# An investigation into the fish farming practices of Uganda

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*Contents*

*Table of Contents*



*Table of figures*

*Acknowledgements*

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Introduction

The culture of fish is a 3000 year old industry which has only experienced rapid development in the last 40 years. Today, the industry supplies fish whish accounts for half the world's consumption. One of the most common species cultures is tilapia (*Oreochromis niloticus*), and its production is increasing. In 1950 worldwide production was 4128T, increasing to over 3 million tonnes in 2009. In the UK the demand for the species is increasing. This demand has been met by an increase in the import of fish from overseas and increasingly, the development o indoor recirculating systems, To such an extend that in 2008 the Environment agency held a symposium on tilapia culture in the UK to identify the challenges and opportunities and prioritise research.

As a lecturer in aquaculture it is incumbent on me to teach the farming of a variety of fish species. Students, upon qualification, are then able to develop fish farming in the or abroad. With the UK tilapia farming industry still in its infancy there are limited opportunities to update my practical knowledge or its practices, so I looked overseas. Uganda was investigated for a number of reasons: it too has a growing tilapia culture industry (though more productive than the UK's): from 5MT in 1984 to over 11000MT in 2006. Uganda has the advantage of being English speaking. It's politically stable and safe – unlike many African nations, and it cultures fish in a variety of methods, from small scale, extensive/subsistence level to commercial ventures. So from 13 July – 5 August 2010 I visited a total of 7 fish businesses within Uganda, usually staying for a number of days so that I could be involved in a range of practical tasks and procedures and gain a full understanding of the methods and challenges involved. I would also use the opportunity to investigate a number of other fish industries and farms culturing the other main food fish – catfish – to compare and contrast with the UK situation.

Site 1: 'Pets Alley' Aquarium and Pet supplies. Kampala. Mr S Kamugisha

The aquarium trade in Uganda has increased a great deal recently, yet the industry is still very much in its infancy compared to the UK. Most domestic aquaria are sold on 'contract' – an arrangement very uncommon in the UK but one that might be investigated. The aquarium is bought 'leasehold', so to speak, and Pets alley is under contract to install and maintain it regularly. The customer has the benefit of a decorative, thriving aquarium with no effort and the retailer benefits from the servicing charges and provision of wear and tear, food, medication and so on. The most similar arrangement in the UK is where a discreet business will maintain aquarium (often in hospitals and waiting rooms) but there is no connection with retail sales. In the UK, a recent survey found that 50% of aquarium keepers leave the hobby within 3 years. The drop out from the hobby (due to lack of success or an underestimation of the effort required) is regarded as the main limitation of the UK aquatics industry so this practice may be a way of addressing the situation.

Uganda contains or borders a number of vast lakes: Wamala, Kyoto, Albert and Victoria – the latter being the 2nd largest freshwater body in the world. The vast majority of the fish species are endemic and unique to the lakes. Also, many species are highly valued by British aquarium keepers for their uniqueness and beauty. It was surprising, then, to find that none are kept in aquaria in Uganda! This may be because of their familiarity. Instead, the most popular fish is the goldfish in its various forms (shubumkin and so on).
Aquarium manufactures are predominantly Tetra and Sera. Both are German companies and very prominent in the UK.

Site 2. Aquaculture Research and Development Centre (part of the National Agriculture Research Organisation). Kajjansi, Entebbe. Dr J. Rutaisire

The Aquaculture Research Centre in Entebbe is responsible for developing the best culture methods for tilapia and catfish and investigating new species.
The centre has enjoyed a substantial investment by the Chinese, apparently because the fish farms in China are contaminated or inadequate for current demands. Such investment has allowed the construction of enormous so called 'recirculating' culture systems (where water is continually re-used and so must be constantly circulated through filters) (see fig 1). Such systems are used – albeit on a smaller scale – in the UK for culturing tilapia so I spent some time with the engineers understanding the mechanics of water flow and treatment through the system.

Figure 1 Recirculating culture system

The earth ponds (see fig 2) are run on a 'semi-static' basis (where water is moved into the pond then partially replaced when it has deteriorated) – a practice common in the UK because it uses a fraction of the (expensive) water that a 'flow-trough' system uses (where water continually passes through the culture system and then on to waste) but still maintains a degree of quality. The water used is from streams and agricultural runoff rich in nutrients. This, combined with the fish waste, light and warmth produces a fish algal soup in the ponds; a process known as eutrophication. Whist nutrient-rich habitats are desirable to an extent, high levels are algae result in very low oxygen levels in ponds, particularly at dawn, and cause other essential parameters such as pH to fluctuate wildly. Eutrophication is well known in the UK so it was interesting to see its management in tropical countries. The semi-static flow through the pond means that upon the water becoming too green a large water change can be performed.

