	72	545	5.7	–	406	406	1400	4.1	5.7	1360	97	213	157
1	7	Pig	97	5.2	27.1	8500	4.8	41	6680	79	496	74	455	4.7	–	41	41	1400	5.3	7.4	1450	> 100	206	142
1	10	Pig	101	4.8	26.7	17000	1.6	27	7360	43	230	31	203	2.0	–	0	0	2800	1.9	5.3	4560	> 100	172	38
1	12	Pig	102	4.4	27.1	17000	3.5	59	17200	> 100	742	43	683	6.7	–	20	20	2800	4.0	11.2	2710	97	217	80
2	5	Pig	90	3.9	24.3	8500	3.6	30	6627	78	1123	169	1093	12.1	–	0	0	820	23.0	19.0	–	–	318	–
2	8	Pig	90	4.0	24.1	8500	4.0	37	6630	78	1218	184	1181	13.1	–	0	0	1000	20.0	20.0	–	–	506	–
2	9	Pig	90	3.5	24.2	8500	3.6	30	7793	92	1127	145	1097	12.2	–	0	0	100	20.0	20.0	–	–	247	–
2	2	Pig	90	4.9	24.6	17000	2.7	45	15141	89	1287	85	1242	13.8	–	0	0	1190	44.0	52.0	–	–	132	–
2	3	Pig	90	4.3	24.3	17000	2.1	36	14282	84	1114	78	1078	12.0	–	0	0	1190	44.0	52.0	–	–	37	–
2	11	Pig	90	5.2	24.1	17000	3.7	63	16133	95	1823	113	1760	19.6	–	0	0	1180	44.0	52.0	–	–	262	–
2	1	Pig	90	4.0	24.5	8500	2.8	24	8503	100	1148	135	1124	12.5	–	0	0	1000	20.0	20.0	–	–	300	–
2	4	Pig	90	1.5	24.2	8500	2.6	22	8503	100	1216	143	1194	13.3	–	0	0	1000	20.0	20.0	–	–	501	–
2	7	Pig	90	3.4	24.3	8500	4.3	36	8517	100	1729	203	1693	18.8	–	0	0	1000	20.0	20.0	–	–	311	–
2	8	Pig	90	5.2	24.1	17000	3.7	64	14424	85	1327	92	1263	14.0	–	0	0	1190	44.0	52.0	–	–	270	–
2	10	Pig	90	3.5	24.3	17000	3.9	66	12377	73	1609	130	1543	17.1	–	0	0	1190	44.0	52.0	–	–	320	–
2	12	Pig	90	4.3	24.4	17000	4.1	70	17221	> 100	1791	104	1721	19.1	–	0	0	1180	44.0	52.0	–	–	469	–
3	2	Pig	98	3.1	28.1	8500	4.4	37	9550	> 100	1003	105	965	10.1	–	491	491	1400	0.7	1.0	840	60	107	127
3	4	Pig	98	1.9	27.9	8500	2.8	24	7430	87	627	84	603	6.3	–	661	661	700	0.7	0.5	280	40	74	263
3	11	Pig	102	2.3	27.8	8500	2.5	21	7510	88	799	106	778	7.6	–	701	701	700	0.6	0.4	400	57	118	286
3	6	Pig	97	2.7	27.5	17000	3.7	63	14780	87	1201	81	1138	12.2	–	32	32	1650	0.7	1.2	1280	78	164	128
3	8	Pig	98	3.7	27.5	17000	3.7	63	14970	88	1436	96	1373	14.0	–	372	372	2800	0.6	1.7	1550	55	161	104
3	9	Pig	104	2.3	27.5	17000	3.3	56	16030	94	1492	93	1436	13.8	–	26	28	2800	0.6	1.7	1440	51	208	144
3	3	Pig	99	3.5	27.8	8500	2.5	21	7730	91	851	110	829	8.4	–	580	580	700	0.7	0.5	760	> 100	181	238
3	7	Pig	104	2.8	27.9	8500	3.7	32	7630	90	963	126	931	9.0	–	513	513	1400	0.6	0.8	940	67	174	185
3	10	Pig	103	2.4	27.6	8500	3.7	32	8910	> 100	1054	118	1023	9.9	–	1020	1020	1400	0.6	0.8	930	66	170	183
3	1	Pig	96	1.4	27.9	17000	4.7	81	14400	85	1100	76	1020	10.8	–	36	36	2800	0.8	2.2	930	33	159	171
3	5	Pig	96	2.3	27.9	17000	2.4	41	14220	84	1347	95	1306	13.6	–	682	682	1400	0.7	1.0	1080	77	218	202
3	12	Pig	103	2.4	27.7	17000	2.7	46	13330	78	1549	116	1503	14.6	–	118	118	1400	0.6	0.8	990	71	270	273
4	2	Pig	95	1.5	25.6	8500	4.4	38	7130	84	1152	182	1114	11.7	–	1	1	1400	10.0	13.9	1340	96	490	366
4	4	Pig	91	0.3	25.3	8500	2.9	24	8350	98	930	111	906	10.0	–	1	1	720	3.7	2.7	700	97	152	217
4	11	Pig	94	0.6	24.8	8500	3.8	33	7150	84	1018	142	985	10.5	–	1	1	720	(4.0)	2.9	710	99	140	197
4	6	Pig	96	1.1	24.9	17000	3.5	60	14500	85	1486	103	1426	14.9	–	10	10	1400	10.0	13.9	2450	> 100	822	253
4	8	Pig	100	0.9	25.1	17000	5.1	87	15160	89	1698	112	1611	16.1	–	1	1	1220	(5.0)	6.1	1160	95	261	225
4	9	Pig	93	0.3	24.8	17000	2.9	47	14470	85	1466	101	1417	15.2	–	12	12	1210	(5.0)	6.1	1150	95	222	193
4	3	Pig	96	0.5	25.3	8500	4.4	38	7550	89	1033	137	995	10.4	–	1	1	1400	10.0	13.9	1360	97	430	316
4	7	Pig	96	0.5	25.4	8500	4.4	38	7920	93	1225	155	1187	12.4	–	1	1	1400	10.0	13.9	1300	93	407	313
4	10	Pig	92	0.4	24.8	8500	4.0	34	8000	94	1052	132	1018	11.1	–	1	1	720	(4.0)	2.9	650	90	148	227
4	1	Pig	94	0.5	25.4	17000	3.5	60	15850	93	1697	107	1637	17.4	–	13	13	2800	10.0	27.9	2810	> 100	902	321
4	5	Pig	92	0.5	25.3	17000	4.0	68	16620	98	2011	121	1943	21.1	–	7	7	1220	(5.0)	6.1	740	61	188	254
4	12	Pig	95	0.7	24.7	17000	3.8	65	17170	> 100	1867	109	1802	19.0	–	77	77	1210	(6.7)	8.1	1230	> 100	220	179
5	6	Pig	175	1.8	26.7	8500	3.0	25	7490	88	1862	249	1837	10.5	161	1340	1501	1500	19.4	29.0	1250	83	450	360
5	8	Pig	177	1.3	27.0	8500	3.0	25	7620	90	1706	224	1681	9.5	258	991	1249	1500	1.9	3.0	1020	68	370	363
5	9	Pig	178	1.3	27.1	8500	3.0	25	7630	90	2375	311	2350	13.2	302	2311	2613	1500	11.0	16.0	1160	77	510	440
5	2	Pig	176	2.1	27.0	8500	3.4	29	6520	77	1420	218	1391	8.0	343	2871	3214	1500	14.5	9.7	1060	71	276	260
5	7	Pig	177	1.8	27.2	8500	2.9	24	7740	91	1750	227	1726	9.7	547	2982	3529	1500	2.2	3.0	1180	79	365	309
5	12	Pig	185	1.5	27.0	8500	3.3	28	7470	88	1420	190	1392	7.5	421	2597	3018	1500	6.7	10.0	1920	> 100	603	314
5	1	Pig	175	2.0	26.8	17000	2.6	44	14860	87	2718	183	2674	15.3	278	1231	1509	3000	4.1	12.0	1890	63	605	320
5	10	Pig	183	1.6	27.0	17000	2.7	45	13910	82	3268	235	3223	17.8	302	2140	2442	3000	6.6	19.0	1900	63	488	257
5	11	Pig	185	1.3	26.9	17000	2.7	46	13250	78	2620	198	2575	13.9	365	1960	2325	3000	11.0	33.0	2060	69	566	274
5	3	Pig	179	1.6	27.0	17000	2.5	42	14010	82	1890	135	1848	10.3	434	2856	3290	3000	3.7	11.0	1690	56	334	198
5	4	Pig	181	1.2	26.8	17000	2.6	43	13390	79	2499	181	2456	13.6	427	2278	2705	3000	2.7	8.0	2100	70	382	182
5	6	Pig	182	0.7	27.2	17000	2.7	46	14050	83	2783	198	2737	15.0	675	3332	4007	3000	5.0	15.0	2270	76	456	201
6	14	Pig	59	0.7	24.8	16825	9.1	61	13575	81	686	51	625	10.6	–	5	5	2975	154.0	458.0	2200	74	643	292
6	20	Pig	59	0.5	25.4	16825	10.1	68	14075	84	1265	90	1197	20.3	–	25	25	2975	148.0	440.0	2775	93	774	279
6	13	Pig	58	0.8	24.7	16825	6.2	42	14150	84	1075	76	1033	17.8	–	8	8	2975	139.0	414.0	2475	83	665	269
6	19	Pig	58	0.6	25.5	16825	13.2	89	14400	86	860	60	771	13.3	–	13	13	2975	156.0	464.0	2725	92	688	252
8	13	Duck	103	3.6	25.7	8500	1.8	15	6275	74	486	78	471	4.6	–	375	375	1400	2.2	3.0	1475	> 100	185	125
8	15	Duck	102	3.6	25.7	8500	2.1	18	150	2	26	173	8	0.1	–	0	0	1400	2.8	4.0	2575	> 100	330	128
8	16	Duck	105	3.4	25.8	8500	2.1	18	5050	59	304	60	286	2.7	–	0	0	1400	2.2	3.0	1325	95	209	158
8	20	Duck	101	2.9	26.1	17000	2.0	34	8957	53	478	53	444	4.4	–	0	0	2800	1.9	5.0	2350	84	262	112
8	23	Duck	103	4.1	26.3	17000	2.1	36	11275	66	500	44	464	4.5	–	0	0	2800	2.2	6.0	3275	> 100	188	57
8	18	Duck	104	3.1	25.8	17000	2.1	36	10275	60	491	48	455	4.4	–	0	0	2800	2.2	6.0	2400	86	226	94
8	19	Duck	95	3.4	26.4	8600	2.2	19	7675	90	461	60	442	4.7	–	12	12	1400	2.4	4.0	1000	71	114	114
8	21	Duck	102	3.0	26.0	8500	2.0	17	7650	90	579	76	562	5.5	–	125	125	1400	1.7	2.0	1100	79	180	164
8	17	Duck	105	4.2	25.9	8500	2.1	18	6350	75	486	73	448	4.3	–	0	0	1400	2.6	4.0	1425	> 100	206	144
8	22	Duck	102	3.9	26.0	17000	2.1	36	6675	39	686	103	650	6.4	–	0	0	2800	2.6	6.0	2700	96	275	102
8	24	Duck	103	3.6	25.9	17000	2.1	36	13175	78	632	48	596	5.8	–	0	0	2800	2.2	6.0	3000	> 100	212	71
8	14	Duck	96	2.7	25.8	17000	2.0	34	11275	66	720	64	686	7.2	–	0	0	2800	1.4	4.0	2025	72	385	190
9	13	Duck	105	1.4	25.7	8500	2.0	17	6875	81	924	134	907	8.6	–	25	25	1400	(54.0)	76.0	1300	93	481	370
9	15	Duck	106	1.2	25.6	8500	2.0	17	8550	100	907	106	890	8.4	–	75	75	1400	(54.0)	76.0	875	82	327	374
9	16	Duck	106	1.5	25.6	8500	2.0	17	7650	90	931	122	914	8.8	–	50	50	1400	(54.0)	76.0	975	70	299	307
9	20	Duck	94	1.8	25.8	17000	2.0	34	14525	85	1211	83	1177	12.5	–	0	0	2800	(54.0)	151.0	1650	59	252	153
9	23	Duck	98	2.6	25.7	17000	2.0	34	13350	79	1194	89	1160	11.8	–	0	0	2800	(54.0)	151.0	1875	67	416	222
9	18	Duck	107	1.4	25.6	17000	2.0	34	13850	81	1566	113	1532	14.3	–	0	0	2800	(54.0)	151.0	1650	59	369	224
9	19	Duck	94	1.8	25.8	8500	2.0	17	8275	97	890	108	873	9.3	–	125	125	1400	(54.0)	76.0	1175	84	259	220
9	21	Duck	97	1.1	25.6	8500	2.0	17	7800	92	813	104	796	8.2	–	0	0	1400	(54.0)	76.0	675	48	374	554
9	17	Duck	107	1.8	25.6	8500	2.0	17	6575	77	771	117	754	7.0	–	100	100	1400	(54.0)	76.0	950	68	339	357
9	22	Duck	97	1.4	25.7	17000	2.0	34	14475	85	1206	83	1172	12.1	–	0	0	2800	(54.0)	161.0	2000	71	459	230

		Channa striata									Market size fish		All fish				Daily
Y	Y/d	N_i	$\bar{W}_i$	W_i	N_h	%S	W_h	$\bar{W}_h$	Y	Y/d	Y	Y/d	Y	Y/d	Animal biomass	Manure	manure load
211	2.2	100	1.0	0.1	40	40	7	165	6	0.1	595	6.1	694	7.2	0	0	–
106	1.1	100	1.0	0.1	30	30	5	167	5	0.1	407	4.2	508	5.3	0	0	–
55	0.5	200	1.0	0.2	120	60	9	75	9	0.1	88	0.9	88	0.9	0	0	–
84	0.7	200	1.0	0.2	100	50	12	120	12	0.1	344	3.3	347	3.3	0	0	–
135	1.3	100	1.0	0.1	40	40	8	204	8	0.1	417	4.1	526	5.2	1322	3665	36
166	1.7	100	1.0	0.1	50	50	6	120	6	0.1	312	3.2	312	3.2	1320	3218	33
93	0.9	200	1.0	0.2	80	40	14	169	13	0.1	567	5.7	582	5.9	1363	3086	31
115	1.2	200	1.0	0.2	60	30	10	167	10	0.1	609	6.2	609	6.2	1344	3117	31
207	2.2	100	–	–	20	20	5	225	4	0.0	757	8.0	1163	12.2	1893	5006	53
199	2.1	100	–	–	30	30	5	175	5	0.1	659	6.8	700	7.2	1928	5014	52
167	1.7	200	–	–	10	5	1	50	0	0.0	371	3.7	371	3.7	2150	4263	42
206	2.0	200	–	–	100	50	19	186	19	0.2	908	8.9	928	9.5	2188	5363	53
299	3.3	100	–	–	–	–	3	–	3	0.0	1395	15.5	1395	15.5	3123	3826	43
485	5.4	100	–	–	–	–	3	–	3	0.0	1669	18.5	1669	18.5	3219	3804	42
227	2.5	100	–	–	–	–	19	–	18	0.2	1343	14.9	1343	14.9	3360	3797	42
80	0.9	200	–	–	–	–	13	–	13	0.1	1335	14.8	1335	14.8	3242	3851	43
0	0.0	200	–	–	–	–	5	–	5	0.1	1083	12.0	1083	12.0	3134	3780	42
210	2.3	200	–	–	–	–	15	–	15	0.2	1985	22.1	1985	22.1	2234	3708	41
280	3.1	100	–	–	–	–	9	–	8	0.1	1413	15.7	1413	15.7	4506	5844	65
481	5.3	100	–	–	–	–	11	–	11	0.1	1686	18.7	1686	18.7	4493	5631	63
291	3.2	100	–	–	–	–	13	–	13	0.1	1997	22.2	1997	22.2	4565	5839	65
218	2.4	200	–	–	–	–	25	–	24	0.3	1506	16.7	1506	16.7	3881	5848	65
268	3.0	200	–	–	–	–	14	–	13	0.1	1825	20.3	1825	20.3	4617	5692	63
417	4.6	200	–	–	–	–	35	–	34	0.4	2173	24.1	2173	24.1	5250	5704	63
106	1.1	100	1.0	0.1	70	70	26	376	26	0.3	1098	11.4	1589	16.6	1580	3706	38
73	0.8	100	1.0	0.1	60	60	25	418	25	0.3	701	7.3	1362	14.2	1552	3678	38
118	1.2	100	1.0	0.1	40	40	19	480	19	0.2	915	9.0	1616	15.8	2095	5340	52
163	1.8	200	1.0	0.2	140	70	39	276	39	0.4	1340	14.4	1372	14.8	1513	3510	36
159	1.6	200	1.0	0.2	100	50	39	392	39	0.4	1571	16.0	1943	19.8	1922	3364	34
206	2.0	200	1.0	0.2	170	85	51	302	51	0.5	1693	16.3	1719	16.5	1986	4317	42
181	1.8	100	1.0	0.1	90	90	36	402	36	0.4	1046	10.6	1626	16.4	1966	4644	47
173	1.7	100	1.0	0.1	110	100	51	465	51	0.5	1155	11.1	1668	16.0	2155	5755	55
170	1.7	100	1.0	0.1	20	20	8	385	8	0.1	1209	11.7	2229	21.6	2068	5535	54
157	1.6	250	1.0	0.3	220	88	57	259	57	0.6	1233	12.8	1269	13.2	1986	4644	48
217	2.3	200	1.0	0.2	70	35	34	490	34	0.4	1557	16.2	2239	23.3	2149	5380	56
262	2.5	200	1.0	0.2	70	35	23	328	23	0.2	1795	17.4	1913	18.6	2415	6378	62
476	5.0	300	20.4	6.1	210	70	19	106	13	0.1	1604	16.8	1604	16.8	6516	8573	90
149	1.6	300	18.7	5.6	180	60	28	159	22	0.2	1078	11.9	1079	11.9	6490	7747	85
137	1.5	300	7.7	2.3	160	53	21	132	19	0.2	1141	12.1	1142	12.2	7140	7763	83
608	6.3	300	8.4	2.5	170	57	26	152	24	0.2	2058	21.4	2068	21.5	6042	8045	84
255	2.6	300	7.1	2.1	100	33	11	115	9	0.1	1875	18.8	1876	18.8	6166	8456	85
216	2.3	300	9.4	2.8	180	60	15	83	12	0.1	1645	17.7	1659	17.8	6878	7766	84
417	4.3	300	18.6	5.6	220	73	24	109	18	0.2	1430	14.9	1431	14.9	7492	10287	107
393	4.1	300	8.7	2.6	200	67	21	107	18	0.2	1599	16.7	1600	16.7	7759	10090	105
145	1.6	300	8.9	2.7	70	23	10	140	7	0.1	1170	12.7	1171	12.7	8081	9812	107
874	9.3	300	19.1	5.7	210	70	25	119	19	0.2	2530	26.9	2543	27.0	7523	9908	105
182	2.0	300	8.2	2.5	160	53	24	148	22	0.2	2146	23.3	2153	23.4	8219	9950	108
212	2.2	300	3.9	1.2	100	33	13	131	12	0.1	2026	21.3	2103	22.1	8205	9917	104
421	2.4	300	1.3	.4	150	50	35	383	35	0.2	2293	13.1	3794	21.7	3982	14809	85
360	2.0	300	1.3	.4	120	40	75	748	75	0.4	2123	11.9	3372	19.0	4296	15969	90
494	2.8	300	1.3	.4	100	33	59	591	59	0.3	2903	16.3	5518	31.0	4097	15215	85
266	1.5	0	–	–	–	–	–	–	–	–	1657	9.5	4871	27.8	4318	15732	90
362	2.1	0	–	–	–	–	–	–	–	–	2088	11.8	5617	31.7	4284	15251	86
593	3.2	0	–	–	–	–	–	–	–	–	1985	10.7	5003	27.0	4653	17214	93
593	3.4	400	(45.0)	18.0	210	53	176	800	158	0.9	3425	19.6	4934	28.2	4374	15873	91
469	2.6	400	(40.0)	16.0	100	25	82	820	66	0.4	3758	20.5	6200	33.9	4340	15845	87
533	2.9	400	(38.0)	15.0	100	25	54	537	39	0.2	3147	17.0	5473	29.6	4533	17011	92
323	1.8	0	–	–	–	–	–	–	–	–	2171	12.1	5325	30.5	4354	16164	90
374	2.1	0	–	–	–	–	–	–	–	–	2830	15.6	5535	30.6	4289	16167	89
441	2.4	0	–	–	–	–	–	–	–	–	3178	17.5	7185	39.5	4345	16340	90
185	3.1	200	8.2	1.6	150	75	18	118	16	0.3	826	14.0	831	14.1	9431	7785	132
334	5.7	200	11.1	2.2	125	63	25	200	23	0.4	1554	26.3	1579	26.8	9133	7955	135
251	4.3	200	9.9	2.0	100	50	12	117	10	0.2	1294	22.3	1302	22.4	10293	8017	138
224	3.9	200	9.9	2.0	125	63	16	124	14	0.2	1009	17.4	1022	17.6	10084	9182	158
182	1.8	100	1.0	0.1	75	75	13	175	13	0.1	666	6.5	1041	10.1	1073	5562	54
326	3.2	100	1.0	0.1	100	100	17	170	17	0.2	351	3.4	351	3.4	1073	5474	54
206	2.0	100	1.0	0.1	100	100	19	188	19	0.2	511	4.9	511	4.9	1073	5878	56
257	2.6	200	1.0	0.2	0	0	0	0	0	0.0	701	6.9	701	6.9	1073	5436	54
182	1.8	200	1.0	0.2	150	75	18	118	18	0.2	664	6.5	664	6.5	1073	5562	54
220	2.1	200	1.0	0.2	25	12	2	75	2	0.0	677	6.5	677	6.5	1073	5625	54
110	1.2	100	1.0	0.1	25	25	4	150	4	0.0	556	5.9	568	6.0	1692	7319	77
178	1.8	100	1.0	0.1	100	100	15	150	15	0.2	740	7.3	880	8.6	1692	7919	78
201	2.0	100	1.0	0.1	0	0	0	0	0	0.0	649	6.2	649	6.2	1892	8990	86
269	2.6	200	1.0	0.2	125	62	38	305	38	0.4	957	9.4	957	9.4	1692	8675	85
206	2.0	200	1.0	0.2	25	12	2	100	2	0.0	804	7.8	804	7.8	1692	8809	86
381	4.0	200	1.0	0.2	75	38	8	100	8	0.1	1075	11.2	1075	11.2	1692	8045	84
405	3.9	100	38.0	3.8	75	75	15	200	11	0.1	1323	12.6	1348	12.8	1621	8623	82
251	2.4	100	38.0	3.8	75	75	22	300	18	0.2	1159	10.9	1234	11.6	1624	8710	82
223	2.1	100	38.0	3.8	25	25	8	321	4	0.0	1141	10.8	1191	11.2	1624	8710	82
101	1.1	200	38.0	7.6	125	62	36	290	28	0.3	1306	13.9	1306	13.9	1595	7600	81
265	2.7	200	38.0	7.6	25	12	3	108	0	0.0	1420	14.5	1420	14.5	1603	7977	81
218	2.0	200	38.0	7.6	75	37	22	300	14	0.1	1764	16.5	1764	16.5	1626	8710	81
183	2.0	100	38.0	3.8	0	0	0	–	0	0.0	1052	11.2	1177	12.5	2658	12672	135
298	3.1	100	38.0	3.8	0	0	0	–	0	0.0	1090	11.2	1090	11.2	2668	13098	135
263	2.5	100	38.0	3.8	50	50	15	300	11	0.1	1028	9.6	1128	10.5	2711	14702	137
308	3.2	200	38.0	7.6	125	62	38	230	30	0.3	1510	15.6	1510	15.6	2668	13098	135

