My Mdudu Days

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Table of Contents

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Introduction

For a very long time, I have dreamed of the opportunity to travel to Africa. Through high school, my interest in Africa evolved into a general interest and concern for poverty and world hunger in developing nations. Thus, after learning about the World Food Prize Youth Institute from a friend, I knew immediately this was of great interest to me. I went directly to the faculty sponsor at Ames High School and reserved the space for the Youth Institute the following year. Not long after, my sponsor received the information for the next Youth Institute. Without delay, I began to ponder and research materials for my paper.

Studying Africa was an easy choice for me. I studied the African continent to find the area with the most poverty. This area became the focus of my Youth Institute paper. Studying West Africa, rice farming, the role of women, and food insecurity was a large task, but was well worth the work involved. I read books, papers, and websites to find as much information as possible. The Youth Institute paper gave me the opportunity to extensively learn more about a subject I found very interesting.

Once I arrived at the Youth Institute in October, I found the same excitement. I listened to as many speakers at the Symposium as possible, viewing power points and taking notes. At mealtime I strategically placed myself at tables hoping to have as many interesting people as possible to talk to and learn from. On Saturday after presenting my paper, I prepared myself to listen to the international internship presentation. I already knew I would apply, having read about the program both online and in the pamphlet. As I listened to the wide variety of experiences I imagined the possibilities for my own internship, should I be accepted into the program.

After the long application process and the interview, I hesitantly opened the envelope with the World Food Prize letterhead to find out my fate. Thankfully the letter sent me good news of acceptance into the program, and a few weeks later I tore open another letter to find out I would be spending my summer in Kenya.

I spent my summer in Nairobi, Kenya, at the International Centre of Insect Physiology and Ecology (ICIPE). ICIPE was founded in 1970 with the intention to carry out scientific research focusing on tropical issues in the developing world. Today, ICIPE's objectives are to help ensure food security and better health for humankind and its livestock; to protect the environment; and to conserve and make better use of natural resources. [1]

ICIPE's mission is to help alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building. To achieve their mission and objectives ICIPE is

[1] Why ICIPE?, http://www.icipe.org/about/index.html

divided into four divisions: Plant, Animal, Human, and Environmental Health. Though I had an overview of the four divisions' projects, I spent my summer as part of the Plant Health team.

The Plant Health division of ICIPE focuses on three research areas: horticultural crop pests, staple food crop pests, and locusts and migratory pests. The goal of the Plant Health Team, the oldest research area at ICIPE, is to contribute to "improved sustainable food security and environmental health through developing integrated pest management (IPM) options that fit farmer's needs because they have been developed on the farm and with farmer participation."[2]

When I learned I would be working with insects I wasn't exactly thrilled; I have not always been one to live in harmony with the six-legged creatures. Nonetheless I was willing to learn, so I spent my summer in Nairobi. Mdudu is the Kiswahili word for insect. The local name for the Nairobi ICIPE complex has therefore been termed Duduville. Insects were my life for eight weeks this summer. There were even insects on my bed and the teacups (don't worry those were just pictures).

I left my home in Ames, Iowa this summer as a new high school graduate to spend my summer working half way around the world. Before I left, I was warned I would be changed by my experience, but I had no idea what to expect. I returned home only two months older, and as they told me, I have changed. Change occurs in many forms, expected and unexpected. Filled with adventure, wadudu, unexpected experiences, and transformation; this is my dream come true; this is my Ruan-Borlaug Internship in Kenya.

[2] Plant Health, http://www.icipe.org/research_areas/plant_health/index.html

The Diamondback Moth Experience

My research at ICIPE was in the Horticulture Crop Pests Department of the Plant Health Division. The Horticulture Department deals with pests of fruit and vegetable crops. I worked under Dr. Bernard Löhr, the Head of the Plant Health Division at ICIPE and the leader of the Diamondback Moth (DBM) research. Though Dr. Löhr was in charge, I worked primarily with graduate students and the senior research assistant, Mr. Gatama Gichini.

In my first days and weeks at ICIPE, my task was to learn about the DBM project. I read papers and books to familiarize myself with subjects previously unknown to me: Biocontrol, Integrated Pest Management (IPM), parasitoids, and the life of DBM. I also spent time helping collect data for the research being done on Biocontrol of DBM. In my first few weeks in Kenya I traveled to Wundanyi (Figure 1) and Matuu to investigate cabbage and kale plants.

Figure 1: A photograph of DBM team members surveying a kale field in Wundanyi.

In these first field study trips I learned about cabbage and kale farming, pests of crucifer plants, and information about many other tropical crops. I helped collect data that was used to determine the prevalence of DBM in the fields. Beyond this, data was also taken on other pests and parasitoids. I learned to identify white flies, various species of aphids, other pests and diseases, and to determine whether or not pests had been parasitized. The field experiences were a perfect introduction to agriculture in Kenya because I got to see many farms and new crops.

After a few weeks I began to understand the subject and was given my own research assignment. I would be studying the egg mortality of DBM. I was given a general outline and from there I started to design the methodology for the experiment. With continued reading about egg parasitoids and cage studies, I was able to form a basic plan to study the factors contributing to egg mortality in a field situation.

While working at ICIPE, my research was completed independent of the other graduate students' projects. Though not critical to the project, I was glad to have an assignment

that I was able to plan and carry out from beginning to end. I worked among graduate students from various backgrounds, including students from across Africa and Europe, with specialization in various sciences and economics.

In the beginning, I was unable to understand the purpose of my research. How do all of the separate research projects complete the goals of the DBM project and ICIPE mission? How do moth eggs relate to food insecurity? Soon my questions were answered.

In a local newspaper's story on the DBM project the author wrote, "Eaten daily, either raw in salads, steamed, boiled or fried, cabbages and their cousin kale serve as important cash-generating crops in many households, and are used as fodder for animals."[3] The Diamondback Moth project recognized the importance of cabbage and kales in Kenyan and East African food security because the DBM heavily infests this family of plants and has developed resistance to all commercial pesticides.

