Harvesting Equality

Because every fish produced is a meal, curing world hunger at the source.



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"Food is the moral right of all who are born into this world." – Norman Borlaug

My *infinite* thanks to…

The World Food Prize Organization, for providing me with this life-changing opportunity

The WorldFish Center & staff, for their guidance and collective wisdom

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Lisa Fleming, a constant friend

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Dr. Borlaug, for his lasting influence on the world and inspiring story

Your wisdom has taught me…

We are all humans; we live, laugh, and smile in all languages.

Separation is artificial; understanding and compassion are essential.

Nothing is impossible with the support of those who care.

INTRODUCTION

From a far enough distance, even the vastness of the Nile and the expanses of Cairo feel unreal and unimaginable. I remember I once viewed hunger the same way, as a distant tragedy of statistically massive proportions. As my plane gently floated down over Cairo, I stared in awe at the giant river snaking across a sprawling city that was unimaginable to me before that point. Stepping off the plane, the dry, arid heat of Cairo first hit my body, enveloping my senses in a way words can hardly describe. In time, the realities of hunger overcame me in the same way, as an irreversible shift in thinking that sparked with a swift tap on my window.

It was nearly a month later in the busy streets of Zagazig. The Egyptian sunset had calmed my usual intensity and lulled me into a dreamy, relaxed frame of mind. I waited outside while Mr. Samir bought food for the trainees, allowing every detail of my surroundings to pour over me. It was then that the boy approached the car, surprising me with a touch of my window. The look he gave me has been in my mind ever since. In his face I saw not just a boy, but a little brother of mine, and I was filled with remorse when I saw his outstretched hand. Every part of me wanted to protect the boy from his surroundings, to bring him home and show him the life he deserves, but I had no idea how. In time my shocked silence was replaced by an unwavering compassion and an overwhelming duty to protect others from living the life that this boy faced. That transition wasn't an easy one.

It was through my work at the WorldFish Center that the image of the boy transformed from a symbol of sadness and regret to one of inspiration. This summer brought life to everything I have learned and gave meaning to my work, education, and explorations. I bring back with me a renewed sense of motivation and understanding. My time at the WorldFish Center has shown me that the stream of lab work and research is my opportunity to open the door, give the boy a meal, and finally make peace over a missed opportunity. In this sense, I have learned that there is hope in every new fish produced. Dr. Gamal has guided me to appreciate that each of these fish is a meal, a source of life. The circumstances in the world are dire, but the human will is stronger. I now realize the opportunity to open that car door wide, to put food on empty plates, and to embrace those who have had backs turned on them.

BEFORE EGYPT

This transformation began last fall, after the World Food Prize conference and ceremony, as the attendees were able to see all of the past interns present their experiences. I remember having a pit in my stomach as I picked up the application forms, because I knew I would take the application seriously, worry about it, and potentially change my entire summer in exchange for a life-changing experience. It was a good decision, but not an easy one. I knew I'd miss the familiar routines, familiar food, and most importantly, familiar people. I had no idea where I wanted to go, although some of the interns from previous years could talk for hours about their experience, and each thought their location was the best. Many had learned languages, written extensively, and made positive impacts on the people and world around them. It sounded like a profound opportunity, but at that point, that is all that it was; a faint chance at an opportunity.

After perfecting my application and sending it in, along with a slew of other applications for scholarships and colleges, I reached the dreaded waiting period. Finally, I got a letter from Lisa Fleming inviting me to come down and interview. This, of course, was the perfect storm of high stress situations. The combination of nice clothing, important people, competition, and a part of my future made me more uncomfortable than any foreign food ever would. I met Frank and Stephen, both of whom I would see and hear a lot about in the future. The interview went well, and I remember Lisa saying my hands weren't as icy cold as the interns they had interviewed so far that day. I was just glad to be done.

In almost no time everything became very, very real. I got my passport back, was accepted as a Borlaug-Ruan intern, found out I was going to Egypt, received countless shots, bought some acceptable clothing, and somehow managed to graduate amid the chaos. It's still a big blur in my mind.

ARRIVAL

Before I knew it, I was walking off a plane in Cairo with a big backpack, a huge suitcase, and enough questions to weigh me down for the whole ride to Abbassa. I had no idea what to expect. I had a culmination of the fragments of information given to me by previous interns, a few books, and orientation. Of course, none of that could ever prepare me for the next two months that would completely change the way I view my place in the world.

Soon I was in a car with Mr. Samir and a driver, rushing through Cairo traffic at 140 kilometers per hour. I was initially very intimidated by the Egyptian style of driving, which would be called reckless and illegal back home. Stop lights are only obeyed when there is a police officer there to enforce it, speed limits are nonexistent, and the unmarked streets are filled with people, donkey carts, and cars in any arrangement that will fit. Cars are often inches away from another car or a person who simply walked into the street expecting everyone to swerve around them. There are very few times that any specific lanes are followed, and passing usually involves making a third lane in the middle of the street rather than waiting for a gap in oncoming traffic. Soon this free flowing style of traffic and the constant blaring of horns became normal for me, and I could easily sleep in the back of a car without worrying about arriving home safely.

After a little over an hour we rolled onto the dirt roads of Abbassa. The street was filled with large puddles that the car had to maneuver around, and children often were sitting or playing in the path of the car. I remember how skinny the children looked; they didn't have the roundness in their faces as you see in many American children. I remember pondering whether this was attributed to the high sugar diets of many American children, or a nutritional problem in Abbassa. Everything was new and unexplainable to me at that point. As we finally drove into the complex, I had my first glimpse of the WorldFish Center. It appeared as a place of refuge for me in a foreign land. The facilities looked clean and the signs were in English, and I began to feel at home. I carried my suitcase into my room and collapsed into bed, overcome by the weight of exhaustion.

LEARNING ABOUT THE CENTER

The next day I began my first week at the WorldFish center, which was full of opportunities to explore the center, become comfortable with my surroundings, and meet the people who would become my newest friends and mentors. I spent my first week working with each of the different areas of the WorldFish center and learning what their jobs involve. This knowledge would be important when I chose an area of study the following week. I also learned that the mission of the WorldFish center is to improve aquaculture and fishery practices through research and training, both of which I would soon become involved in.

Although I struggled to remember every name that first week, I found it paradoxically easy to remember small details about the people I met. My office mate, Ahmed, was to be married during July. Mr. Samir, Mr. Waheed, and Dr. Mohamed Yehia all had boys ages 15 or 16, who I would later meet. These small details gave my peers a very personable, almost fatherly aura. I had known them for a few days and still struggled with their names, yet I knew they were my friends. Mr. Waheed was an especially friendly man who I worked with many times during the first week, and I remember how I was first introduced to him. The first day I was there I went out to the hatchery for the first time and I was helping count fry, my first encounter with the fish. The entire

group was out there, and they were teasing Mr. Waheed for being the only one with his name, saying his name meant he was unique. It made sense because the number one is “Wahed” in Arabic, and most of the people I met had the names Ahmed, Mohamed, or Mahmoud. I knew that he must be a friendly person if the group was teasing him, and I chose to work with him the next day for this reason.

I spent most of the next day observing the work done in the hatchery. This section has fiberglass tanks for egg hatching and many concrete tanks for fry. We worked with the concrete tanks, which contain both fully grown Tilapia and also many fry. There were about 10,000 fry in each tank and thirty-two adult Tilapia, twenty-four females and eight males. This selection is chosen because males can fertilize females with a ratio of three to one. The purpose of these tanks was two-fold: first, to allow fry to grow to a big enough size to be moved to the ponds, and secondly, to create new eggs, restarting the hatchery process. The process was simple. We ran a net through the entire tank, scooped all the fish out of the water into buckets, and collected the eggs from the bottom of the net and from the females’ mouths. The fry were then graded, which means they were placed in nets of varying sizes, allowing the small ones to fall through and the bigger ones to be collected. Once the fish were graded, they were put into separate, larger tanks with fish of their same grade. They would grow in these larger tanks for about two weeks before being transferred to the ponds. I didn’t know at this point that I’d be using fry just like those for my experiment only a week later.

