Making Experiment Station Results More Useful to African Fish Farmers[1]

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Abstract

Rather than using more or less ideal conditions for setting experimental controls, the use of conditions similar to those likely to be encountered by farmers should produce research results which are realistically achievable on the farm. ICLARM has developed an approach to farmer-led experimentation which utilizes a spreadsheet to collate and analyze data collected from participating farmers. The simulation of actual management practices utilized by farmers produced results in replicated on-station trials which were within 11% of net yields on-farm. In addition to giving researchers a tool for comparing farm and station management practices, giving farmers a realistic indication of what yields will be if a technology is adopted should help overcome the problems of disillusionment often encountered when farm results fall below those expected by researchers on the basis of experiment station studies.

Introduction

Researchers are frequently accused of pursuing their esoteric projects disconnected from the real world. In the case of agricultural research, this impression stems from the fact that technologies developed on experimental stations sometimes fail on-farm. This failure is often the result of researchers having ignored biotechnical and social constraints faced by farmers. For example, local availability of land, labor, inputs and capital are often overlooked by the scientists who wish to optimize efficiency and productivity and tend to think in global or regional terms. In addition, specialization in the scientific community leads researchers to concentrate on specific technologies or crops and ignore other enterprises in which the farmer is engaged.

On-farm research also has problems and is not a panacea for the recurrent problems of technology development and transfer. Farmers do not always accurately report their inputs and outputs. Differences in location, plot sizes, soil types, experiences of farmers, etc., make data variability high and its analysis difficult. Communication between researchers and rural peasants often breaks down.

The International Center for Living Aquatic Resources Management (ICLARM) is engaged in a project to design experimental methods for conducting on-farm experiments which are both realistic and scientifically controlled. The development of PondSim, a spreadsheet which attempts to mimic input regimes used by farmers, for on-station use is part of that project.

Monitoring and Simulating On-farm Conditions

PondSim is a simple spreadsheet which uses data collected on-farm to generate input regimes which can be used by researchers to mimic the conditions on smallholdings. Combined with farmer-participatory research and development, it can be a powerful tool for improving the applicability of research results to real farm conditions.

Dataforms are completed during (weekly) farm visits. The amount of various inputs and the way in which they were used by farmers are recorded. Samples of each material used are brought back to the laboratory for analysis. Each sample is analyzed for dry matter, organic matter, nitrogen and phosphorus. All the data, from the laboratory and collected during farm visits, are loaded into a spreadsheet. PondSim then calculates the average amount of various inputs used per unit area in a given time period, compiles these data and transfers them to a user-interactive table. This allows the researcher to compare the farm data with data from the experiment station to make a best fit.

A Case Study from Malaŵi

During the period 24 February-18 March 1993 seven farm ponds and four ponds at the Malawi National Aquaculture Center (NAC) were stocked with a mixed-sex polyculture of *Oreochromis shiranus* and *Tilapia rendalli*. Each farmer had a different size of pond and selected a different stocking rate and a different initial size of fish. The pond areas at the NAC are fixed at 200 m^2, an average of 18.6 m^2 smaller than the

[1]Some of the information in this paper was presented as 'Farmer-Scientist Research Partnerships and Smallholder Integrated Aquaculture' in Malawi to the Technical Center for Agricultural and Rural Co-operation (CTA) and the Belgian Royal Academy of Overseas Sciences Seminar on the Management of Integrated Freshwater Agro-Piscicultural Ecosystems in Tropical Areas, 16-19 May 1994, Brussels, Belgium.

