Kenya Aquaculture Farmer to Farmer Program
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Final Trip Report

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Jewlet Farms, Kendu Bay
Enos Were, Managing Director

Enos is an enterprising individual who is concentrating on developing his two farms after quitting his role at Dominion Farms in August, 2012.

His focus is on tilapia, though he does keep some catfish (*Clarias gariepinus*) at the lower farm.

The upper farm, deep in the hills above Kendu Bay, only has tilapia. The farm is 4 acres, comprised of 16 ponds. Because of the difficult, rolling topography, the pond walls tend to be very tall on the uphill side. As he covets every single square meter of culture space, the sides of the ponds are exceedingly steep, greater than 1:1.


Picture 001 Jewlet Upper Farm Pond Banks

The upper farm water is sourced from a shallow well, only 3 meters deep. There are some natural springs that he allows to flow into the ponds, but these volumes are minimal. The natural spring flows are milky in color.

He has no water chemistry data.

There are times of the year, approximately two months in duration, where water is in short supply. He has developed water management strategies whereby he moves water from one pond to the next in order to conserve not only volume, but also fertility. The lowest temperature occurs in the "winter", June through August, when the water may drop as low as 19 C. The past year the temperature only reached down to 21 C, an occurrence he termed "a blessing".

The fish are fed a 'mash' of freshwater shrimp, sunflower cake and rice and/or wheat bran. He has a hammer mill and a mixer on site.

The fish are a pure strain of Nile tilapia. The broodstock range from 200-500 g. To spawn, they are stocked in the "breeding ponds", which range from 200 to 800 square meters, at 1-2 fish per square meter. The sex ratio is from 1.5 to 2 females per male.

Every 14 to 21 days, depending on the seasonal temperature, the breeding pond is completely drained and harvested. The goal is to harvest yolksac fry. If eggs that are about to hatch are harvested, these are suspended on hapa mesh 1 cm below the surface of the water to maximize warmth, and are hatched within a day.

Picture 006 Jewlet Upper Farm Tilapia Nests at Harvest

The lower farm is located along the shores of Lake Victoria. This operation has ponds up to a quarter acre in size.

Hapas measuring 5m x 10m x 1.2m deep are utilized for breeding. These are stocked with 3-4 brooders per square meter, at a ratio of 3 females:1 male. The hatchlings are harvested every 14-21 days, depending on temperature.

Picture 013 Jewlet Lower Farm Spawning Hapas

Enos imported breeding hapas from Thailand, and now produces them for sale locally.

At both farms, the hatchlings are fed a hormone-treated feed for 28 days in a nursery pond that has an active zooplankton bloom. The ratio of hormone to feed to ethanol is 60mg/1 kg/0.5 liter.

The combined production from both farms last year was 6 million fry. Sale price ranges from 4-7 KSh/fry. The fry are mostly sold at 0.3-0.5g, about 1 cm length, though fry up to 5g are also sold, with no additional premium charged for the increased size. Interestingly, though approximately 90% of his fry sales are sold as "sex-reversed", he also sells the other 10%, not sex-reversed, for the exact same price.

Enos has a hatchery building at the lower farm, but it is not equipped or utilized.

Picture 019 Hatchery at the Jewlet Lower Farm

No water chemistries are taken at either farm. He "observes the ponds", which implies he monitors the blooms, and notes if the fish are piping for oxygen, at which time he adds water.

He applies agricultural lime (CaCO3) at a rate of 100kg per 800 square meters in the lower farm ponds, and has noted an increase in fry production and survival, at least for a short period of time immediately following the liming.

Total people trained: Nine Male, One Female

Problems Enos identified:

1) The facilities are expanding as rapidly as possible, as there is high demand for his fry. He has virtually no room to expand at the upper farm, unfortunately, and can only significantly expand the lower.
2) The upper farm produces much more fry per square meter than the lower farm. The ranges are 220-260 fry per square meter in the upper farm, and 80-100 fry per square meter in the lower farm.
3) The fry from the lower farm have poor survival and growth, compared with those from the upper farm. High mortality occurs when transporting the lower farm fry as well.
4) Enos hopes to hatch eggs in the hatchery someday, though this technology appears to be a ways off. No equipment such as hatch jars have been purchased.