I also learned a lot about catfish from Mr. Waheed. I learned the techniques for natural and artificial spawning from him over the course of my stay. Artificial spawning involves removing the head of a living male catfish, cracking open the jaw, and removing the pituitary gland. The male fish must be alive when the pituitary gland is harvested in order for it to remain intact. The gland is then used to make an injection that prepares female eggs for fertilization, which happens within only twelve hours after application. The eggs are then fertilized by removing the males’ testes and applying semen to eggs after removing them from the female. The natural spawning is an easier method where three females are checked by hand for mature eggs, and then placed with three males in a small net. The small living space and proper water depth encourage the catfish to breed, and every time I witnessed it the next day the net was filled with eggs. The eggs are then siphoned out of the water and put into a tank in the hatchery. The natural spawning is most commonly used because it is easier and effective.

It was interesting to see the relationship between the workers and Mr. Waheed because they worked inside the tanks netting fish while he was outside the tank sorting the fish. They all appeared to be great friends, but everywhere I went it seemed like the researchers stood by and watched as the workers did all of the hard work. I felt somewhat out of place standing by the researchers as the workers were in the water, because I didn’t feel like I had earned the spot. Most of the researchers have PhDs and knew the details of aquaculture in and out, and I felt like I was only playing the part at first. This pressure eased as I got to know the workers and communicated with them using the little Arabic that I had learned, but I always felt a bit out of place standing over men who had been working hard at the WorldFish center long before I ever arrived. It was reassuring to see how eager they were to get to know me, and I embraced every opportunity to help out that I could. Later I would spend a lot of time working side by side with these workers, which relieved these feelings. At first, though, I worried about appearing elitist.

The next day I was able to work with Dr. Mohamed Fathi in the fish health department. We started by preparing a mixture of clove oil, alcohol, and water to anesthetize the fish. Soon after putting the fish in the drugged water, they flopped over, which I fondly remember Dr. Mohamed Fathi calling “going to sleep.” The fish would recover if put back into fresh water, but for now they were much easier to handle. I picked up a fish and

we began with a dissection, which was a good opportunity to review fish anatomy. As we went, we collected samples from both internal organs and external locations. We then viewed these samples under a microscope and were able to make conclusions about the diseases afflicting the fish. In all, we found a diseased batch of fish, diagnosed the problem, and medicated the tank that very day. I was very interested, and attended more sessions on the subject when the trainees came.

After learning about fish health, the next day I also was able to work with Mr. Diaa Kenawy and Dr. Mohamed Abdul-Quader in the general lab, where different parameters are used to evaluate a ponds health. These measurements are essential in finding and solving problems in ponds before they become lethal to the fish. This frequent monitoring is also important in research analysis because different options may be more or less viable depending on the water quality. Later I would use these measurements as a major part of my research project, and I quickly became comfortable with the general lab.

On the following day I worked with a set of fish that were pampered due to their genetic superiority. These fish were tagged, which meant a chip was put underneath their skin. The tags are used to prevent interbreeding between fish that have very similar DNA, such as those from the same parents. This helps prevent recessive allele traits and disease susceptibility associated with genetically homogenous fish. The fish are identified with a tag reader and tracked in a complicated computer program. This information is used to breed fish that have a rapid growth rate. This research has an important impact on fish farmers because it allows them to make the best use of the limited growing season. In some cases it makes Tilapia farming possible. The end result is a larger harvest, more food, and more income for the farmer.

I was later able to try fish tagging on my own when the trainees came. There are four main types of tagging, which include branding, fin clipping, external tags, and internal tags. Branding and fin clipping can be somewhat ineffective because fish will eventually heal. They are good for research lasting for a shorter period of time and are cheaper. The external tags can sometimes injure the fish because they hang from a string attached through the base of the dorsal fin, which other fish sometimes think is food. The internal tags, which are read by a tag reader, seemed to be the most reliable method. We sedated the fish and tried each type of tagging. Branding requires some experience because you must burn far enough into the skin to make a permanent mark, but not far enough to kill the fish. The external tagging is done by a needle that passes through the fish before being tied in a knot. The internal tags were placed inside a small incision into the abdomen. All of the fish I tagged were alive after the operation, but my inexperienced hands had caused much more damage than an experienced fish tagger would have done.

I also spent a day with Dr. Mohamed Yehia learning about fish nutrition and seeing the ponds. He would later be my mentor for my research project and would help me pick a topic the following week. The fish nutrition department is important because fish feed costs many farmers over half of their production cost, and studies correlate the feed input weight to the fish output weight directly. After learning about the fish feed and then visiting the ponds, all of my learning from the past week became coherent. I could see the fish living and thriving in the ponds due to the attention and research done by everyone at the WorldFish center.

I finally began to see how the research all came together at the WorldFish center and the purpose of the work. The fish health department compares different medicines, their effectiveness, and cost. The genetics department focused on improving growth rates and yields. The fish nutrition department makes cost effective feed to lessen the impact of food expenses and directly enhance the growth of the fish. The hatchery work is important because fry are the seeds of the fish crop, and strong, healthy fry are essential to producing Tilapia

effectively. The chemistry lab maintains stable water conditions in which the fish thrive and grow to their potential. All of these areas put a lot of effort into training programs to spread these methods to fish farmers across the continent. Even more fascinating is how this knowledge is spread again by word of mouth around the region when these training courses are completed. The impact of the combined efforts in the WorldFish center is a strong force in the fight against poverty and hunger by improving fisheries and aquaculture practices around the world.

ADJUSTING TO EGYPT

Not only was I learning about fish, but I was also working hard on learning Arabic. I was amazed how fast I could learn new words, and I remember comparing what I had learned in the first week to what I learned in an entire year of Spanish one during high school. At first, the common conversation words were very easy to practice and stuck after only a day or two of practice. In time my learning slowed considerably because I was comfortable with the most common phrases and sentences. Without a book or a teacher I was unable to move beyond specific sentence structures and verbs because Arabic is so different from English. In the following weeks some of the trainees would teach me the Arabic alphabet and some basic grammar points, but it became considerably harder to advance my language. During the first week, though, I exhausted my brain daily with more Arabic than I could absorb at once.

The best way for me to learn Arabic was sitting and talking with the security after the center closed down in the evening. During the first few weeks I would visit with the security for hours at a time, learning about Arabic, culture, and friendship. Only one of the security men spoke English. His name was Mohamed, and he was eager to teach me pages upon pages of new Arabic words and phrases every day. It took me weeks to memorize them all, but I had plenty of opportunities to practice with the other four men who joined us in our conversations. They graciously offered me food, even though, as I later learned, they didn't always have money to afford meat for their meals. My first reaction was to bring them fish whenever possible as a way to say thank you for their generosity at a time where I felt like a stranger in a new world.

Another friendly face was that of Mr. Samir. He took care of me throughout my stay, and during the first week it was comforting to know that someone was watching out for me. In the first few days after arriving, we went down to Zagazig for the first time to buy some food. My surroundings were absolutely overwhelming. There were many small stores, and we went to one that had a good collection of food that I was used to. We also visited a small shop where I was able to buy fresh fruit, which was some of the best I ever tasted. The bustling streets and the unfamiliar food took over my senses that afternoon, invigorating me to explore and to learn about Egypt.

Also that weekend he took me to the Suez Canal, which was a great example of Egypt's economic potential. There were military guards all over because it is a tourist location, and the government wants to make foreigners feel safe. However, I wasn't used to being unable to take pictures of certain locations or seeing armed police on the streets, so it had the opposite effect. Mr. Samir assured me that it was not a problem, and I relaxed. During all of my trips, Mr. Samir was an excellent tour guide. I learned a lot about the history of the Suez Canal, and then he took me to eat a traditional Egyptian dinner. The food was very good, and I felt more comfortable knowing that I would enjoy Egyptian food during the summer.