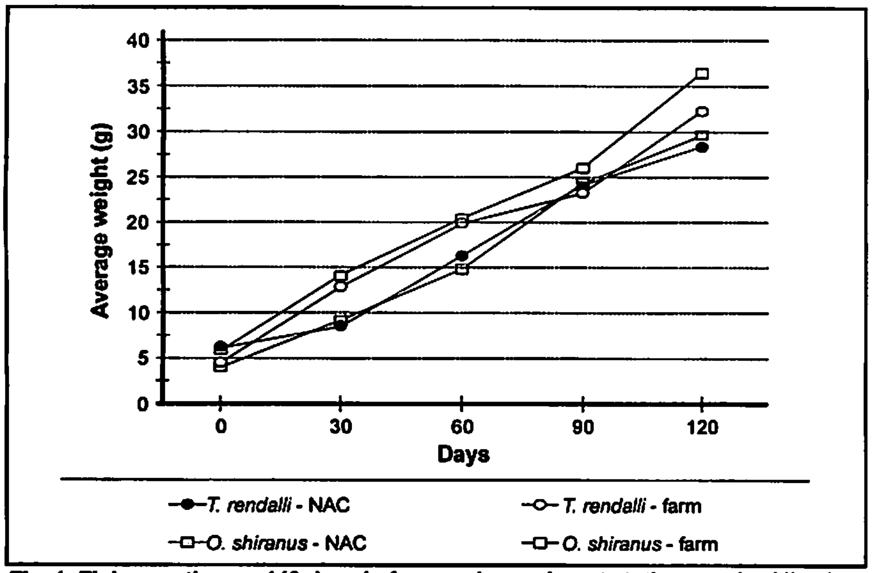

Fig. 1. Fish growth over 149 days in farm and experiment station ponds. All values are statisically identical (P<0.05).

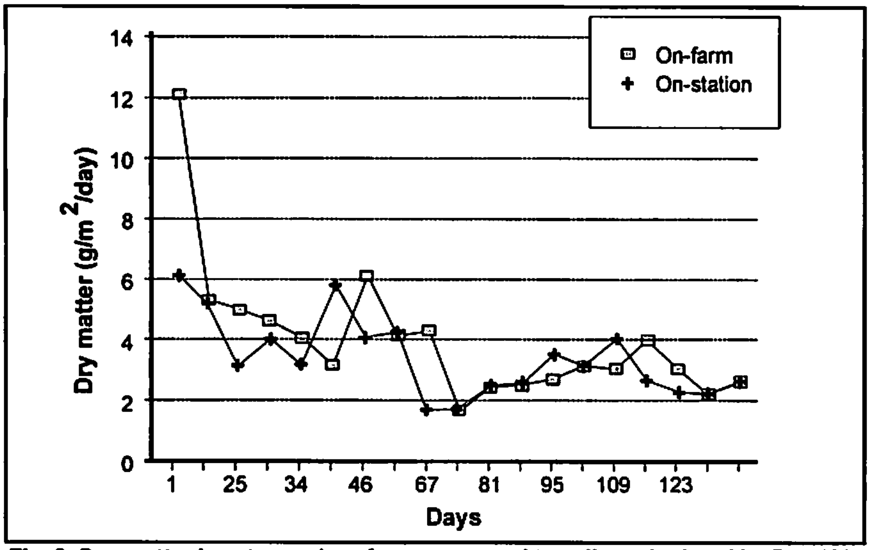

Fig. 2. Dry matter inputs used on-farm compared to a diet calculated by PondSim and used on the experiment station. Values after the first week are not significantly different.