Fish Stocking and Harvest Summaries

						Oreochromis niloticus												*Cyprinus carpio*						
Exp. no.	Pond no.	Animal type	Days	DO	Temp.	N_i	$\bar{W}_i$	W_i	N_h	%S	W_h	$\bar{W}_h$	Y	Y/d	R_s	R_h	ΣR	N_i	$\bar{W}_i$	W_i	N_h	%S	W_h	$\bar{W}_h$
9	24	Duck	98	2.3	25.6	17000	2.0	34	11450	67	948	83	914	9.3	–	0	0	2800	(54.0)	151.0	1675	60	310	185
9	14	Duck	105	1.6	25.5	17000	2.0	34	14500	85	1370	95	1336	12.8	–	50	50	2800	(54.0)	151.0	1675	60	438	262
10	15	Chicken	93	1.5	27.2	17000	2.8	47	12575	74	1178	99	1131	12.2	–	555	555	3000	0.7	2.0	2300	77	235	112
10	19	Chicken	90	0.9	27.8	17000	4.2	72	15325	90	1562	106	1490	16.6	–	834	834	3000	0.7	2.0	2425	81	685	315
10	22	Chicken	91	1.8	27.4	17000	2.2	37	11125	65	1425	136	1388	15.3	–	38	38	3000	0.7	2.0	2375	79	288	132
10	16	Chicken	92	1.3	27.2	17000	2.4	42	11400	67	1162	108	1120	12.2	–	45	45	3000	0.7	2.0	2575	86	384	162
10	21	Chicken	89	1.0	27.2	17000	2.5	43	11000	65	1420	137	1377	15.5	–	65	65	3000	0.7	2.0	2750	92	485	192
10	23	Chicken	91	1.8	27.4	17000	2.5	43	10000	59	1568	167	1525	16.8	–	30	30	3000	1.3	4.0	2550	85	460	200
10	13	Chicken	95	1.0	27.1	17000	3.8	64	13100	77	1335	106	1271	13.4	–	805	805	3000	0.6	2.0	1875	77	200	119
10	14	Chicken	95	0.8	27.5	17000	2.7	46	16375	96	1574	98	1528	16.1	–	890	890	3000	0.5	2.0	2650	96	320	131
10	20	Chicken	90	1.0	27.6	17000	2.5	43	16750	99	1818	113	1775	19.7	–	782	782	3000	0.8	2.0	2275	76	328	162
11	14	Chicken	100	3.0	23.5	17000	9.0	154	13875	82	1049	76	895	9.0	–	0	0	1500	5.0	8.0	875	58	176	202
11	21	Chicken	100	2.6	23.6	17000	9.9	168	10575	62	965	91	797	8.1	–	0	0	1500	5.0	7.0	1025	68	255	249
11	17	Chicken	101	4.5	23.3	17000	9.9	168	11750	89	810	89	642	6.4	–	0	0	1500	11.4	17.0	1175	78	235	200
11	19	Chicken	100	2.3	23.9	17000	9.4	160	13500	79	1200	89	1040	10.5	–	0	0	1500	11.2	17.0	1275	85	330	259
11	15	Chicken	101	2.5	23.2	17000	9.8	167	12575	74	915	73	748	7.4	–	80	80	1500	8.3	12.0	1300	87	250	192
11	22	Chicken	99	3.5	23.7	17000	10.0	170	8475	50	680	80	510	5.2	–	0	0	1500	6.7	10.0	1450	97	255	176
11	13	Chicken	100	2.9	23.4	17000	9.9	170	7350	43	618	84	448	4.5	–	0	0	1500	11.6	18.0	1229	82	251	205
11	20	Chicken	100	3.0	23.7	17000	10.0	170	13475	79	838	62	668	6.7	–	170	170	1500	10.0	15.0	1375	92	200	145
12	14	Chicken	93	1.0	27.8	17000	6.5	110	15275	90	1662	109	1552	16.7	–	0	0	1250	2.3	3.0	900	72	250	278
12	21	Chicken	93	0.8	27.6	17000	8.5	144	12350	73	1715	139	1571	16.9	–	0	0	1250	2.9	4.0	875	70	200	229
12	15	Chicken	93	0.8	27.6	17000	5.3	90	11350	67	1513	133	1423	15.3	–	0	0	1250	2.3	3.0	725	58	200	276
12	20	Chicken	93	0.7	27.4	17000	6.7	114	12475	73	1432	114	1318	14.2	–	0	0	1250	2.2	3.0	1225	98	225	184
14	4	Pig	155	–	25.1	28500	27	773	17030	60	2713	159	1940	12.5	695	1780	2475	1500	25.0	38.0	1290	86	425	329
14	9	Pig	162	–	24.3	28500	29	834	20430	72	3827	188	2993	18.5	224	452	676	1500	25.0	38.0	1450	97	286	197
14	5	Pig	164	–	25.4	28500	27	764	21100	74	3792	180	3028	18.5	–	408	408	1500	11.6	17.0	1110	73	278	253
																							Clarias batrachus	
14	10	Pig	162	–	25.3	28500	23	666	20680	72	3836	186	3170	19.6	–	19	19	1500	5.1	8.0	1200	80	256	313
																							Clarias batrachus	
18	18	Chicken	85	–	–	17000	8.7	148	15575	92	1375	88	1227	14.4	–	0	0	2500	6.1	15.3	775	31	66	85
18	22	Chicken	85	–	–	17000	10.0	170	15175	89	1100	73	930	10.9	–	0	0	2500	6.0	15.1	350	14	32	90
18	16	Chicken	85	–	–	17000	10.0	170	14925	88	1213	81	1043	12.3	–	0	0	2500	6.4	16.0	600	24	42	70
18	17	Chicken	85	–	–	17000	10.0	170	14125	83	1113	79	943	11.1	–	0	0	2500	5.7	14.3	425	17	34	80

						Channa striata					Market size fish		All fish		Animal		Daily manure
Y	Y/d	N_i	$\bar{W}_i$	W_i	N_h	%S	W_h	$\bar{W}_h$	Y	Y/d	Y	Y/d	Y	Y/d	biomass	Manure	load
159	1.6	200	38.0	7.6	75	37	18	100	10	0.1	1083	11.1	1083	11.1	2672	13277	135
287	2.7	200	38.0	7.6	100	50	10	210	2	0.0	1625	15.5	1675	16.0	2702	14366	137
232	2.5	375	2.0	1.0	125	33	13	169	12	0.1	1376	14.8	1931	20.8	–	1908	21
683	7.6	375	2.1	1.0	275	92	43	192	42	0.5	2215	24.6	3049	33.9	–	1847	21
286	3.1	375	1.9	1.0	125	33	15	203	14	0.2	1688	18.6	1726	19.0	–	1867	21
382	4.2	375	1.7	1.0	375	100	60	184	59	0.6	1561	17.0	1606	17.5	–	5638	61
483	5.4	375	1.8	1.0	200	53	22	108	21	0.2	1881	21.1	1946	21.9	–	5391	61
456	5.0	375	2.0	1.0	300	80	41	137	40	0.4	2021	22.2	2051	22.5	–	5594	61
198	2.1	300	1.9	1.0	200	67	24	159	23	0.2	1492	15.7	2297	24.2	–	9643	102
318	3.3	300	2.1	1.0	300	100	42	168	41	0.4	1887	19.9	2777	29.2	–	9615	101
326	3.6	375	1.7	1.0	250	67	52	207	51	0.6	2152	23.9	2934	32.6	–	9246	103
168	1.7	750	1.0	1.0	125	17	13	102	12	0.1	1075	10.8	1075	10.8	–	522	5
248	2.5	750	1.0	1.0	100	13	21	208	20	0.2	1065	10.8	1065	10.8	–	522	5
218	2.2	750	1.0	1.0	225	30	26	117	25	0.3	885	8.8	885	8.8	–	1044	10
313	3.2	750	3.7	3.0	350	47	40	114	37	0.4	1390	14.0	1390	14.0	–	1044	10
238	2.4	750	1.0	1.0	75	10	11	143	10	0.1	996	9.9	1076	10.7	–	1535	15
245	2.5	750	1.0	1.0	225	30	23	103	22	0.2	777	7.9	777	7.9	–	1535	16
233	2.3	750	1.0	1.0	100	13	12	125	11	0.1	692	6.9	692	6.9	–	2022	20
185	1.9	750	4.2	3.0	75	10	12	167	9	0.1	862	8.6	1032	10.3	–	2022	20
247	2.7	750	1.3	1.0	75	10	4	55	3	0.0	1802	19.4	1802	19.4	–	9012	97
196	2.1	750	1.5	1.0	100	13	12	115	11	0.1	1778	19.1	1778	19.1	–	9012	97
197	2.1	750	1.4	1.0	50	7	4	90	3	0.0	1623	17.5	1623	17.5	–	12256	132
122	2.4	750	1.5	1.0	50	7	5	99	4	0.0	1544	16.6	1544	16.6	–	12256	132
387	2.5	0	0.0	0.0	100	–	70	700	70	0.5	2397	15.5	4872	31.4	5447	12639	82
248	1.5	0	0.0	0.0	60	–	23	380	23	0.1	3264	20.2	3940	24.3	5859	13071	81
261	1.6	300	20.0	6.0	270	90	245	907	239	1.5	3554	21.7	3962	24.2	5591	13305	81
		1000	5.9	6.0	100	10	32	315	26	0.2							
248	1.5	300	24.0	7.0	190	63	66	347	59	0.4	3525	21.8	3544	21.9	5322	12989	80
		1000	5.9	6.0	170	17	54	320	48	0.3	1287	15.1	1287	15.1	–	12835	151
51	0.6	500	1.4	0.7	175	35	10	60	9	0.1	952	11.2	952	11.2	–	12835	151
17	0.2	500	1.4	0.7	125	25	6	51	5	0.1							
26	0.3	500	1.4	0.7	175	35	9	51	8	0.1	1077	12.7	1077	12.7	–	17170	202
20	0.2	500	1.4	0.7	325	65	19	58	12	0.1	975	11.4	975	11.4	–	17170	202

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
01	01	081578	090578	6.9	10.9	8180	0	53	IF	0	0	0
01	01	090578	092078	10.9	11.8	8180	0	91	IF	0	0	0
01	01	092078	100578	11.8	12.5	8180	0	124	IF	0	0	0
01	01	100578	102078	12.5	13.3	8180	16	157	IF	0	0	0
01	01	102078	110678	13.3	13.0	8180	51	191	IF	0	0	0
01	01	110678	112078	13.0	15.1	8180	84	226	IF	0	0	0
01	02	081578	090578	7.2	9.9	15420	0	24	PIG	40	771	11
01	02	090578	092078	9.9	11.8	15420	0	41	PIG	40	962	29
01	02	092078	100578	11.8	10.3	15420	0	56	PIG	40	1374	33
01	02	100578	102078	10.3	12.4	15420	4	71	PIG	40	1384	36
01	02	102078	110678	12.4	13.7	15420	6	86	PIG	40	1706	40
01	02	110678	112278	13.7	14.2	15420	13	101	PIG	40	2034	42
01	03	081678	090578	6.7	7.0	15230	0	21	PIG	40	780	11
01	03	090578	092078	7.0	9.4	15230	0	41	PIG	40	966	29
01	03	092078	100578	9.4	10.2	15230	0	59	PIG	40	1183	33
01	03	100578	102078	10.2	11.2	15230	0	79	PIG	40	1383	36
01	03	102078	110678	11.2	12.0	15230	0	95	PIG	40	1680	39
01	03	110678	112378	12.0	14.3	15230	0	115	PIG	40	2039	43
01	04	082178	090578	7.0	6.9	8160	0	22	PIG	60	1125	39
01	04	090578	092078	6.9	10.8	8160	0	54	PIG	60	1377	43
01	04	092078	100578	10.8	11.9	8160	0	88	PIG	60	1619	40
01	04	100578	102078	11.9	13.0	8160	61	121	PIG	60	1895	51
01	04	102078	110678	13.0	14.2	8160	191	156	PIG	60	2277	55
01	04	110678	112478	14.2	16.5	8160	333	194	PIG	60	2739	62
01	05	082178	090578	7.7	6.8	7160	0	15	IF	0	0	0
01	05	090578	092078	6.8	8.3	7160	0	31	IF	0	0	0
01	05	092078	100578	8.3	10.6	7160	0	48	IF	0	0	0
01	05	100578	102078	10.6	11.6	7160	15	65	IF	0	0	0
01	05	102078	110678	11.6	12.2	7160	47	83	IF	0	0	0
01	05	110678	112578	12.2	13.4	7160	82	104	IF	0	0	0
01	06	081178	090578	6.9	10.2	6190	0	21	PIG	40	775	26
01	06	090578	092078	10.2	10.9	6190	0	46	PIG	40	975	30
01	06	092078	100578	10.9	11.4	6190	0	66	PIG	40	1159	33
01	06	100578	102078	11.4	11.6	6190	16	85	PIG	40	1372	36
01	06	102078	110678	11.6	12.8	6190	50	105	PIG	40	1713	40
01	06	110678	112578	12.8	13.9	6190	89	130	PIG	40	2066	43
01	07	081778	090578	6.8	7.1	6680	0	27	PIG	60	1132	38
01	07	090578	092078	7.1	11.7	6680	0	62	PIG	60	1475	45
01	07	092078	100578	11.7	11.2	6680	0	94	PIG	60	1725	50
01	07	100578	102078	11.2	14.1	6680	7	126	PIG	60	1998	53
01	07	102078	110778	14.1	15.0	6680	21	161	PIG	60	2558	59
01	07	110778	112078	15.0	16.1	6680	35	193	PIG	60	3060	64
01	08	082378	090578	5.3	4.8	3830	0	12	IF	0	0	0
01	08	090578	092078	4.8		3830	0	20	IF	0	0	0
01	08	092078	100578			3830	0	28	IF	0	0	0
01	08	100578	102078			3830	0	36	IF	0	0	0
01	08	102078	110678			3830	0	44	IF	0	0	0
01	08	110678	120278		8.7	3830	0	55	IF	0	0	0
01	09	082278	090578	4.9	5.4	2820	0	16	PIG	40	928	29
01	09	090578	092078	5.4	7.3	2820	0	43	PIG	40	1076	31
01	09	092078	100578	7.3	9.5	2820	0	72	PIG	40	1242	34
01	09	100578	102078	9.5	11.3	2820	0	101	PIG	40	1448	37
01	09	102078	110778	11.3	12.7	2820	0	131	PIG	40	1800	40
01	09	110778	112978	12.7	14.4	2820	0	159	PIG	40	2294	44
01	10	082278	090578	4.9		7360	0	15	PIG	60	1179	33
01	10	090578	092078			7360	0	42	PIG	60	1527	36
01	10	092078	100678		7.7	7360	0	70	PIG	60	1611	39
01	10	100678	102078	7.7	8.5	7360	0	98	PIG	60	1917	42
01	10	102078	110778	8.5	10.0	7360	0	129	PIG	60	2568	47
01	10	110778	120878	10.0	12.4	7360	0	168	PIG	60	3294	50
01	11	082278	090578	6.9	9.2	13350	0	11	IF	0	0	0
01	11	090578	092078	9.2	9.0	13350	0	25	IF	0	0	0
01	11	092078	100578	9.0	9.6	13350	0	39	IF	0	0	0
01	11	100578	102078	9.6	11.8	13350	0	54	IF	0	0	0
01	11	102078	110778	11.8	12.2	13350	1	70	IF	0	0	0
01	11	110778	112578	12.2	12.6	13350	2	87	IF	0	0	0
01	12	082278	090578	5.8	8.2	17200	0	26	PIG	60	1353	42
01	12	090578	092078	8.2	9.3	17200	0	56	PIG	60	1470	45