On the ride home my first real problem with the language barrier occurred after we dropped off Mr. Samir. The driver remembered last year when Santiago visited, who happened to really like ice cream. I am lactose intolerant and this posed a small problem when he brought me a large cup of ice cream to eat. I was

unable to explain to him why I couldn't eat it. My solution was to call Mr. Samir on the phone and have him explain the situation, which worked well. I was relieved that I was able to explain the situation because the last thing I wanted to do was offend the driver who was so generous towards me.

As the first week drew to a close, most of my thoughts were inward. I spent most of my time working to improve my knowledge of Arabic, reading to understand more about Tilapia, and balancing my activities to adjust to the entirely new world of Egypt. I struggled to eat on a regular schedule, adjust to the time change, and find time to contact home. Later these thoughts would become automatic and I would be thrust into new understanding of the world as I turned my attention to those around me. In the same way that the first week of work prepared me for my research ahead, the first week also allowed me to become comfortable enough to really examine the situation in Egypt. It wasn't long until I could sit down for the evening and discuss involved issues such as worldwide relations, politics, and problems of hunger and poverty.

CHOOSING MY RESEARCH PATH

Before I knew it, I had already spent a week at the WorldFish center and become comfortable with the day to day operations. My second week was focused heavily on designing a research project for the rest of the summer. I also began to look outward and learn as much as possible about Egypt. I would spend the morning discussing research projects with Dr. Mohamed Yehia and the afternoon shadowing the different researchers. I used these opportunities to learn about the personal lives of those I spoke with and to discuss all of the different issues faced by Egyptians. Before I knew it Dr. Gamal had approved a research plan for me and I had a much better feel for what life in Egypt was like for the different socioeconomic classes.

My first approach to finding a research topic was to make a big organized chart of all my options. I split up all the different sections of the WorldFish center that I had worked in, the different problems that they attempt to solve, and how each could be explored and quantified. I enjoyed going around speaking with the different researchers to find out what information would be helpful to them, a strong deciding factor in my final decision. Once I had a long list of possibilities, I began the process of narrowing down my research to a single project.

I also pondered what a meaningful research project would be, and decided what characteristics would be present in an ideal situation. My goal was to find a project that was useful to the center, had an impact on the world around me, provided a solid learning opportunity, and worked well in the time allotted. After examining all of my options under these priorities, I deduced that work with pond productivity, feed cost reduction, or fry stocking densities would be most likely to fit these criteria. I quickly wrote up proposals and discussed them at length with Dr. Mohamed Yehia.

In our discussions we were able to sort the list into a first, second, and third pick. This was not an easy process and it required many questions and discussion. The pond productivity experiment would likely take many months longer than I was able to stay in Abbassa. Although the center was focusing on it, I didn't want to leave a burden on the researchers after I left, or delay my research paper. The feed quality test I designed also had its flaws. It had been done before and was heavily researched for Tilapia, so the data would not be very meaningful. This quickly put it at the bottom of my list. The final option, to test the viability of different stocking densities, still intrigued me. This interest was piqued when Dr. Mohamed Yehia explained that this was something being researched at the center during the summer. I was excited about this idea, and we contacted Dr. Gamal to have a meeting and discuss my research plans.

That afternoon we all sat down for a meeting and discussed my research plan. Dr. Gamal allowed me to research stocking density in six of the outdoor ponds. I was happy to hear I would be able to work outside. Also, I learned that these ponds would be used as examples for the trainees coming through that summer. This was a great opportunity to be involved in the training, which I have learned is a very effective tool. This reminded me of my initial research period where I learned how farmers who learn new techniques often teach their neighbors about them, and subsequently new technology can spread across a region. This was very meaningful for me, and solidified my choice for the summer. Dr. Mohamed Yehia assured me that the research was useful to the center, and in my reading I found that in previous studies optimal stocking densities often differed. I was excited to get started.

FINDING MY PURPOSE

During this time period I also found meaning in my work by seeing the people whose lives are impacted by changes in the production of staple foods such as Tilapia. Now that I was comfortable with the center, I went to Abbassa occasionally to buy food or get a haircut. I also visited other major cities during the weekend when I visited places around Egypt and went to the markets to buy food. During these times, many things I had read about concerning poverty became real. To know that there are children going hungry in the world is one thing, to have one approach you is another. It is like knowing how many gallons of water are in the sea without seeing it, or knowing how many stars exist in the galaxy without ever sitting on the front porch on a clear summer night. Although most people I met had done well for themselves, there were a few times I was approached on the streets during my stay. It helped to consider that the WorldFish Center is making a difference in changing the fates of those people, and that I was helping.

The majority of my understanding came from conversations with the staff at the WorldFish Center. I spent most of my time at the center, and during the day I had many opportunities to talk with the staff. I stopped by to update Dr. Gamal on my research frequently, and I was glad that he took interest in my activities. Because he was willing to take time out of his busy schedule to talk to me, I gained a new perspective on my work, and was able to see the links between my research and the problems of poverty and hunger.

In one conversation with Dr. Gamal at the beginning of my experiment, I questioned how my work would help feed people. He explained to me with a metaphor of fry as seeds and grown fish as a crop. He explained that my work was helping to produce the seeds more effectively. Most importantly he taught me the importance of even a small improvement. Every extra fish produced is a meal. If money, feed, and land are used more efficiently, they can produce more fish or be used to make other crops, which will enhance the livelihood of the farmer. My work was to help discover these small improvements and spread the knowledge to those who will benefit from it. I remember the feeling once the connections all clicked in my head. I used to feel like the amount of poverty and hunger in the world was an insurmountable problem, but once I knew I was making a difference to change them, that feeling reversed. I was eager to research, and I felt accomplished after every day of work. This transition from feeling helpless to being empowered was the most important discovery I have ever made, and I will always be very thankful for all of those who provided me with that opportunity.

When I shadowed the researchers at the WorldFish Center we would often talk about politics and other issues in the world. It was an interesting subject for a number of different reasons. All of the individuals I talked to at the WorldFish Center are smart, aware, and worldly people who had many insightful views on different subjects. It was also interesting to hear first-hand how life in Egypt is. There were two opinions that I often heard while in Egypt. The first was that government had done little over the last thirty years because the same

president had stayed in power the entire time. For this reason his approval rating was low, which reminded me of home. The second observation, which seemed closely linked, was that wages were low. This observation made more sense to me once I heard from the security men that they weren't always able to afford fish or a meat with their meals. This stuck with me because they were comfortably employed men working in a nice facility filled with hundreds of thousands of fish. I then realized that my work was just as much about making sure these men could have fish for dinner as it was any other person.

I was finally able to see the end result when I attended a harvest early in the morning during my third week. The harvest tied everything I had learned together and served as another bridge between the lab work and the dinner plate. Towards the end of the WorldFish property there are large earthen ponds where fish are able to grow to their full adult potential. The harvesting process began at the crack of dawn by draining the ponds out as early as 5 AM. Nets were placed over the drains to keep the fish in the pond, where they were collected in plastic crates. These crates were then hauled up to the side of the pond where they were graded on big tables with holes in each corner. Depending on the weight, we threw the fish into the proper corner, where they fell into another crate. The crates of the biggest fish were then collected and weighed, and many times we harvested over a ton of fish in a morning. I usually helped out in the fish sorting area, and learned quickly that Tilapia fan out their fins with sharp edges when they are stressed. I cut up my hands on the first day before borrowing some gloves from Mr. Rezk, who oversees the whole operation. The fish harvest served as a physical representation of the work being done at the WorldFish center, and it helped me connect my work to the end result of fish production.

BEGINNING RESEARCH

Before I knew it I had begun preparations for my experiment, met a new group of trainees, gained a roommate, and started writing my research paper. There were more activities during the third week than I could possibly attend, and I kept busy from six in the morning until midnight some days. I made new friends from many different countries in Africa, listened to conversations in at least six languages, and relaxed in the evenings with chess or soccer. The third week was the busiest week of my time, and also the most interactive.