Figure 2 Semi-static culture ponds – note water being piped in at the near side

Refinement of standard practices was also observed. Catfish are grown at a stocking density of 15 per square meter and harvested at a market size of 500g within 7 months. Tilapia broodstock are kept as mixed sex groups in ponds (fig 3). Fry are continually cropped. Indeed, considering it is a research facility, I was surprised at the lack of control in fry production. It would be better to know and control the number and progeny of the fry more than continual cropping allows). Of the resulting fry, some are raise in pond, others in cages.

Cage culture is a relatively recent culture method in Uganda and I was interested in its application to the UK's situation. The advantages are that an extremely high stocking density of fish can be raised in a small space (100 fish per m2). Yet good conditions are maintained because of the volume of water and exchange within the cages (fig 3). Also, harvesting is much easier - the cages are simply lifted from the water. The 'disadvantage is the food must be floating as sinking pellets would clearly sink through the cage, beyond the fishes' reach. Optimal stocking densities and culture regimes are still being perfected and I look forward to receiving their finding. The limitations to fish arming were largely dissimilar to those of the UK, but typical of an emergent industry; namely food quality and availability. There is one feed supplier – Ugachick – in the whole of Uganda which can therefore demand high prices for a product of dubious quality. To combat this, the Entebbe centre is constructing its own food mill. Although here are several fish food manufacturers in the UK the market for tilapia food is not significant enough, yet. The UK is however in the fortunate position of suing the next- best alternative (a carp diet) until demand is met with economical production. The other problem in Uganda is predators, of which there is an abundance in Uganda. Several familiar enemies: the heron, the cormorant, the king fisher (4 species!). These are discouraged by growing fish in deep water so they can escape the surface feeding birds. Also, some unfamiliar enemies: snakes and monitor lizards. These re discouraged by keeping pond banks mown short and removing scrubby refuges.

Figure 3 Cage culture

Site 3. Umoja Fish Farm, Kampala. Jocylyn Rugunda.

Umoja fish farm cultures tilapia, catfish and goldfish. It is a medium sized farm with a hatchery, 5 nursery ponds and 4 on growing ponds. It is also developing a recirculation system.

The tilapia, as at Kjansssi, are allowed to spawn continually in ponds at a ration of 3F to 1 M. The fry are netted out when there is an order and sold on. Catfish are maintained in broodstock ponds at a density of 1-1.5kg/m2. In order to breed they mist be artificially induced. Males are sacrificed and their pituitary gland (at the base of the brain) is removed and masked into saline. This releases the breeding-stimulating hormones (such as gonadotrophins) stored there. This preparation is then injected into females at a weight to weight ratio – i.e. one, three kg male will induce three, 1kg females. Eighteen hours later they are stripped of eggs, and another male sacrificed to remove the testes to fertilize. When I suggested using the same male, the difficulty was explained that it is not possible to keep the milt cool and viable for the 18 ours interim between induction and stripping. Females after stripping are returned to the ponds and will be ready again within a few months. The eggs are photosensitive so the hatchery is maintained in darkness. They are also very sensitive to temperature fluctuations. Water from a borehole is used in the hatchery because it is clean and free f diseases ad potential predators (dragonfly larvae and the like) but the problem is the temperature fluctuations. In the day time the air temperature heats the water to 24C but at night it can drop to 19. Therefore the water is heated continually to maintain a constant temperature. The fry are fed a small shrimp called *Artemia* as is the practice in the UK. After 2-3 days they are gradually weaned onto a high protein (45%) dry diet. In growing on the main concern is water quality, particularly dissolved oxygen, carbon dioxide and ammonia. The manager informed me that if these are optimal then stress, and consequently disease, are eliminated; a good strategy that I will reiterate to students in the UK. The fry are then sold on to other fish farms or grown n. The farmers appeared to be the main market. Larger, 2-3 ,month old fry, used to be in high demand as bait for the Nile perch of lake Victoria, though, interestingly, with the collapse of that fishery de to over exploitation the consequent demand for bait has been decimated. Some fry are on-grown to adults, and even reach 1-1.5 kg after a year or even 9 months if feeding is intensive. The manager