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SECCHI DISK
26.8	209.0	346.0	14.6	66.8	6.30	0	0	0			38.5
28.1	238.0	374.0	12.2	37.0	3.80	0	0	0			31.0
28.5	242.0	330.0	13.8	61.8	5.90	0	0	0			
26.5	196.0	302.0	10.6	57.1	4.70	0	0	0			19.0
26.5	252.0	353.0	8.7	104.1	6.30	0	0	0			25.0
26.0	372.0		.3	65.5	4.80	0	0	0			16.5
27.3	209.0	346.0	14.6	66.8	4.90	0	0	0			32.3
27.9	238.0	374.0	12.2	37.0	5.10	0	0	0			36.6
28.2	242.0	330.0	13.8	61.8	4.60	0	0	0			
27.0	196.0	302.0	10.6	57.1	6.10	0	0	0			30.3
26.5	252.0	353.0	8.7	104.1	5.50	0	0	0			37.0
26.1	351.0		.3	68.3	4.80	0	0	0			20.3
26.8	209.0	346.0	14.6	66.8	5.30	0	0	0			31.9
27.9	238.0	374.0	12.2	37.0	5.40	0	0	0			34.0
28.7	242.0	330.0	13.8	61.8	5.50	0	0	0			
26.9	196.0	302.0	10.6	57.1	6.60	0	0	0			27.5
26.3	252.0	353.0	8.7	104.1	5.90	0	0	0			22.5
25.8	355.0		.7	70.3	5.30	0	0	0			20.9
27.1	209.0	346.0	14.6	66.8	5.40	0	0	0			37.2
27.9	238.0	374.0	12.2	37.0	5.20	0	0	0			33.5
28.5	242.0	330.0	13.8	61.8	4.60	0	0	0			
27.2	196.0	302.0	10.6	57.1	5.90	0	0	0			24.0
26.5	252.0	353.0	8.7	104.1	4.40	0	0	0			27.0
26.1	311.0		.7	71.7	5.50	0	0	0			23.0
27.4	209.0	346.0	14.6	66.8	6.10	0	0	0			34.5
28.1	238.0	374.0	12.2	37.0	4.80	0	0	0			29.1
28.3	242.0	330.0	13.8	61.8	5.00	0	0	0			
27.0	196.0	302.0	10.6	57.1	6.40	0	0	0			23.8
26.5	252.0	353.0	8.7	104.1	7.40	0	0	0			20.0
25.7	382.0		.6	68.2	3.20	0	0	0			22.5
27.1	209.0	346.0	14.6	66.8	4.80	0	0	0			34.1
28.1	238.0	374.0	12.7	37.0	5.20	0	0	0			26.8
28.5	242.0	330.0	13.8	61.8	5.00	0	0	0			
26.9	196.0	302.0	10.6	57.1	5.20	0	0	0			16.2
26.3	252.0	353.0	8.7	104.1	4.60	0	0	0			18.0
25.5	372.0		.6	68.2	4.60	0	0	0			16.5
27.3	209.0	346.0	14.6	66.8	5.60	0	0	0			47.1
27.6	238.0	374.0	12.2	37.8	4.80	30	0	0			26.8
28.2	242.0	330.0	13.8	61.8	5.20	0	0	0			
26.8	196.0	302.0	10.6	57.1	5.20	0	0	0			17.0
26.5	252.0	353.0	8.7	104.1	5.10	0	0	0			21.0
26.0	427.0		.3	65.5	5.30	0	0	0			23.8
26.7	209.0	346.0	14.6	66.8	5.80	0	0	0			18.4
27.9	238.0	374.0	12.2	37.0	6.00	0	0	0			22.8
28.0	242.0	330.0	13.8	61.8	5.70	0	0	0			
26.7	196.0	302.0	10.6	57.1	6.10	0	0	0			10.0
26.0	252.0	353.0	8.7	104.1	5.80	0	0	0			14.0
25.2	407.0		.5	78.9	5.50	0	0	0			25.7
27.2	209.0	346.0	14.6	66.8	5.50	0	0	0			19.6
27.6	238.0	374.0	12.2	37.0	5.10	0	0	0			37.5
28.0	242.0	330.0	13.8	61.8	4.90	0	0	0			
26.5	196.0	302.0	10.6	57.1	5.10	0	0	0			22.0
26.0	252.0	353.0	8.7	104.1	3.90	0	0	0			15.0
25.3	407.0		.5	80.9	3.80	0	0	0			13.3
27.2	209.0	346.0	14.6	66.8	4.80	0	0	0			16.8
28.1	238.0	374.0	12.2	37.0	5.60	0	0	0			33.0
28.0	242.0	330.0	13.8	61.8	4.90	0	0	0			
26.2	196.0	302.0	10.6	57.1	5.80	0	0	0			14.5
26.2	252.0	353.0	8.7	104.1	4.70	0	0	0			15.0
25.5	427.0		.5	82.1	3.70	0	0	0			25.0
26.8	209.0	346.0	14.6	66.8	5.70	0	0	0			24.6
27.9	238.0	374.0	12.2	37.0	5.80	0	0	0			36.0
28.3	242.0	330.0	13.8	61.8	5.20	0	0	0			
26.8	196.0	302.0	10.6	57.1	6.70	0	0	0			21.0
26.7	252.0	353.0	8.7	104.1	5.00	0	0	0			13.0
25.8	427.0		.5	68.2	5.40	0	0	0			10.3
27.3	209.0	346.0	14.6	66.8	4.90	0	0	0			28.2
27.9	238.0	374.0	12.2	37.0	6.20	0	0	0			35.0

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
01	12	092078	100578	9.3	10.2	17200	0	89	PIG	60	1719	49
01	12	100578	102078	10.2	11.8	17200	3	121	PIG	60	2250	56
01	12	102078	110778	11.8	13.7	17200	9	156	PIG	60	2937	62
01	12	110778	112778	13.7	14.4	17200	16	196	PIG	60	3402	68
02	01	121578	010679	5.8	8.7	8500	0	54	PIG	60	3525	68
02	01	010679	013079	8.7	13.3	8500	0	126	PIG	60	4146	62
02	01	013079	021479	13.3	14.5	8500	0	186	PIG	60	4827	65
02	01	021479	030179	14.5	17.2	8500	0	233	PIG	60	5382	65
02	02	121579	010679	5.1	8.6	15141	0	62	PIG	40	2428	40
02	02	010679	013079	8.6	10.4	15141	0	82	PIG	40	2936	42
02	02	013079	021479	10.4	12.3	15141	0	99	PIG	40	3546	43
02	02	021479	030179	12.3	15.5	15141	0	112	PIG	40	3954	42
02	03	121579	010679	5.2	7.9	14282	0	37	PIG	40	2440	40
02	03	010679	013079	7.9	9.8	14282	0	37	PIG	40	2898	42
02	03	013079	021479	9.8	12.5	14282	0	37	PIG	40	3360	43
02	03	021479	030179	12.5	14.4	14282	0	37	PIG	40	3740	43
02	04	121579	010679	5.5	8.7	8500	0	78	PIG	60	3525	59
02	04	010679	013079	8.7	12.9	8500	0	200	PIG	60	4191	62
02	04	013079	021479	12.9	16.2	8500	0	300	PIG	60	4809	64
02	04	021479	030179	16.2	19.5	8500	0	382	PIG	60	5313	65
02	05	121579	010679	5.9	9.5	6627	0	55	PIG	40	2612	41
02	05	010679	013079	9.5	12.4	6627	0	131	PIG	40	3088	43
02	05	013079	021479	12.4	15.4	6627	0	195	PIG	40	3274	43
02	05	021479	030179	15.4	16.9	6627	0	244	PIG	40	3460	43
02	06	121579	010679	5.8	10.2	6630	0	79	PIG	40	2956	40
02	06	010679	013079	10.2	13.5	6630	0	201	PIG	40	2956	43
02	06	013079	021479	13.5	17.0	6630	0	305	PIG	40	3466	43
02	06	021479	030179	17.0	17.9	6630	0	385	PIG	40	3836	43
02	07	121579	010679	5.9	11.2	8500	0	55	PIG	60	3483	68
02	07	010679	013079	11.2	15.2	8500	0	129	PIG	60	4167	63
02	07	013079	021479	15.2	16.2	8500	0	191	PIG	60	4953	65
02	07	021479	030179	16.2	18.5	8500	0	239	PIG	60	5514	64
02	08	121579	010679	5.9	8.9	14424	0	78	PIG	60	3597	67
02	08	010679	013079	8.9	10.6	14424	0	133	PIG	60	3654	68
02	08	013079	021479	10.6	13.9	14424	0	180	PIG	60	4002	61
02	08	021479	030179	13.9	14.7	14424	0	216	PIG	60	4314	63
02	09	121579	010679	5.9	11.4	7793	0	47	PIG	40	2596	41
02	09	010679	013079	11.4	13.9	7793	0	105	PIG	40	3116	43
02	09	013079	021479	13.9	15.1	7793	0	153	PIG	40	3654	43
02	09	021479	030179	15.1	18.9	7793	0	191	PIG	40	3988	42
02	10	121579	010679	5.9	10.1	12377	0	84	PIG	60	3687	60
02	10	010679	013079	10.1	13.3	12377	0	152	PIG	60	4299	63
02	10	013079	021479	13.3	14.8	12377	0	210	PIG	60	4986	65
02	10	021479	030179	14.8	18.8	12377	0	254	PIG	60	5394	65
02	11	121579	010679	6.2	9.3	16133	0	77	PIG	40	1616	39
02	11	010679	013079	9.3	11.4	16133	0	130	PIG	40	2018	43
02	11	013079	021479	11.4	12.6	16133	0	175	PIG	40	2476	40
02	11	021479	030179	12.6	13.9	16133	0	210	PIG	40	2756	42
02	12	121579	010679	6.6	9.6	17221	0	102	PIG	60	4170	63
02	12	010679	013079	9.6	10.8	17221	0	208	PIG	60	4869	65
02	12	013079	021479	10.8	14.1	17221	0	297	PIG	60	5703	64
02	12	021479	030179	14.1	16.3	17221	0	366	PIG	60	6150	62
03	01	062079	071079	5.7	8.7	14400	0	19	PIG	100	1200	18
03	01	071079	072479	8.7	11.6	14400	0	46	PIG	100	1355	21
03	01	072479	080779	11.6	13.1	14400	4	69	PIG	100	1575	24
03	01	080779	082179	13.1	14.4	14400	12	92	PIG	100	1920	64
03	01	082179	090479	14.4	14.9	14400	20	115	PIG	100	2455	74
03	01	090479	091879	14.9	16.3	14400	28	138	PIG	100	3060	84
03	01	091879	092479	16.3	16.9	14400	34	154	PIG	100	3590	91
03	02	062079	071079	6.4	11.4	9550	0	12	PIG	80	916	14
03	02	071079	072479	11.4	12.8	9550	0	31	PIG	80	1092	17
03	02	072479	080779	12.8	14.1	9550	48	46	PIG	80	1280	19
03	02	080779	082179	14.1	15.1	9550	161	62	PIG	80	1532	51

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SCCHI DISK
28.3	242.0	330.0	13.8	61.8	4.80	0	0	0			
26.9	196.0	302.0	10.6	57.1	5.00	0	0	0			15.7
26.5	252.0	353.0	8.7	104.1	4.30	0	0	0			22.0
26.0	427.0		.5	71.1	2.20	12	0	0			5.9
24.0	452.0		1.6	127.8	5.00	0	0	0			
23.3	562.0		1.0	151.2	4.40	0	0	0	.190		
25.3	563.0		.0	132.3	3.40	0	0	0	.280		
26.5	573.0		.0	113.5	2.60	0	0	0	.310		
24.3	452.0		1.6	127.8	5.60	0	0	0			
23.2	562.0		1.0	151.2	5.10	0	0	0	.181		
25.0	563.0		.0	132.3	4.95	0	0	0	.180		
26.8	573.0		.0	113.5	3.55	0	0	0	.226		
23.5	452.0		1.6	127.8	4.90	0	0	0			
23.5	562.0		1.0	151.2	4.90	0	0	0	.138		
25.0	563.0		.0	132.3	4.00	0	0	0	.295		
26.2	573.0		.0	113.5	2.50	0	0	0	.317		
23.3	452.0		1.6	127.8	2.71	40	20	0			
23.1	562.0		1.0	151.2	1.64	57	57	14	.173		
25.2	563.0		.0	132.3	.35	100	100	66	.220		
26.2	573.0		.0	113.5	.56	100	75	50	.256		
23.5	452.0		1.6	127.8	4.96	0	0	0			
23.2	562.0		1.0	151.2	4.02	0	0	0	.220		
24.8	563.0		.0	132.3	3.56	0	0	0			
26.5	573.0		.0	113.5	2.31	25	0	0	.231		
23.8	452.0		1.6	127.8	5.60	0	0	0			
23.1	562.0		1.0	151.2	4.93	0	0	0	.253		
24.5	563.0		.0	132.3	1.90	100	0	0	.255		
25.8	573.0		.0	113.5	1.78	50	0	0	.317		
23.7	452.0		1.6	127.8	4.20	0	0	0			
23.3	562.0		1.0	151.2	4.23	0	0	0	.235		
24.7	563.0		.0	132.3	2.67	0	0	0	.108		
26.4	573.0		.0	113.5	1.61	75	0	0	.301		
23.5	452.0		1.6	127.8	6.99	0	0	0			
23.1	562.0		1.0	151.2	5.11	0	0	0	.137		
25.0	563.0		.0	132.3	4.63	0	0	0	.160		
25.8	573.0		.0	113.5	3.45	0	0	0	.248		
24.0	452.0		1.6	127.8	4.20	0	0	0			
23.0	562.0		1.0	151.2	3.96	0	0	0	.127		
24.7	563.0		.0	132.3	3.56	0	0	0	.215		
26.1	573.0		.0	113.5	1.86	0	0	0	.340		
23.8	452.0		1.6	127.8	5.75	0	0	0			
23.1	562.0		1.0	151.2	4.65	0	0	0	.175		
25.2	563.0		.0	132.3	1.02	100	33	33	.435		
26.2	573.0		.0	113.5	.67	100	75	25	.236		
23.8	452.0		1.6	127.8	7.02	0	0	0			
23.0	562.0		1.0	151.2	5.44	0	0	0	.127		
24.5	563.0		.0	132.3	4.70	0	0	0	.265		
25.8	573.0		.0	113.5	2.48	0	0	0	.287		
24.2	452.0		1.6	127.8	4.83	0	0	0			
23.3	562.0		1.0	151.2	5.74	0	0	0	.138		
24.7	563.0		.0	132.3	3.10	0	0	0	.205		
26.2	573.0		.0	113.5	2.23	50	0	0	.312		
27.3	358.0	355.0	7.2	38.5	.87	86	71	29	.127		
29.4	546.0	235.0	1.8	59.2	.82	100	83	17	.024		40.6
27.5	169.0	313.0	12.0	70.5	1.43	83	17	0	.056	533	32.5
26.2	240.0	133.0	17.5	62.0	2.87	17	0	0	.129		27.3
28.8	558.0	158.0	8.0	63.5	1.22	100	20	0	.082		27.2
28.6	454.0	464.0	5.5	73.9	1.42	83	0	0	.073		26.2
27.1	282.0	383.0	11.4	104.3	1.30	100	0	0	.090		26.1
27.7	358.0	355.0	7.2	38.5	2.57	27	14	0	.150		
29.7	546.0	235.0	1.8	59.2	3.11	0	0	0	.020		28.0
27.5	169.0	313.0	12.0	70.5	3.75	0	0	0	.017	533	16.8
26.2	240.0	133.0	17.5	62.0	4.22	0	0	0	.120		24.5