After finalizing my research plan with Dr. Gamal, Dr. Mohamed Yehia requested that I write my lab report without the results that first week, so I began reading papers on stocking density. Both Drs. Mohamed Yehia and Diaa Kenawy would oversee my project, and I discussed different aspects of my experiment with them on a daily basis for the rest of my stay. During that week my roommate returned from one of the other farms and I met him for the first time. His name is Patrick and he is a college student in Arizona. His dad studies Tilapia in the United States, and was able to send me a few excellent research papers. Using the papers I received, my past reading, and many conversations with the researchers, I began writing.

During the evenings I would focus on organizing the project for the weeks to come. I started by making a calendar of all of the tests and then writing a weekly check list in order to ensure I complete every necessary step. I then worked on the data tables that would be used that way I could easily enter the numbers in the future and keep track of pages of data. In a similar fashion I made an online spreadsheet with the interns contact information. This was helpful throughout the summer because it allowed us to keep in touch. I later benefitted greatly for organizing my research ahead of time because I was quickly filling up my journal with new data.

While working on my research paper and schedule in my spare time, I also attended many sessions with the trainees. I was able to revisit the fish health department, learn more water quality lab measurements, and most importantly, learn how to stock a pond. Using my ponds as an example, the trainees witnessed the

stocking process from beginning to end. We began by draining the ponds, removing any fish, and leaving them to dry for a few days. Once the ponds were empty, they were sterilized with a commercial disinfectant to kill any remaining fish or bugs in the pond. The ponds were then ready to fill and be tested for the initial water parameters. Finally, they were ready to receive the fish. Three of the ponds were to be filled with 5,000 fish, and three other ponds were to be filled with 1,000 fish. These represented stocking densities of five fish per cubic meter and twenty-five fish per cubic meter.

Finally the day had come to put fish into the ponds. All the trainees and many of the researchers came out to help move the fish from the hatchery out to the pond. To count out roughly 18,000 fish we started with a small net of about 300 fry. We counted the fish held by this small net and found their combined weight. This gave us an average weight for all of the fish. We then used these small nets to fill large buckets with an estimated 1,000 fish. We filled eighteen buckets and took two trips out to the ponds by truck to put the fish into their new homes. Dr. Mohamed Yehia and I then figured out how much feed each pond would receive based on their weight. We taught the trainees how to do the math to figure out how much feed to use, and then I had a small training session of my own to teach the trainees about water quality parameters. I was excited to have fish in the ponds to work with and to be a part of the training. This was one of my favorite days of the entire stay.

The trainees attended a lot of these events during their stay, and I went to many of their classes during my spare time. This was a good opportunity to learn more about the different aspects of fish farming while getting to know the trainees. I made friends with the trainees and during the evenings we played soccer games. I learned during this time that soccer is a universal language that bridges gaps between many different people. During our games we had people of all ages playing. The teams were both mixed with people who spoke English, Arabic, French, Spanish, and Swahili. It was a memorable experience to play a big game with trainees from all over Africa, the college guy who cooked our food, and the researchers. It was another example of how human qualities bridge any language or preconceived barrier. It was another of my greatest experiences in Egypt.

BECOMING INVOLVED IN THE CENTER

Soon after my ponds were filled, the trainees returned back to another location to continue their work. The center became dramatically quieter, and I was able to spend a lot of time writing and doing water quality tests. During my first few weeks I had learned how to test different water parameters, and now that I had a pond filled up I was in charge of actually doing them. Also, with my new free time and knowledge about the different water quality tests, I was able to become involved with other projects in the center by testing water and observing the ponds.

Over the next six weeks, water quality tests became my new expertise. During the rest of my stay I would test dissolved oxygen and temperature six times a week, pH and ammonia three times a week, and take a large weekly sample as the basis for many other tests. To test the oxygen I would get up at six and take an hour long loop around the complex, measuring each pond. I would then repeat this loop again at 3 PM. I also took samples during this time to get the pH and ammonia levels back in the lab. Every Tuesday I would take a larger sample for the weekly measurements. I would use this sample to test phosphorous, nitrate, hardness, and alkalinity, which were time consuming tests I did during the day. On a weekly basis I would also go out to the field and measure evaporation, seepage, and water turbidity based on my schedule. Chlorophyll was not tested because my ponds were not fertilized and used artificial feed therefore the plant growth was small. I learned how to do the test anyway and was able to use it on samples from other experiments.

Soon I began to see the more subtle information gained from my work. When I was out at the ponds in the morning taking dissolved oxygen, I would check to see if any fish came up for air because this was an indication that the oxygen levels were at a dangerous point. Oxygen usually runs at its lowest point during the morning because it is consumed by the life forms in the pond during the night when very little is produced. I became fascinated to see how the different oxygen levels would change throughout the day and how they affected the fish. I learned over time to become more aware of the fish the same way one may learn when a dog needs food or to be let out. In the same way I could find meaning in the fish coming to the surface at different points in the day, or see small differences in their anatomy that would indicate problems of fish health.

The biggest indicator of the ponds health was found during our fish samples. This was when we collected fish from each pond, weighed them, and measured their length. I was always a bit anxious to take the next fish sample because it was the basis of my experiment and I enjoyed the reassurance that the fish were still alive and healthy. It was also the basis for feeding, so we would calculate the updated feed amounts whenever we took a fish sample. The numbers collected in the sample were then used to find the K Factor, which is a relationship between the weight and the length of the fish. I enjoyed seeing how the different stocking density affected the weight, length, and even K Factor of the fish. It was an exciting event to print off a new chart and table of information showing the growth trends, which I could then show to Drs. Mohamed and Diaa.

As time passed I began to see how the different parameters of the pond all came together to promote or inhibit fish growth. As I became comfortable with the research I began to ask more in depth questions about what the different parameters meant for fish health, which helped me to see the big picture. It amazed me to see how intertwined the measurements became. For example, phosphorous promotes growth of zooplankton and phytoplankton, which can both help and hurt fish growth. This is because they can be eaten by fish, but at the same time they absorb oxygen which can be damaging at night if there is too much biomass in the ponds. Similarly, pH is affected by a number of different variables, which can be narrowed down by examining the turbidity and alkalinity levels of the water. Of course, there are different ranges of all of the parameters that are helpful and harmful to Tilapia, and the end result could be seen during the fish samples. Realizing the interconnectivity of all aspects of the ponds made me realize that a pond is a complex habitat that must be maintained in order for fish to grow at their potential.

These observations stemmed not only from research in my own ponds, but also from helping other researchers. I helped take measurements for Dr. Ahmed Nasralla who was working on pond productivity, which was an interest of mine. He did this by keeping records of the seepage and evaporation in the ponds, which I later was able to start measuring on my own ponds also. His ponds were very different from mine, though, because he was using fertilized earthen ponds which had a very different set of conditions. The fertilizer made his ponds very green, which meant that oxygen levels were much more variable. They ranged from as low as .3 mg/L to over 26 mg/L. This gave me a comparison point for my own ponds, which fluctuated between 5 mg/L and 15 mg/L depending on the time of day. I also was able to see the differences in levels such as phosphorous and nitrate, which helped me gain a perspective on my own ponds. The oxygen levels were on a tighter range because my phosphorous levels were low due to the lack of fertilizer. The lack of phosphorous slowed zooplankton and phytoplankton growth, which limited oxygen consumption during the night and production during the day. This provided a more stable condition for my ponds.

During many times the different water tests gave unfavorable results. Dr. Ahmed's ponds had dangerously low oxygen levels and had to slow fertilizer use and increase water flow. A similar issue occurred with some of the genetic experiment ponds that I was helping test, which recovered over the course of a week.

My ponds faced seemingly ever increasing pH levels that reached a dangerous point about four weeks into the experiment. To examine the problem further we analyzed the different causes, and I took extra measurements of turbidity and pH at different times of the day to determine a solution. We began cycling the water on all six ponds more frequently, which helped reduce the pH. It was less effective because the canal water had a pH of almost nine, which helped explain why it was so high in the first place. Also, we used the alkalinity measurements to help explain the high pH and explain the small increase of the high density ponds pH over the low density pH. These constant adjustments to maintain water parameters were a major part of my learning at the WorldFish Center.