reiterated observation I have heard form UK carp farmers, namely that feeding little of a nutritious, high protein diet is more economical than feeding a greater quantity of a less nutritious food, though the total const of either might be equal. The current theory is that a fish fed infrequently will extract every bit of nutrient from the food. Again, this is worth repeating to potential farmers of any fish species in the UK.
The manger explained that there is a large potential market: indeed they cannot produce enough fry. The main limitations are the lack of sufficient, heated water and availability of suitable food.
Fish are grown in mud ponds, as in the UK, but there is some trouble with sediment. With every harvest or grading fish would dive into the mud and damage themselves or remove their protective mucus layer with a consequent increase in disease - to the extent that the farm could loose 60% of smaller fish. Then ponds with a rubber liner were tried but, interestingly, because of a lack of the natural filtration abilities of bacteria in the sediment the farmers found that the water quality deteriorated. In the end, the farm only uses earth ponds but they are stocked with much larger size fry which is more robust and losses have been minimised. This conferred the other advantage of protection against predators (again, mainly birds). This is the first commercial farm I had visited so it was refreshing to see a cost benefit strategy in operation. Due to the lack of water it was more financially viable to produce a high number of fry than a lower number of table fish. Also initiated by lack of water was an investment into recirculation systems which use the same water continually and are therefore extremely water efficient. Though the initial investment was costly results have been very promising. It was interesting to note how similar the designs of the systems was to their equivalent in the UK where the financial burden of energy for heating water had encouraged their use in tilapia culture systems.

Site 4. Edrhon Fish Farm. Edwin Bwule. Kampala.

Edrhon is a small scale, subsistence farm with just three ponds culturing catfish and tilapia. At the start of the farming cycle the ponds are dried and treated with agricultural lime for 7 days to sterilize them. Water is then added from a communal well. Chicken manure is added to fertilise the water. Tilapia benefit from some algae in the water as food and security. The level of algae is measured by the opacity of their water and controlled by adding more manure or water changes with fresh water as appropriate. At this stage the fish are added, Mr Bwule buys 10cm fingerlings (from suppliers including Namuyenje fish farm). The larger size has a greater survival rate. Mr Bwule pays a premium for the fingerlings to be graded before delivery as grading them upon delivery resulted in up t 50 mortalities. Fry are fed to satiation. Sampling to check on growth is done every month initially, then subsequently less so when the progress can be assessed by eye at feeding. Due to the expense and scarcity of formulated food, the algae in the ponds is the main food of the fish, augmented with chicken food which was surprisingly well accepted by the fish. The tilapia are ready for the market (350g) after 8-9 months. In terms of economics, the fingerlings are purchased at USh100-200. If sold fresh they might sell for USh3000 per 1kg of fish, which it seems, does not give much of a margin -- much the same as trout farmers in the UK. However, Mr Bwule found that by smoking the fish (done by his wife) the value can be added so that they can be sold for USh6000. Such is the popularity of the smoked fish that they are unable to keep up with demand. The farm was a model of what can be achieved when resources and investment is limited, but the procedures well managed and the marketing potential thought through. The use of algae is infeasible in the UK as tilapia cannot survive let alone grow outside in the sun

(such as it is) in the UK. Perhaps there is some possibility of investigating culture in greenhouses if the effects on temperature could be controlled.

Site 5. Namuyenje Fish Farm, Mukuno. Mr Omar Wadda

Namuyenje fish farm is a substantial farm, invested in heavily by Mr Wadda, an engineer by training and owner of 60 acres of which 20 acres is dedicated to the farm. At present, the farm covers about 2/3 of the land allocated to it but it is expanding continually. The farm produces both tilapia and catfish, though predominantly the former because the demand and profit from them is greater. Mr Wadda explained that it was very straightforward to raise tilapia to 150g. The growth was very quick to this size. What was a greater challenge was raising the fish to 500g (a size easily sold at market) economically. The larger market size (than say Edrhon's harvest size of 350g) was due to the proximity of Lake Victoria where tilapia of 1kg were currently caught. Growing fish to 1kg was out of the question, but the current investment was from Mr Wadda's prediction that the lake's fishery would collapse and then culture fisheries would be in an enviable position. Such prediction is neither unprecedented nor unreasonable: the most abundantly cultured fish in the UK, Salmon, was initiated by their declining wild stocks, and the culture of cod is developing for the same reason.

The main limitations of the farm are; predators (the farm was in a very rural location and birds abundant) and materials – seine nets with a small mesh size are difficult to obtain since the government banned them in response to the falling wild fish stocks. So every net must be specially made.