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
03	02	082179	090479	15.1	15.5	9550	274	77	PIG	80	1916	59
03	02	090479	091879	15.5	16.4	9550	386	93	PIG	80	2444	67
03	02	091879	092479	16.4	18.0	9550	467	104	PIG	80	2948	74
03	03	062079	071079	5.5	9.5	7730	0	19	PIG	100	1215	19
03	03	071079	072479	9.5	11.5	7730	0	51	PIG	100	1390	21
03	03	072479	080779	11.5	13.1	7730	57	78	PIG	100	1605	25
03	03	080779	082179	13.1	14.4	7730	190	104	PIG	100	1905	64
03	03	082179	090479	14.4	15.2	7730	323	130	PIG	100	2375	73
03	03	090479	091879	15.2	16.3	7730	456	157	PIG	100	2970	83
03	03	091879	092479	16.3	18.6	7730	551	175	PIG	100	3505	90
03	04	062079	071079	5.7	10.0	7430	0	8	PIG	80	900	14
03	04	071079	072479	10.0	11.3	7430	0	21	PIG	80	1068	17
03	04	072479	080779	11.3	13.1	7430	65	32	PIG	80	1244	19
03	04	080779	082179	13.1	14.1	7430	217	43	PIG	80	1496	50
03	04	082179	090479	14.1	14.3	7430	366	53	PIG	80	1896	58
03	04	090479	091879	14.3	15.7	7430	520	64	PIG	80	2412	67
03	04	091879	092479	15.7	17.0	7430	626	72	PIG	80	2900	74
03	05	062079	071079	5.3	8.5	14220	0	24	PIG	100	1300	20
03	05	071079	072479	8.5	10.7	14220	0	62	PIG	100	1495	23
03	05	072479	080779	10.7	12.3	14220	67	94	PIG	100	1745	60
03	05	080779	082179	12.3	12.5	14220	224	125	PIG	100	2100	68
03	05	082179	090479	12.5	14.1	14220	380	157	PIG	100	2615	77
03	05	090479	091879	14.1	14.3	14220	537	189	PIG	100	3275	87
03	05	091879	092479	14.3	16.4	14220	648	211	PIG	100	3850	95
03	06	062379	071179	6.1	9.3	14780	0	17	PIG	80	916	14
03	06	071179	072579	9.3	11.5	14780	0	45	PIG	80	1036	16
03	06	072579	080879	11.5	11.8	14780	2	69	PIG	80	1196	18
03	06	080879	082179	11.8	13.0	14780	10	93	PIG	80	1432	49
03	06	082179	090579	13.0	14.5	14780	17	118	PIG	80	1824	57
03	06	090579	091879	14.5	15.2	14780	25	142	PIG	80	2332	66
03	06	091879	092479	15.2	15.5	14780	30	159	PIG	80	2784	72
03	07	062379	071179	5.6	10.3	7630	0	17	PIG	100	1210	19
03	07	071179	072579	10.3	12.3	7630	0	46	PIG	100	1430	22
03	07	072579	080879	12.3	14.1	7630	34	71	PIG	100	1705	26
03	07	080879	082179	14.1	14.8	7630	147	96	PIG	100	2035	66
03	07	082179	090479	14.8	16.0	7630	261	120	PIG	100	2535	76
03	07	090479	091879	16.0	16.1	7630	378	145	PIG	100	3170	86
03	07	091879	092779	16.1	16.9	7630	475	166	PIG	100	3880	95
03	08	062379	071179	5.7	9.0	14970	0	16	PIG	80	1048	16
03	08	071179	072579	9.0	10.7	14970	0	42	PIG	80	1232	19
03	08	072579	080779	10.7	12.2	14970	21	64	PIG	80	1427	50
03	08	080779	082179	12.2	13.6	14970	100	86	PIG	80	1732	55
03	08	082179	090479	13.6	14.8	14970	183	109	PIG	80	2156	63
03	08	090479	091879	14.8	15.4	14970	266	132	PIG	80	2732	71
03	08	091879	092979	15.4	17.6	14970	340	152	PIG	80	3364	79
03	09	062379	071179	5.8	9.1	16030	0	20	PIG	80	1040	16
03	09	071179	072579	9.1	11.3	16030	0	51	PIG	80	1212	19
03	09	072579	080779	11.3	12.3	16030	1	78	PIG	80	1416	49
03	09	080779	082179	12.3	13.5	16030	6	105	PIG	80	1736	55
03	09	082179	090479	13.5	14.5	16030	12	133	PIG	80	2192	63
03	09	090479	091879	14.5	16.1	16030	17	100	PIG	80	2717	71
03	09	091879	100479	16.1	21.9	16030	23	191	PIG	80	3496	80
03	10	062379	071179	6.2	9.7	8910	0	16	PIG	100	1185	18
03	10	071179	072479	9.7	12.5	8910	0	41	PIG	100	1350	21
03	10	072479	080779	12.5	13.9	8910	45	63	PIG	100	1570	24
03	10	080779	082179	13.9	15.0	8910	255	86	PIG	100	1895	63
03	10	082179	090479	15.0	15.8	8910	465	109	PIG	100	2370	73
03	10	090479	091879	15.8	16.1	8910	675	132	PIG	100	2990	83
03	10	091879	100579	16.1	17.0	8910	900	157	PIG	100	3965	96
03	11	062579	071179	5.2	9.7	7510	0	10	PIG	80	1200	18
03	11	071179	072579	9.7	12.4	7510	0	27	PIG	80	1359	21
03	11	072579	080879	12.4	13.2	7510	21	43	PIG	80	1579	52
03	11	080879	082179	13.2	13.9	7510	162	59	PIG	80	1900	58
03	11	082179	090579	13.9	15.3	7510	309	75	PIG	80	2400	67
03	11	090579	091879	15.3	16.5	7510	455	91	PIG	80	2960	74
03	11	091879	100579	16.5	17.9	7510	612	108	PIG	80	3188	77
03	12	062579	071179	5.2	9.3	13330	0	22	PIG	100	1325	20
03	12	071179	072579	9.3	12.2	13330	0	61	PIG	100	1510	23
03	12	072579	080879	12.2	13.5	13330	3	98	PIG	100	1740	60
03	12	080879	082179	13.5	13.7	13330	27	133	PIG	100	2090	67

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SCCHI DISK
28.9	558.0	158.0	8.4	63.5	3.42	0	0	0	.045		25.4
28.7	454.0	464.0	5.5	73.9	2.17	33	0	0	.099		19.4
27.5	282.0	383.0	11.5	104.3	1.60	100	0	0	.077		27.9
27.6	358.0	355.0	7.2	38.5	4.59	0	0	0	.180		
28.3	546.0	235.0	1.8	59.2	3.41	0	0	0	.016		34.8
27.3	169.0	313.0	12.0	70.5	3.98	0	0	0	.016		30.6
26.9	240.0	133.0	17.5	62.0	4.42	0	0	0	.144		28.2
28.8	558.0	158.0	8.0	63.5	3.05	0	0	0	.046		26.2
28.6	454.0	464.0	5.5	73.9	1.45	67	33	17	.064	435	20.1
26.9	282.0	383.0	11.4	104.3	2.30	33	0	0	.052		18.5
27.7	358.0	355.0	7.2	38.5	.84	100	86	27	.170		
29.3	546.0	235.0	1.8	59.2	.67	100	67	33	.220		27.3
27.2	169.0	313.0	12.0	70.5	2.94	17	0	0	.026		27.4
25.9	240.0	133.0	17.5	62.0	4.05	0	0	0	.100	165	27.6
28.9	558.0	158.0	8.0	63.5	1.84	60	0	0	.053		27.6
28.7	454.0	464.0	5.5	73.9	1.63	83	17	0	.082	287	29.1
27.3	282.0	383.0	11.4	104.3	1.30	100	0	0	.082		27.9
27.4	358.0	355.0	7.2	38.5	3.29	29	0	0	.138		
29.4	546.0	235.0	1.8	59.2	2.49	0	0	0	.010		45.1
27.2	169.0	313.0	12.0	70.5	2.79	0	0	0	.048		29.2
26.1	240.0	133.0	17.5	62.0	3.28	17	0	0	.128	236	27.0
28.9	558.0	158.0	8.0	63.5	.84	100	60	20	.150		24.2
28.9	454.0	464.0	5.5	73.9	1.03	100	33	0	.064		25.7
27.3	282.0	383.0	11.4	104.3	.90	100	33	33	.060		26.7
27.3	349.0	368.0	7.2	749.8	2.41	14	0	0	.108		
29.1	523.0	475.0	1.8	61.2	2.60	0	0	0	.020		22.8
26.7	131.0	278.0	12.0	69.9	3.70	0	0	0	.026		20.3
25.6	258.0	133.0	13.1	63.2	4.05	0	0	0	.135	164	29.3
28.4	558.0	158.0	7.5	63.1	2.46	0	0	0	.035		16.6
28.0	454.0	463.0	7.2	75.1	1.56	100	0	0	.051		13.4
26.9	282.0	383.0	11.4	104.3	1.90	67	0	0	.051		18.5
28.0	350.0	368.0	3.3	74.9	2.79	14	0	0	.148		
29.3	536.0	475.0	2.5	61.2	2.94	0	0	0	.200		53.4
27.2	131.0	278.0	9.3	69.9	3.68	0	0	0	.032		24.2
25.9	258.0	133.0	13.1	63.2	4.40	0	0	0	.125	185	25.3
28.8	558.0	158.0	8.0	63.5	2.44	20	0	0	.074		25.2
28.6	454.0	415.0	546.0	73.8	1.41	83	33	0	.076		30.6
27.1	353.0	383.0	10.6	104.6	1.20	100	0	0	.048		29.3
27.4	350.0	368.0	3.3	74.9	4.76	0	0	0	.122		
29.0	536.0	475.0	2.5	61.2	3.94	0	0	0	.016		17.8
26.8	131.0	291.0	12.0	71.7	4.07	0	0	0	.033		16.3
25.9	258.0	133.0	17.5	62.0	6.12	0	0	0	.112		23.1
28.4	558.0	158.0	8.0	63.2	2.89	0	0	0	.070	377	19.6
28.2	454.0	415.0	5.5	73.8	1.78	83	0	0	.071		17.1
26.8	368.0	383.0	10.0	95.9	1.40	67	33	0	.071		18.3
27.4	350.0	368.0	3.3	74.9	1.86	29	0	0	.118		
29.5	536.0	475.0	2.5	61.2	3.10	0	0	0	.022		31.1
26.7	131.0	291.0	12.0	71.7	3.30	0	0	0	.036		18.1
25.7	258.0	133.0	17.5	62.0	4.03	0	0	0	.125		23.2
28.6	558.0	158.0	8.0	63.2	1.82	80	0	0	.052	356	19.8
28.2	454.0	415.0	5.5	73.8	.98	100	33	0	.064	1059	18.7
26.8	317.0	383.0	19.6	85.3	1.60	100	0	0	.064		18.4
27.6	350.0	368.0	3.3	74.9	3.38	0	0	0	.115		
29.1	536.0	514.0	1.9	61.2	4.02	17	0	0	.018		17.4
26.7	131.0	313.0	11.9	60.2	1.25	100	50	0	.052		15.4
25.9	258.0	133.0	13.1	62.2	3.50	0	0	0	.105		22.7
28.8	558.0	158.0	8.0	63.2	1.90	60	0	0	.056	279	21.8
28.3	454.0	415.0	5.5	73.8	1.95	67	0	0	.066		17.4
26.8	303.0	383.0	21.5	86.5	.80	100	67	0	.053		16.4
27.8	350.0	368.0	8.7	70.4	2.95	14	0	0	.165		
29.2	536.0	240.0	2.5	61.2	2.37	17	0	0	.019		10.9
26.5	131.0	277.0	9.3	69.9	3.43	0	0	0	.026		16.8
25.9	258.0	133.0	13.1	63.2	4.27	0	0	0	.124		21.2
28.8	551.0	158.0	7.5	63.1	1.80	40	0	0	.059	221	21.4
28.2	453.0	415.0	5.9	75.1	.77	100	67	33	.068		21.3
26.9	310.0	383.0	20.6	83.8	.63	100	100	0	.068		27.9
27.8	350.0	368.0	8.7	70.4	2.74	14	0	0	.175		
29.5	536.0	240.0	2.5	61.2	2.84	33	0	0	.018		48.2
26.8	131.0	277.0	9.3	69.9	2.90	0	0	0	.022		25.4
25.9	258.0	133.0	13.1	63.2	3.92	0	0	0	.118		25.6

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
03	12	082179	090579	13.7	15.3	13330	51	169	PIG	100	2605	77
03	12	090579	091979	15.3	16.8	13330	76	207	PIG	100	3200	86
03	12	091979	100679	16.8	17.3	13330	103	248	PIG	100	4175	98
04	01	100379	102279	4.8	10.4	15850	0	116	PIG	100	5085	107
04	01	102279	110579	10.4	12.2	15850	0	270	PIG	100	6200	100
04	01	110579	111979	12.2	15.5	15850	1	400	PIG	100	7130	105
04	01	111979	120379	15.5	16.7	15850	4	539	PIG	100	8040	107
04	01	120379	121779	16.7	18.2	15850	7	660	PIG	100	8925	108
04	01	121779	122879	18.2	18.5	15850	10	776	PIG	100	9605	105
04	01	122879	010580	18.5	18.9	15850	12	865	PIG	100	10095	105
04	02	100579	102279	6.1	10.5	7130	0	57	PIG	80	4268	87
04	02	102279	110579	10.5	13.4	7130	0	134	PIC	80	5208	81
04	02	110579	111979	13.4	16.3	7130	0	204	PIG	80	6024	85
04	02	111979	120379	16.3	17.2	7130	0	275	PIG	80	6824	86
04	02	120379	121779	17.2	18.5	7130	0	345	PIG	80	7600	85
04	02	121779	122879	18.5	19.6	7130	0	407	PIG	80	8244	108
04	02	122879	010880	19.6	19.8	7130	0	462	PIG	80	8784	108
04	03	100479	102979	6.0	12.0	7550	0	68	PIG	100	5230	109
04	03	102979	111279	12.0	15.0	7550	0	148	PIG	100	6425	101
04	03	111279	112679	15.0	16.5	7550	0	209	PIG	100	7260	105
04	03	112679	121079	16.5	17.6	7550	0	270	PIG	100	8145	108
04	03	121079	122179	17.6	18.6	7550	0	324	PIC	100	8945	107
04	03	122179	010980	18.6	19.2	7550	0	384	PIG	100	9710	106
04	04	101179	102979	2.7	9.1	8350	0	17	PIG	80	4472	89
04	04	102979	111279	9.1	13.7	8350	0	44	PIG	80	5472	83
04	04	111279	112679	13.7	15.4	8350	0	67	PIC	80	6192	86
04	04	112679	121079	15.4	16.4	8350	0	90	PIG	80	6996	86
04	04	121079	122179	16.4	17.1	8350	0	110	PIG	80	7652	85
04	04	122179	011080	17.1	18.5	8350	0	136	PIG	80	8232	82
04	05	101179	102979	4.8	9.5	16620	0	24	PIG	100	5880	113
04	05	102979	111279	9.5	13.5	16620	0	56	PIG	100	6900	104
04	05	111279	112679	13.5	14.9	16620	0	83	PIG	100	7800	107
04	05	112679	121079	14.9	16.8	16620	2	111	PIG	100	8775	108
04	05	121079	122179	16.8	17.2	16620	4	136	PIG	100	9575	106
04	05	122179	011180	17.2	17.4	16620	6	167	PIG	100	10300	104
04	06	100379	102279	5.0	9.3	14500	0	74	PIC	80	3984	85
04	06	102279	110579	9.3	12.1	14500	0	179	PIG	80	4832	79
04	06	110579	111979	12.1	13.5	14500	1	267	PIG	80	5576	83
04	06	111979	120379	13.5	15.6	14500	3	362	PIG	80	6376	86
04	06	120379	121779	15.6	15.9	14500	5	445	PIG	80	7208	86
04	06	121779	122879	15.9	17.9	14500	7	524	PIG	80	7832	84
04	06	122879	010780	17.9	18.1	14500	9	590	PIC	80	8228	83
04	07	100479	102279	4.4	10.5	7920	0	51	PIG	100	5010	106
04	07	102279	110579	10.5	13.9	7920	0	116	PIG	100	6290	101
04	07	110579	111979	13.9	16.1	7920	0	174	PIG	100	7250	105
04	07	111979	120379	16.1	17.2	7920	0	231	PIG	100	8230	108
04	07	120379	121779	17.2	19.0	7920	0	288	PIC	100	9120	107
04	07	121779	122879	19.0	19.4	7920	0	339	PIG	100	9815	105
04	07	122879	010880	19.4	19.6	7920	0	384	PIG	100	10385	103
04	08	100479	102979	5.8	12.9	15160	0	38	PIG	80	4008	85
04	08	102979	111279	12.9	13.2	15160	0	91	PIG	80	5548	83
04	08	111279	112679	13.2	14.8	15160	0	131	PIG	80	6272	86
04	08	112679	121079	14.8	16.1	15160	0	167	PIG	80	6948	86
04	08	121079	122179	16.1	16.6	15160	0	199	PIG	80	7492	85
04	08	122179	010980	16.6	19.2	15160	0	234	PIG	80	8136	83
04	09	101179	102979	2.7	8.6	14470	0	27	PIG	80	5236	82
04	09	102979	111279	8.6	13.2	14470	0	64	PIG	80	5716	84
04	09	111279	112679	13.2	14.7	14470	1	97	PIG	80	6492	86
04	09	112679	121079	14.7	15.6	14470	4	129	PIG	80	7228	86
04	09	121079	122179	15.6	16.5	14470	6	158	PIG	80	7832	84
04	09	122179	011280	16.5	17.0	14470	10	196	PIG	80	8508	81
04	10	101179	102979	5.0	10.1	8000	0	17	PIG	100	5825	113
04	10	102979	111279	10.1	13.8	8000	0	42	PIG	100	6710	103
04	10	111279	112679	13.8	15.7	8000	0	64	PIG	100	7610	106
04	10	112679	121079	15.7	17.5	8000	0	86	PIG	100	8545	108
04	10	121079	122179	17.5	18.0	8000	0	106	PIG	100	9370	107
04	10	122179	011179	18.0	19.2	8000	0	131	PIG	100	10260	103

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH_3-NH_4	PRIMARY PROD	SCCHI DISK
28.7	558.0	158.0	7.5	79.6	2.31	0	0	0	.036	506	23.6
28.4	434.0	453.0	6.5	82.2	1.30	100	33	0	.072		20.8
27.0	305.0	383.0	10.1		1.10	100	33	0	.055		27.9
27.5	351.0	405.0	5.1	92.3	.38	100	100	67	.071		22.9
26.9	429.0	373.8	1.1	101.9	.44	100	100	71	.133	550	23.7
26.6	431.0	339.1	4.0	117.4	.39	100	10	71	.147		19.2
25.2	578.0	375.1	1.8	140.2	.46	100	100	71	.103		15.8
22.7		387.9	.0	156.6	.73	100	67	33	.168	823	11.7
22.9		341.7	.5	143.0	.73	100	75	0	.074		13.7
24.3			.0	133.6	.60	100	100	0	.028		15.8
27.8	351.0	405.0	2.4	96.7	.72	100	100	0	.185		34.1
26.5	429.0	373.8	1.1	92.3	1.02	100	57	14	.087	387	32.1
26.9	431.0	339.1	4.0	101.9	1.25	100	43	14	.136		30.0
25.5	578.0	375.1	1.8	117.4	1.25	14	43	0	.085		20.1
23.1		387.9	.0	140.2	2.77	17	0	0	.135	761	16.2
23.3		341.7	.5	156.6	2.18	25	0	0	.050		17.0
24.8			.0	143.0	1.85	50	0	0	.023		15.6
27.1	446.0	415.7	2.8	275.1	.27	0	0	100	.075		27.9
26.7	306.0	311.6	1.4	96.4	.49	100	100	71	.082	440	26.0
26.3	547.0	410.1	3.7	99.4	.29	100	100	100	.095		20.6
24.3	582.0	381.5	2.1	117.6	.38	100	100	83	.088		18.9
22.5		358.2	.0	155.8	.38	100	100	100	.111	586	12.4
23.6		321.9	.3	190.2	.97	100	100	33	.023		11.5
27.5	532.0	452.8	2.1	133.8	.42	100	100	83	.089		26.3
27.1	306.0	311.6	2.8	96.4	.20	100	100	100	.108	564	21.5
26.4	545.0	410.1	1.4	99.4	.24	100	100	100	.100		20.4
24.4	582.0	381.5	3.7	117.6	.29	100	100	100	.086		16.0
22.5		358.2	.0	155.8	.33	100	100	100	.110	730	15.2
23.6		321.9	.4	146.2	.31	100	100	100	.030		15.9
27.3	532.0	452.8	2.1	133.8	.28	100	100	100	.072		19.7
26.6	306.0	311.6	2.8	96.4	.56	100	100	9	.277	489	20.0
26.7	545.0	410.1	1.4	99.4	.27	100	100	100	.458		26.3
24.5	582.0	381.5	3.7	117.6	.40	100	100	67	.089		22.8
22.6		358.2	.0	155.8	1.25	100	80	0	.110		19.0
23.6		321.9	.4	134.0	.64	100	100	17	.027	480	25.6
27.2	351.0	405.0	5.1	92.3	.53	100	100	67	.034		16.8
25.5	429.0	373.8	1.1	101.9	1.00	100	57	29	.237	513	26.1
26.4	431.0	339.1	4.0	117.4	.41	100	100	71	.217		22.5
24.8	578.0	375.1	1.8	140.2	.82	100	100	67	.074		18.8
22.0		387.9	.0	156.6	1.85	100	100	17	.103	453	14.3
22.6		341.7	.5	143.0	2.70	25	0	0	.046		14.0
23.9			.0	147.4	1.10	100	50	0	.000		13.7
27.5	351.0	405.0	3.7	95.2	.33	100	100	83	.328		28.8
26.7	429.0	373.8	1.1	92.3	.41	100	100	71	.278	577	26.5
26.6	431.0	339.1	4.0	101.9	.34	100	100	86	.283		27.5
25.2	578.0	375.1	1.8	117.4	.61	100	100	50	.228		24.2
22.9		387.9	.0	140.2	.58	100	67	33	.117	477	17.8
23.1		341.7	.5	156.6	.65	100	75	25	.038		14.4
24.1			.0	143.0	.35	100	100	50	.020		12.2
27.3	351.0	415.7	2.8	275.1	.63	100	83	33	.287		28.2
25.8	429.0	311.6	1.4	96.4	1.20	100	67	17	.173	505	27.3
26.1	431.0	410.5	3.7	99.4	.73	100	71	43	.123		25.1
24.1	578.0	381.5	2.1	117.6	.85	100	67	33	.071		17.9
22.2		358.2	.0	155.8	.81	100	60	0	.110		14.7
23.3		321.9	.3	190.2	1.01	100	33	0	.027	361	16.6
27.1	53.2	452.8	2.1	133.8	.05	100	83	67	.323		27.5
26.1	306.0	311.6	2.8	96.4	.23	100	100	86	.121		31.1
26.1	545.0	410.1	1.4	99.4	.42	100	100	57	.113	756	24.2
23.9	582.0	381.5	3.7	117.6	.32	100	100	83	.077		16.5
21.9		358.2	.0	155.8	.31	100	100	100	.084		11.8
23.2		321.9	.4	210.0	.25	100	100	100	.015	658	11.4
26.9	532.0	450.8	2.1	133.8	.29	100	100	100	.150		29.0
26.4	306.0	311.6	2.8	96.4	.66	100	100	57	.151		31.1
26.1	545.0	410.1	1.4	117.6	.36	100	100	86	.171	765	26.9
23.9	582.0	381.5	3.7	155.8	.42	100	100	67	.063		16.4
22.1		358.2	.0	210.0	.43	100	100	60	.080		13.5
22.9		321.9	.4	144.5	.50	100	100	33	.020	644	14.6