MAKING EGYPT HOME

Another factor I had to account for when scheduling out my research was the vacation trips on the weekends with Mr. Samir. He always planned great trips for me and took me to very nice hotels. We visited the Red Sea with his son Mohamed, St. Catherine's Cathedral, the pyramids, Cairo, and Alexandria. We also had an opportunity to go to two fish farms and see the applications of the research done at the WorldFish Center.

I felt a little guilty sometimes because many Egyptians cannot afford to see the pyramids, much less take six hour car trips all around the country. Many times when I talked about my trips at the center, people would say they haven't been able to go to that location because they can't get time off of work or it is expensive. We always stayed at nice hotels that were most likely very expensive, and I sometimes wondered how many fish could have been bought if I had stayed at a cheaper hotel and given away the extra money. This reminded me of a story Lisa Fleming told me when I was feeling guilty about having so many luxuries back home. She explained the response of a professor sitting at the highest table at the YI hunger banquet. He said that he felt responsible, but not guilty. This helped me deal with these situations and I realized that my new awareness should be a source of motivation and not something to feel bad about.

The locations I visited always had new opportunities to learn about different cultures. At the Red Sea, I stayed at a nice resort filled with many Europeans. There are very few Americans who visit Hurghada, and I felt more comfortable around the locals who worked at the hotel than with the Europeans. I spoke a little Arabic with the hotel staff, and we talked about soccer. Many of them spoke a little English also, and they were very excited to talk to me. In comparison, the way the Europeans dressed astounded me because I was used to the more conservative clothing of Egyptians who always wear pants. The Europeans of all ages, genders, and body types wore small bathing suits and walked around with very little clothing in comparison to what I am used to. I usually tried to avoid the busy hours and would go to the sea during the evening to relax and enjoy the view. The breeze was calming and it allowed me to appreciate the beauty in Egypt.

In the same way, the beauty of the mountains and the cool crisp air around St. Catherine's Cathedral put me at peace. It was a complete contrast to the busy streets of Cairo because the place seemed almost deserted at most points in time. Only during the day at the cathedral did I see the masses of people I had become accustomed to. There was a lot to learn at St. Catherine's because it is the home of a mosque, a temple, and a church. Although there were different religions, nationalities, and languages all in the same place, I felt a unifying presence in St. Catherine. It reminded me of my discussions with the staff at the center. We often talked about religion, and how both Islam and Christianity are religions of peace. I learned to look past the small differences that divide people and appreciate the similarities.

The pyramids allowed me to delve into the history of Egypt, and Mr. Samir proved to be a wonderful tour guide yet again. We took a boat ride on the Nile, which was a good opportunity to learn about the history

of ancient Egypt. When we arrived at the pyramids, I was silenced by their size and age. To imagine the structures being built even with modern technology would be a feat in its own, but the pyramids left me speechless. Mr. Samir took me to some good photo locations, and it was a good opportunity to take some pictures with him. I never could have imagined how big the pyramids really are until I was able to see them in person.

Towards the end of my stay, I was able to make it to a few fish farms, which helped me understand the value of my work and how technology and research are applied. I visited Kafer El Shekh, a commercial fish farm run by Dr. Ismail Redwan. During my time there, Dr. Ismail showed me all of the different technologies that he uses to maximize his fish output. After studying fish stocking density at the WorldFish Center, I was amazed at how densely he could stock the fish with his system of renewing the water constantly. I was working with five to twenty five fish per cubic meter, but he was working with over a thousand. The downside was that if he was unable to power his water pumps for an hour, all of the fish would die.

The water recycling process is achieved by using a single pump and gravity to keep the water moving. The pump is placed at the end of a large dark room with pipes across the ceiling. Water flows from the pump through the pipes, falling through small holes. The water then passes through boxes covered in bacteria that consume the waste products from the fish. The boxes are in place to increase surface area and the effectiveness of the bacteria. By the time the water reaches the bottom of the room, it is refreshed and ready to be reused in the ponds. Drains at the bottom continually cycle the water through the ponds, and a loop is created.

The ability to dramatically increase stocking density while reusing water is impressive. It is also very relevant because water is a becoming an even more valuable commodity in Egypt and around the world. Egypt is especially vulnerable to water shortages because using the Nile to grow crops in desert like conditions takes massive amounts of water. Preservation of water is important, and this method allows the best of both options. Water can be cycled continuously which allows a high stocking density, so less land and filled ponds are required, while at the same time reusing water instead of continuously requiring new water. The potential for this technology as Egypt's power infrastructure becomes more stable are enormous.

Another technology was a system that the fish would basically feed themselves. There is a funnel of food that has a loosely attached bottom. The bottom is attached to a large ring that sits near the surface of the water. When fish are hungry, they move closer to the surface, and subsequently bump the ring, which releases food. When they are no longer hungry they return lower depths, and food isn't wasted. This saves time for the farmer and helps cut down on excess feeding, which accounts for a large portion of fish farmers expenses, especially as the prices for food increase worldwide. Increasing pond productivity and using feed effectively are both relevant to current trends in the world. As these technologies are used more commonly, they will certainly have an impact on the amount of fish that is able to be produced in the world.

Towards the end of my stay I was invited to visit the homes of some of the staff I had worked with during my time. Dr. Mohamed Yehia had me over for the evening and I had a great time meeting his family. I had wonderful food and was able to relax in his comfortable house. I also learned a lot about Egyptian and Islamic culture during that time. They were very accommodating, which is good because I had many questions for them. I talked to his fifteen year old son and eighteen year old daughter and learned about the school system and life as a teenager in Egypt. Many aspects seemed similar. They enjoyed staying up late and sleeping in during the summer and spent a lot of time with friends. I will always remember the kindness of those at the WorldFish Center, and there is not a day that I don't think about them.

SAYING GOODBYE

During the last two weeks I worked on concluding my research and writing my intern paper. I also took time to visit with my friends from the WorldFish Center during my free time because I knew I would soon be leaving them. I made a few final trips to Abbassa to experience the culture before I left, and I began to realize how much I would miss Egypt. I kept the windows of my apartment open that way I could enjoy the natural beauty of the Egyptian sunsets in the evening, and I found peace in my surroundings. I also reflected on my time in Egypt and prepared to take what I learned and continue service upon returning home.

The last week seemed to go very fast because I was busy tying all the loose ends on my research project. I had many different discussions with Drs. Mohamed, Diaa, and Gamal about the results and how to analyze the data I had collected. It was a lot of work, especially around my other plans for dinners and visits. Even amidst the torrent of activities towards the end of my stay, I treasured every moment to sit and speak with the staff.

In conjunction with the research paper I had kept busy writing a daily blog throughout my internship. It was a great way to keep everyone updated on what I was doing, and has been a good way to store memories from the trip. Towards the end of the internship I realized I had written over 150 pages during my internship, and decided to have them printed into a book to remember my internship by.

As a final way to say goodbye, I planned a party for the WorldFish Center the week that I was leaving. I got the idea when a few of the staff at the WorldFish Center had children who finished secondary school and bought bottles of soda for everyone at the center. I decided I would like to do something similar because it would be a good way to say thank you and include everyone at the center. I spoke or worked with almost all of the staff at the center at one point or another, and I was eager to thank them for being so accommodating throughout my time in Egypt. I gave them my sincerest thanks for memories and teaching that will stick with me for the rest of my life.

MOVING FORWARD

Egypt has affected the way I view the world on many different levels. I now spend more time reading about international news, and I tend to look for different angles on what I hear. In Egypt I was able to see both CNN and Al Jazeera, which often had different takes on the same events. I have learned to be more cautious about the media, while at the same time staying as informed as possible. I believe there is a strong need for better communication between the US and the Middle East because, as I have learned in Egypt, many people in both the US and the Middle East have preconceived notions about the other that are not true. Increased global awareness and empathy on both sides would certainly yield positive results.