Recommendations:

1) Although we did not have any water testing equipment, the symptoms of poor production, survival and growth are consistent with low divalent cations (Mg, Ca). While many factors, from genetics to densities, can result in poor growth, the telltale symptom was poor fry survival when handled, especially in transport: this is a classic soft-water problem. This diagnosis is further corroborated by the fact that when he added CaCO3, the survival was notably higher.

   My recommendation was to get a test kit for Total Alkalinity (please!), if nothing else. Target 150 mg/l; add CaCO3 until this level is achieved. And when the pond is drained, add the lime to the soil, and plow it in deep so lime can neutralize the soil acids. He indicated it would be difficult to get a plow in some of these ponds, and asked would it be ok to rake the lime into the muck to the depth of the rake head. I agreed this would probably be his best option for application, as he does not have the recourse to drain and dry any of the lower farm ponds due to seepage.

2) Grow grass on the steep pond bank slopes of the upper farm to stabilize the soil. He has begun to transplant the grass in small patches, but this process needs to accelerate or he will lose his very tall, very steep pond walls.

3) Verify his sex-reversal success. His ratio of hormone/feed/ethanol is reasonable. But to be pulling out hatchlings that may be as old as 21 days is the first critical mistake, as tilapia become sexually differentiated at Day 21 +-3 post hatch, which would imply that a

certain percentage of his hatchlings would already have become sexually differentiated before the hormone treatment had begun.

Further confounding his sex-reversal procedure is placing the hatchlings in a fertile pond with a robust zooplankton bloom. The fry will preferentially eat natural food; exposure to hormone-treated diets would be compromised, if any would occur at all.

Finally, he says he tests for sex-reversal success once the fingerlings reach 5g. That is too small. All fingerlings look male at that size. They need to be at least 25g for accurate sexing, and even then the oviduct vent is difficult to see to an untrained eye. The use of a dilute food dye to enhance the presence of the oviduct vent at 25g will provide verifiable accuracy.

4) Utilize the newest, well-established sex-reversal technologies .

We discussed the increased efficiencies of pulling eggs and hatching them in jars, and treating the hatchlings with hormone-treated feed as the sole source of nutrition, as per the well-established technologies in Thailand/Philippines/Bangladesh. He is interested in these technologies, and inferred he was starting to develop the hatchery to do just this, even pulling a wire out of an outlet at the hatchery building and saying "See?"

But Enos does not believe he has a problem with sex-reversal, claiming "99% male". This is a claim I cannot support based on the procedures I have seen.

Further, he says he gets the same price for his fingerlings whether they are sex-reversed or not. This is a critical issue: if there is no market force driving sex-reversal efficiencies, there is no need to increase efficiencies. He made it clear that buyers preferentially seek his fish because they trust him, and though he sells 90% of his fish as "sex-reversed", he openly sells the remaining 10% at the same price.

As the fish culture industry matures, there will come a time when he will seek true sex-reversal efficiencies. I perceive Enos is a far-reaching thinker who will respond to those markets with a higher quality product. Until that time, recommendations such as increasing his Alkalinity will boost his immediate production numbers, and perhaps that is the best we can hope for until market forces become more compelling.

Dominion Farms

I received a lengthy introduction to the facility by facility Director Chris Abir. He felt the greatest problems for the facility were bureaucracy-related: Hormone was expensive and difficult to obtain; tariffs on imported goods were onerous; bribes were rife. There were overlapping institutions and jurisdictions, licenses required, and audits performed at random. The VAT was 16% on everything in the industry. The sclerotic government, all while touting "Fish Production!" did everything to stymie their efforts. Spoken like a frustrated administrator.

But technical problems? None, really, that he could enumerate.

The Acting Hatchery Manager, Maurice Mbori, provided the tour of the facility, and he the one to whom I directed my technical queries and provided my detailed analyses.