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
05	06	040980	042380	15.2	16.3	7490	0	152	PIG	100	2450	74
05	06	042380	050780	16.3	17.3	7490	0	185	PIG	100	2715	79
05	06	050780	052180	17.3	18.2	7490	0	219	PIG	100	3066	84
05	06	052180	060380	18.2	18.7	7490	0	252	PIG	100	3645	92
05	06	060380	061780	18.7	19.1	7490	0	284	PIG	100	4285	100
05	06	061780	070280	19.1	20.2	7490	181	319	PIG	100	4850	105
05	06	070280	071780	20.2	22.5	7490	554	355	PIG	100	5720	113
05	06	071780	073080	22.5	22.6	7490	864	389	PIG	100	6660	103
05	07	022480	031280	6.0	9.8	7740	0	19	PIG	100	1720	26
05	07	031280	032680	9.8	12.2	7740	0	50	PIG	100	2025	66
05	07	032680	040980	12.2	14.2	7740	0	79	PIG	100	2335	72
05	07	040980	042380	14.2	16.5	7740	0	107	PIG	100	2755	79
05	07	042380	050880	16.5	18.0	7740	233	137	PIG	100	3030	83
05	07	050880	052180	18.0	19.4	7740	574	166	PIG	100	3390	89
05	07	052180	060480	19.4	19.5	7740	917	193	PIG	100	3995	96
05	07	060480	061880	19.5	20.3	7740	1329	222	PIG	100	4630	103
05	07	070280	071280	20.3	20.4	7740	1660	250	PIG	100	5200	108
05	07	071780	071780	20.4	21.4	7740	2071	280	PIG	100	6105	99
05	07	071780	073080	21.4	21.9	7740	2420	309	PIG	100	7110	105
05	08	022480	031180	5.7	11.2	7620	0	19	PIG	100	1890	63
05	08	031180	032580	11.2	12.0	7620	0	49	PIG	100	2065	67
05	08	032580	040980	12.0	13.5	7620	0	78	PIG	100	2370	93
05	08	040980	042380	13.5	15.2	7620	0	107	PIG	100	2840	81
05	08	042380	050880	15.2	16.6	7620	0	137	PIG	100	3080	84
05	08	050880	052180	16.6	17.4	7620	0	166	PIG	100	3325	89
05	08	052180	060480	17.4	18.2	7620	0	194	PIG	100	3920	95
05	08	060480	061880	18.2	19.2	7620	95	223	PIG	100	4665	104
05	08	061880	070280	19.2	19.5	7620	316	252	PIG	100	5490	110
05	08	070280	071780	19.5	20.0	7620	579	282	PIG	100	6140	99
05	08	071780	073080	20.0	20.7	7620	704	311	PIG	100	6890	104
05	09	022480	031180	5.9	10.3	7630	0	37	PIG	100	1680	26
05	09	031180	032580	10.3	12.8	7630	0	77	PIG	100	1820	62
05	09	032580	040880	12.8	14.7	7630	0	116	PIG	100	2195	69
05	09	040880	042280	14.7	16.9	7630	0	155	PIG	100	2565	76
05	09	042280	050880	16.9	18.1	7630	0	194	PIG	100	2790	80
05	09	050880	052080	18.1	19.7	7630	0	230	PIG	100	3130	85
05	09	052080	060380	19.7	21.4	7630	0	266	PIG	100	3750	93
05	09	060380	061880	21.4	22.7	7630	226	306	PIG	100	4415	101
05	09	061880	070280	22.7	23.3	7630	694	346	PIG	100	5100	107
05	09	070280	071780	23.3	24.0	7630	1223	387	PIG	100	5970	113
05	09	071780	073080	24.0	24.1	7630	1541	425	PIG	100	6710	103
05	10	022480	031180	4.7	9.1	13910	0	38	PIG	100	1740	27
05	10	031180	032580	9.1	11.7	13910	0	75	PIG	100	1905	63
05	10	032580	040880	11.7	14.5	13910	31	111	PIG	100	2240	70
05	10	040880	042280	14.5	16.7	13910	217	147	PIG	100	2615	81
05	10	042280	050880	16.7	17.1	13910	438	186	PIG	100	2875	81
05	10	050880	052080	17.1	18.4	13910	636	221	PIG	100	3290	86
05	10	052080	060480	18.4	19.3	13910	831	256	PIG	100	3790	94
05	10	060480	061880	19.3	20.3	13910	1078	293	PIG	100	4535	102
05	10	061880	070180	20.3	20.5	13910	1285	328	PIG	100	5620	111
05	10	070180	071680	20.5	21.1	13910	1557	364	PIG	100	6370	101
05	10	071680	072980	21.1	21.2	13910	1741	400	PIG	100	6830	104
05	11	022480	031280	5.4	10.1	13250	0	56	PIG	100	1940	64
05	11	031280	032680	10.1	12.2	13250	0	99	PIG	100	2185	69
05	11	032680	040980	12.2	14.5	13250	0	140	PIG	100	2530	75
05	11	040980	042380	14.5	15.1	13250	0	180	PIG	100	2900	82
05	11	042380	050780	15.1	15.9	13250	0	220	PIG	100	3120	85
05	11	050780	052180	15.9	17.0	13250	0	261	PIG	100	3455	90
05	11	052180	060480	17.0	18.5	13250	134	301	PIG	100	3975	96
05	11	060480	061880	18.5	18.6	13250	480	341	PIG	100	4645	103
05	11	061880	070280	18.6	19.5	13250	760	382	PIG	100	5460	110
05	11	070280	071780	19.5	19.9	13250	1117	423	PIG	100	6300	101
05	11	071780	073080	19.9	20.5	13250	1357	464	PIG	100	6975	104
05	12	022480	031280	5.7	10.9	7470	0	36	PIG	100	2055	67
05	12	031280	032680	10.9	13.6	7470	0	84	PIG	100	2330	72
05	12	032680	040980	13.6	15.8	7470	0	129	PIG	100	2635	77
05	12	040980	042380	15.8	16.7	7470	129	173	PIG	100	2990	63
05	12	042380	050880	16.7	17.5	7470	408	220	PIG	100	3245	87
05	12	050880	052180	17.5	19.3	7470	706	265	PIG	100	3675	92
05	12	052180	060480	19.3	20.0	7470	963	308	PIG	100	4205	99
05	12	060480	061880	20.0	20.2	7470	1215	353	PIG	100	4800	105

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SECCHI DISK
27.0		428.0	.7	133.5	1.70	83	0	0	.024	294	9.4
27.6		729.0	.0	133.5	1.60	100	0	0	.070	499	11.6
27.7			551.0	148.5	2.10	17	17	0	.044	466	14.4
27.8			13.1	108.5	2.31	33	0	0	.096		13.8
27.3	555.0		.1	138.5	1.52	83	0	0	.094		16.4
28.1	326.0	336.0	10.5	116.6	.60	100	100	33	.047	614	20.4
27.8		364.0	21.3	71.0	.82	100	67	17	.184		21.8
27.6		382.0	13.8	115.2	1.90	60	20	0	.120	597	20.2
25.7		491.0	.1	122.5	2.60	17	17	17	.060		
24.4		444.0	1.2	153.0	1.70	67	17	0	.493		26.4
24.8		330.0	.0	195.8	3.02	0	0	0	.081		22.0
27.5		428.0	.7	133.5	1.30	100	17	0	.064		21.3
28.1		729.0	.2	129.7	2.11	50	0	0	.060		20.1
28.2			5.7	143.0	2.11	33	0	0	.070	517	20.8
28.4	437.0		13.1	114.3	2.01	50	0	0	.140		23.9
28.2	560.0		.1	134.6	1.30	100	17	0	.090		21.3
28.5	338.0	336.0	11.8	126.0	.92	100	33	17	.045		18.2
28.2		364.0	21.3	71.0	.10	83	67	33	1.070		24.1
27.6		395.0	13.8	115.2	2.21	60	0	0	.403		21.0
25.9		494.0	.1	115.5	2.04	67	17	0	.059		
24.3		448.0	.5	167.7	1.30	83	33	0	.052		17.9
24.5		335.0	.7	205.8	1.10	50	0	0	.080		12.8
27.0		428.0	.7	133.5	1.20	100	17	0	.065		13.4
27.9		729.0	.2	129.7	1.00	100	50	33	.060		15.5
28.1			5.7	143.0	.80	100	67	17	.043		17.7
28.2	437.0		13.1	114.3	1.70	83	0	0	.203		19.5
27.8	560.0		.1	134.6	1.40	83	33	0	.082		18.0
28.2	338.0	336.0	11.8	126.0	.90	100	50	17	.044		15.3
27.9		364.0	21.3	71.0	.90	100	50	50	.180	539	17.2
27.3		395.0	13.8	115.2	1.42	80	60	0	.168		22.2
26.8		494.0	.1	115.5	1.90	67	33	0	.282		
24.3		448.0	.5	167.7	1.50	83	0	0	.170		18.9
24.5		344.0	.7	212.0	2.30	33	0	0	.072		15.3
27.3		401.0	.7	133.0	1.20	83	33	33	.444		14.6
27.8		716.0	.2	129.0	1.00	100	67	0	.063		18.7
27.8			5.3	147.0	1.70	67	0	0	.050	955	14.6
28.0			13.8	107.7	2.00	67	0	0	.210		16.0
27.8	552.0		.1	138.0	1.30	67	33	17	.080	589	13.2
27.8	338.0	335.0	11.8	126.0	.30	100	100	83	.061	673	12.7
27.9		364.0	21.3	71.4	.40	100	100	67	.270		14.8
27.6		382.0	13.8	115.2	.40	100	100	80	.840		23.0
25.5		495.0	.1	115.5	2.10	50	17	0	.061		
29.2		448.0	.5	167.7	1.70	83	0	0	.123		22.0
24.5		344.0	.7	212.0	2.70	17	0	0	.100		17.7
27.1		401.0	.7	133.0	1.10	83	67	0	.050		15.0
27.9		717.0	.2	129.0	1.30	100	33	0	.130	748	15.3
27.8			5.3	147.0	1.40	83	33	0	.050		14.6
28.3	437.0		11.9	113.0	1.60	83	33	0	.190		17.3
27.9	560.0		.1	126.0	1.10	100	50	17	.070	529	19.2
28.1	338.0	257.0	11.2	126.9	1.00	100	50	0	.043		20.8
28.0		400.0	21.1	71.9	1.70	50	33	17	.162	298	27.1
27.7		356.0	13.1	116.9	1.90	40	0	0	.200	316	19.1
25.3		493.0	1.4	119.6	2.00	50	17	0	.063		
24.1		444.0	1.2	177.5	1.30	83	33	17	.340	657	18.1
24.4		299.0	.0	195.7	1.20	83	33	17	.060		14.4
27.0		428.0	.7	133.5	1.00	83	50	33	.050		12.7
27.6		795.0	.0	132.4	1.60	67	17	0	.050		13.7
28.0			5.5	139.7	1.20	100	33	0	.050	864	13.8
28.1	437.0		13.1	114.0	1.90	50	17	0	.212		15.0
27.4	560.0		.1	134.6	1.00	100	33	0	.080		14.0
28.1	338.0	335.0	11.8	126.0	.80	100	83	17	.040		16.6
28.1		364.0	21.3	71.0	.70	100	67	50	.140		19.6
27.5		395.0	13.8	115.2	.70	100	60	60	.213	368	15.1
25.6		492.0	.1	125.6	2.00	50	17	0	.060		
25.3		444.0	1.2	177.5	.80	100	67	0	.120		18.1
24.5		299.0	.0	195.7	1.40	83	17	0	.083	681	15.6
27.0		428.0	.7	133.5	1.00	83	50	17	.060	403	15.5
28.0		795.0	.2	129.7	1.70	83	0	0	.059	494	17.0
28.1			5.7	143.0	1.90	50	0	0	.050		14.5
28.2	437.0		13.1	114.0	2.20	33	0	0	.180		14.3
27.7	560.0		.1	134.6	1.40	100	0	0	.070		12.4

Fish Growth and Water Quality Summary

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
05	12	061880	070280	20.2	20.3	7470	1468	393	PIG	100	5665	112
05	12	070280	071780	20.3	21.0	7470	1807	444	PIG	100	6505	102
05	12	071780	073080	21.0	21.6	7470	2018	489	PIG	100	7125	105
06	13	020180	021580	8.7	10.5	14150	0	459	PIG	120	8995	128
06	13	021580	022980	10.5	12.9	14150	0	539	PIG	120	10164	146
06	13	022980	031480	12.9	14.1	14150	4	622	PIG	120	11403	129
06	14	020180	021580	9.7	11.3	13575	0	447	PIG	140	8208	114
06	14	021580	022980	11.3	12.5	13575	0	523	PIG	140	9288	143
06	14	022980	031480	12.5	13.9	13575	2	602	PIG	140	10494	128
06	19	020180	021580	12.6	13.8	14075	0	540	PIG	140	8680	148
06	19	021580	022980	13.8	14.7	14075	0	631	PIG	140	9982	173
06	19	022980	031480	14.7	16.9	14075	6	725	PIG	140	11256	155
06	20	020180	021580	9.4	11.7	14400	0	519	PIG	120	7812	126
06	20	021580	022980	11.7	12.7	14400	0	585	PIG	120	9036	136
06	20	022980	031480	12.7	14.9	14400	0	653	PIG	120	10236	136
07	17	090980	100980	11.7	14.8	170000	0			0	0	0
07	18	090980	100980	11.9	14.2	17000	0			0	0	0
07	24	090980	100980	11.7	14.4	17000	0			0	0	0
08	24	090278	091578	5.0	5.2	13175	0	19	DUCK	1500	1040	52
08	24	091578	092978	5.2	6.1	13175	0	46	DUCK	1500	1305	66
08	24	092978	101378	6.1	8.4	13175	0	75	DUCK	1500	1540	77
08	24	101378	110278	8.4	10.7	13175	0	110	DUCK	1417	1835	92
08	24	110278	111478	10.7	12.2	13175	0	142	DUCK	1250	1889	95
08	24	111478	121378	12.2	14.0	13175	0	183	DUCK	1250	2097	106
08	13	090278	091578	5.0	6.5	6275	0	15	DUCK	1000	693	35
08	13	091578	092978	6.5	9.1	6275	0	38	DUCK	1000	870	44
08	13	092978	101378	9.1	8.9	6275	0	64	DUCK	1000	1040	52
08	13	101378	110278	8.9	11.9	6275	94	95	DUCK	917	1193	60
08	13	110278	111478	11.9	13.4	6275	182	123	DUCK	750	1133	57
08	13	111478	121378	13.4	15.3	6275	295	159	DUCK	750	1258	63
08	14	090278	091578	5.0	5.7	11275	0	30	DUCK	1500	1040	52
08	14	091578	092978	5.7	8.5	11275	0	83	DUCK	1500	1305	66
08	14	092978	101378	8.5	9.4	11275	0	141	DUCK	1500	1540	77
08	14	101378	110278	9.4	12.3	11275	0	210	DUCK	1417	1835	92
08	14	110278	111478	12.3	12.8	11275	0	274	DUCK	1250	1889	95
08	14	111478	120678	12.8	15.7	11275	0	341	DUCK	1250	2086	105
08	15	090278	091578	5.1	4.9	150	0	25	DUCK	1000	693	34
08	15	091578	092978	4.9	6.3	150	0	68	DUCK	1000	870	43
08	15	092978	101378	6.3	9.0	150	0	114	DUCK	1000	1040	52
08	15	101378	110278	9.0	12.2	150	0	170	DUCK	917	1193	60
08	15	110278	111478	12.2	14.2	150	0	221	DUCK	750	1133	57
08	15	111478	121278	14.2	17.5	150	0	285	DUCK	750	1257	63
08	16	090278	091578	5.0	5.4	5050	0	16	DUCK	1000	693	35
08	16	091578	092978	5.4	7.7	5050	0	42	DUCK	1000	870	49
08	16	092978	101378	7.7	8.9	5050	0	71	DUCK	1000	1040	52
08	16	101378	110278	8.9	12.1	5050	0	105	DUCK	917	1193	60
08	16	110278	111478	12.1	12.3	5050	0	136	DUCK	750	1133	67
08	16	111478	121578	12.3	15.7	5050	0	179	DUCK	750	1259	63
08	17	090278	091578	5.0	5.1	6350	0	16	DUCK	1500	1040	52
08	17	091578	092978	5.1	7.7	6350	0	42	DUCK	1500	1305	66
08	17	092978	101378	7.7	10.2	6350	0	70	DUCK	1500	1540	77
08	17	101378	110278	10.2	11.8	6350	0	104	DUCK	1417	1835	92
08	17	110278	111478	11.8	13.7	6350	0	134	DUCK	1250	1889	95
08	17	111478	121578	13.7	15.5	6350	0	175	DUCK	1250	2099	105
08	19	090278	091578	5.0	7.1	7675	0	12	DUCK	1500	1040	52
08	19	091578	092978	7.1	8.5	7675	0	27	DUCK	1500	1305	66
08	19	092978	101378	8.5	12.2	7675	0	44	DUCK	1500	1540	77
08	19	101378	110278	12.2	12.5	7675	3	64	DUCK	1417	1835	92
08	19	110278	111478	12.5	12.9	7675	7	83	DUCK	1250	1889	95
08	19	111478	120578	12.9	14.2	7675	10	102	DUCK	1250	2083	104
08	20	090278	091578	5.0	6.9	8075	0	22	DUCK	1000	693	35