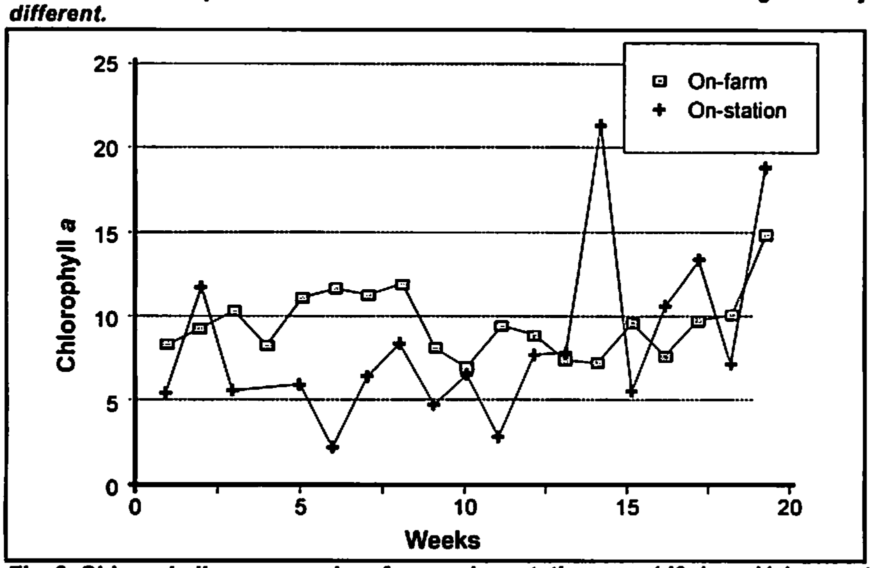

Fig. 3. Chlorophyll a measured on-farm and on-station over 149 days. Values not subjected to statistical analysis.

farmers' ponds. Stocking weights and numbers in the four ponds at the NAC were based on averages of those used by farmers.

Fish were sampled every 30 days and were harvested after an average of 149 days (range 137-158 days). Fish were counted and individually weighed. Average weights were compared using Student's t-test (Zar 1974).

Weekly sampling of farm input materials began on 4 March and proceeded until 16 July. Sampling involved collection of 100-300 g samples of all materials used since the last sample and asking the farmers how much of each material was introduced into the pond during the interval. Often the farmer kept track of inputs by volume (i.e., in units of baskets or cans per week). Potential pond inputs available at the NAC were also sampled weekly.

All samples of pond input materials were analyzed for dry matter, organic matter, nitrogen and phosphorus content following standard methods (AOAC 1975). The total wet weight of each material put into each farm pond as well as its proximate analysis were then loaded into PondSim. The spreadsheet was used to estimate the average total dry matter, organic matter, total nitrogen and total phosphorus fed to the pond per m^2. These values were then compared with user-generated combinations of materials available on-station to formulate a pond input regime which quantitatively and qualitatively simulates the inputs used on-farm.

To monitor the impact of these inputs on water quality, water samples were analyzed weekly for measurement of chlorophyll *a*, total alkalinity, total dissolved solids and total suspended solids using standard methods (APHA 1989).

COMPARISON BETWEEN FARM AND STATION RESULTS

The average weight of fish for different sampling periods was not significantly different (P<0.05) for farm and station ponds (Fig. 1) and net yield was also the same (P<0.05) on-farm and on-station.

PondSim calculated an average input regime which allowed researchers to accurately simulate the on-farm inputs. Fig. 2 shows the dry matter inputs used by farmers and researchers. Organic matter, nitrogen and phosphorus inputs showed similar trends. The choice of monitoring parameters depends on how inputs are used in the pond. If the inputs serve as a direct fish food, then the important water quality parameters to be considered might be dissolved oxygen and temperature. On the other hand, if inputs are used primarily as fertilizers to feed natural pond food organisms and are only indirectly consumed by fish, then water quality parameters such as chlorophyll *a* and total suspended solids might be valuable indicators of productivity.

In this study, total suspended solids (TSS) fluctuated widely in both farm and research station ponds. This high variability renders interpretation difficult. It certainly indicates that TSS is highly sensitive to temporary environmental conditions and, therefore, might be more useful as an indicator of potentially dangerous short-term trends in water quality than as a predictor of pond productivity over an entire growing season.

Considering the similarity in fish growth between farm and station, total dissolved solids (TDS) on-farm averaged 80 mg/l but was highly variable. On-station, it was more stable but lower, averaging about 40 mg/l. TDS is clearly a poor predictor of pond productivity.