Dominion is a huge facility. There are integrated land crops as well as fish production on approximately 2500 hectares. There are religious overtones to the operation, as discussed by previous F2F experts. It has been a private facility for the past eight years, after getting a long term lease from the government. The facility was in a state of disrepair and dysfunction when leased.

The water source for the facility is from a large canal, which is directed to the pond area from a river diversion dam.

The hatchery building is of fabric roof over metal frame, open on two sides. There are 21 round cement tanks measuring 2.0m diameter, 1.0m deep, with conical bottoms. There are 18 small troughs 1.0m long, 0.3m wide and 0.2m deep. There are 6 longer troughs 2m long, 0.3m wide and 0.2m deep. In three of the cement circulars, small hapas were hung; all the other tanks in the hatchery were completely empty. There were fish in only one hapa; there was significant mortality, and no obvious care.

Prior to this year (and most likely corresponding with the activities of Enos Were, who worked here until August), production was 4-6 million ‘sex-reversed’ fry per month. Now it was down to 2 million/mo. Previously, they sold 90+% of their fry. Now they sell only 30-40%; the rest are stocked in their grow-out ponds.

The hatchery and sex-reversal procedures were, not unsurprisingly, identical to those of Enos Were, at his upper farm. There are breeding ponds and nursery ponds. Breed ponds were stocked at 3 fish per square meter, at a ratio of 3 females to 1 male. All fish are removed after 9 days, then fed a hormone-treated feed for one month in nursery ponds that are blooming with zooplankton. Maurice claims 98% male, and says he has verified the sex ratio “after two months, when the fish are 5 grams”.

Picture 024 Breeding Ponds at the Dominion Farm

The ratio of hormone/feed/ethanol is suspect. Maurice gave it as 50g hormone/10 kg feed/1 liter ethanol. I spent quite a bit of time going through these numbers, writing them down, asking Julius to confirm, and this is what Maurice says they use. I repeated "50 grams, or 50 mg?" wrote it down and pointed to the obvious difference, and asked Maurice and Julius for confirmation, again and again. Maurice said they make lots of treated feed at a time, and this is their ratio. This is way off: this would be 100x the hormone per kg of feed, and there is no way 10kg of feed can be saturated with hormone using only one liter of ethanol; they would need a minimum of 5 liters. The desired ratio, for reference, is 50-60mg hormone/1 kg feed/1 liter ethanol.

Their production facilities are accelerating forward. There are plans to construct 120 one acre ponds. Eleven of these have been constructed to date. These are simple rectangles, water inflow on one end, outflow through a monk on the other, with depths ranging from 0.6m in the shallow end to 1.3m in the deep end.

The production in these one acre ponds have been reasonably impressive, if we are to believe the data: stocked with 80,000 advanced fingerlings (10cm), the tilapia achieve a mean weight of 450g in 6 months. These ponds receive a fill of water from the canal, and the fish are cultured utilizing a combination of green water and supplemental feeding, a semi-intensive culture methodology. The diet was of unknown ingredients; it was steam pelleted, utilizing obviously dull knives that pinched and crushed the pellet in the process. The pellet had a lot of fines and poor integrity. The fish were fed 40kg 3x/d.

I use the term "fish were fed" loosely here, and this was a point of discussion. A woman, obviously low in the pecking order, was the fish feeder. She simply dumped buckets of feed into the pond, tightly against the grassy shore. Though the feed floated for a short period of time, the wind, blowing into our faces, exacerbated the piling of the feed against and into the shoreline grasses. While the fish fed voraciously, there was a lot of uneaten feed that fell apart. Lots of fines disappeared as a cloud into the wind.

I brought a quarter bucket of feed to the upwind side of the pond, and discussed how we wish the feed to move across a larger area of the pond for better access, and how to use the wind to assist us rather than work against us. Though I proceeded with the demonstration in a smiling, light-hearted manner, and Maurice was the feeder, I could see the body language of the woman, hands on cocked hips: she perceived this was additional work of which she wanted no part. When we finished the demonstration and returned to the feed storage area, she filled the bucket completely full, and with impunity, dumped the feed, again, in the same spot she had dumped the last one, where the feed, again, jammed into the grass against the pond bank, and disintegrated.