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SCCHI DISK
28.1	338.0	335.0	11.8	126.0	1.06	100	33	0	.040		13.7
27.9		364.0	21.3	71.0	.80	100	67	33	.130	327	20.3
27.3		395.0	13.8	1152.0	1.70	60	0	0	.333	430	16.5
23.7	393.9		.0	175.0	1.40	72	29	0	.140		
25.4	429.9		.0	162.2	.56	100	80	60	.110	807	
25.1	464.7		.0	126.5	.35	100	100	75	.136		
23.8	393.9		.0	175.0	.81	100	71	14	.119		
25.4	429.9		.0	162.2	.74	100	60	20	.096	729	
25.1	464.7		.0	126.5	.48	100	100	75	.110		
24.9	393.9		.0	175.0	.60	100	72	29	.196		
25.4	429.9		.0	162.2	.62	100	100	0	.024		
26.0	464.7		.0	126.5	.48	100	100	75	.061	850	
24.8	393.9		.0	175.0	.69	100	86	14	.077		
25.4	429.9		.0	162.2	.46	100	100	60	.078	939	
26.0	464.7		.0	126.5	.30	100	100	0			
27.0	354.7		8.1	64.2							
27.0	354.7		8.1	64.2							
27.0	354.7		8.1	64.2							
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
26.1	220.7	325.6	12.2	51.2	5.50	0	0	0			19.3
27.2	517.6	336.1	10.5	91.0	4.10	0	0	0			19.0
25.8	376.5		.4	94.2	3.30	33	0	0			21.8
25.0	475.5		.4	118.1	2.40	29	14	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
26.2	220.7	325.6	12.2	51.2	5.50	0	0	0			15.0
26.9	517.6	336.1	10.5	91.0	3.30	0	0	0			15.8
25.3	376.5		.4	94.2	3.40	0	0	0			19.3
24.7	475.5		.4	118.1	3.00	14	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
26.8	220.7	325.6	12.2	51.2	4.20	0	0	0			10.5
26.5	517.6	336.1	10.5	910.0	2.20	50	0	0			12.0
25.4	376.5		.4	94.2	1.80	67	0	0			15.0
24.8	430.0		.5	148.4	2.70	29	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
27.2	220.7	325.6	12.2	51.2	5.70	0	0	0			9.2
26.8	517.6	336.1	10.5	91.0	3.40	13	0	0			11.0
25.1	376.5		.4	94.2	3.60	0	0	0			15.2
24.8	462.3		.4	117.5	2.60	14	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
26.2	220.7	325.6	12.2	51.2	5.90	0	0	0			14.0
26.8	517.6	336.1	10.5	91.0	3.20	25	0	0			14.0
25.0	376.5		.4	94.2	2.80	33	0	0			10.0
24.8	451.5		.4	116.7	2.60	36	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
27.1	220.7	325.6	12.2	51.2	6.90	0	0	0			19.0
26.8	517.6	336.1	10.5	91.0	4.30	0	0	0			19.4
25.8	376.5		.4	94.2	3.20	33	0	0			19.1
24.8	451.5		.3	116.7	3.30	14	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
27.5	220.7	325.6	12.2	51.2	4.00	0	0	0			23.5
27.2	517.6	336.1	10.5	91.0	3.60	0	0	0			14.0
26.0	376.5		.4	94.2	3.50	33	0	0			21.5
25.0	464.2		.6	117.3	2.80	14	0	0			
26.5	244.2	387.3	11.9	36.7							

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
08	20	091578	092978	6.9	8.7	8975	0	56	DUCK	1000	870	44
08	20	092978	101378	8.7	10.2	8975	0	93	DUCK	1000	1040	52
08	20	101378	110278	10.2	11.9	8975	0	137	DUCK	917	1193	60
08	20	110278	111478	11.9	12.2	8975	0	178	DUCK	750	1133	57
08	20	111478	121178	12.2	14.8	8975	0	228	DUCK	750	1257	63
08	21	090278	091578	5.0	6.0	7650	0	13	DUCK	1500	1040	52
08	21	091578	092978	6.0	7.7	7650	0	37	DUCK	1500	1305	66
08	21	092978	101378	7.7	11.5	7650	0	62	DUCK	1500	1540	77
08	21	101378	110278	11.5	12.1	7650	32	93	DUCK	1417	1835	92
08	21	110278	111478	12.1	12.9	7650	62	121	DUCK	1250	1889	95
08	21	111478	121278	12.9	15.2	7650	99	156	DUCK	1250	2096	105
08	22	090278	091578	5.0	5.9	6675	0	23	DUCK	1500	1040	52
08	22	091578	092978	5.9	6.6	6675	0	59	DUCK	1500	1305	66
08	22	092978	101378	6.6	8.8	6675	0	97	DUCK	1500	1540	77
08	22	101378	110278	8.8	11.5	6675	0	143	DUCK	1417	1835	92
08	22	110278	111478	11.5	11.7	6675	0	185	DUCK	1250	1889	95
08	22	111478	121278	11.7	14.7	6675	0	238	DUCK	1250	2096	105
08	23	090278	091578	5.0	5.6	11275	0	17	DUCK	1000	693	35
08	23	091578	092978	5.6	7.3	11275	0	41	DUCK	1000	870	44
08	23	092978	101378	7.3	9.2	11275	0	67	DUCK	1000	1040	52
08	23	101378	110278	9.2	11.3	11275	0	98	DUCK	917	1193	60
08	23	110278	111478	11.3	12.5	11275	0	126	DUCK	750	1133	57
08	23	111478	121378	12.5	12.8	11275	0	162	DUCK	750	1259	63
08	18	090278	091578	5.0	5.4	10275	0	16	DUCK	1000	693	35
08	18	091578	092978	5.4	6.6	10275	0	42	DUCK	1000	870	44
08	18	092978	101378	6.6	9.6	10275	0	71	DUCK	1000	1040	52
08	18	101378	110278	9.6	10.3	10275	0	105	DUCK	917	1193	60
08	18	110278	111478	10.3	11.2	10275	0	136	DUCK	750	1133	57
08	18	111478	121478	11.2	14.0	10275	0	178	DUCK	750	1260	63
09	14	012279	020279	7.7	8.6	14500	0	215	DUCK	1250	2475	125
09	14	020279	021679	8.6	11.5	14500	1	252	DUCK	1250	2681	135
09	14	021679	030579	11.5	13.4	14500	13	295	DUCK	1250	2738	138
09	14	030579	041879	13.4	14.1	14500	34	378	DUCK	1250	2881	145
09	15	012279	020279	7.7	8.8	8550	0	132	DUCK	750	1485	75
09	15	020279	021679	8.8	10.0	8550	2	164	DUCK	750	1609	81
09	15	021679	030579	10.0	14.3	8550	18	200	DUCK	750	1643	83
09	15	030579	041979	14.3	17.5	8550	51	274	DUCK	750	1733	87
09	16	012279	020279	7.3	8.7	7650	0	125	DUCK	750	1485	75
09	16	020279	021679	8.7	12.9	7650	1	154	DUCK	750	1609	81
09	16	021679	030579	12.9	13.7	7650	12	186	DUCK	750	1643	83
09	16	030579	041979	13.7	19.4	7650	34	252	DUCK	750	1733	87
09	17	012279	020279	7.8	8.9	6575	0	134	DUCK	1250	2475	125
09	17	020279	021679	8.9	12.0	6575	3	167	DUCK	1250	2681	135
09	17	021679	030579	12.0	13.6	6575	24	205	DUCK	1250	2738	138
09	17	030579	042079	13.6	18.9	6575	68	282	DUCK	1250	2894	146
09	18	012279	020279	7.3	8.2	13850	0	200	DUCK	750	1485	75
09	18	020279	021679	8.2	10.4	13850	0	227	DUCK	750	1609	81
09	18	021679	030579	10.4	13.5	13850	0	258	DUCK	750	1643	83
09	18	030579	042079	13.5	17.0	13850	0	322	DUCK	750	1736	87
09	19	012279	020279	7.8	9.1	8275	0	122	DUCK	1250	2475	125
09	19	020279	021679	9.1	11.7	8275	4	148	DUCK	1250	2681	135
09	19	021679	030579	11.7	14.7	8275	37	178	DUCK	1250	2738	138
09	19	030579	040779	14.7	17.8	8275	90	227	DUCK	1250	2819	142
09	20	012279	020279	6.9	8.8	14525	0	176	DUCK	750	1485	75
09	20	020279	021679	8.8	10.8	14525	0	191	DUCK	750	1609	81
09	20	021679	030579	10.8	12.2	14525	0	207	DUCK	750	1643	83
09	20	030579	040779	12.2	15.0	14525	0	234	DUCK	750	1691	85
09	21	012279	020279	7.3	9.0	7800	0	148	DUCK	1250	2475	125
09	21	020279	021679	9.0	11.7	7800	0	190	DUCK	1250	2681	135
09	21	021679	030579	11.7	13.9	7800	0	237	DUCK	1250	2738	138
09	21	030579	041079	13.9	17.3	7800	0	314	DUCK	1250	2831	142
09	22	012279	020279	7.1	8.0	14475	0	226	DUCK	1250	2475	125
09	22	020279	021679	8.0	11.9	14475	0	268	DUCK	1250	2681	135
09	22	021679	030579	11.9	13.1	14475	0	318	DUCK	1250	2738	138

Fish Growth and Water Quality Summary

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SCCHI DISK
27.5	245.4	324.5	14.5	58.1							
26.9	220.7	325.6	12.2	51.2	4.10	0	0	0			16.0
27.1	517.6	336.1	10.5	91.0	2.40	63	0	0			17.0
26.0	376.5		.4	94.2	2.60	33	0	0			20.1
25.0	458.0		.4	115.1	2.70	21	14	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
26.3	220.7	325.6	12.2	51.2	3.90	0	0	0			23.5
27.3	517.6	336.1	10.5	91.0	2.30	50	0	0			24.7
26.1	376.5		.4	94.2	2.60	33	0	0			13.5
24.9	462.3		4.3	117.5	3.20	21	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
26.5	220.7	325.6	12.2	51.2	5.80	0	0	0			24.8
27.3	517.6	336.1	10.5	91.0	2.30	38	0	0			25.0
25.8	376.5		.4	94.2	3.60	22	0	0			24.5
24.9	462.3		4.3	117.5	4.10	0	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
27.6	220.7	325.6	12.2	51.2	5.90	0	0	0			23.3
27.3	517.6	336.1	10.5	91.0	4.70	0	0	0			25.0
25.8	376.5		.4	94.2	3.20	33	0	0			21.3
25.0	458.6		4.2	117.3	3.10	14	0	0			
26.5	244.2	387.3	11.9	36.7							
27.5	245.4	324.5	14.5	58.1							
26.2	220.7	325.6	12.2	51.2	4.50	0	0	0			12.3
27.0	517.6	336.1	10.5	91.0	3.00	0	0	0			14.0
25.8	376.5		.4	94.2	2.80	33	0	0			20.0
24.9	459.7		.4	117.3	2.50	29	14	0			
23.8	599.9		.3	141.2	3.00	14	0	0	.140		15.0
24.3	578.4		.0	139.5	2.10	67	0	0	.240		
26.3	544.3		.0	132.3	2.40	11	0	0	.370		
26.0	659.5		.0	111.7	.80	100	87	13			
23.9	599.9		.3	141.2	2.90	14	0	0	.180		21.4
24.4	578.4		.0	139.5	1.00	100	56	11	.240		
26.3	544.3		.0	132.3	1.20	100	0	0	.110		
26.1	372.7		.0	111.7	.80	80	47	0			
24.0	599.9		.3	141.2	2.60	29	0	0	.160		25.3
24.5	578.4		.0	139.5	1.80	67	0	0	.310		
26.3	544.3		.0	132.3	1.70	56	0	0	.210		
26.1	372.7		.0	111.7	1.00	100	60	13			
23.9	599.9		.3	141.2	3.80	0	0	0	.130		23.6
24.6	578.4		.0	139.5	1.60	67	22	0	.370		
26.3	544.3		.0	132.3	1.70	67	0	0	.240		
26.2	673.0		.0	111.6	1.40	80	40	0			
24.0	599.9		.3	141.2	1.90	57	14	9	.140		24.7
24.4	578.4		.0	139.5	1.50	67	67	11	.260		
26.3	544.3		.0	132.3	1.40	78	22	0	.700		
26.1	673.0		.0	111.6	1.30	80	27	0			
24.0	599.9		.3	141.2	3.00	0	0	0	.220		19.8
25.3	578.4		.0	139.5	2.50	0	0	0	.300		
26.3	544.3		.0	132.3	2.40	11	0	0	.280		
26.4	561.4		.0	104.2	.70	100	80	27			
24.0	599.9		.3	141.2	2.60	0	0	0	.220		16.5
25.0	578.4		.0	139.5	2.10	33	0	0	.250		
26.3	544.3		.0	132.3	2.30	44	0	0	.280		
26.5	561.4		.0	104.2	1.00	80	40	0			
24.0	599.9		.3	141.2	2.70	24	0	0	.170		19.2
25.0	578.4		.0	139.5	1.50	67	0	0	.290		
26.0	544.3		.0	132.3	.60	100	100	22	.350		
26.1	553.0		.0	105.4	.70	100	80	53			
23.5	599.9		.3	141.2	2.30	29	0	0	.200		21.8
25.0	578.4		.0	139.5	1.20	100	33	0	.180		
26.5	544.3		.0	132.3	1.00	100	44	0	.580		

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
09	22	030579	041079	13.1	15.7	14475	0	402	DUCK	1250	2831	142
09	23	012279	020279	6.7	8.5	13350	0	215	DUCK	750	1485	75
09	23	020279	021679	8.5	11.7	13350	0	251	DUCK	750	1609	81
09	23	021679	030579	11.7	12.1	13350	0	293	DUCK	750	1643	83
09	23	030579	041179	12.1	17.1	13350	0	366	DUCK	750	1703	86
09	24	012279	020279	7.2	9.6	11450	0	189	DUCK	1250	2475	125
09	24	020279	021679	9.6	11.8	11450	0	211	DUCK	1250	2681	135
09	24	021679	030579	11.8	13.2	11450	0	236	DUCK	1250	2738	138
09	24	030579	041179	13.2	16.9	11450	0	280	DUCK	1250	2838	143
09	13	012279	020279	7.5	9.2	6875	0	167	DUCK	750	1485	75
09	13	020279	021679	9.2	11.0	6875	1	219	DUCK	750	1609	81
09	13	021679	030579	11.0	14.7	6875	6	279	DUCK	750	1643	83
09	13	030579	041879	14.7	18.6	6875	17	396	DUCK	750	1729	87
10	13	032480	041580	5.5	10.5	5040	0	25	CHIC	5000		100
10	13	041580	042980	10.5	12.6	5040	0	62	CHIC	5000		109
10	13	042980	051380	12.6	15.4	5040	107	92	CHIC	5000		94
10	13	051380	052780	15.4	15.8	5040	295	121	CHIC	5000		89
10	13	052780	061080	15.8	17.1	5040	483	150	CHIC	5000		115
10	13	061080	062780	17.1	17.4	5040	691	182	CHIC	5000		101
10	14	032480	041580	5.9	9.9	6350	0	39	CHIC	5000		100
10	14	041580	042980	9.9	11.6	6350	0	99	CHIC	5000		109
10	14	042980	051380	11.6	13.4	6350	119	146	CHIC	5000		94
10	14	051380	052780	13.4	14.4	6350	326	193	CHIC	5000		89
10	14	052780	061080	14.4	16.6	6350	534	240	CHIC	5000		115
10	14	061080	062780	16.6	16.8	6350	764	292	CHIC	5000		101
10	15	032680	041580	6.3	8.1	4780	0	27	CHIC	1000		21
10	15	041580	042980	8.1	12.1	4780	0	70	CHIC	1000		22
10	15	042980	051380	12.1	12.9	4780	56	105	CHIC	1000		19
10	15	051380	052780	12.9	14.5	4780	185	140	CHIC	1000		18
10	15	052780	061080	14.5	16.4	4780	314	175	CHIC	1000		23
10	15	061080	062780	16.4	17.3	4780	458	214	CHIC	1000		20
10	16	032680	041580	4.7	8.2	4310	0	44	CHIC	3000		63
10	16	041580	042980	8.2	11.4	4310	0	114	CHIC	3000		65
10	16	042980	051380	11.4	13.8	4310	5	172	CHIC	3000		56
10	16	051380	052780	13.8	14.4	4310	16	230	CHIC	3000		53
10	16	052780	061080	14.4	16.5	4310	27	269	CHIC	3000		69
10	16	061080	062680	16.5	17.5	4310	39	351	CHIC	3000		61
10	19	032780	041580	5.3	12.4	5880	0	74	CHIC	1000		21
10	19	041580	042980	12.4	13.4	5880	0	199	CHIC	1000		22
10	19	042980	051380	13.4	15.8	5880	76	306	CHIC	1000		19
10	19	051380	052780	15.8	16.8	5880	288	412	CHIC	1000		18
10	19	052780	061080	16.8	17.5	5880	500	518	CHIC	1000		23
10	19	061080	062580	17.5	17.7	5880	720	628	CHIC	1000		20
10	20	032780	041580	5.2	10.8	6450	0	36	CHIC	5000		107
10	20	041580	042980	10.8	14.1	6450	0	96	CHIC	5000		109
10	20	042980	051380	14.1	14.6	6450	71	147	CHIC	5000		94
10	20	051380	052780	14.6	15.6	6450	270	198	CHIC	5000		89
10	20	052780	061080	15.6	16.2	6450	469	248	CHIC	5000		115
10	20	061080	062580	16.2	17.1	6450	675	301	CHIC	5000		101
10	21	032880	041580	3.6	9.5	4150	0	54	CHIC	3000		55
10	21	041580	042980	9.5	12.2	4150	0	143	CHIC	3000		65
10	21	042980	051380	12.2	14.4	4150	5	219	CHIC	3000		56
10	21	051380	052780	14.4	16.3	4150	22	290	CHIC	3000		53
10	21	052780	061080	16.3	18.0	4150	39	366	CHIC	3000		69
10	21	061080	062580	18.0	18.9	4150	56	444	CHIC	3000		61
10	22	032780	041580	4.4	8.8	4200	0	32	CHIC	1000		21
10	22	041580	042980	8.8	12.3	4200	0	84	CHIC	1000		22
10	22	042980	051380	12.3	14.0	4200	3	128	CHIC	1000		19
10	22	051380	052780	14.0	16.1	4200	12	172	CHIC	1000		18
10	22	052780	061080	16.1	17.6	4200	22	216	CHIC	1000		23
10	22	061080	062680	17.6	17.8	4200	32	263	CHIC	1000		20
10	23	032780	041580	4.7	10.6	3750	0	52	CHIC	3000		64
10	23	041580	042980	10.6	16.4	3750	0	134	CHIC	3000		65
10	23	042980	051380	16.4	16.9	3750	3	206	CHIC	3000		56
10	23	051380	052780	16.9	17.4	3750	10	275	CHIC	3000		53
10	23	052780	061080	17.4	20.4	3750	18	345	CHIC	3000		69
10	23	061080	062680	20.4	20.7	3750	26	420	CHIC	3000		61