Chlorophyll *a* was very similar between the two data sets (Fig. 3) and may be a better indicator of productivity than TSS or TDS. An examination of fish stomach contents showed that all sizes of fish were consuming inputs directly. The relative contribution of directly and indirectly consumed inputs would thus be needed to calibrate chlorophyll *a* for use in predicting pond output of various species.

Table 1. The PondSim Farm Materials File. Materials are characterized in terms of nitrogen (N), phosphorus (P) dry matter (DM) and organic matter (OM). Multiple analyses done during different seasons or for materials from more than one farm are averaged to give values which are put into the Input Data File (Table 2).

Material	Code	Category*	N (g/kg/DM)	P (g/kg/DM)	DM	OM	Average
Goat manure	1	manure	40.8	4.47	0.50	0.32	3
Chicken manure	2	manure	3.0	4.82	0.74	0.27	1
N'Sima	3	wet	91.0	n/a	0.23	n/a	1
Watermelon	4	wet	33.9	3.00	0.06	0.05	1
Pumpkin, fruit	5	wet	23.2	2.60	0.11	0.10	1
Pumpkin, leaves	6	wet	41.4	2.79	0.14	0.09	1
Pumpkin, flowers	7	wet	54.0	n/a	0.03	n/a	1
Madeya	8	dry	22.2	4.08	0.65	0.54	9
Termites	9	protein	600.0	n/a	0.50	n/a	1
Napier grass	10	dry	24.3	1.73	0.31	0.25	2
Crotalaria	11	wet	30.3	2.77	0.24	0.22	7
Guava	12	wet	15.0	n/a	0.12	n/a	1
Coco-yam, leaves	13	wet	31.4	1.11	0.15	0.12	1
Pea/bean pods	14	dry	24.1	0.90	0.90	0.86	4
Pigeon pea, leaves	15	wet	30.2	2.40	0.35	0.32	4
Sweet potato, leaves	16	wet	30.2	2.76	0.11	0.09	7
Tridax procumbens	17	wet	119.0	n/a	0.14	n/a	1
Cassava, leaves	18	wet	40.5	5.95	0.16	0.15	6
Turnip tops	19	wet	43.3	3.59	0.20	0.14	3
Mixed grass	20	dry	13.5	1.85	0.48	0.38	2
Aligone	21	wet	n/a	n/a	0.16	n/a	1
Mango fruit	22	wet	350.0	1.00	0.17	0.17	1
Leucaena	23	dry	41.1	1.47	0.31	0.27	2
Maize stovers	24	dry	7.0	5.08	0.90	0.72	2

*Materials are categorized in terms of manures, wet or dry material (i.e., < or > 25% dry matter, respectively) and proteinaceous materials (>5% nitrogen).

Table 2. The PondSim Input Data File.

Week: 29 16 - 22 July

Farmer	Pond area (m²)	Date (days)	Interval (kg/interval)	Code*	Input	Manure	Categories: Dry	Categories: Wet	Categories: Protein
1	241	16	7	1	4.1	4.1	0	0	0
		16			2.5	0	0	2.5	0
2	283	16	7	8	3.5	0	3.5	0	0
3	227	16	7	8	7.0	0	7.0	0	0
				1	7.8	7.8	0	0	0
4	199	21	7	8	13.8	0	13.8	0	0
5	141	22	7	8	4.9	0	4.9	0	0
6	171	21	7	8	5.1	0	5.1	0	0
				4	5.0	0	0	5.0	0
7	293	22	7	8	9.4	0	0	0	9.4
Average			7		9.0	0.19	0.54	0.12	0.15

*Material code from Table 1.

How PondSim Works

PondSim is composed of four pages in any Windows® spreadsheet. The four pages are: 1) Farm Materials; 2) Input Data; 3) Data Summation; and 4) Simulation.