There are many artificial divisions between people, but I have learned that human characteristics go beyond race or religion, and permeate any location or language barrier. My preconceptions about the Middle East and Islam have dissolved, and I now realize that Islam contains a diverse population of people with many different opinions, the same way one might view the wide array of Christians. My time in Egypt allowed me to see the detail and beauty in Egyptian culture, prayer, and language that once seemed half a world away. This new appreciation for different cultures extends beyond those of Egypt or the Middle East, and I realize now the importance of sharing culture and learning about the world as we become even more interdependent as time passes. Peaceful dialogue and mutual understanding can never be under estimated.

My trip has also motivated me to be a catalyst of change upon returning home. Statistics about hunger are now much more than just depressing information; now I view them as opportunities. I look forward to working within my community and my university next year, and I am glad to have begun establishing a network of people who share my compassion. I now realize that I have grown up with every door open and any opportunity available. I plan on harnessing that potential in order to make the world a better place, because every person is worth fighting for. I have already begun thinking about possibilities for my Honors project, leadership programs, and fraternity links. The two biggest life lessons I bring home with me are an appreciation for every individual human being and the knowledge that I can make a difference. The Borlaug-Ruan internship has had a life altering effect that will be a part of me forever.

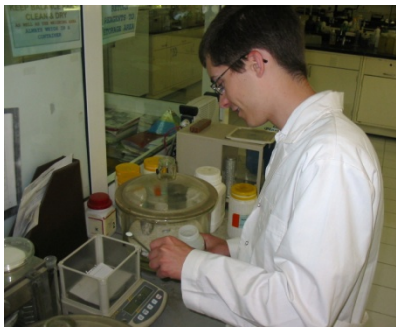
Of course, one cannot look forward without also considering the past. Egypt will always have a special place inside of me filled with memories of the summer. It wasn't until the last few days of the internship to discover how much I would miss it. The same way I had missed the green grass, big trees, and occasional downpours back home, I found that I missed the Egyptian sunsets and cool night breeze after returning. Most of all I remember the companionship. I remember discussing with Dr. Diaa how after everything started to make sense, it ended. I'll always remember his response: "Well, that's life."

Pictures

Grading Tilapia fry

Transferring Fry to the ponds

Sorting Tilapia during the fish harvest



Preparing a combined reagent to test phosphorous

Preparing samples for analysis with the spectrometer to find nitrate absorbance

Checking our measurements during the fish sample

Analyzing phosphorous absorbance in order to determine the concentration

Using filtration to prepare water samples and analyze chlorophyll levels

Collecting fish from the concrete ponds to sample their weight and length

Effect of Different Stocking Densities on Growth of Nile Tilapia in Nursing Ponds

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Under the direction of Dr. Gamal El-Naggar PhD, WorldFish Center

Abstract: Stocking densities of fry Nile Tilapia were tested in an extensive setting using unfertilized concrete ponds. Stocking densities of 5 fish per square meter and 25 fish per square meter were used. Ponds were stocked with an initial average weight of 0.176 grams, and fish were grown to be fingerlings. Weight, length, food conversion, mortality, and water quality were used as indicators for viability. Over the first six weeks lower stocking densities had increased weight and length over higher stocking density fish, and had a weight between 1.4 and 1.9 times that of the higher stocking density. Water quality remained healthy for all stocking densities, but show trends toward problems as fish size increases, especially in higher density ponds. The data suggests that in an extensive fingerling production environment stocking densities of 5 fish per cubic meter are more viable than 25 fish per cubic meter due to the increased growth rates.

Introduction:

Nile Tilapia *(Oreochromis niloticus)* is a widely used species in aquaculture and as one of the most commonly farmed food fish it is an essential source of nutrients for many. (El-Sayed, 2002) Improving yields is essential for improving the livelihood of fish farmers and ensuring food security for those who depend on this species for food. To maximize fish output while lowering costs, fish ponds should be kept as near to the stocking capacity as possible without overstocking. This is because stocking capacities, growth, and survival are closely related. (Huang, 1997) Stocking density is an important calculation to be considered when stocking and harvesting a pond. Current information about stocking densities of Tilapia is inconsistent and may require further study. (El-Sayed, 2002) This study involved testing of different stocking densities in order to maximize the number of fish that can be grown in a cubic meter, which allows farmers to use their land and water efficiently. It may also indicate a point that Tilapia growth is diminished due to overstocking. Increased stocking density can inhibit growth and lead to increased mortality due to water quality degradation. Increased biomass leads to higher consumption of oxygen and potentially lower oxygen levels during the early morning when dissolved oxygen levels are lowest. Dissolved oxygen is the first limiting factor of stocking density. (Musig) Secondly, increasing biomass will lead to a build-up of ammonia. Ammonia is more harmful to fish as pH increases due to the levels of un-ionized particles. (Musig) Water quality is an important indicator of pond health due to the direct impact on growth, health, and mortality of fish.

Index Descriptors:

Nile Tilapia, Stocking Density, Carrying Capacity, Water Quality, Concrete Ponds

Hypothesis:

I believe that the ponds with a higher stocking density will have a lower growth rate, a decreased water quality, and a lower survival rate due to the increased competition for space and oxygen, along with the increased amount of waste produced. I also predict that the lower stocking density stocking will be more economical in most situations due to the increased number of fatalities and slower growth associated with high stocking densities.

Background:

As explained by Dr. Gamal El-Naggar PhD, there are often bottlenecks in the production of fingerlings and output is dependent on the number of eggs that survive the initial growth period. In an analogy of a field, seeds are

fundamental to growing a good crop, because no matter how much land a farmer has, he can only grow as many crops as he has seeds. Quality of the seeds is important to ensure that the crop is maximized. This concept applies to fish. Total output is limited by the amount of healthy fingerlings produced in a season. By optimizing stocking density, fish can be produced more efficiently, especially on limited amounts of land and water, which is the case for small farmers.

The end result and goal of optimizing pond stocking density is to increase output and thus increase food security of Tilapia farmers. As taught by Dr. Gamal, small changes in costs or output have a large effect on the small farmer who is dependent on Tilapia for food security. New information can have a great impact due to the spread of knowledge between farmers in a region.

Previous studies have shown correlation between stocking rate and survival among fry, although it is debated at what point Tilapia stocking is most efficient. In a situation where a hatchery is used, the stocking density of the fry produced affects the survival of those fry. (Huang, 1997) In this situation where land, water, and number of fry are all limiting quantities, information about the effects of stocking density are valuable. Currently, information about the biological effects of stocking density of Tilapia is sparse. (Huang, 1997) In this study, water quality was closely monitored in order to explore the effects of stocking capacity.

Because of the pressures of increased stocking density, different methods of farming have been developed. There are intensive, semi-intensive, and extensive, which vary in upkeep cost, stocking density, and amount of control exercised over the pond. Most farmers use extensive farming methods because the technology and knowledge required for intensive farming is much more demanding. If oxygen and pH are maintained at a high enough level while keeping other water qualities safe, the mortality rate and lower growth rate of Tilapia can be reduced. (Siddiqui, 1989) In this experiment, extensive methods were used. The pond water was not circulated, chemicals were not added, and medicines were not used.

Methods and Materials:

In order to determine the viability of different stocking densities, survival rate and growth rates were used as key indicators. Also, water quality was tested to explain the stresses on the fish. This allowed detection and diagnosis of problems before they become lethal to the fish. It also showed where extra expenses may be incurred due to a larger stocking density. Ponds of 200 square meters, filled to approximately 1m depth, were used for the experiment. These ponds had concrete walls and an earthen bottom. The initial water stocked in the ponds had a pH of 8, ammonia level of .87 PPM, and nitrogen lower than the diction level..