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SECCHI DISK
26.3	553.0		.0	105.4	1.40	100	13	0			
24.0	599.9		.3	141.2	4.20	0	0	0	.150		20.8
24.8	578.4		.0	139.5	2.80	0	0	0	.370		
26.3	544.3		.0	132.3	2.40	11	0	0	.580		
26.4	655.6		.0	106.8	2.00	73	0	0			
23.8	599.9		.3	141.2	3.20	0	0	0	.165		20.2
24.8	578.4		.0	139.5	1.70	56	0	0	.300		
26.0	544.3		.0	132.3	2.40	33	0	0	.620		
26.3	655.6		.0	106.8	2.10	60	0	0			
23.8	599.9		.3	141.2	2.40	5	0	0	.170		20.3
24.6	578.4		.0	139.5	2.40	33	0	0	.360		
26.3	544.3		.0	132.3	1.30	100	22	0	.550		
26.3	659.5		.0	111.7	.80	100	67	20			
25.2		307.3	.3	183.1	1.60	60	50	50	.078	482	30.0
27.5		581.0	.0	132.0	.50	100	100	67	.059		21.3
27.6		632.6	.0	164.1	.30	100	100	100	.074	669	14.0
27.5			5.6	123.5	1.30	83	50	33	.058		24.9
28.0			2.2	124.2	.90	100	67	17	.110		21.5
27.9			4.0	145.0	.60	100	83	17	.137		15.5
26.7		307.3	.3	183.1	1.50	60	50	30	.074		35.0
27.5		581.0	.0	132.0	.50	100	100	50	.052		21.7
27.5		632.6	.0	164.1	.40	100	100	83	.064		12.3
27.5			5.6	123.5	.50	100	100	67	1.220		22.1
28.1			2.2	124.2	.70	100	83	17	.128	999	21.7
27.8			4.0	145.0	.72	100	83	0	.172		15.4
25.2		317.7	.0	195.7	3.00	10	0	0	.078	539	27.9
27.5		581.0	.0	132.0	2.00	50	50	33	.036		20.9
27.3		632.6	.0	164.1	.30	100	100	100	.080		12.9
27.4			5.6	123.5	1.40	67	50	33	.097		21.0
28.2			2.2	124.2	1.10	83	67	33	.076	422	26.0
28.0			4.0	145.0	.94	83	67	0	.066		16.7
25.0		317.7	.0	195.7	1.20	60	60	40	.077		44.0
27.6		581.0	.0	132.0	.50	100	100	33	.032	469	40.3
27.7		632.6	.0	164.1	.80	100	67	17	.063		28.2
27.4			5.6	123.5	1.70	67	17	0	.128		20.9
28.0			2.2	124.2	1.82	67	33	0	.078		24.8
28.0			4.0	145.0	1.48	100	0	0	.066		18.3
25.8		316.2	.0	177.7	1.10	80	60	40	.071	521	28.4
28.3		581.0	.0	132.0	.30	100	100	83	.037	1107	26.8
28.3		632.6	.0	164.1	.30	100	100	100	.059		20.2
27.7			5.6	123.5	1.20	83	33	0	.134	678	23.0
28.6			2.2	124.3	1.70	67	17	0	.086		26.0
28.6			4.0	145.0	.65	100	83	33	.078		19.8
25.6		316.2	.0	177.7	1.10	80	70	40	.086		24.5
28.1		581.0	.0	132.0	.40	100	83	83	.035	945	27.3
28.1		632.6	.0	164.1	.20	100	100	100	.058		20.6
27.6			5.6	123.5	1.90	67	33	17	.073		20.8
28.5			2.2	124.2	1.31	83	50	17	.108	384	23.5
28.4			4.0	145.0	.79	100	83	17	.078		18.4
25.5		314.4	.0	176.1	1.50	80	40	30	.081		26.4
27.6		581.0	.0	132.0	.40	100	100	67	.021		17.5
27.3		632.6	.0	164.1	.70	83	83	50	.054		15.1
27.3			5.6	123.5	1.40	83	67	50	1.214	475	26.0
28.2			2.2	124.2	.73	100	83	33	.202		16.4
28.0			4.0	145.0	.70	100	83	17	.303		15.0
25.6		316.2	.0	177.7	4.80	10	0	0	.065		53.2
28.2		581.0	.0	132.0	2.60	33	0	0	.022		33.8
77.8		632.6	.0	164.1	2.20	50	50	0	.053		13.9
27.4			5.6	123.5	1.83	67	17	0	.162		19.0
28.0			2.2	124.2	1.28	83	50	33	.080		24.1
28.1			4.0	145.0	1.01	83	67	33	.071		21.5
25.4		316.2	.0	177.7	4.40	20	0	0	.135	66	55.6
28.0		581.0	.0	132.0	.50	100	83	50	.020		33.5
28.2		632.6	.0	164.1	.30	100	100	100	.050		21.6
27.4			5.6	123.5	.80	100	83	17	.133		20.7
27.8			2.2	124.2	.76	100	68	33	.076	424	28.4
27.9			4.0	145.0	.62	100	83	33	.070		19.6

EXPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
11	13	111080	120180		11.8	7350	0	42	CHIC	1000		20
11	13	120180	121580	11.8	12.8	7350	0	83	CHIC	1000		22
11	13	121580	122980	12.8	13.7	7350	0	116	CHIC	1000		19
11	13	122980	011281	13.7	14.7	7350	0	148	CHIC	1000		17
11	13	011281	012981	14.7	15.4	7350	0	185	CHIC	1000		23
11	13	012980	021880	15.4		7350	0	228	CHIC	1000		19
11	14	111080	120180		11.6	13875	0	26	CHIC	250		5
11	14	120180	121580	11.6	12.2	13875	0	55	CHIC	250		6
11	14	121580	122980	12.2	13.7	13875	0	79	CHIC	250		5
11	14	122980	011281	13.7	14.3	13875	0	102	CHIC	250		4
11	14	011281	012981	14.3	14.5	13875	0	128	CHIC	250		6
11	14	012981	021881	14.5		13875	0	159	CHIC	250		5
11	15	111080	120180		11.7	12575	0	37	CHIC	750		15
11	15	120180	121580	11.7	12.7	12575	0	78	CHIC	750		17
11	15	121580	122980	12.7	13.5	12575	8	111	CHIC	750		14
11	15	122980	011281	13.5	14.4	12575	25	144	CHIC	750		13
11	15	011281	012981	14.4	14.7	12575	44	180	CHIC	750		17
11	15	012981	021881	14.7		12575	68	225	CHIC	750		15
11	17	111080	120180		11.1	11750	0	40	CHIC	500		10
11	17	120180	121580	11.1	12.5	11750	0	77	CHIC	500		11
11	17	121580	122980	12.5	12.8	11750	0	108	CHIC	500		10
11	17	122980	011281	12.8	14.0	11750	0	138	CHIC	500		9
11	17	011281	012981	14.0	15.2	11750	0	171	CHIC	500		12
11	17	012981	021881	15.2		11750	0	211	CHIC	500		10
11	19	111080	120180		11.5	13500	0	50	CHIC	500		10
11	19	120180	121580	11.5	12.6	13500	0	106	CHIC	500		11
11	19	121580	122980	12.6	14.1	13500	0	150	CHIC	500		10
11	19	122980	011281	14.1	15.1	13500	0	194	CHIC	500		9
11	19	011281	012981	15.1	15.5	13500	0	243	CHIC	500		12
11	19	012981	021881	15.5		13500	0	300	CHIC	500		10
11	20	111080	120180		10.1	13475	0	35	CHIC	1000		20
11	20	120180	121580	10.1	11.7	13475	0	67	CHIC	1000		22
11	20	121580	122980	11.7	11.8	13475	19	93	CHIC	1000		19
11	20	122980	011281	11.8	12.5	13475	56	120	CHIC	1000		17
11	20	011281	012981	12.5	14.0	13475	97	149	CHIC	1000		23
11	20	012981	021881	14.0		13475	145	182	CHIC	1000		19
11	21	111078	120178		11.4	10575	0	33	CHIC	250		5
11	21	120180	121580	11.4	12.7	10575	0	77	CHIC	250		6
11	21	121580	122980	12.7	14.3	10575	0	112	CHIC	250		5
11	21	122980	011281	14.3	15.4	10575	0	147	CHIC	250		4
11	21	011281	012981	15.4	16.8	10575	0	186	CHIC	250		6
11	21	012981	021881	16.8		10575	0	231	CHIC	250		5
11	22	111080	120180		12.2	8475	0	36	CHIC	750		15
11	22	120180	121580	12.2	12.4	8475	0	79	CHIC	750		17
11	22	121580	122980	12.4	14.6	8475	0	114	CHIC	750		14
11	22	122980	011281	14.6	15.4	8475	0	149	CHIC	750		13
11	22	011281	012981	15.4	15.8	8475	0	187	CHIC	750		17
11	22	012981	021881	15.8		8475	0	231	CHIC	750		15
12	14	033081	042281		11.3	15275	0	34	CHIC	7500		150
12	14	042281	050581	11.3	14.9	15275	0	81	CHIC	7500		166
12	14	050581	051981	14.9	15.9	15275	0	117	CHIC	6400		128
12	14	051981	060381	15.9	17.3	15275	0	156	CHIC	4300		86
12	14	060381	061781	17.3	17.4	15275	0	194	CHIC	1150		23
12	14	061781	070181	17.4	17.3	15275	0	231	CHIC	0		0
12	15	033081	042281		12.3	11350	0	28	CHIC	10000		200
12	15	042281	050581	12.3	14.6	11350	0	66	CHIC	10000		221
12	15	050581	051981	14.6	15.8	11350	0	94	CHIC	8550		171
12	15	051981	060381	15.8	17.6	11350	0	125	CHIC	5750		115
12	15	060381	061781	17.6	17.9	11350	0	156	CHIC	1550		31
12	15	061781	070181	17.9	19.6	11350	0	185	CHIC	0		0
12	20	033081	042281		11.0	12475	0	30	CHIC	7500		150
12	20	042281	050581	11.0	14.8	12475	0	73	CHIC	7500		166
12	20	050581	051981	14.8	15.8	12475	0	106	CHIC	6400		128
12	20	051981	060381	15.8	16.5	12475	0	140	CHIC	4300		86
12	20	060381	061781	16.5	17.5	12475	0	175	CHIC	1150		23
12	20	061781	070181	17.5	18.0	12475	0	208	CHIC	0		0

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SCCHI DISK
25.7	462.1		.9	50.3	2.01	17	0	0	.175		
25.4	385.7		.2	32.0	.60	100	75	25	.225	771	
22.5	455.9		.0	106.8	1.30	100	40	20	.455		
22.5	432.1		.0	180.9	3.70	0	0	0	.348		
20.9	421.0		.0	189.2	5.10	0	0	0		229	
23.1	546.6		.0	152.8	4.10	0	0	0			
26.2	462.1		.9	50.3	2.30	67	17	0	.097	898	
25.4	385.7		.2	32.0	.70	100	75	25	.298		
22.5	455.9		.0	106.8	1.60	60	20	0	.190		
22.6	432.1		.0	180.9	3.40	0	0	0	.259		
20.6	421.0		.0	189.2	4.80	0	0	0			
22.9	546.6		.0	152.8	4.30	0	0	0			
25.3	462.1		.9	50.3	2.10	33	17	0	.113		
25.3	385.7		.2	32.0	.70	100	75	25	.140	452	
22.3	455.9		.0	106.8	2.30	40	0	0	.180		
22.3	432.1		.0	180.9	3.60	0	0	0	.291		
21.0	421.0		.0	189.2	4.70	0	0	0			
22.8	546.6		.0	152.8	3.90	0	0	0			
26.3	462.1		.9	50.3	3.00	0	0	0	.185	645	
25.1	385.7		.2	32.0	2.60	0	0	0	.170		
22.5	455.9		.0	106.8	4.80	0	0	0	.143		
22.1	432.1		.0	180.9	5.90	0	0	0	.305		
20.5	421.0		.0	189.2	5.70	0	0	0		234	
22.7	546.6		.0	152.8	5.20	0	0	0			
27.0	462.1		.9	50.3	2.90	17	0	0	.127	398	
25.5	385.7		.2	32.0	.80	100	100	0	.170		
22.6	455.9		.0	106.8	1.30	80	40	0	.134	458	
22.1	432.1		.0	180.9	2.10	50	17	0	.356		
21.5	421.0		.0	189.2	3.90	0	0	0		305	
23.6	546.6		.0	152.8	2.02	71	0	0		455	
26.9	462.1		.9	50.3	1.70	67	17	0	.213		
25.8	385.7		.2	32.0	1.10	100	50	0	.168		
22.3	455.9		.0	106.8	1.90	60	0	0	.150	204	
22.5	432.1		.0	180.9	3.80	0	0	0	.205		
21.4	421.0		.0	189.2	5.50	0	0	0			
22.5	546.6		.0	152.8	3.60	14	0	0			
26.4	462.1		.9	50.3	2.40	13	0	0	.123		
25.2	385.7		.2	32.0	.60	100	75	50	.145		
22.2	455.9		.0	106.8	.90	100	60	0	.113	1012	
22.3	432.1		.0	180.9	2.30	50	0	0	.293		
21.3	421.0		.0	189.2	5.10	0	0	0		356	
23.5	546.6		.0	152.8	3.50	14	0	0			
26.5	462.1		.9	50.3	2.20	33	0	0	.109		
25.5	385.7		.2	32.0	.60	100	100	25	.153		
22.5	455.9		.0	106.8	1.10	100	20	0	.135		
22.5	432.1		.0	180.9	6.00	0	0	0	.309		
21.3	44.0		.0	189.2	5.90	0	0	0			
23.3	546.6		.0	152.8	4.90	0	0	0			
26.9	675.5		14.2	152.0	1.91	100	50	25	.300	502	21.3
27.9	554.8		.0	124.4	.24	100	100	100		579	
28.6	407.0		2.4	75.6	.26	100	100	100	.197	610	14.5
29.2	467.7		9.5	43.3	.58	100	100	50	.145	585	16.0
27.7			21.5	49.6	1.20	100	50	0	.580	288	23.8
27.2					1.30	100	33	0	.570		15.6
27.0	675.5		14.2	152.0	1.53	75	75	75	.590	480	20.3
27.7	554.8		.0	124.4	.21	100	100	100		1004	
28.2	407.0		2.4	75.6	.15	100	100	100	3.300	1134	17.6
28.7	467.7		9.5	43.3	.43	100	100	75	4.600	648	
27.3			21.5	49.6	.85	100	67	33	1.360		22.0
27.3					.83	100	100	0	3.030	446	16.6
26.8	675.5		14.2	152.0	1.53	75	75	75	.700	593	20.0
27.7	554.8		.0	124.4	.14	100	100	100		694	
28.1	407.0		2.4	75.6	.15	100	100	100	1.000	727	11.5
28.2	467.7		9.5	43.3	.44	100	100	100	4.000	1002	12.2
27.1			21.5	49.6	.78	100	67	33	1.050	984	19.5
27.1					.80	100	100	0	.640		23.7

XPRMNT CODE	POND NO	DATE1	DATE2	L1	L2	TILAPIA NO	RECRUITS	CARP BIOMASS	LIVESTOCK TYPE	NO OF ANIMALS	ANIMAL BIOMASS	DRY MATTER
12	21	033081	042281		12.8	12350	0	28	CHIC	10000		200
12	21	042281	050581	12.8	17.1	12350	0	66	CHIC	10000		221
12	21	050581	051981	17.1	18.0	12350	0	94	CHIC	8550		171
12	21	051981	060381	18.0	18.7	12350	0	125	CHIC	5750		115
12	21	060381	061781	18.7	20.4	12350	0	156	CHIC	1550		31
12	21	061781	070181	20.4	19.4	12350	0	185	CHIC	0		0
14	04	112280	120580			17030	0	54	PIG	80	2389	66
14	04	120580	121980	13.9	14.9	17030	163	88	PIG	80	2869	73
14	04	121980	010281	14.9	15.0	17030	330	123	PIG	80	3584	81
14	04	010281	011581	15.0	15.2	17030	497	157	PIG	80	4279	87
14	04	011581	013081	15.2	16.4	17030	691	192	PIG	80	4912	80
14	04	013081	021381	16.4	17.3	17030	983	228	PIG	80	5528	83
14	04	021381	030281	17.3	17.9	17030	1084	266	PIG	80	6183	86
14	04	030281	031381	17.9	18.6	17030	1437	301	PIG	80	6756	86
14	04	031381	032781	18.6	19.4	17030	1400	333	PIG	80	7264	86
14	04	032781	041081	19.4	20.2	17030	1657	366	PIG	80	7836	84
14	05	111480	120580			17030	0	0	PIG	80	2343	66
14	05	120580	121980	14.0	13.4	21100	47	62	PIG	80	3084	76
14	05	121980	010281	13.4	15.2	21100	84	84	PIG	80	3856	84
14	05	010281	011581	15.2	15.9	21100	120	105	PIG	80	4600	90
14	05	011581	013081	15.9	16.9	21100	157	128	PIG	80	5240	82
14	05	013081	021381	16.9	16.2	21100	195	151	PIG	80	5780	84
14	05	021381	030281	16.2	17.5	21100	237	175	PIG	80	6352	86
14	05	030281	031381	17.5	18.7	21100	274	198	PIG	80	6928	86
14	05	031381	032781	18.7	20.1	21100	307	218	PIG	80	7528	85
14	05	032781	041081	20.1	19.9	21100	343	239	PIG	80	8440	81
14	09	112080	120580			17030	0	0	PIG	80	2378	66
14	09	120580	121980	12.9	13.0	20430	42	72	PIG	80	3185	77
14	09	121980	010281	13.0	15.1	20430	83	93	PIG	80	4000	85
14	09	010281	011581	15.1	15.3	20430	130	114	PIG	80	4738	91
14	09	011581	013081	15.3	16.1	20430	175	135	PIG	80	5356	82
14	09	013081	021381	16.1	21.6	20430	257	157	PIG	80	5940	85
14	09	021381	030381	21.6	17.9	20430	289	185	PIG	80	6610	86
14	09	030381	031381	17.9	19.0	20430	350	208	PIG	80	7344	86
14	09	031381	032781	19.0	20.1	20430	365	225	PIG	80	8010	83
14	09	032781	041081	20.1	19.7	20430	436	245	PIG	80	8585	80
14	10	111880	120580			17030	0	0	PIG	80	2409	67
14	10	120580	121980	11.5	13.2	20680	2	45	PIG	80	2659	70
14	10	121980	010281	13.2	15.1	20680	4	66	PIG	80	3640	82
14	10	010281	011581	15.1	15.0	20680	5	87	PIG	80	4299	88
14	10	011581	013081	15.0	15.4	20680	7	108	PIG	80	4924	80
14	10	013081	021381	15.4	16.5	20680	7	130	PIG	80	5548	83
14	10	021381	030381	16.5	17.2	20680	9	158	PIG	80	6236	86
14	10	030381	031381	17.2	19.4	20680	11	181	PIG	80	6838	86
14	10	031381	032781	19.4	19.3	20680	14	198	PIG	80	7354	86
14	10	032781	041081	19.3	20.1	20680	16	218	PIG	80	7805	84