The effects of the DBM are detrimental to cabbage and kale farmers. In the Larval stage of the insect, small green caterpillars feed on the vegetables causing leaves to look skeletonized while leaving behind black fecal matter (Figure 2). Without control the pest damage can lead to 100% loss of crops. Continued spraying of chemical pesticides, while doing nothing to control the pest, only cause more harmful effects to consumers, producers, and the environment while raising production costs.

Figure 2: A photograph of a kale leaves with damage by the DBM.

The DBM project has been working since 1995 to develop Integrated Pest Management Solutions for this pest. A native larval parasitoid exists but does not provide sufficient control of pests so other possibilities were explored. After extensive background research to ensure the biocontrol agents would be safe for the environment, the DBM team released exotic larval-pupal parasitoid *Diadegma semiclausum* in the highlands of Kenya. The parasitoid uses the larva and pupa of the DBM as a host for eggs. The pupa develop into a dark brown color and instead of emerging normally as an adult DBM, they emerge as an adult wasp.

[3] Saving The Cabbage, http://www.icipe.org/news_and_events/pr007.html

Two years after the release, the project has been deemed successful. The following is an excerpt from an article released in a daily Kenyan newspaper. The article is covering the release of the DBM parasitoid in the highlands. This portion describes the direct effect of the project on cabbage and kale farmers. [4]

> As in most cases, benefits of this nature tend to be ambivalent. The reduction of the diamond-back moth has meant lower production costs. (The Umoja Self-Help Group has worked it out to Sh1 per cabbage.) With minimal damage to the crops, farmers are able to get greater volumes cultivating the same area. Mwacharo used to plant just 25gm of seeds. He has now upped this to 50gm, giving him 5,000 heads, and intends to double that in the near future. Cabbage farming has become attractive again and more farmers are returning to it. As a result, production, according to Onano, has gone from 25 tonnes to 30 tonnes per hectare. This is not necessarily good for the market, as over-supply will lower prices.
>
> Mwacharo is not worried about such a possibility: "Farmers are not stupid... they talk to one another," he says. "You won't find everyone in this valley growing cabbages."…
>
> The Wundanyi farmers seem geared for prosperous cabbage farming, especially if they heed the advice District Agricultural Officer Munyi Ali Mwakuvunza, who while commending the biological control project, also urges: "*Mwerefu ni mwenye kushika* (The wise one understands and embraces it)..."
>
> No doubt the Wundanyi farmers share this same viewpoint. The women with their bright *khangas*, and the enthusiastic father-of-three Mwacharo, are all singing from the same hymn-sheet.

While this parasitoid is controlling DBM in the highlands, the species is not functional in the climate of the semi-arid lowlands, so a new parasitoid had to be studied for release in this environment. While at ICIPE I had the opportunity to witness the release of the exotic parasitoid *Cotesia plutellae*, a larval parasitoid from South Africa and Taiwan, into the lowlands of Kenya, in village near Matuu (Figure 3). The DBM team had been studying this parasitoid and after adequate research, the insect was safe to be released. The release was a very important event for the DBM team. News reporters and members of the Ministry of Agriculture were there with DBM team members and local crucifer farmers to observe the release (Figure 4). Dr. Löhr, Director General Christian Borgemeister and others spoke at the release about the hope for farmers. Graduate students spoke directly to the farmers in Kiswahili to share methods and practices with them for the parasitoid to be successful.

[4] Wasp vs. Moth, http://www.icipe.org/news_and_events/pr2005062201.html

Figure 3: A photograph of the rural areas outside of Matuu, located in the semi-arid lowlands of Kenya.

Figure 4: A photograph of Dr. Bernard Lohr addressing a group of farmers, journalist, ministers, and DBM team members about the parasitoid release.

It is too soon to remark on the success of the recent release, but results similar to the highlands are expected. For the highlands and the lowlands, the beneficial effects parasitoids will continue to expand over time naturally and with the help of more releases done with the help of the Kenyan Ministry of Agriculture. Though releases are completed, research is still being done on the economic impact of the IPM strategies. With the new biocontrol agents, farmers are able to produce better crops without spending money on pesticides.

The work of the DBM project directly helps increase food security among small-scale farmers in East Africa, while protecting the environment. It not only increases income among rural farming families, but also helps prevent "hidden hunger," or a vitamin and nutrient deficiency. The work of ICIPE also produces opportunities for continued education for Africans. Most of the work being done in the DBM project is by masters and doctoral students. Education is a critical step forward for developing countries, and creating experts in areas relating to food security will continue to benefit the Kenyan and African economies, beyond the initial work helping crucifer farmers.

I now understood how all of the research completed the goals of the DBM project, but the general project I described still does not provide the answer to the question, how do moth eggs relate to food insecurity? To achieve an understanding I began my own research project.

As I prepared and began my research I continued learning about the project and the processes for research. With the input and suggestions of Dr. Löhr, graduate student Caleb Momanyi, and Mr. Gichini, I finalized my methodology. I began by practicing setup for oviposition by DBM on kale plants. I released male and female DBM with the plants in a cage overnight to allow time for the DBM to oviposit. Next, I marked and counted eggs on the upper and lower surface to practice the techniques needed for my data collection. I performed two counting practice runs. After finding a shortage of eggs in each practice run, I revised my methodology for the oviposition process. In an attempt to obtain more eggs in this process the kale leaves were sprayed with cabbage juice, which after trials proved to solve the problem. With revisions in place, I began my first

set of data collection in the field. By the time I collected my first round of data it was apparent that my methodology had flaws and needed more revisions.

Originally I marked and counted the eggs on each leaf in the lab, transported them to the field in the vehicle, planted the eggs, and caged them. Many eggs were lost through this process so I threw out my first set of data and started over. With modifications in place, I began my field research again. This time I took the kales to the field and planted them before marking and counting the eggs, which helped control the margin of error. After comparing the second data set with the first trial it was apparent that fewer eggs were lost with the revised methodology.

After beginning my research I made a timeline in order complete my studies in time. For the most part, field studies were completed on schedule. With a few changes due to "African time"— the inattention to a strict schedule— I was able to complete four full sets of data collection. Along with field research to study natural enemies in the field, I was also given the task of studying the effects of rainfall on egg mortality. There was not a piece of equipment in existence at ICIPE to serve the purpose of simulating rainfall, so I was also given the task of constructing a device.