Fish are cultured in ponds and cages. The latter are held in a reservoir fed by underground springs whish subsequently drain into the rest of the farm. The cages -2mx2mx1.5m – are stocked with 2000-2500 tilapia of 30-35g. With intensive feeding dish are ready for harvest in 5-7 months. Feed, again, is difficult to obtain. Currently the food manufacture (Ugachick) is using soybean mean instead of fishmeal. Soybean is known to be less usable and palatable to fish. This was evident in the fishes' poor feeding response. The farm is trailing the culture of two tilapia species; the usual O *niloticus* and *Tilapia zilli*. Mr Wadda had heard anecdotal evidence that the latter out performed the former. Though in trials to date there has been no significant difference.

The culture of tilapia starts by conditioning the broodstock which are separated into ponds according to sex to avoid unwanted breeding. Fish are fed 5% BW for 2 weeks. Then they are transferred to breeding ponds for 2 weeks at a ration of three females to one male. In the 3$^{rd}$ week the adults are netted out, with a wide gauge net, and then the fry are netted out with a finer net. The fry are transferred to nursery ponds which have been fertilized as described previously so that natural food is abundant. The breeding pond is left to drain and dry (fig 4). After 1 month in the nursery ponds the fry reach 3g and are sold or transferred to grow out ponds where they are fed pellet. Due to the lack of food availability Mr. Wadda was planning on making his own fish-food. Small, sardine-like fish are available from the lake and could be ground to supply fish meal which when added to other readily available ingredients such as cassava flour, could be pelleted to make a better diet than that available from Ugachick. Furthermore, it would mitigate the variability and unchallenged price rises experienced with Ugachick's feeds. In a business where profit margins are small, having such an unregulated variable cost is untenable.

Figure 4 Dried breeding pond

Catfish are spawned as previously described. Though at Namuyenge there is ice to keep the gonads of the males (sacrificed for their pituitary) fresh to fertilize the eggs. After 24 hours the eggs hatch and feed on their yolk sac until the 3rd day when they are fed live food. Live food is cultured by mixing a small amount of chicken manure with dry grass. Green water and fresh water (50:50) is added and after 4 days the broth is teaming with microscopic organisms, ideal as a first food. I was intrigued to learn this method of live-food culture as successful methods are always being investigated for the culture of ornamental fish at Sparsholt college. I will get the students to investigate if they can replicate this method for their projects. Cat fish grow at a prodigious rate and after 3 days live food is too small for them so they are transferred to a fine crumb feed. This continues in the hatchery for 2 months until the fish reach 10g when they are ready for stocking into ponds or selling on. An innovative way of heating the hatchery has been developed by Mr. Wadda, consisting of a black pipe laid in a spiral and slowly draining into a central reservoir (picture), the heated water is then mixed with the cool borehole water to reach 28$^{o}$C. Enough excess warm water is generated to be stored to last through the night. Though such a method could not be relied upon with the vagaries of a British summer, it could be investigated as potentially contributing some heated water and thereby offsetting heating costs. Solar power water heaters are of course available, but are notoriously expensive, whereas this version costs no more than a black pipe.

Site 6. Kikota Integrated Farm, Soroti. Mr. P. Ontario

Kikota is a medium sized tilapia and catfish farm. It is owned by Mr. Ongaria, a businessman involved in IT. Within the 5 acres are chicken, goat and cattle rearing, as well as various crops. The aquaculture venture is only 2 years old and was initiated by Mr. C. Oberis, an aquaculture graduate who wanted an investor and landowner to develop his ideas with. The farm itself, and its aims, are similar to the other sites. What was useful and interesting about Kikota was seeing the effects of poor management on the farming process.

Mr. Ongaria very rarely visits the farm, and Mr. Oberis is employed as a fisheries officer. So the farm is run by two nephews of Mr. Oberis without training in aquaculture but who follow a set of guidelines and duties laid down weekly by Mr. Oberis.

Water is pumped from a well by a solar pump – the first I had seen in my visits – which only works in bright sunshine. Because, if the day is overcast (or of course at night) the pump doesn't work, water is stored in a reservoir water tower. This gets very warm and being straight from the ground, virtually absent in oxygen.

The day I arrived catfish eggs were hatching. Ugachick did not have any food available, so there was nothing to feed the fry on. They were unaware of if, or how, to culture live food like Namuyenge. The culture troughs were filled with water from the tank which was 5 degrees warmer than the egg trough, and the fry were shaken into it. The water in the trough was static and cooled during the night. Every day the workers were instructed to conduct a water change which they did by siphoning out the fry into sieves, cleaning the troughs and refilling them with the warm water before shaking the sieves back into the tanks. Not surprisingly, considering Umoja's explicit description of the fry's sensitivity to temperature fluctuations, mortality runs at about 90%.