Farm Materials

The Farm Materials File (Table 1) is used to record the proximate analyses of materials used by farmers. Each material is assigned a code number which the spreadsheet uses to locate the appropriate row when making later calculations. Values in each column represent averages of a variable number of replications, one for each time that material appeared in the samples collected from farmers (i.e., the number of weeks in which that material was used by at least one farmer). The average value in each column must therefore be recalculated weekly and the number in the 'Average of' column updated by the user. The spreadsheet automatically calculates the values for nitrogen and phosphorus (as grams per kilogram of wet material input) for use in later functions. Materials are classified into categories according to the following criteria: Dry Materials (>25% dry matter); Wet Materials (<25% dry matter); Proteinaceous Materials (>5% Nitrogen); Manures.

Input Data

After each weekly sampling, farm pond input data are loaded into the input data file (Table 2). Each farmer is assigned a number at the beginning of the study. The date is recorded for filing purposes. The interval between samples is recorded for use in calculating daily averages. The code and wet weight of input for each type of material(s) used by the farmers during the week are loaded in the appropriate columns. The wet weight of each material is also listed according to the category to which it belongs for purposes of later simulation.

The spreadsheet uses the proximate analysis data in the farm materials file and the wet material input data recorded in the input data file to calculate the following parameters: (i) average input of major nutrients per farm pond; (ii) total inputs of major nutrients per square meter per day; (iii) nitrogen and phosphorus inputs as percentages of dry matter inputs; (iv) cumulative inputs over the sampling period per square meter; and (v) averages for all farmers of all the above for the sampling period.

Data Summation

The data summation file (Table 3) is simply a log of the parameters calculated by the input data file. These are tabulated for use in data analysis, charting and record-keeping. The data summation file also includes parameters for use in interpreting input data such as the urea equivalent of the nitrogen input (such types of data are often of more use to farmers than raw nitrogen data). The values in the data summation file can be easily modified to present data in any form deemed most desirable by the user. Also included, but not shown, is a record of all the weekly simulations calculated as described below.

Table 3. The PondSim Data Summation File showing daily average and cumulative inputs (N = nitrogen; P = phosphorus; DM = dry matter; and OM = organic matter).

	Average input (per m²/day)					Cumulative inputs to date (per m²)				
Week	Total (kg wet)	N (g)	P (g)	DM (kg)	OM (kg)	Wet (kg)	N (g)	P (g)	DM (kg)	OM (kg)
1	0.019	0.210	0.036	0.009	0.008	0.131	1.467	0.251	0.063	0.053
2	0.019	0.210	0.036	0.009	0.008	0.262	2.934	0.501	0.127	0.105
3	0.019	0.210	0.036	0.009	0.008	0.393	4.401	0.752	0.190	0.158
4	0.019	0.210	0.036	0.009	0.008	0.524	5.868	1.003	0.253	0.211
5	0.019	0.210	0.036	0.009	0.008	0.655	7.335	1.253	0.317	0.264
6	0.019	0.210	0.036	0.009	0.008	0.786	8.802	1.504	0.380	0.316
7	0.019	0.210	0.036	0.009	0.008	0.917	10.269	1.755	0.443	0.369
8	0.019	0.210	0.036	0.009	0.008	1.048	11.736	2.005	0.506	0.422
9	0.031	0.532	0.049	0.013	0.008	1.263	15.462	2.349	0.596	0.478
10	0.012	0.132	0.021	0.006	0.005	1.418	17.211	2.643	0.670	0.540
11	0.013	0.618	0.017	0.006	0.004	1.511	21.482	2.764	0.710	0.565
12	0.007	0.089	0.012	0.003	0.002	1.563	22.110	2.845	0.731	0.580
//										
47	0.003	0.037	0.007	0.002	0.001	3.077	47.338	6.139	1.555	1.234
48	0.004	0.108	0.009	0.002	0.002	3.139	48.927	6.264	1.587	1.262
49	0.004	0.108	0.009	0.002	0.002	3.201	50.517	6.388	1.620	1.289
50	0.007	0.098	0.018	0.004	0.004	3.495	54.727	7.161	1.809	1.449
51	0.004	0.108	0.009	0.002	0.002	3.557	56.317	7.286	1.842	1.476
52	0.004	0.108	0.009	0.002	0.002	3.169	57.907	7.410	1.874	1.504