I discussed with Maurice that oftentimes the person who feeds the fish is the lowest person in the farm, when in fact they should be higher up in education and experience to better understand the dynamics involved. I explained the concept of feeding to 90% of satiation, to watch the feeding behavior, and when the feeding frenzy begins to slow, that is good enough for that feeding, and to stop there; do not overfeed. The difference in how efficient the fish will feed goes straight to the bottom line, as feed is the highest operating cost of a fish farm. This efficiency issue would be more pronounced utilizing this particular fish feed of such poor integrity, as the time it took for the pellet to disintegrate was quite short.

The monk drainage structure was designed to have the boards inserted or removed by forklift: The monk boards were all connected with metal bands, and there was a metal loop at the top to enable the tong of the forklift to hook and lift. This mechanized concept is in keeping with a larger, overall attempt to reduce manual labor and intensify production in the facility (i.e. see next section on intensive high-density circular ponds). This push by management to mechanize something as simple as placing a board higher or lower to adjust the water level is ludicrous. The monk is a simple outflow structure that is designed with two sets of grooves to guide boards along their path. One should not have to call in a forklift to grab the metal loop at the top of a series of connected boards to adjust the water level in the pond. One should simply lift a board out or place one in.

There were no water chemistry kits or data of any kind.

Lastly, in addition to the one acre rectangular ponds, there are eight circular ponds designated for intensively culturing tilapia to market size. These ponds are lined with concrete, with a floor that is sloped down to a center drain. The ponds are 20m diameter, and DEEP, at least 3m in the center (Though Maurice could not give me an accurate depth, one pond was partially drained, and it was *at least* 3m deep.)

These circulars were designed to culture tilapia intensively, in a single-pass open system (water flowing in, water flowing out at all times). The water comes from the canal/river system, and as it was very turbid, so was the water in the pond.

Picture 030 Concrete-lined 20 meter diameter circular pond, with turbid inflow water.

This type of high-density system depends on a constant supply of high-quality inflow water to provide the oxygen necessary for the fish. The diet is not supplemented by zooplankton blooms;

100% of the nutrition has to be provided by the formulated diet. Temperature in the pond will be the same as the temperature of the inflow water.

Not surprisingly, growth was poor in these ponds. Stocked at 40,000 fingerlings/pond, it took more than one year (compared with 6 months in the 1 acre ponds) to achieve the targeted weight of 450g.

There are a number of problems with the large circular ponds:

1) The turbidity is extreme. I placed my hand in the water, and lost sight of it at less than 10cm. Tilapia are sight-feeders, and do not do well when they cannot see the food.
2) The diet, the same steam-pelleted crumble applied to the one acre ponds, is nowhere near a complete source of nutrition.
3) The ponds are too deep. The excessive water depth serves no useful purpose, tilapia are not deep water fish, and will not occupy these depths.
4) Further, the center drains are pulling water off the top. Especially in this type of single-pass circular flow design, the center drain should utilize a venturi pipe. A venturi pulls water (and settleable solids, and anoxic water) off the bottom.
5) I am sure the temperature stays far below the optimum temperature for growth (OTG) for tilapia, which is around 29C. It was estimated at 23C on the day we visited. Every degree C lower than the OTG results in a loss of 6% of potential growth, even if all other high-density assumptions are met.

Overall Farm Recommendations:

Hatchery

The hatchery operations are identical to Enos' upper farm:

Recommendations:

1) Breed the tilapia in hapas; pull fertilized eggs and hatch them in jars, as per the Thai/Philippine/Bangladesh models. F2F expert Amrit Bart suggested a two-week course in hatchery operations at his facility, AIT, and I concur. An immersion into real sex-reversal technologies and procedures would vastly accelerate Dominion's hatchery facility forward.
2) Standardize the ratio of hormone/feed/ethanol along industry norms.
3) Verify sex reversal. The reported "99% male" is very questionable.

One Acre Grow-out Ponds

The one acre ponds, managed semi-intensively, are the best hope for this operation.