The survivors, at 2g, are moved to nursery ponds, where they are fed a low protein adult food that is manually ground down by the staff on a daily basis. During my stay at the farm, the catfish fingerlings were graded by pulling a net through the ponds (picture) on to the bankside. From here they were picked by hand into a bucket. From the bucket they were netted out and handpicked again into 2 grades: small and large. There was no weight taken or count made. Unsurprisingly considering the handling, time spent in the air and water changes from bucket to bucket, the grading results in heavy mortalities.

Tilapia culture is similarly haphazard. There is one mixed broodstock pond. Occasionally, a small gauge net is dragged through it, the fry, adults and copious mud brought out on to the hot bank. The adults are thrown back and the fry picked out of the mud into buckets. The procedure is repeated several times until the buckets are emptied into the nursery ponds. Mortalities amongst the clay covered, oxygen starved fry are high.
Feeding of the ongrowing fish is haphazard. There is no knowledge of the number of fish, their weight or the appropriate amount of food to feed.

Despite all this, my stay was very useful. It clarified the importance of trained, knowledgeable staff and that aquaculture cannot run successfully via a to-do list, and of the importance of planning everything from the number of fish produced to the availability and management of waste and feeding. And it presented a number of excellent scenarios (which I was able to advise upon) which can be given to my students as real life situations for them to analyze and develop their own ideas from.

Site 7. Source of the Nile. Jinja. Dr Damien Desprez.

The Source of the Nile (SON) fish farm was the largest and most well developed fish farm I visited. It is purely tilapia. Its current site, at the North East corner of Lake Victoria and a t the mouth of where the lake becomes the river Nile, was first viewed as a potential site only 3 years ago. The owners of the business, British based, had a tilapia production facility in Zimbabwe, but due to the political unrest of that country were looking to set up elsewhere. The site benefits in having a substantial flow of water for its cages (picture) and a large area for its ponds (picture), which are leased from the prison on a site opposite the lake to the town of Jinja.

The company's largest customer for whole tilapia is the UK, but more and more it is experiencing a growth in its fry production. It supplies much of Uganda. 300,000 fry in 2008 double that in 2009. The customer base is changing however. The American government's development project 'US Aid' set up many small-scale fish farms from 2000, but pulled out in 2008 largely due to the tragedy of 9-11. Since then, the orders from small-scale farms have dwindled, reflecting the demise of the businesses, and a few strong projects have grown instead, placing large orders. Nevertheless, its biggest customer for fry is Kenya. The government there has, in a substantial development project, offered training, grants and free fry to people wishing to set up tilapia projects. Currently SON supplies $4 \times 10^6$ fry per year to Kenya.

The production manager is European, Dr D. Desprez, and he has meticulously planned a very organized production protocol.

At the inception of the project, 8 bloodlines or strains of fish were selected from 3 lakes around the region (Kyoga, Albert and Victoria). This has remained the bloodlines for all the fry grown at the farm. To maintain genetic diversity, spawning males from one group are crossed with females from another. To avoid predators building up in ponds (such as dragonfly larvae) the breeding ponds are left dry until immediately before adding the broodstock (picture). Liming is not done as it appeared to confer no benefit in their trials. The adults are allowed to breed for 24 days in the ponds. Three times within that period, the adults are netted out and the pond drained. The fry are then collected from a concreted drainage basin (picture). They are collected (mud-free) from here in buckets and counted. It is usual to get 100,000 fry per 'spawning run.' The fry are then transferred in oxygen (pictured) to happas. These are rectangular nets (actually mosquito nets for single beds!) staked into ponds. The fry are then 'treated.' This involves feeding them a diet laced with testosterone for 21 days a known volume 8x/day (fig 5). This changes them to all male fish. Females are not desirable in tilapia farming as they become sexually mature at a small age and thenceforth invest all their energy into raising fry rather than growing. They also provide a distraction from growing for the males (who build nests, display and fight to win them). Ponds are filled from a land based small river but the lake water quality is better and more stable so plans are afoot to pump it from there. The fry food is made on site with 70% fishmeal made from the waste fish from the lake catches, to give a protein of excellent quality and level of 45%. Growth, unsurprisingly, is very rapid (In their own trials, fish fed on the commercial food grew to 200mg in 2 weeks, whereas those fed on their own crumb reached 450mg). Fry must be graded regularly and for this an ingenious method has been developed.