After consulting with Dr. Löhr, Mr. Gichini, and my father, I began to make sketches of various possibilities for rainfall simulation. After finalizing a plan I worked with the construction engineers at ICIPE to build my rainfall device. It was impossible to build a state of the art device that monitored exact flow and velocity of water, but my design was adequate and economical for the research needed. The first attempt to simulate rainfall on plants failed. I spent an afternoon outside on a ladder with duct tape in hand attempting to maintain water flow through the device only to find myself at the end of the day in wet clothes and no data. Thankfully with the help of the ICIPE engineer I was able to modify the design and carry out the simulations successfully on the second try.

I finally was able to see why the eggs of the Diamondback moth related to food insecurity, even if not in a direct or critical manner. To better communicate the results of my research as a part of the larger project, I have included my formal research paper.

Egg Mortality Factors of *Plutella xylostella (Lepidoptera: Plutellidae)* in Cultivated Crucifers

Introduction

Crucifers, the family of vegetables including cabbage and kale, are an important crop to small-hold farmers, women, and unemployed peri-urban youth in Kenya.[5] Sukuma wiki, or kale, and cabbage are commonly eaten with meals to supplement the maize based diet, adding vitamins and nutrient to the diet. Also, crucifers are sold at the local market and provide supplemental income.

Larvae of the Diamondback Moth (DBM), *Plutella xylostella* (Lepidoptera: Plutellidae), infest and destroy crucifer plants worldwide and the pest has developed resistance to commercial pesticides. Though DBM is unaffected by the pesticides, farmers continue to spray at high frequencies. This habit negatively affects crop yield because the pesticides kill natural predators and parasitoids of DBM. The International Centre of Insect Physiology and Ecology (ICIPE) Plant Health Division has been working to study DBM and find biological control agents to implement into an Integrated Pest Management (IPM) system for Kenyan and East African farmers. Two years ago, one exotic larval parasitoid *Diadegma semiclausum* was released for control of DBM in crucifers grown in highland conditions. In June 2005, another exotic larval parasitoid, *Cotesia plutellae,* was released into the semi-arid lowlands of Kenya.

In the final stages of the research project, the mortality of DBM eggs is now being considered. So far, the majority of research has been focused on the larval and pupal stages of the DBM to work with biocontrol agents. To form a more concrete overview of the life cycle of DBM, mortality factors including native parasitoids, rainfall, and natural predation will be studied.

The goal of this study is to form a more concrete overview of the DBM egg life stage, as minimal data has been collected. Exploratory studies considered natural parasitoids, natural predation, and rainfall as possible egg mortality factors. To do this, two experiments were performed, one using field studies and one with rainfall simulation.

Materials and Methods: Field Studies

Field studies were conducted in the rural areas surrounding Matuu, a semi-arid lowland climate (S 01^{o} 09’ 26.8”, E 037^{o} 31’ 45.7”) and Limuru, a highland area (S 01^{o} 08’ 04.3”, E 036^{o} 37’ 23.6”) (Figures 1-3). The studies were performed between 5 July, 2005 and 26 July, 2005. Kale plants used in the field studies were raised in the ICIPE greenhouse. DBM used for oviposition were lab reared at ICIPE. Preparation of plants was done by spraying the kales with cabbage juice. In practice before studies, this method provided a larger amount of eggs after oviposition and was continued for each field study.

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[5] Löhr, Expanding biological control of the diamondback moth, *Plutella xylostella* L. in Eastern and Southern Africa

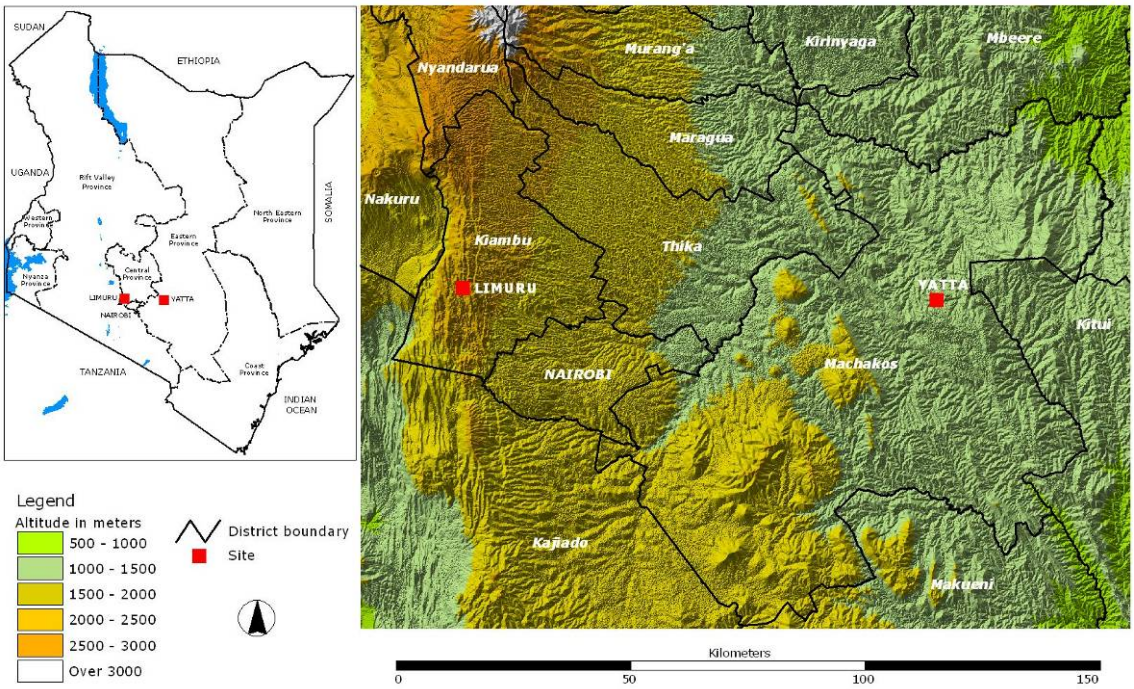

Figure 1: A relief map of field study sites in Kenya.

Figure 2: Field site near Matuu, in the Yatta Irrigation Scheme, pictured with cages.