Simulation

The simulation file (Table 4) is a user interactive page which collects pre-calculated data on average farm inputs for use in designing on-station diets which approximate as closely as possible those used by the farmers. Proximate analysis data are loaded for materials which are available on the experiment station. These are often fewer in number than those used by farmers. Since an average of what all farmers are using is desired, the various inputs must be reduced to their important constituent nutrients.

The values in the FARM row near the bottom of the file are extracted from the data summary file. The values in the

Total WM file are varied by the user to create as close a fit as possible to the FARM values. When the fit is acceptable to the user, the values in the Total WM column are used to formulate the experiment pond's input regime for that week. The data from the various columns are then recorded in the data summary file as described above.

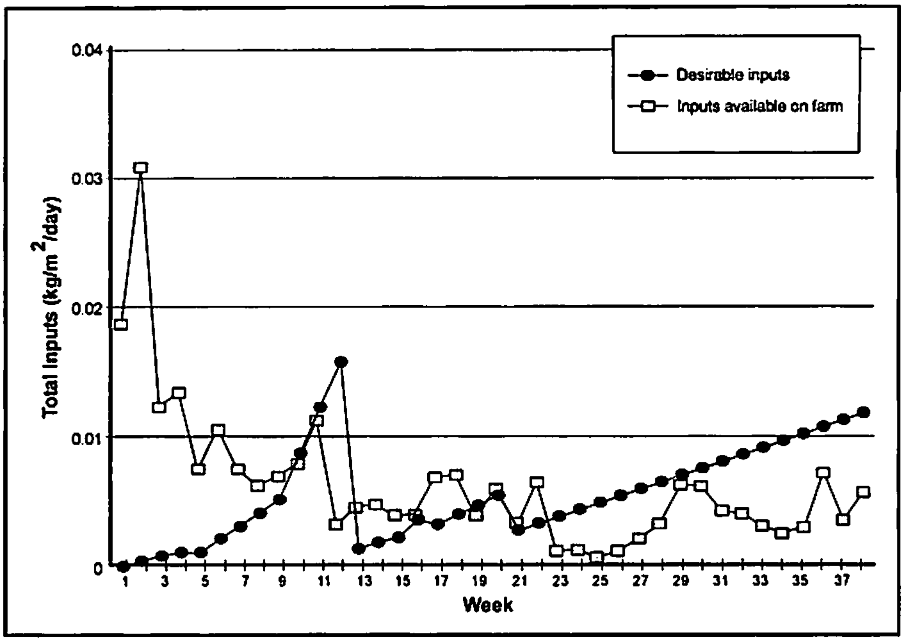

Fig. 4. The availability of inputs on-farm compared to those required tp maximize the production of tilapia under ideal circumstances.

Conclusions

Rather than using ideal conditions for setting experimental controls, the use of conditions similar to those likely to be encountered by farmers should produce research results that are realistically achievable on the farm. However, the feeding methods accepted by researchers may be violated. Fig. 4 illustrates the difference between inputs made to a pond managed according to the seasonal availability of labor, water and feeds on Malawian smallholdings, and those which would be used in an ideal situation (e.g., periodic stock harvesting and regular feeding with high quality feeds on the basis of individual fish body weight). The difference between the yields achieved by researchers working under optimal conditions and PondSim-controlled studies may well be proportional to the discrepancy between the theoretical and realized productivity of a particular technology. Giving farmers a realistic indication of what yields will be achievable if a technology is adopted should help overcome the problems of disillusionment often encountered when farm results fall below those expected by researchers on the basis of experiment station studies.

Once a technology is adopted by farmers, PondSim can then be used either directly or as a component of a participatory research approach (Brummett and Noble 1995) to improve yields.