Figure 5 Feeding tilapia fry

All fry are transferred from the happas into a small cage suspended in another happas and covered by fine mesh. Water is gently wafted into the cage and the fry respond by swimming against it. Those that can fit swim right through the small cage into the happas. Thus fry of 0.06 – 0.07g are graded out. The remaining fish are then moved into a larger gauge net and then the process is repeated, extracting fish of 0.08 – 0.1g. The largest grade fry (remaining in the small cage) are then transferred to a final happas. In this way the fry are graded with minimal stress, no direct contact, minimal exposure to air, and very accurately. The smaller grade fish are thus provided with the space and access to food that their larger siblings prevented. This method is directly applicable to the UK and easily transferred. After grading, a sample of fry is counted and batch weighed to obtain the average weight. The remaining fry in the happas are then weighed to calculate their number and know how many fry are being transferred to the on-growing happas. In ongrowing, fry are fed a measured amount of food 6 times per day. Previously, fry were grown on to 10g before transfer to cages, as a fine grade net (to make the cage from) was unavailable. Now, such a mesh is available and fry are transferred from as little as 1g. Growth in cages is better than in ponds because of the constant access to fresh, oxygenated water. The only issue with the cages are the growing number of pelicans who, though they cant reach the fish, are fascinated by them and on sitting on the cages foul and damage them and scare fish from the feeders. A solution to this has yet to be found. Once in the cages, the fish are fed from a demand feeder (pictured), fish hitting a pendulum in the water (in their search for food) will cause food to drop down from the hopper. With such intensive feeding, growth is very rapid, up to 600g in 6 – 9 months (average 8) and harvests of 2.5 tonne per cage have been obtained (though usually nearer 1.5 tonne). Nevertheless due to the current prevalence of a wild fishery, the sale of fry, rather than larger fish, is more straightforward and more profitable.

## Conclusion

In conclusion the aims of the investigation have been achieved.

Through visiting a number of fish farms I have gained insight and experience into the practical tasks involved in the whole production cycle, from hatchery to harvest. The methods were, in fact, surprisingly similar to the methods used in the UK in farming tilapia and other species. Therefore I am confident that the skills I pass on to students will serve them well in whatever aspect of fish farming they progress on to.

It was useful to visit farms demonstrating a range of development, from subsistence to commercial, extensive to intensive. Lessons were to be learned from both. The substantial recirculating system design at Kajansi can be applied, perhaps on a scaled down version, to its equivalent in UK tilapia farms. The parsimonious feeding of a nutrient rich diet, rather than standard or excessive feeding of a cheap alternative is worth reiterating to students. The merit of considering a ‘value-added’ approach to marketing as practiced at Edrhon where smoking fish doubles their value, with very little outlay. This has been adopted in the UK for salmon and trout so it would be interesting to investigate the potential for the product in our own markets. In any case, it is a useful business model to explain. The use of algae as a substitute food should be investigated as it could considerably cut down on the most expensive element of any fish farm operation, namely the food. The live-food culture method perfected at Namuyenge is directly applicable and very useful in culturing all small fish larvae in the UK. The meticulous planning and breeding protocol seen at the Source of the Nile fish farm demonstrates how many tilapia can be produced when parameters are

controlled and optimal. Finally the brilliant method for grading fry which not only saves on manpower, but is much better for the fish.

Overall, the clear lesson to take back to students is that a small tilapia unit can be as successful as a substantial farm if it is thoroughly planned. The low-scale operations do have a place in the market as long as the following are considered before the venture is undertaken.

- Availability of water and efficient, economically heating
- Availability of a consistent, economic, suitable food.
- Fully trained and knowledgeable staff and management who are given incentives to maximize production
- A controlled, stable market
- A clear business plan where all fixed and variable costs are considered and weighed against the income generated.

Of immediate application are the live food culture and grading procedure. Sparsholt college runs a substantial culture system for tilapia, catfish, carp and ornamental species and these lessons will be implemented directly.
Other concepts will be considered with the hatchery managers of Sparsholt to see whether working models could be developed and their merits tested before disseminating to students and future Tilapia conferences in the UK.
Certainly the future of the tilapia industry in the UK looks bright. The demand is clearly there based on SONS exports. As familiarity grows, so will demand, and with the findings of this visit, the students and potential tilapia farmers of the UK will be ready to meet this demand.