Recommendations:

1) Improve feeding technique. Distribute the feed to the pond on the upwind side to spread feeding activity and opportunity in the pond.
2) Feed to 90% of satiation during each feeding.
3) Obtain a farm water test kit that covers the full range of basic parameters.
4) Change the monk boards from all-connected, requiring a mechanized lift, to individual boards that are manually placed one at a time in the concrete grooves. Sometimes older, proven technologies are better; not everything has to be mechanized.

Circular Ponds

The notion that fish, specifically tilapia, can be rapidly and predictably cultured in a high-density system is well accepted. Loading factors such as Piper's and Klontz's have been developed, tested and operated commercially with tilapia since the 1970s with great success. A high-density, single-pass open system has as the core assumptions the inflow water is clear, is at the optimum temperature for growth of the desired species, and is at 100% of oxygen saturation. To carry this high-density loading concept from the linear raceway to a circular system, water flow efficiencies have to be maximized: in a circular system, water has to be spun at a velocity to centripedally sump the solids to the center, and the effluent has to be pulled off the bottom with a venturi pipe. Finally, the diet has to supply 100% of the nutritional requirements of the fish.

A stocking rate of 40,000 in this volume is far below the densities of tilapia achieved in high-density systems elsewhere, worldwide. They have reduced the stocking rate to 30,000 per pond with the fond hope that their growth will increase, perceiving that the problem is density.

Why the poor growth? Other F2F experts have suggested that genetics are playing a role here, and this may be true to a small degree.

However, all of the high-density single-pass open system design and operation assumptions mentioned above are violated in this design, and I believe it is far more a design and operation problem than a genetic one.

How can we improve the flawed design we have? These recommendations will not enable the design to ever achieve what other high-density single-pass open systems achieve worldwide, but they will increase production somewhat:
1) Minimize inflow water when the canal system is turbid.
2) Provide oxygen with supplemental aeration, utilizing a 5hp rotary-vein blower that would inject air (oxygen) to the deepest portion of the pond. This will supplement dissolved oxygen during low inflow times.
3) The center drain requires a venturi pipe to pull the effluent water off the bottom of the pond.
4) The diet should be re-formulated to meet 100% of the tilapia's nutritional requirements.
5) If possible, provide an extruded diet rather than a steam-pelleted diet. This would retain its integrity much better than the poorly manufactured diet currently utilized, and would have zero fines.

ThinQubator Aquaculture

Otieno Okello, Owner, Manager

The logic of raising fish in a recirculating system has been raised by previous F2F experts, and justifiably so. But Mr. Okello is a firm believer in the concept after his observations and experience in South Africa. He has operational systems that I reviewed, and he consults on design for small recirculating systems that are in the start-up phases elsewhere in the country, especially near Nairobi.

He observes that Nairobi is "going crazy for fish", a recent, accelerating trend that shows no sign of abatement. He is involved in the initial design and construction of hatchery facilities near Nairobi that are targeting the production of 200,000 fingerlings per month, and grow-out facilities that will produce 4 tons per month. These are all recirculating systems.

His system was a patchwork of tanks and lined ponds. He utilized electric pumps to move water from low sump areas directly back into the tanks; his greatest operating expense by far was electrical consumption. He had no water chemistry information whatsoever. He complained of algal blooms.

Picture 036 A ThinQubator fish pond, with a top drain design.

I spent a lot of time going through all the assumptions of a fully operational, commercial-scale recirculating system. He was a sponge for new technologies, and was very appreciative of the time we spent penciling out page after page of design criteria, parameters and specifications.

Picture 044 Sack of pumice stone currently utilized as part of the biofilter system.

Recommendations:

1) Reduce power consumption by utilizing airlift for water movement. Design parameters and specifications with drawings were provided.
2) Eliminate pumice stone; these are a liability, not an asset. These rocks were in sacks in the sump areas, sealed, and were doing nothing but clogging with organic debris, creating pockets of anaerobic decomposition, consuming oxygen and producing toxic gasses of Hydrogen Sulfide (H_2S) and Methane (CH_4).
3) Change the biofilter design to utilize a self-cleaning reactor, with airlift flow through the filter. A sample filter block of Brentwood Industries CF1900 was provided as a template for local manufacture. Parameters and design specifications were provided for nitrification, surface area requirements, and air delivery to the reactor.
4) Collect solids more efficiently utilizing conical traps and tube settlers. Design parameters, specifications and reference web pages were supplied.
5) Improve feed quality. Specifically, utilize extruded feeds to eliminate fines, work directly with feed manufacturers to improve quality and digestibility, and reduce the crude fiber content.