Figure 3: Field site near Limuru pictured with cages.

Each data set required nine kale plants. After being sprayed with cabbage juice, the kales were placed into two mesh wire cages and approximately 25 pairs of male and female DBM were released into each. The following day, the kales were transported to the designated field site. Plants were given I.D. numbers and dispersed through the field according to cage exclusion requirements (Table 1). In each region of the field the kale was planted in a random position, so as not to form rows.

Table 1: The figure illustrates the outlay of kale plants in the field study. OCG, Open-caged with insect glue; FCG, Fully caged with insect glue; OC, Open-caged, no glue.

6 OCG	3 FCG	9 OC
8 OC	5 OCG	2 FCG
1 FCG	7 OC	4 OCG

Plants were watered to prevent shriveling. After planting, the DBM eggs were marked with a permanent marker, counted, and recorded per leaf. If necessary, a small brush and water was used to remove excess or clumped eggs. The maximum allowance of eggs was six on the upper surface and four on the lower surface.

After egg data was recorded, the kale plants were placed under the cage conditions. An open cage refers to a wooden box outline, covered on the top surface with a clear plastic sheet to prevent rainfall influence (Figure 4). A full cage refers to an identical wooden structure with plastic top, but also is covered on the sides by metal mesh (Figure 5). The mesh prevents large insects from entering via flying. Three cage conditions were studied to look at different possibilities for egg mortality. The full cage with insect glue was used to exclude ground fauna and large flying insects. The open cage with glue was used to exclude only ground fauna. The open cage with no glue had no exclusions.

Figure 4: Photograph of an open cage with a kale plant inside

Figure 5: Photograph of a closed cage with a kale plant inside

During the field studies precipitation was monitored with a rain gauge and the temperature was monitored with a data logger. No rainfall occurred while the plants were left in the field in any of the four sets. After 24 hours in the lowlands, or 48 hours in the highlands, cages were removed. Different times were used because of the difference in climate. In the lowlands where the weather is warmer, the eggs were exposed for a shorter period of time because eggs are more likely to emerge earlier than in the highlands. Following removal of cages, each leaf was removed from the plant, the eggs were recounted, and the leaf was placed into a closed plastic container. Plastic

boxes were returned to the lab for monitoring. Water was sprinkled into the container to prevent leaf shriveling.

The eggs were monitored in the lab, and one week after the introduction of plants into the field, the final data for the set was collected. With a microscope, eggs were surveyed to determine if parasitized. Parasitism by known egg parasitoid, *Trichogrammatoidae spp*., is evident when the egg appears black in color. Also, the emergence of DBM larvae was noted.

Materials and Methods: Rainfall Simulation

The second portion of the study was done on 20 July 2005 on the grounds of the ICIPE, Nairobi. Kale plants having undergone identical oviposition and marking processes as the kales for field studies were used for rainfall studies. Kale plants spent 10 minutes under the rainfall simulator (Figure 6). Three plants were tested at each of the intensity levels: low, medium, and high. The low intensity level used a bottle sprinkler that had .5 mm diameter holes. Medium intensity used .75 mm diameter. The highest intensity used a bottle sprinkler with holes having a diameter of 1 mm. Plants at low intensity were monitored until emergence. A control was monitored until emergence, which used three plants that had not been subjected to rainfall simulation.

Figure 6: Rainfall simulator used a wooden frame that help plastic bottles that had holes drilled in the bottom to produce a varied levels of simulated rainfall.

Results and Discussion

Egg Mortality in the field

The results from studies give only a brief overview of what happens to DBM eggs while in a field (Table 2). Experiments performed were to form a broad understanding of what was happening to the eggs in the field.

Table 2: Egg mortality cage condition averages data from field studies in Yatta and Limuru.

	Average Percentage Eggs Lost per leaf--top	Standard Deviation	Average Percentage Eggs Lost per leaf--bottom	Standard Deviation	Average Percentage Eggs Black per leaf--top	Standard Deviation	Average Percentage Eggs Black per leaf--top	Standard Deviation
FCG Yatta	0.041	0.047	0	0	0	0	0	0
FCG Lim	0.023	0.036	0.117	0.204	0.010	0.024	0	0
OCG Yatta	0.083	0.088	0.271	0.406	0.126	0.233	0.023	0
OCG Lim	0.023	0.078	0.096	0.2	0.009	0.021	0	0
OC Yatta	0.048	0.089	0.118	0.183	0.123	0.191	0.024	0.058
OC Lim	0.028	0.068	0.056	0.086	0.02	0.049	0	0

Data were collected on the emergence of DBM eggs into larvae after field exposure. It was very difficult to collect accurate data on emergence when monitoring eggs in the plastic boxes in the eggs, thus the overall emergence data was unreliable. Even without the emergence data it is possible to look at egg mortality predation in terms of egg loss and parasitism in terms of black eggs, which will be explained later. Further refined studies would be needed to determine exact emergence percentages. A control would be needed to determine the emergence of eggs unexposed to field conditions.

Natural Predation as an Egg Mortality Factor

The eggs lost between introduction in the field and collection can be explained by three possibilities: natural predation or removal of the eggs in the field, negligence of the egg-laying female in placement and gluing of eggs causing eggs to fall off, and eggs unintentionally removed during the counting and caging process. The third possibility is human error and would be similar for all treatments and therefore should not affect the results.

The average percentage of eggs lost on the upper surface of leaves shows no significant differences between cage conditions. In the average percentages lost, Yatta has a slightly higher egg loss in all cage conditions then Limuru which stays around 2% lost. Overall the percentages are minimal. Eggs lost on the bottom of leaves show no trends among the different cage conditions or fields. The percentages lost on the lower surface are more varied and the range includes more significant percentages, but all of the results display very large standard deviations. The high standard deviation downplays the accuracy of percentages lost on the lower surface.

Overall data does not present that there is a significant presence of DBM egg predators causing egg loss in the fields studied. The small losses and lack of trends show that there is no DBM egg natural predator. It is expected that natural predators will be larger flying insects or ground fauna. In the full cage, the glue prevented effects from ground fauna and the wire mesh prevented large flying insects. Yet, with these controlled, there was still a loss of eggs similar to other cage conditions which could be due to factors other then predators as discussed earlier.