The first step in the process was to stock the ponds. The fish were previously graded in order to maintain consistency among the ponds when comparing growth. The ponds were originally filled with other fish, so the first step was to remove as many fish as possible with large nets. Ponds were then drained until only puddles remained in the bottom, where any remaining fish could be collected. After the pond dried for 24 hours, the pond was sterilized with commercial household bleach and left for another 24 hours before being re-filled. This ensured that the ponds did not have any fish inhabiting the water before the initial stocking.

When the ponds were filled and free from fish, the process of transferring fry from the hatchery began. After ensuring that the fish were graded and of a very similar size, a sample was taken with a small net. These fish were then counted and weighed as a whole. The combined weight was divided by the number of fish in the sample to find an average weight, which was .1763158 grams. Then, because the number of fish in the net was known, the net was used to fill buckets of 1000 fry. For example, if the small net held 200 fish, 5 scoops of fry

would fill a bucket. 18 buckets were filled and transferred to the ponds by truck. Ponds 1, 3, and 5 each received one bucket of 1000 fish, while ponds 2, 4, and 6 were filled with 5000 fish each. This represents 5 fish per square meter for the low density ponds and 25 fish per cubic meter for the high density ponds.

Two days after the fish were added to the pond, feeding was started. Each pond received 10% of total fish weight in artificial food containing 25% protein. This occurred three times daily, at 10:00 AM, 12:30 PM, and 2:30 PM.

After filling the ponds, the following measurements were taken according to their schedule, starting from the day when the fish were stocked in the pond. In this case, fish were stocked on a Monday, so water conditions and sampling ran on a weekly pattern starting on Monday. The process for each test is explained, and results are listed in the data tables.

Survival rate – A major conclusion of the study because fish death destroys valuable food. When a pond is overstocked, harmful conditions build up, stress increases, and sickness is more common. This was tested at the end of the experiment by finding a mean weight then weighing the output from each pond. We used a similar method to measure the fry input. Survival rate was measured when fish are harvested at the termination of the experiment.

Weight – Measured by collecting a sample from each pond, counting and weighing them, and finding an average weight. This was tested every two weeks. K Factors were then determined using these weights to find a relationship between weight and length of the fish.

DO (Dissolved Oxygen) and Temperature – Both temperature and dissolved oxygen change at different times of the day, and must be maintained in certain ranges for fish to live. Tilapia breed in temperatures above 25 degrees Celsius and growth is inhibited under 15 degrees Celsius. Dissolved oxygen should be above 3 mg/L in the early morning for optimal fish growth. If a pond has too many life forms in it, it can run very low on oxygen during the night and morning when plants in the water aren't doing light reactions. It is usually at its lowest point in the early morning, and its height in the later afternoon, which is when recordings were taken. Both variables are recorded by a DO meter which is placed in the water for 30 seconds after calibrating. Both were tested between 6- 7 AM and 3-4 PM three times per week.

pH – Beyond a certain range of pH growth can be inhibited, sickness induced, or mortalities incurred. pH above 9.0 can be unhealthy for Tilapia and when pH passes 9.5 it can become dangerous. The usual range for Tilapia is between 6 and 9. Water samples were collected from each pond, brought to the lab and tested by a pH meter three times weekly.

Ammonia – Caused by a buildup of fish waste, high ammonia levels mean that water needs to be refreshed. Levels are optimal below .5 PPM total ammonia nitrogen and become dangerous as they increase. Ammonia was tested by taking a water sample three times weekly, putting 5 mL of water into two beakers each, and then placing the beakers in a holster that contains a wheel. Five drops of Nessler solution were added to the right beaker and shaken, and then the wheel is spun until the shade of orange matches. At the point where the colors were the same, there is a number that indicates the level of ammonia in the water sample. This was recorded three times a week, at the same time as pH.

Turbidity – A buildup of algae, phytoplankton, or zooplankton reduces turbidity and can increase pH and change other variables in a pond. This was measured by placing the Secchi disk into the water until the black and white

segments are indistinguishable when the disk is spun. At that point, the depth is recorded. This measurement was taken once weekly.

Alkalinity – Alkalinity levels can affect pH, and are tolerable between 50-300 PPM. This is a slow changing variable that is measured by titrating H_2SO_4 into 50 mL of pond water + 5 drops of methyl orange solution. When the solution turns from orange to pink, the mL of titrant is recorded and multiplied by 100 to find the measurement of alkalinity. This was tested every three weeks.

Hardness – Preferably maintained greater than 100 PPM. Taken along with alkalinity, hardness is measured by titrating EDTA into 50 mL of pond water + 1 mL of buffer solution + 5 drops of Eriochrome Black t-indicator. The mL of titrant is recorded when purple changes to blue, and then multiplied by 20.02 to find a hardness measurement.

Phosphorous – Important part of fertilization due to its impact on phytoplankton and zooplankton growth, which affect oxygen and pH. It was tested weekly. 25 mL of pond water was filtered and covered. A combined reagent was made using 50 mL 5N sulfuric acid, 10 ML ammonium molybdate, 5 mL potassium antimonyl tartarate, and 30 mL of ascorbic acid. The ascorbic acid was prepared freshly from 1.76 gm powder dissolved in 100 mL distilled water. Once the combined reagent was formed, the pond samples were uncovered and 1 drop of phenol phythlaline was added. If the samples turned pink following the drop, 1 drop of 5N sulfuric acid was added and then stirred. Then, 4 mL combined was added to each pond sample. Once this mixture was completed, the samples were examined at 880mm on a spectrometer. Absorbance was recorded and converted to concentration using a formula found previously using known substances.

Nitrate – Very important part of pond health, preferably kept under 1 PPM. It was tested weekly. 50 mL of water was filtered and evaporated on a heating source. After drying, 1 mL of Phenodisulfonic acid was rubbed into the dish with a stirring rod. Then, 25-35 mL of distilled water was added. The contents were transferred to a beaker where 4 mL of concentrated ammonium hydroxide was added. Distilled water was then added to bring the mixture to 50 mL total volume. A blank was prepared from 1 mL phenodisulfonic acid, 4 mL conc. Ammonium hydroxide, and 45 mL distilled water. The spectrometer was set to 410 nm, and the blank was used to zero the reading. Samples were then tested and absorbance was recorded. A conversion sheet was then used to find concentration based on the absorbance number.

Seepage and Evaporation – Measurements of water lost from the pond were used in a center wide study of pond productivity, unrelated to stocking density. Seepage was measured weekly, and evaporation was measured every other week. Measurement tubes were placed in the pond a week after the beginning of the experiment and filled to the zero markers on the inside and covered. Every week following, the inside and outside change in water was recorded. The change in the water level inside the covered tube represents seepage only, while the change outside the tube represents seepage and evaporation. Subtracting the inside change from the outside change found evaporation.

Results and Discussion:

Growth

Figure 1 and Figure 2 show the impact of increased stocking density on fish growth by tracking weight gain and length. At the stocking density of 5 fish per cubic meter, weight varied between 140% and 150% of the stocking

density of 25 fish per cubic meter in each sample. Growth rate varies inversely with stocking density. As the trial is continued these numbers will likely continue along this trend.

At the end of the trial the fish will be removed from the pond and counted, and mortality rate will then be found. Also, using this data, total feed intake and feed consumption ratios can be found. After harvesting the fish, much more information about the viability of each stocking density will be known.

Water Quality

Water quality factors remained fairly constant during the first six weeks of the experiment because the carrying capacity was not reached in either situation. Trends in pH and dissolved oxygen show where future problems might occur as fish size increases in the ponds. Also, because the ponds had the water changed weekly, artificial feed was used, and fertilizers were not used, water quality in all stocking densities was stable.

Phosphorous and nitrate levels remained at a safe, low level. Because natural feed and fertilizers are not used in any ponds, phosphorous levels will likely remain low throughout the experiment. Nitrate levels may increase as the fish grow, but have not shown any differentiation so far.