Picture 041 Otieno Okello and John Woiwode in the ThinQubator fish greenhouse.

Kibos Integrated Fish Farm
Lake Basin Government Project

Maurice Midamba Assistant Manager

The farm was started in 1984. It comprises an area of 14 hectares, with 19 ponds. The facility was first set up to raise tilapia, but over-breeding and excessive fingerling production soured the initial operators on tilapia production. They brought in *Clarias* to eat excessive tilapia reproduction, creating a culling procedure that was too effective, resulting in “just a few” catfish that were “huge”. They have balanced the stocking ratios somewhat over the years, and now they average 50% tilapia survival reaching the targeted weight of 250g.

The water is sourced from two shallow borehole wells, 9 and 12 m deep. It is pumped up approximately 6 meters to a head tank that has an estimated 10,000 liter capacity. This head tank is plumbed to provide gravity-fed water to all hatchery tanks as well as all grow-out ponds.

The ponds are currently stocked as: 4 tilapia nursery ponds, 1 catfish fingerling pond, and 3 catfish brooder ponds. The rest are either of unknown stocks or not stocked at all. The only feed provided is rice bran, broadcast on the pond surface.

There are no water quality data.

The facility sells “fish for the table”, tilapia of 200-300g. There were no records of sales volumes. Any sales proceeds are sent to the government from this quasi-public/private facility. Their salaries are paid by the government, but Maurice has to request for any capital funds, and says he provides double what the government gives back to the facility. This is a source of great frustration and irritation to him.

For the spawning of the Clarias, he utilizes donor males for their pituitary glands, and uses water lettuce (*Pistia spp*) roots for egg incubation. The fry of both tilapia and catfish are fed rice bran.

The tilapia are spawned by stocking 3 females per 1 male per square meter in one of two "Circular Breeding Ponds". These ponds are concrete circular tanks, 64 square meters surface area, approximately one meter deep, with sloping bottom to the center. The tanks utilize a center drain, though the drain pulls water only from the top. He complained that manure build-up from the fish was a problem, and when they try to net the larval fish, they get suffocated in the thick organic debris. We discussed the use of a venturi pipe to pull the water from the bottom of the tank. Detailed drawings and specifications were provided.

Picture 050 Maurice Midamba next to one of the two circular breeding tanks at the Kibos Integrated Fish Farm.

The two 64 square meter circulars were attached by a very small (3/4") drain at the edge of the tank (not the center drain) that connected to two cement raceways. The hopeful, ostensible purpose of this unusual system was to have the fry flush from the circulars to the raceways, where they could be cultured for a short period of time before distribution.

This is a flawed design and concept. When tilapia fry are first released from the mouth of the female, they form a small cloud, and stay in their tight group near the shore, or tank wall, near the surface, for 24-48 hours, getting more dispersed by the day. They don't go deep. They are also very delicate at this stage; forcing them through a small floor drain fitting would result in significant mortality.

I recommended that he construct a metal-framed fry net of 0.3m x 0.3m x 0.3m, using mosquito net mesh. First thing in the morning, every morning, he should walk around the tank and carefully scoop out the small cloud of fry, which would be gathered near the surface along the tank wall, and take them to the nursery.

He hand-sexes his fingerlings at between 10 and 40 grams. I recommended waiting until 25 grams, and to utilize a food dye to enhance the presence of the oviduct vent.

Maurice complained that he gets fungus on his fish, and since he cannot use malachite green anymore, he was at a loss what could substitute that was inexpensive and effective. I recommended salt, an Indefinite Treatment (no flushing required, no time limit) of 1 ppt. I indicated that salt would not only kill the fungi with this longer exposure, but would help repair the tissue damage, in fact would trigger mucous secretion that would cover the wound while assisting in osmoregulation during the recovery of the tissue.