Natural Parasitism as an Egg Mortality Factor

The presence of black eggs in the collected data, as with predation, shows no significant trends between number of black eggs and cage conditions or field study sites. Some minimal trends can be seen in Yatta where in both open cage conditions upper surface the average of black eggs was about 12-13%, in the lower surface black eggs averaged near 2.3%, and in the closed cage no black eggs were found. Yet, in Limuru, black eggs did occur in closed cage conditions, so it can no be concluded that black eggs never occur in closed conditions. Samples of black eggs were not consistent throughout a plant, cage condition, or data set. Though presence of black eggs is variable, it cannot be overlooked.

The *trichogramma* genus of egg parasitoid is commonly identified in different species when eggs turn black after parasitism.[6] After locating black eggs on the kale leaves, eggs continued to be monitored for emergence. In the primary findings of black eggs, there was never emergence. In the last set of black eggs, they were monitored in a warmer lab, and after a few days emerged as *Trichogrammatoidae sp. nr. Lutea.* The possibilities for the lack of emergence for the other eggs include misinterpretation of black eggs or the effects of chemical application, but more likely, the inadequate emergence conditions. The eggs were kept in a lab which is cooler then the needed emergence condition. This is supported by the observation that shortly after the last set of eggs was moved to a warmer climate they emerged even though they had passed the expected emergence time period of eggs in the correct conditions.

Rainfall as an Egg Mortality Factor

For separate upper and lower surface data, the results do not directly increase with water intensity, in the average proportion, the eggs lost increases with increasing intensity (Table 3). It is evident that rainfall has a larger effect on egg mortality then the other factors found in the field.

Table 3: Rainfall simulation data results.

Low Intensity	Average Proportion Lost per leaf--Top	Standard Deviation	Average Proportion Lost per leaf--Bottom	Standard Deviation	Average Proportion Lost per leaf–Top and Bottom	Standard Deviation
Totals	0.627	0.171	0.133	0.176	0.509	0.082
Medium Intensity	Average Proportion Lost per leaf--Top	Standard Deviation	Average Proportion Lost per leaf--Bottom	Standard Deviation	Average Proportion Lost per leaf–Top and Bottom	Standard Deviation
Totals	0.591	0.104	0.833	0.204	0.621	0.105
High Intensity	Average Proportion Lost per leaf--Top	Standard Deviation	Average Proportion Lost per leaf--Bottom	Standard Deviation	Average Proportion Lost per leaf–Top and Bottom	Standard Deviation
Totals	0.779	0.195	0.571	.0405	0.842	0.089

[6] The Trichogramma Manual, http://insects.tamu.edu/extension/bulletins/b6071.html#taxonomy%20and%20identification

Eggs were kept on leaves in boxes after rainfall for a week to monitor emergence, but no emergence occurred. There was no time to rerun the trial and monitor for emergence under different conditions, so more data is needed to make conclusions on the effects of emergence on rainfall.

Though rainfall did cause a significant amount of egg loss, it is significant to note the infrequency of rains. From March to June there are long rains in Kenya and from October to December there are short rains.[7] Even during these periods it is not guaranteed that the rain will coincide with the egg stage of the DBM lifecycle.

Conclusions and Recommendations

1) Natural predation is an insignificant factor of DBM egg mortality at field sites.
2) Parasitoid *Trichogrammatoidae sp. nr. lutea* is present in the highlands and plays a minimal role in egg mortality.
3) Evidence of *Trichogrammatoidae sp.* is in the lowlands demonstrated by the appearance of black eggs, but more studies which track emergence are need to confirm. The parasitoid in the lowlands also plays a minimal role in egg mortality.
4) Rainfall is a significant source of egg mortality, but rainfall amounts are variable with changing weather so it cannot be depended on as a consistent egg mortality factor.
5) The natural egg mortality rate of DBM exists but is very small. More specific studies should follow to explore parasitism rates.

[7] Weather and Climate in Kenya, www.southtravels.com/africa/kenya/weather.html

Experiences and Adventures

In the weeks before I left for Kenya, my mind reviewed its fears of my upcoming adventure. My biggest fear was that I would travel all the way to Kenya and spend the whole eight weeks locked inside the ICIPE Research Compound without experiencing the country and culture. I was warned not to go anywhere alone, and I did not anticipate finding any age mates with whom I could have adventures in Kenya. After three and a half days in Kenya, my fears were relieved.

Before my travels, I was designated a "Kenyan Mother" at ICIPE, Susan Kariuki, who would watch out for me during my stay. On the Friday following my arrival, Susan invited me to travel with her to a family reunion in Nukuru, Kenya. I didn't ask many questions, and agreed immediately, excited for the opportunity to leave the ICIPE Complex. So, on my first weekend in my new home, I ventured off into Kenya. The drive alone was amazing. I had come to love driving around Kenya because of the people along the roads and the new and changing scenery. No matter the destination, I always found we ended up getting stuck and slowed down by the horrible driving, lack of traffic law enforcement, and terrible roads. On this trip, we passed through the Great Rift Valley. The Great Rift Valley stretches from Ethiopia to Malawi and is lined with lakes, volcanoes, and lush green plants.

Nakuru is one of the larger cities in Kenya, but nothing compared to Nairobi. My newfound family and I traveled to the outskirts of the town where the reunion was to be held. It is hard to describe the neighborhood, but looking around, it was apparent that poverty was present. I got out of the car and for the first time, had the experience of being stared at. One child even stated the obvious, and called out Mzungu (white person) as he looked on at me.

Time and time again during my stay in Kenya, I found myself the object of intense staring, especially in the rural areas. I quickly realized, that the staring was not meant to be hateful or discriminatory, but simply observing something unfamiliar. In this first experience, I learned a simple technique to use with children. Children stared the most, but I discovered that if I looked into their faces and smiled, the shocked staring would end after a few seconds of contemplation, and a smile would break onto their face as well.

Family ties in Kenya are extensive. My experience at the family reunion was only the beginning. It seems that every other week I would meet more and more relatives of the Kariuki family, spanning throughout Kenya. Susan introduced me to her relatives as her eldest daughter and they all warmly welcomed me. As soon as we finished greeting, shaking hands, and hugging, we grabbed a plate and began to serve ourselves from the line of huge pots filled with foods I had never encountered before. Festivities such as this one were never without food and usually a goat or two would be slaughtered for the occasion.