MEAN AM TEMP	BRIGHT SUNLIGHT	MEAN LIGHT	RAINFALL	WIND	MEAN AMDO	DAYS AMDO	AMDO L 1	AMDO L 0.5	NH3-NH4	PRIMARY PROD	SCCHI DISK
27.0	675.5		14.2	152.0	1.63	75	50	50	.680	505	29.1
28.1	554.8		.0	124.4	.26	100	100	100		987	
28.5	407.0		2.4	75.6	.18	100	100	100	.340	1021	14.0
28.5	467.7		9.5	43.3	.54	100	100	75	.280	862	
27.2			21.5	49.6	.97	100	67	33	.510		12.5
27.0					.78	100	75	25	.650	823	17.1
27.2	483.0		.0	71.0							
28.6	426.0		.2	74.1							
24.8	499.0		.0	135.8							
25.1	448.0	307.0	.0	181.9							
24.0	410.0		.0	192.5							
25.0	596.0		.0	171.2							
25.4	560.0		.0	135.9							
23.5	666.0		.0	159.9							
23.9	675.0		.0	161.6							
25.6	649.0		.0	165.9							
27.2	492.0		.0	52.2							
28.6	426.0		.2	74.1							
24.8	449.0		.0	135.8							
25.1	448.0	307.0	.0	181.9							
24.0	410.0		.0	192.5							
25.0	596.0		.0	171.2							
25.4	560.0		.0	135.9							
23.5	666.0		.0	159.9							
23.9	675.0		.0	161.6							
25.6	649.0		.0	165.9							
27.2	484.0		.0	69.9							
28.6	426.0		.2	74.1							
24.6	449.0		.0	135.8							
25.1	448.0	307.0	.0	181.9							
24.0	410.0		.0	192.5							
25.0	596.0		.0	171.2							
25.3	560.0		.0	135.9							
23.5	666.0		.0	159.9							
23.9	675.0		.0	161.6							
25.6	649.0		.0	165.9							
27.3	500.0		.0	56.3							
28.6	426.0		.2	74.1							
24.6	449.0		.0	135.8							
25.1	448.0	307.0	.0	181.9							
24.0	410.0		.0	192.5							
25.0	596.0		.0	171.2							
25.3	560.0		.0	135.9							
23.5	666.0		.0	159.9							
23.9	675.0		.0	161.6							
25.6	649.0		.0	165.9							

Appendix D
Project Technical Personnel

Name	Date	Position
Joey Carrillo, B.S.	6/1981 – 12/1981	Research Assistant (Livestock)
Emmanuel Cruz, Ph.D.	1/1978 – 12/1981	Project Co-Leader
Estella Cruz, B.S.	5/1979 – 12/1981	Assistant Chemist
Martin de la Cruz	5/1979 – 5/1981	Research Aide (Fish)
Balfour Hepher, Ph.D.	7/1978	Consultant
Peter van der Heijden, B.S.	2/1980 – 10/1980	Graduate Student Intern
Hans van Weerd, B.S.	5/1979 – 11/1979	Graduate Student Intern
Kevin Hopkins, Ph.D.	9/1979 – 12/1981	Project Co-Leader
Margarita Hopkins, M.S.	1/1980 – 12/1981	Affiliate Scientist (Economics)
Perlina Inocencio, B.S.	5/1978 – 12/1981	Chemist
Eddie Lopez, B.S.	1/1979 – 5/1979	Research Assistant (Fish)
Mario Marquez, B.S.	7/1979 – 12/1981	Research Assistant (Livestock)
Alex de la Peña, B.S.	5/1981 – 12/1981	Research Assistant (Fish)
R.S.V. Pullin, Ph.D.	4/1979 – 12/1981	ICLARM Aquaculture Program
Oscar Quines, M.S., D.V.M.	6/1979 – 12/1981	Parasitologist
Gerald Schroeder, Ph.D.	3/1978 – 8/1978	Consultant
Alex Serra, B.S.	6/1978 – 6/1979	Research Assistant (Livestock)
Reuben Sevilleja, M.S.	11/1980 – 12/1981	Study leader (Economics)

Appendix E

Project Publications/Reports as of 31 December 1982

Cruz, E.M. and K.D. Hopkins. 1980. Tests on the integration of pig and fish production. *In* Animal Production Systems for the Tropics. International Foundation for Science Provision Report No. 8, Stockholm, Sweden.

Cruz, E.M. and K.D. Hopkins. 1981. Utilization of untreated pig manure in freshwater fish culture. Philipp. J. Vet. Animal Sci. 4.

Cruz, E.M. and Z.H. Shehadeh. 1980. Preliminary results of integrated pig-fish and duck-fish production tests, p. 225-238. *In* R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conference Proceedings 4. 258 p.

Hopkins, K.D. 1982. Outstanding yields and profits from livestock—tilapia integrated farming. ICLARM Newsletter 5(3): 13.

Hopkins, K.D. and E.M. Cruz. 1980. High yields but still questions: three years of animal-fish farming. ICLARM Newsletter 3(4): 12-13.

Hopkins, K.D., E.M. Cruz, M.L. Hopkins and K.C. Chong. 1981. Optimum manure loading rates in tropical freshwater fishponds receiving untreated piggery wastes, p. 15-29. *In* The ICLARM-CLSU integrated animal-fish farming project; poultry fish and pig-fish trials. ICLARM Technical Reports 2. 29 p.

Hopkins, K.D., D. Pauly, E.M. Cruz and J.H. van Weerd. 1982. An alternative to predator-prey ratios in predicting recruitment. Meeresforsch. 29: 125-135.

Sevilleja, R.C. 1982. Economic analysis of integrated pig-fish farming operations in the Philippines, p. 75-81. *In* Aquaculture Economics Research in Asia: proceedings of a workshop held in Singapore, 2-5 June 1981. International Development Research Centre, Ottawa, Canada and the International Center for Living Aquatic Resources Management, Manila, Philippines.

Appendix F
Fish Length-Weight Relationships

Oreochromis niloticus

Sample range : 4.3-22.0 cm, 0.8-210.8 g
Sample size : 611
Equation : $W = 0.0118\ L^{3.216}$

Where W = weight in grams and L = total length in centimeters

Correlation Coefficient (R) = 0.9861

Channa striata

Sample range : 3.2-43 cm, 0.4-660 g
Sample size : 244
Equation : $W = 0.0145\ L^{2.858}$

Correlation Coefficient (R) = 0.9924

Appendix G
Tabulated Data on Pond Plankton

Table 1. Details of plankton samples.

Experiment number	Animal type	Number of samples
5	Pigs	34
10	Chickens	31
11	Chickens	17
12	Chickens	33
14	Pigs	28

Table 2. Phytoplankton density in pig-fish ponds.

Date	Manure load (kg/ha/day)	Density (no./l x 10^3) Chlorophytes	Cyanophytes	Euglenophytes/ Chrysophytes	Total
Experiment 5 (1980)					
3/13–3/26	67	2.0	29.6	56.6	88.1
3/27–4/09	72	8.2	88.5	2.1	98.8
4/10–4/23	78	3.2	26.2	5.2	34.6
4/24–5/08	82	1.4	53.1	3.6	58.1
5/09–5/21	88	3.9	34.8	26.0	64.8
6/05–6/18	102	9.5	10.7	15.9	36.1
7/18–7/30	104	0.2	7.4	1.0	8.7
Experiment 14 (1981)					
1/31–2/13	83	174.2	247.2	3.5	425.0
2/14–3/02	86	205.2	101.4	20.1	326.7
3/03–3/13	86	60.9	170.6	5.6	237.2
3/14–3/27	86	21.0	123.8	17.8	162.6
3/28–4/10	84	6.7	55.0	6.3	68.0

Table 3. Percentage of biweekly sampling periods in which listed phytoplankton genera occurred, were the most dominant within their taxonomic group, and most dominant overall.

Genera	Experiment 5 Occurrence	Group dominance	Overall dominance	Experiment 14 Occurrence	Group dominance	Overall dominance
Chlorophytes						
Pediastrum	86	43		83	33	
Scenedesmus	29			67		
Coelastrum	86	14		67	20	20
Cosmarium	43	29		33		
Closterium	43	14		33		
Chlorella	29			50	33	20
Volvox	29			33		
Chlorococcus	14			67		
Ulothrix	14			20		
Microspora	14					

Table 7. Zooplankton species diversity in pig-fish ponds.

Date	Manure load (kg/ha/day)	Shannon-Weaver Diversity index[a] ($\bar{H}$)	Evenness index[b] (e)
Experiment 5 (1980)			
3/13–3/26	67	1.12	0.91
3/27–4/09	72	0.97	0.59
4/10–4/24	78	0.66	0.55
4/25–5/07	82	0.90	0.68
5/08–5/21	88	0.99	0.80
5/22–6/04		0.94	0.85
6/05–6/18	102	0.87	0.80
7/17–7/30	104	0.33	0.48
Experiment 14 (1981)			
1/31–2/13	83	1.32	0.75
2/13–3/02	86	1.40	0.71
3/03–3/13	86	1.47	0.80
3/14–3/27	86	0.98	0.68
3/28–4/10	84	1.30	0.76

[a] $\bar{H} = -\Sigma(n/N)\ ln\ (n/N)$ where n = number of units of each genus/group and N = total number of units (Odum 1971).

[b] $e = \frac{\bar{H}}{ln\ S}$ where S = the number of species.

Table 8. Mean weekly phytoplankton abundance in chicken-fish ponds.

Manure load (kg/ha/day)	Density (no./l x 10^3) Chlorophytes	Cyanophytes	Euglenophytes & Chrysophytes	Total
5	19.6	45.2	40.4	105.2
10	9.1	8.5	4.8	22.4
15	95.8	39.7	163.0	298.5
20a[1]	77.7	15.3	54.1	147.1
20b[2]	5.8	12.2	18.4	36.4
61	27.7	11.9	20.3	59.9
101	42.6	39.1	61.7	143.4
151	355.5	75.8	27.4	458.7
202	200.1	297.5	24.2	521.8

1 = Experiment 11; 2 = Experiment 10.

Table 9. Percent of weekly sampling periods in which listed phytoplankton genera occurred in chicken-fish ponds.

Genera	Mean manure load (kg dry matter/ha/day) 5	10	15	20a	20b	61	101	151	202
Chlorophytes									
Pediastrum	100	100	50	100	87.5	85.7	75	100	100
Scenedesmus	100	100		100	62.5	42.8		71.4	77.7
Closterium	100	50				14.2			66.6
Cosmarium	25	100	50	100	75	28.5	100		33.3
Coelastrum	25				25	42.8	50	100	77.7
Chlorella	50	25			25	42.8	50	42.8	55.5

Table 9 (continued). Percent of weekly sampling periods in which listed phytoplankton genera occurred in chicken-fish ponds.

Genera	Mean manure load (kg dry matter/ha/day)								
	5	10	15	20a	20b	61	101	151	202
Selenastrum		25	50					14.8	
Kirchneriella	25		50						
Trochisia		25						14.2	33.3
Sphaerocystis					25	42.8	25	85.7	66.6
Ankistrodesmus	25		50						11.1
Volvox						28.5	25	42.8	
Golenkinia						14.2			
Actinastrum								57.1	44.4
Chroococcus					12.5	14.2	25	42.8	33.3
Aphanocapsa								42.8	11.1
Anacystis								28.5	33.3
Micratinium									33.3
Tetraedron								14.2	
Oocystis								28.5	11.1
Eudorina									33.3
Pachycladon								14.2	11.1
Gloeocystis									11.1
Cyanophytes									
Lyngbya	100	50	100		37.5	71.4	25	71.4	100
Microcystis	75	25	25		37.5	57.1	100	87.5	66.6
Oscillatoria		25			37.5	28.5	75	87.5	22.2
Merismopedia	75	25				28.5		14.2	11.1
Synechocystis					37.5			28.5	
Spirulina							25	28.5	
Gloecapsa	25								
Euglenophytes and Chrysophytes									
Euglena	100	75	100	100	100	100	75	42.8	100
Phacus	50	75	25		87.5	71.4	75	57.1	77.7
Trachelomonas	25	25	100	50	25	28.5	25	42.8	44.4
Navicula	25	25	25	50	12.5	14.2	25		11.1
Pinnularia			25	50	12.5				

Table 10. Percent of weekly sampling periods in which listed phytoplankton genera were the most dominant within each taxonomic group in chicken-fish ponds.

Genera	Mean manure load (kg dry matter/ha/day)								
	5	10	15	20a	20b	61	101	151	202
Chlorophytes									
Pediastrum	25	50	50		37.5	42.8			100
Cosmarium	25		50	100	25		50		
Chlorella	25				12.5			50	
Scenedesmus	25	25			25				
Coelastrum						28.5	25	50	
Trochisia		25							
Golenkinia						28.5			
Sphaerocystis							25		
Cyanophytes									
Microcystis	75		50		50	43.1		100	40
Lyngbya	25	100	50	100	25	28.5			60
Oscillatoria					25	14.2	100		
Merismopedia						14.2			
Euglenophytes and Chrysophytes									
Euglena	75	75	100	100	87.5	57.1	100	50	75
Phacus		25			12.5	28.5		50	25
Trachelomonas	25					14.2			

Table 11. Percent of weekly sampling periods in which listed phytoplankton genera were the most dominant in chicken-fish ponds.

Genera	Mean manure load (kg dry matter/ha/day)								
	5	10	15	20a	20b	61	101	151	202
Chlorophytes									
Pediastrum		50			12.5	20			40
Cosmarium			25	100					
Scenedesmus		25							
Coelastrum							33.3	50	
Golenkinia						20			
Chlorella								50	
Cyanophytes									
Microcystis	25				12.5	20			20
Lyngbya					12.5				40
Oscillatoria					12.5		33.3		
Merismopedia	25								
Euglenophytes and Chrysophytes									
Euglena	50	25	75		50	40	33.3		

Table 12. Phytoplankton diversity in chicken-fish ponds.

Manure load (kg/ha/day)	Shannon-Weaver Diversity index[a] ($\bar{H}$)	Evenness index[b] (e)
5	1.52	0.79
10	1.32	0.78
15	1.13	0.64
20a[1]	0.91	0.60
20b[2]	1.10	0.62
61	1.10	0.70
101	0.84	0.50
151	1.30	0.60
202	1.07	0.54

[a] $\bar{H} = -\Sigma(n/N)\ ln\ (n/N)$ where n = number of units in each genus/group and N = total number of units (Odum 1971).

[b] $e = \frac{\bar{H}}{ln\ S}$ where S = the number of species.

1 = Experiment 11; 2 = Experiment 10.

Table 13. Mean weekly zooplankton abundence in chicken-fish ponds.

Manure load (kg/ha/day)	Density (no./l x 10^3)			
	Rotifera	Cladocera	Copepoda	Total
5	2.9	1.2	8.3	12.4
10	1.3	1.1	6.7	9.1
15	2.7	1.5	12.9	17.1
20a[1]	1.8	1.9	2.5	6.2
20b[2]	1.8	0.6	5.6	7.9
61	7.1	0.1	3.0	10.2
101	5.0	0.8	3.1	8.9
151	36.0	12.7	4.9	53.6
202	26.5	2.9	12.5	52.0

1 = Experiment 11; 2 = Experiment 10.

Table 14. Percent of weekly sampling periods in which listed zooplankton genera occurred in chicken-fish ponds.

Genera	Mean manure load (kg dry matter/ha/day)								
	5	10	15*	20a	20b	61	101	151	202
Rotifera									
Brachionus	100	16.6		50	100	100	100	70	100
Trichocerca	37.5	33.3	100	50	58.3	50	33		
Asplanchna	25				30	25		30	
Filinia	12.5				17	25		40	43.7
Lecane								10	18.7

Table 14 (continued). Percent of weekly sampling periods in which listed zooplankton genera occurred in chicken-fish ponds.

Genera	Mean manure load (kg dry matter/ha/day) 5	10	15*	20a	20b	61	101	151	202
Polyarthra								20	62.5
Gastropus		33.3	100					20	43.7
Keratella								10	6.3
Testudinella								30	43.7
Cephalodella								30	6.3
Asplanchnapus	12.5								
Cladocera									
Moina	12.5	16.6	100	50	33.3	17	17	100	100
Bosmina	12.5	16.6			25				6.3
Diaphanosoma	25	16.6	100	50	17				6.3
Unidentified	12.5	33.3							
Copepoda									
Nauplii	62.5	100	100	100	100	100	83.3	50	70
Copepodites	62.5	66.6	100	25	67	67	17	30	70
Cyclops	12.5	100	100	25	17		50	60	81.2
Cyclopidae	37.5	16.6		25	25				
Harpacticoids							17		

*Based on 1 sample only.

Table 15. Percent of weekly sampling periods in which listed zooplankton genera were the most dominant within each taxonomic group in chicken-fish ponds.

Genera	Mean manure load (kg dry matter/ha/day) 5	10	15	20a	20b	61	101	151	202
Rotifera									
Brachionus	75	25		100	62.5	50	67	100	75
Trichocerca			100		37.5	33	33		
Asplanchna	25					17			
Gastropus		75							25
Cladocera									
Moina	25		75	50	75	100	100	100	100
Bosmina	50	100		50	25				
Diaphanosoma	50		25						
Copepoda									
Nauplii		100	100	100	87.5	75	67	67	75
Copepodites	25				12.5	25	33		25
Cyclops	75							33	

Table 16. Percent of weekly sampling periods in which listed zooplankton genera were the most dominant in chicken-fish ponds.

	Mean manure load (kg dry matter/ha/day)								
Genera	5	10	15	20a	20b	61	101	151	202
Rotifera									
Brachionus	25				11.1	42.8	67	50	75
Trichocerca					33	28.6	33		
Gastropus		50							
Cladocera									
Moina						14.2		50	
Copepoda									
Nauplii	75	50	75	100	55.5	14.2			25
Copepodites			25						

Table 17. Mean zooplankton diversity in chicken-fish ponds.

Manure load (kg/ha/day)	Shannon-Weaver Diversity index[a] ($\bar{H}$)	Evenness index[b] (e)
5	1.09	0.87
10	1.16	1.10
15	1.10	0.70
20a	1.71	0.92
20b	0.97	0.76
61	0.80	0.72
101	0.80	0.71
151	1.51	0.79
202	1.28	0.75

[a] $\bar{H} = -\Sigma(n/N)\ ln\ (n/N)$ where n = number of units in each genus/group end N = total number of units (Odum 1971).

[b] $e = \frac{\bar{H}}{ln\ S}$ where S = the number of species.

1 = Experiment 11; 2 = Experiment 10.