Dissolved oxygen levels have decreased for both stocking densities as biomass increased. So far there has been very little differentiation between oxygen levels between stocking densities. The dissolved oxygen levels are most critical in the early morning. After six weeks, both stocking densities have had a healthy level of oxygen. In the future as the fish grow towards the carrying capacity more oxygen will be used and differences between stocking densities may appear. This difference may be negated due to the increased size of the fish in the lower stocking density. This is because larger fish will consume more oxygen per individual, balancing the effects of having less fish total.

pH levels began with almost identical readings in both stocking densities, then began to show slight differences. As the fish grew, pH levels became slightly larger in the high stocking density ponds. This has the potential to be dangerous to fish and can decrease their growth. Tilapia are best suited in a pH range of six to nine, and during one point where the input canal had a high pH of 8.72, the pH levels in all ponds were higher than nine. In some high stocking density ponds the levels were almost ten, which is a dangerous point for Tilapia. The low stocking density ponds were also high during this time and also reached unsafe levels. Figure 3 shows the slight increase in pH between the stocking densities. This difference could be attributed to minor differences in the alkalinity. Also, the decrease in turbidity during this time period suggests that a buildup of phytoplankton and zooplankton could be the cause. The differences during the first six weeks in pH are insignificant to growth and were high in both cases, but may be an indication of potential future problems.

Ammonia levels also showed a small difference as time progressed, as illustrated in Figure 4. There was slightly more ammonia found in high stocking density ponds after about two weeks. After about five weeks, the differences became more pronounced. This can be attributed to the increased waste produced by more fish in the pond. Ammonia levels during the first six weeks were low enough to be healthy in both stocking densities. The differences in ammonia levels in each stocking density, along with the trend towards separation, shows that ammonia may be a limiting factor of pond growth as fish size increases.

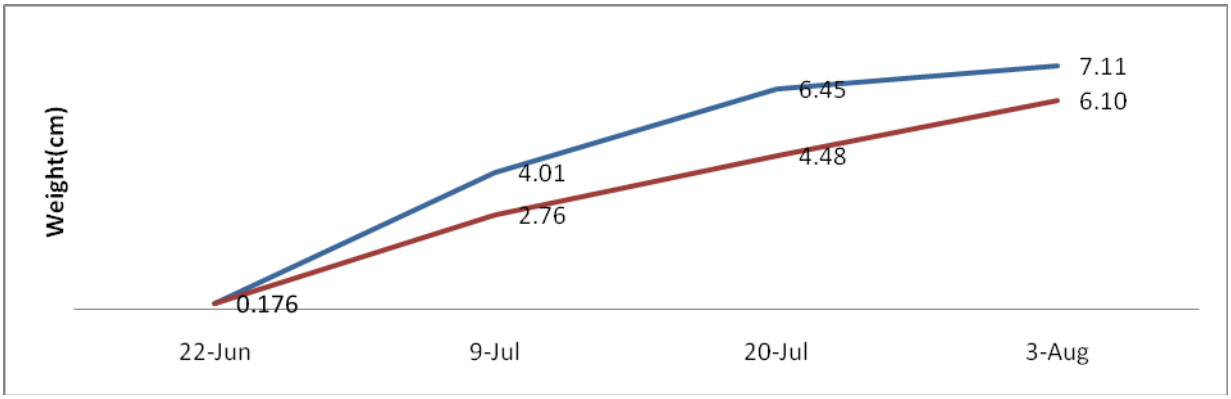

Figure 1. Weight of fish in grams measured every two weeks.

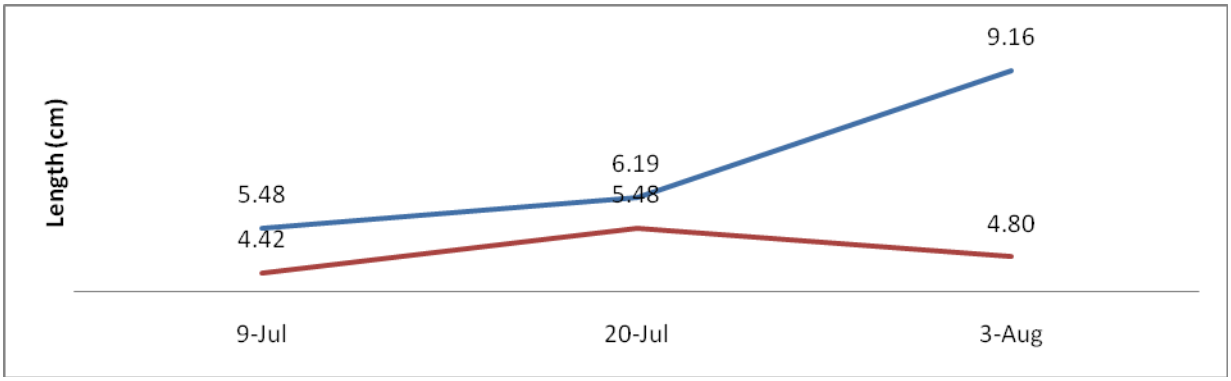

Figure 2. Length of fish in cm measured every two weeks.

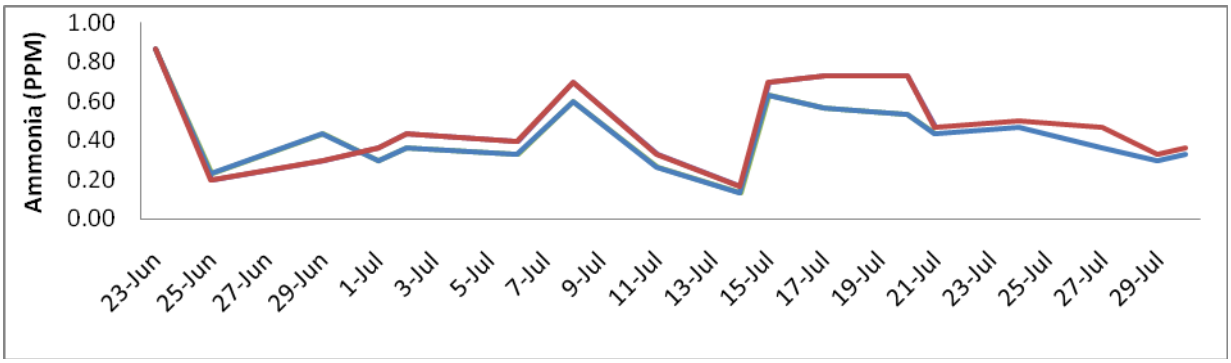

Figure 3. Ammonia levels measured every other day over six weeks.

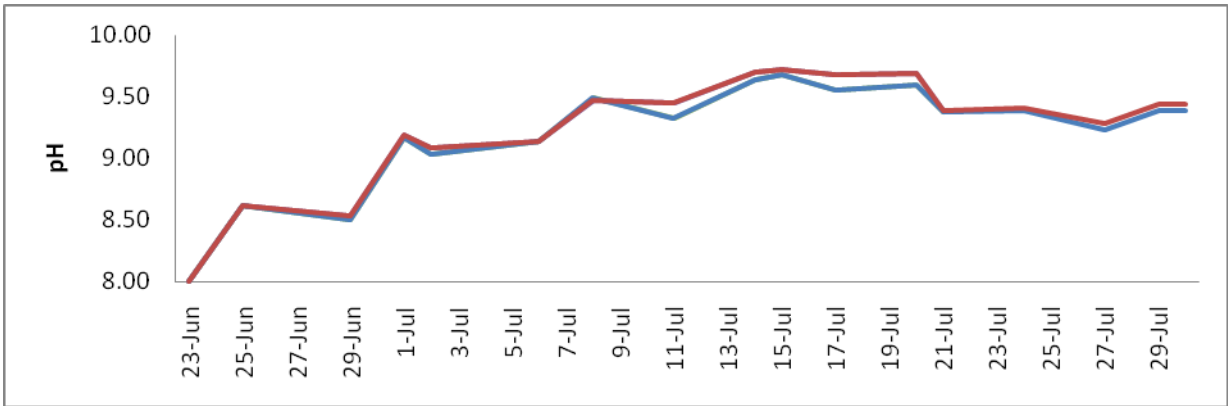

Figure 4. pH measured every other day over six weeks.

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