I sat in the courtyard of some relative's home as I ate and took in my surroundings. My plate was piled with various styles of rice, something that looked like chunky green mashed potatoes, and some chicken. Relatives of all ages were sitting on chairs scattered through the enclosed area and beyond the people was a stable for the cattle. The people around me talked among themselves in a mixture of Kiswahili and their native language, Kikuyu. I didn't try to follow conversations, but instead accepted it as the perfect background music for my first African experience. A few hours later as I was leaving with my family, Tom, Susan's husband told me, "Now you have experienced real Kenya, real Africa." And I knew it was the truth.

The first weekend was only the beginning of my adventures in Kenya (Figure 1). My fears were completely gone. I knew my eight weeks here would be packed with culture, food, family, and Kenyan experiences. The question was, how would I do all of this and an entire research project as well. Thankfully, my research allowed me to probe further into Kenyan culture with my frequent field study trips.

Figure 1: A photograph of Shiku, my younger Kenyan sister, and I with a background of flamingos in Lake Nakuru National Park.

A few weeks into my stay I was given the opportunity to take a four-day field trip to eastern Kenya to collect data for the general DBM project. Upon arrival at our destination I was amazed how quickly the landscape changed from a semi-arid area to rolling green hills. Spending time in Wundanyi, situated in the Taita Taveta hills, was an eye opening experience. When traveling to our field sites each day we would pass many women walking up and down the hills with huge bundles placed on their heads. There were men walking in the hills as well, but very rarely carrying large loads. Seeing the women of Wundanyi like this was a beautiful experience in some ways. Although I was given an overwhelming sense of female power by watching the women throughout the day, at the same time it was frustrating to see the inequality between men and women.

I found sexism to be one of the biggest differences between my home and Kenya. In America, I feel no restrictions due to my gender. In observing and experiencing Kenya, I had the feeling that gender restrictions were present. I find gender issues to be one of the largest issues to deal with in the development of third world countries. The role of the females in developing nations is arguably the remnants of old traditions. I am a firm believer that while ending poverty in developing countries, culture and tradition must not be destroyed. As an outsider and an onlooker, I cannot fully understand the situation.

Yet, seeing the position of the female in Kenya, I also believe that it is unjust to retain many of the traditional roles that allow men to relax while women carry the burden of work.

For one of the few times in my short life, while living in Kenya, I felt that being a female was an unfortunate reality. I was more likely to be in danger in Nairobi. In the eyes of some, I was considered less important or capable than a male. I could not go anywhere alone. These issues are unbelievably frustrating, but I must come to terms with them because if I want to spend time in developing countries, this is the vivid reality of the situation.

On one of my field excursions, I had the opportunity to walk around the small town alone without being in any danger. I walked through the town, immersing myself with the sights of shops, seamstresses, restaurants, the market, the people, and the beautiful surrounding Kenyan countryside. Being in such a small village also implies that very few wazungu (white people) have been encountered. This experience was very humbling because in the time I spent walking around town almost every person stared at me. I was the center of many people's attention. I find myself still unable to describe the experience, but I agree with one colleague's description—I was like a caged animal at a zoo being stared at by every passerby.

When I wasn't traveling with my Kenyan family, I stayed at their home for the weekend (Figure 2). Friday after work, I would drive across town with Susan to her home in Buruburu on the east side of Nairobi. Upon reaching home, Susan would change into more comfortable clothes, while I would settle in on the couch in the living room. Each Friday I spent at her home, without fail, I would find tea awaiting our return home. It is very common in Nairobi, for those who can afford, to have a live-in housekeeper. The Kariuki's live-in helper happened to be a cousin. Susan explained that it was necessary for she and her husband to work and the only way to have kids as well was to hire a housekeeper. So when I arrived at "home," there was always tea and, sometimes, even mandazi, a donut type snack. Mandazi became one of my favorite Kenyan foods. As my time progressed I began to feel more comfortable with my Kenyan family and I was always happy to have this time with them. Susan and her husband were constantly discussing the news and various problems in Kenya, Africa, and the world with me.

Figure 2: A photograph of my Kenyan Mom Susan, her two daughters, and me in their living room.

While in Kenya I spent most of my Saturdays at the Thomas Barnado House, an orphanage in Nairobi. The house is home to more than one hundred children of all ages. Children aged three and up are split into house units, fifteen to twenty children per unit. These units are meant to make the residents' lifestyles more like living in a regular family. Each Saturday, I spent my time working in the nursery. Although I had done my share of babysitting, I was not prepared for fifteen babies at the same time. Thankfully the other "Aunties" were in charge and I just helped out as much as I could. My duties included feeding the babies different varieties of formula and mashed up vegetables, giving baths, changing diapers, dressing, and playing with the babies.

A relative of the Kariuki's had recently purchased a shamba, or plot of land, in Masai country, so one weekend they invited friends and relatives to celebrate. The best way to celebrate anything in Kenya is to slaughter and roast a goat. I tried not to think too much about what I was eating and I was able to enjoy the meal. I found during my stay here, it is best to simply eat what you are given, without evaluating what it may be or from where it came.

After eating the whole group decided to take a walk around the farm to see their new land. As we were walking I encountered two things I never imagined I would see at a family grill out—a Masai Herdsman and a herd of zebras and wildebeests. Upon return from the walk, the sunlight started to fade. Day and night in Kenya are split in half. From six in the morning to six at night, the sun is out. Instead of mingling with the adults, with whom I was only able to catch pieces of their mainly Kiswahili and Kikuyu conversations, I decided to spend the evening with the children. We all sat on the blanket and wrestled around for a bit. It was obvious that many of them had not spent this much time with a mzungu before. At one point we had story time, where I told stories of America. They were amazed that I didn't have to wear a uniform to school.

Though I had many great experiences, I was unable to travel around the world without facing some difficulties. I spent the last two years of high school involved in endless clubs and activities, in and out of school. I rarely had a spare moment. I was always busy and I loved that feeling. Even when school and activities faded away in the last few months of high school, I filled my spare time spending time with friends. I left for Kenya, after one of the busiest weeks of my life that included college orientation and my sister's wedding.