Another problem arose in our wide-ranging discussions: snails were everywhere, in the ponds, in the pipes. How could he rid the farm of these? I stayed with salt as an inexpensive chemotherapeutant: 1 ppt should cause the snails to release from the pipe surfaces, and there is a high probability that the salt would kill them over time as well. We discussed placing the salt in the head tank (1 ppt = 10 kg for the 10,000 liter tank, though I emphasized he should confirm the dimensions/volume of the head tank), and flow the mixture through all the pipes, and keep it in the pipes for a day before flushing it.

Picture 061 Fingerling tilapia ready for harvest.

The uses of all three types of lime were discussed in detail.

Specific Recommendations:

1) Use Ovaprim instead of donor pituitary glands for more predictable spawning of *Clarias*.

2) Use a venturi pipe to pull water (and fish waste) from the bottom of the tanks. Detailed drawings with specifications were provided.
3) Hand-net the newly released hatchlings early in the morning along the wall of the breeding tank with a properly constructed fry net.
4) Use a dilute food dye to enhance oviduct vent presence in fingerlings of 25 grams or greater.
5) Use salt at 1 ppt to treat fungus in broodstock.
6) Use salt at 1 ppt to kill snails in the pipes and tanks.
7) Treat all ponds with agricultural lime ($CaCO_3$) to bring Alkalinity to 150 mg/l.

Eldoret (Formerly Moi) University Fish Farm, Eldoret

Samuel Kipkemoi, Assistant Fish Farm Manager
Josiah Ani, Assistant Fish Farm Manager
Henry Lubanga, Senior Technician
Julius Manyala, Senior Lecturer

The overall facility is 3 hectares in size, with room to expand. There are 42 ponds, mostly very shallow (<0.5m) depth, utilized primarily for research purposes. The facility has as its water sources surface runoff and artesian springs.

There are three species of fish on site: the pure Nile tilapia, the African catfish (*C. gariepinus*), and goldfish (*Carassius auratus*).

Though the facility is ostensibly designed and run for research purposes, there is a commercial aspect as well that is accelerating year by year. Personnel increases reflect these changes, increasing from infrequent part time help to three full time staff. Tilapia are bred often; last year's production was approximately 100,000 fingerlings. The Clarias are bred for select clients on an order basis. No numbers were available for last year's catfish production. The goldfish are infrequently bred, mostly for research and to provide practicum for a university course in Ornamental Fish.

The tilapia are bred in a breeding/spawning pond stocked at 1 fish/ square meter, utilizing a 1:1 sex ratio. They seine out larval fish monthly. No attempt is made to sex-reverse the fish. They sell the fingerlings for 8 KS/fry. Demand outstrips their ability to supply.

They aspire to produce tilapia fingerlings by pulling eggs from broodstock held in hapas, then hatch the eggs in "improvised glass incubators", which I took to mean McDonald-type hatch jars, though they did not know that name. There has been no movement to develop such systems or procedures to date.

The farm also produces market-size tilapia. There are 6 ponds designated for grow-out, though 4 of the 6 are in a state of significant disrepair and are not utilized. In the two functional ponds, 130 kg of fish averaging 250g were produced and sold in 2012. They have aspirations to greatly expand production in 2013, especially if the badly damaged ponds can be renovated; their target for 2013 is 4 tons. The price received for market-size fish in 2012 was KS240/kg; this year the price has been raised to KS300/kg, noting that the city market sells this size tilapia for KS500/kg.

The *Clarias* are spawned utilizing hypophysation. Because of the sacrifice of males to obtain pituitary glands, there are depleted stocks of donor males. There is hope to begin utilizing Ovaprim, which I heartily endorsed. They lamented that Ovaprim, indeed any hormone including Methyltestosterone, are exceedingly difficult to obtain, with layers upon layers of unnecessary bureaucracy stifling access, and in spite of government exhortations to "increase fish production", their hands are tied by the bureaucracy.