Acknowledgments

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Table 4. The PondSim Simulation File. Materials available on the experiment station are characterized in terms of nitrogen (N), phosphorus (P), organic matter (OM), dry matter (DM) and a material type category (see Table 1).

Material	Proximate analysis				Total	Categories				Inputs per m²				
	N	P	OM	DM	WM (kg)	Manure	Dry	Wet	Protein	N (g)	P (g)	DM (kg)	OM (kg)	Avg Fit
Goat manure	31.7	0.412	0.612	0.825	0	0	0	0	0	0	0	0	0	
Chicken manure					0	0	0	0	0	0	0	0	0	
Madeya	37.1	0.365	0.899	0.905	2.5		2.5	0	0	0.420	0.004	0.011	0.010	
Sweet potato leaves	42.5	0.236	0.836	0.200	1.2	0	0	1.2	0	0.051	0.000	0.001	0.001	
Napier grass	33.6	0.186	0.805	0.257	0	0	0	0	0	0	0	0	0	
Leucaena	50.2	0.153	0.864	0.309	0	0	0	0	0	0	0	0	0	
SUM					3.7	0	0.676	0.324	0	0.471	0.004	0.013	0.011	
Size of exptl units (m²) = 200				FARM	3.742	0.00	0.69	0.31	0.00	0.210	0.036	0.009	0.008	
				FIT	0.989	ERR	0.99	1.03	ERR	2.246	0.123	1.383	1.483	1.245

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The Evolution of Body Muscle Composition of the African Catfish *(Clarias gariepinus)* (Burchell 1822)

Jacob Maithya

Abstract

Changes in body muscle composition of *Clarias gariepinus* were studied in fish reared from 1.08 g to 383 g mean body weight in a 201-day culture period. Changes in the amount of protein content, dry matter and ash-free dry matter in the muscle tissue can be described as a function of body weight. The percentage of protein content was observed to be higher in bigger fish. Fat content was low throughout the fingerling stage. Specific growth rate decreased significantly at 400 g mean body weight ($P<0.05$) while feed conversion rate increased. The conclusion, based on the culture conditions in this study, is that the optimal weight for harvesting *C. gariepinus* is 400 g.

Introduction

The culture of the African catfish *(Clarias gariepinus)* has become popular among African fish culturists. The growing interest in *Clarias* culture has been associated with its size, fast growth, omnivorous feeding habits and resistance to extreme environmental conditions. The relatively simple techniques for artificial reproduction, coupled with its widespread availability all over Africa, greatly favor the culture of this species (Ozouf-Costaz et al. 1990). *Clarias* culture in Kenya is presently concentrated in the western region and has almost replaced tilapia culture.

To reduce production costs, the ideal harvesting stage must be known to the farmer. This experiment was designed to assess the changes in the composition of muscle tissue of *C. gariepinus* with reference to fat and protein buildup during its growth.

Materials and Methods

One hundred artificially produced *C. gariepinus* (mean weight 1.08 ± 0.61 g) were randomly selected and used in the experiment. Fish were stocked in two replicate 60 liter culture tanks and reared for 201 days in a flow-through system.

The fish were fed two times daily on an optimal commercial trout diet recommended by Hogendoorn et al. (1983), as the most efficient feed conversion was observed in *C. gariepinus* fed with this diet. Twenty fish from each tank were randomly sampled biweekly for weight and length measurements. At least 5 fish from each tank were killed, filleted and preserved at 20°C for fat, protein, moisture, dry weight (DW) and ash-free dry weight (AFDW) analysis. Crude protein was determined using the Kjeldahl N x 6.25 technique. Crude fat analysis was done using acid hydrolysis followed by fat extraction. Dry weight was obtained by drying muscle samples at 100°C in an oven for a minimum of 16 hours (until constant weight was obtained). Ashing was done overnight at 550°C in a thermoactive muffle furnace.