Arriving at the Guest House in Nairobi, it took me only a few days to realize I was completely alone. I spent my day around people at work, but the evenings would be spent alone. It did not take long for the homesickness and loneliness to set in. All I had was work from 8-5 and beyond that I had nothing. I had gone from being extremely busy to having immense amounts of free time. There were good and bad weeks. As time went on, I found things around the ICIPE complex to keep me a little busy. I found friends in the books I read and I got to know the ICIPE/USAID gym very well. Even after discovering new pastimes, I still awaited the weekends I spent away at the Kariuki's home or traveling.

In my hours of free time I tried to read Kenyan and African literature. I read books of rural and urban Kenyan poverty, of apartheid in South Africa, and of colonization in West Africa. After spending time in Kenya, I felt the words of the various authors ring true. Though I could not relate to the characters, I could see the reality of their situations in the country in which I was living.

Witnessing the poverty in Kenya was not sufficient for a full understanding of the situation. I was very lucky to have had the opportunity to spend time discussing the poverty in Kenya and the state of the world with Kenyans. The best way to learn about a country's problems is to talk about them with the people who live among the problems. One evening, I stayed up until midnight discussing poverty, hunger, Kenya, and American politics with four Kenyan adults. After the discussion I felt as though I could better understand the world and its problems, though it is often very difficult as an outsider looking in. I am still not satisfied with my understanding.

Theft, robbery, and organized crime are prevalent in Nairobi, Kenya, which I experienced firsthand when my bag and camera were stolen in broad daylight. It is the capital of the country and the biggest city. I lived on the outskirts of the city and the majority of my travel into the city resulted in a safe destination. My observations of the city came from inside a car. I looked forward to my weekly drive home with Susan because I was able to have a glimpse inside the lives of Nairobi dwellers. Urban poverty is much different than rural poverty, but still it is hard to understand the full magnitude of the situation.

After weeks of observing the city of Nairobi, the best term I can use to describe it is a collision of African culture and the western world. People from all over Kenya leave behind their rural livelihood in hopes of finding wealth in the city. Matatus, a form of public transportation, rule the world. Traffic laws are rarely obeyed. Billboards rise into the air advertising technology and expensive lotions, things that can only be purchased by the small minority of wealthy in the city. Cinderblock buildings are set back along the roads. City building codes do not exist. Dwellers in these cheap flats could come home to a collapsed building. If you do not make enough money to afford a flat, you are forced to live in one of the numerous slums. The slums are built upon the undeveloped land in Nairobi. One person without a home sets up a shack and soon enough the area is jammed with lean-to type dwellings. There is no water or sewage system. There is very little hope for an escape from this life and the slums have a high concentration of AIDS, prostitution, and drugs.

Along the roads one can see thousands of people walking in all directions. Some people walk along selling secondhand clothes or seemingly useless trinkets. Others simply walk. Some are going, some are coming. As they walk they pass by kiosks selling sodas and who knows what else. They pass open-air markets, stalls piled high with fruits and vegetables, secondhand clothes, and sometimes, live chickens. Some walkers stop at the roadside trash pile to search for food or anything worth selling. A lucky person stops on the corner to buy some dinner from the man roasting maize.

We always locked our doors when driving through the city and I only rolled my window down a crack. It always seemed to be cloudy in Nairobi and the air was filled with pollution from the mufflers of old semi trucks emitting clouds of dark gray smoke; another reason to keep the windows up. In any uninhabited space, there is bound to be a plot of maize. In the mornings, there was a sense of hope, seeing the children in various colored school uniforms, destined to spend the day learning. Escaping from this world is possible, but only in the shopping malls or supermarkets, and only if you have enough money to go to such a place. In one part of town there are big houses. This is where the ambassadors and foreign investors live. The Kenyans found in this neighborhood are house staff or security guards. Nairobi is another world, a collision between the traditional Kenyan lifestyle and the western lifestyle.

During one of my weekend stays with my Kenyan family we went to visit their family farm. In the Nyeri district of the highlands of Kenya, I had a small glimpse into the life of a farmer. Mr. Kariuki inherited the farm from his parents and now the family is trying to rebuild the farm without actually living there. The hired workers take care of everything and the farm is used as an escape from the city life. The farm had been growing coffee for as long as Mr. Kariuki could remember. I helped the workers on the farm sort out the beans and saw the whole process of coffee production at a nearby coffee factory: sorting, deshelling, fermenting, and drying. A lot of work goes into production and coffee farmers are severely underpaid for it. This was my first personal encounter with one of many examples in the world that remind me that trade needs to be made fair. In the end I still did not see anything that looks like the coffee I have seen in America.

Before leaving Kenya I decided that I wanted to spend a couple days on a rural farm, not as a person doing research, but as a farmer. I longed to understand the people of Kenya and such a thing is not possible to learn from the outside looking in. I spent one day with a family in the lowlands and one day with a family in the highlands. Even after such an experience I am nowhere close to understanding their situation and lifestyle, but the experience opened my eyes.

I spent my first day with the wife of a farmer in Yatta (Figure 3). The family has a shamba and also a small store selling sugar, flour, and soda among other things. Their daughter is three and a half, but she cannot speak. As a young baby she was very sick and there was brain damage. She can now recognize her parents and doctors say she should talk soon. My day consisted of a trip to the hospital, washing dishes, collecting firewood, picking kales from the farm, shelling peas, and preparing and serving an afternoon meal. I spoke to the woman some but neither of us could communicate well in the others' mother tongue. In the silence of the warm afternoon as the little girl, Sharon, fell asleep on her mother's lap, I felt at home. Life is simple and could be considered boring. But life in the Kenyan village is something I hope to experience many times in the future.

Figure 3: A photograph of the farmer's wife, her daughter, and me in their house in Yatta.

I also spent a day with a family in Limuru; the family who allowed me to perform research in their field. The family consisted of an elderly couple, their orphaned grandson, and their house girl. Because the mother of the family does not speak very much English, she invited her daughter and grandson from Nairobi. I arrived early in the morning and right away learned how to help milk the cows. Then I sat with the family and enjoyed a nice cup of Kenyan tea, prepared with the milk I had just collected.