The goldfish are spawned utilizing a modification of Hickling's original Malaysian kakaban procedures: The fish are placed in a "bathtub" (sic) of sorts, ¼ full of water, at a sex ratio of 1:1, and the water is allowed to warm in the sun. The next day, the tub is flushed with cold water. Kakabans are placed in this tank, and overnight the fish spawn. The kakabans are removed to a fertilized nursery, and the eggs hatch within 48 hours. The fry are fed rotifers for the first three weeks, then fed artificial feed.

We spent the full morning, into the afternoon, taking water chemistries. Dr. Fitzsimmons had delivered these kits and probes the week before, so the timing was perfect for us to go through detailed procedures. We tested water from three types of ponds: fertilized only, fertilized plus feed, and fed only, all ponds stocked with similar densities of tilapia. We tested for parameters of pH, Alkalinity, Hardness, Ammonia, Nitrite and Dissolved Oxygen.

Picture 082 Sampling water at the Eldoret University Fish Farm.

The results of the three sources of pH readings were variable: the YSI multi-tester gave a much lower pH reading than either the designated pH meter or the Hach kit. The latter two were reasonably close (though the Hach kit is a wide-range tester, and had gradations of 0.5 units, so accuracy was estimated within a wide range). I recalibrated the YSI multi-tester to factory

settings, but that did not improve its accuracy. We did not have access to prepared buffer reagents that could have allowed setting of up to 6 points on the calibration curve.
I recommended that they not use the YSI multi-tester for pH, rather use the pH designated probe or the Hach test kit.

We took our time with each test, establishing exact procedures to be followed, and each person read and interpreted the color developed from the reagents. Procedures of where and how to take water samples, the rinsing of test tubes with test and then DI water, procedures for getting exact volumes in the tubes, capping and mixing procedures for reagents and test waters, and how long to wait between each step were provided in the hands-on practicum.

Picture 084 Testing water chemistries at the Eldoret University Fish Farm. Pictured are Dr. John Woiwode, seated, and Samuel Kipkemoi, Assistant Fish Farm Manager, Josiah Ani, Assistant Fish Farm Manager, and Henry Lubanga, Senior Technician

In addition to the new farm test kit from Hach, there were two new kits from LaMotte for Nitrite and Ammonia. There were no instructions for either kit, and the team was confused how to utilize these. Fortunately I use LaMotte test kits almost exclusively at AquaMatrix. We pulled additional water samples, and with verbal step-by-step instructions, we tested for these two parameters. I then wrote down the step-by-step procedures for them to keep inside the test kit boxes for future reference.

Specific Recommendations:

1) Preferentially use Ovaprim for the spawning of Clarias.
2) Preferentially utilize spring water rather than surface runoff for any spawning and hatchery operations.
3) Renovate the four grow-out ponds as soon as possible to vastly expand tilapia production capabilities.

4) Utilize straw, preferably barley (though wheat or rice will work) to generate zooplankton blooms. Skip inorganic fertilizers completely, and just use a mix of organic manures with straw to generate the richest zooplankton bloom for first-feeding fry in nurseries.
5) Use a dilute food dye, dark blue is best, to enhance the oviduct vent of >25g tilapia fingerlings for accurate hand-sexing. The team was quite interested to hand-sex "sex-reversed fingerlings" obtained from Enos two months previous, that were 4-5g currently. I requested that they wait until the fish were at least 25g before sexing.
6) Target 150 mg/l Total Alkalinity in the ponds, and if less, add agricultural lime. We discussed the purpose of the other two types of lime, CaO and CaOH, and emphasized their role, to kill unwanted fish upon draining. But to enhance productivity, 150 mg/l of CaCO3 should be targeted, tested with the Total Alkalinity kit.
7) Procedural techniques were provided for pond water sampling, mixing of reagents in the test tubes, rinsing with DI water, and interpretation of colors generated.
8) Written step-by-step procedures were developed for the two LaMotte test kits (NO2 and NH3).
9) Detailed discussions were held regarding tilapia sex-reverse procedures, but these procedures could not be carried beyond the conceptual stage because of the status of their spawning operations.