After breakfast, I helped the house girl, Irene, wash dishes, clean the house, and peel potatoes. Then I went with the orphaned grandson and Irene to the shamba to pick onions and carrots for lunch. We began preparing lunch during the midmorning. After a bit of preparation we rested and had a snack of maize roasted on the fire. Soon after the daughter and grandson, Alice and Dennis, arrived. I was not surprised to be so warmly welcomed by the entire family, because I have learned this is the nature of Kenyan people. After chatting with the family some, I was told I was going to learn how to slaughter a chicken. This was certainly a new experience and I admit I was hesitant to even hold the chicken. In the end, I stood on the chicken while Dennis cut its throat (Figure 4).

Figure 4: A photograph of what I describe as "murdering a chicken".

The day passed quicker then I wanted and soon I found myself with an extremely full stomach saying goodbye with hugs and kisses to a family with whom I felt very connected. My day in Limuru stands in my mind as one of my favorite Kenyan experiences. Though I spent the day with almost complete strangers I truly felt as though

I was accepted as a member of their family. I also decided after this experience, that I would like to spend part of my life living in rural Africa. Thankfully I left with addresses and phone numbers in hand, so I will be able to keep in contact with my new family, and visit them upon my return to Kenya.

In the end, my fears of traveling to Kenya without really experiencing Kenya were proven very wrong. After leaving my two month temporary home in Kenya, I am left with vivid memories and lessons learned. The experiences I had vary greatly from urban to rural, animals to scenery, native to tourist. But at the conclusion, I realize the richest experiences were those shared with Kenyan people.

Conclusion

This summer was the biggest challenge of my life thus far. For years I had fully prepared myself for a trip to Africa. In many ways, my years of preparation were more than adequate. I knew the facts; I knew I would witness poverty. Before leaving I was fairly confident that this internship would only be the beginning of my travels and experiences in Africa. Yet even with this strong foundation, I wasn't prepared for this experience.

My experience in Kenya was very unique. I witnessed and was immersed in a great collection of the aspects of life in Kenya. I was a tourist. I was the eldest daughter in an upper-middle class Kenyan family. I was a scientist. I was a student. I was even a member of a Kenyan farming family for a day.

Returning back to the United States was nothing I could prepare for. I am still adjusting and still cannot always put words to the experiences I had in Kenya. I expected to come home from Kenya with answers, but instead I realize how many new questions I have and how many things in my life have been left unanswered by the experience: What should I study in college? How am I able to better understand poverty and hunger? What am I going to do with my life? What does this world really need?

I spent eight weeks living alone in a hotel room inside a barbed wire fence. Outside the fence is a city like I'd never seen before. If I wanted, I could forget where I was, locking myself in the small room and enjoying American TV reruns. But I could never keep my mind from wandering to what lies beyond the barbed wire fence and security system. And now that I am back at home my mind continues to wander constantly to my summer internship.

After two months of life in Kenya, on a continent I had dreamt of, I come back home much happier to be American. The people I met shared things with me that I could never have found in America. I still am very opposed to many American policies and opinions. Consumerism and greed in America continue to anger me. Yet, the immersion into another culture helped me to realize that America is also rich in culture. I spent the Fourth of July alone in my room celebrating with a piece of cake, realizing more then ever how lucky I am to have the freedom of speech, beliefs, and education.

Fifty percent of Kenyans live in poverty and forty percent of people are unemployed.[8] With this in mind, it is hard to believe Kenya is considered to be one of the wealthier nations of Africa. I can list off facts but I cannot fully understand the situation. Living in Kenya brought me closer, but I am far from comprehending poverty and food insecurity in Kenya, Africa, and the world.

Not many 18 year olds have the chance to travel half way around the world and work at an International Research Centre. My time at ICIPE was invaluable. The opportunity

[8] CIA World Fact Book, http://www.cia.gov/cia/publications/factbook/geos/ke.html

allowed me to better understand how a research centre functions and the role it plays in the international development community. I realized that an immense amount of research and work is being done; yet there are still so many problems facing third world countries. I learned the immense importance of a tiny insect. My time at ICIPE gave me research experience that most people do not have until their upper years in the university. Developing methodology and carrying out a research project has allowed me to learn a lot about DBM, crucifers, and scientific research practices. My project was the primary reason for my travels to Kenya. Though performing my research project was most important, the benefits from the trip are much broader than an understanding of egg mortality in DBM.

The combination of adventures, research, and interaction with Kenyan people and culture gave me a fuller experience than I could imagine. As expected, I have changed. And as I anticipated, I am very eager to travel back to Kenya and other countries in Africa. The Borlaug-Ruan Internship intends to give Iowa high school students a chance to be immersed in culture and research experience as a way to promote careers in food and agriculture as well as a better understanding of food insecurity. Before my internship this summer I would have told you I planned to double major in Agronomy and International Agriculture with a minor in Spanish, in order to pursue a career working with food security in the developing world. My experience has helped me to see the problem is more complicated and that understanding agriculture is not enough. After beginning a semester at Iowa State University I can see how my basic crops class will be helpful in situations I experienced this summer and I am planning to explore classes in Political Science, Economics, and Sociology to develop a greater understanding of the situation. Living in Kenya helped me realize that the issues of food insecurity go far beyond facts and figures.

I'd like to think that I had a rough summer, missing my family, working hard, and experiencing the real Africa. I can site experiences that many will never have that opened my eyes to the realities of the world. Thankfully I was not only a tourist in Kenya. Yet it is frustrating to me because I know that while it was nothing like spending my summer at home in America, it was far from the life of the average African. I worked in an orphanage and missed my family, but I had a home and a family waiting for me when I returned. I spent a day in the life of a Kenyan farmer, but really the experience was sugarcoated because the half day I spent there was a mere glimpse of this life. I lived in a barbed wire compound and never visited the slums. Though I am pleased with my experience and know that all of the aspects were priceless, I know there are many things that I have yet to witness. I know now how far I am from understanding, but fortunately my eight weeks in Kenya brought me closer and gave me the desire to better understand food insecurity and poverty in the world.

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