THE WORLD FOOD PRIZE FOUNDATION

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Dairy Cattle Welfare in the Tropics

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I. Acknowledgements

A support system is crucial throughout any journey, big or small. There have been so many people who have assisted me throughout this experience who deserve praise.

Lisa Fleming, Keegan Kautzky, Ambassador Quinn, and the rest of the World Food Prize staff, thank you so much for this amazing opportunity. Your support and guidance throughout this internship was essential to my success. I sincerely hope that I made you, John Ruan III, and Dr. Norman Borlaug proud.

I would also like to thank Mr. Ducey, the educator who encouraged and inspired me. Your passion for agriculture and education has led me to this point in my life. You supported me throughout my time in Freehold Township High School's Animal and Botanical Sciences Academy and helped me become the person I am today. I cannot thank you enough for everything you have taught me.

I would like to thank some of my many mentors at EARTH University. Professor Moro, your guidance throughout this internship was amazing. You gave me the independence to conduct research in a productive way and encouraged me to investigate new ideas and possibilities. I could not have asked for a better advisor. Thank you to the EARTH University Finca Pecuaria and Lecheria staff for teaching me how to work on a farm. You taught a suburban New Jersey girl how to milk cows, castrate pigs, and so much more. Thank you to Sofia Montero and Nico Evers for advising me throughout the internship. Thank you Arnoldo Avilla for taking time out of your busy schedule to teach me about organic farming. Thank you Professor Emilia Villalobos for assisting me with my Spanish during my time here at EARTH. Muchas gracias por su ayuda, Profe.

The biggest part of my support system has been my family and friends. I am so blessed to have all of them in my life. I would like to thank them for their kind words of encouragement throughout this process, I truly could not have done this without them.

Finalmente, muchas gracias a mis amigos de EARTH. Ustedes me ayudaron mucho durante mi pasantía. Su generosidad, amistad, y paciencia significó mucho para mí.

Un abrazo y un beso, y gracias por todo.

II. Personal Introduction

I never thought that I would be involved in agriculture. Growing up in Howell, a small suburban New Jersey town, did not allow me to have many experiences with agriculture. Well, besides the state fair and the occasional petting zoo. From a young age I knew I wanted to be a veterinarian. I never considered the profession as part of agriculture, let alone food insecurity. My school's Animal and Botanical Sciences Academy was where I began to realize the importance of agriculture and how being a veterinarian fit with it. I discovered that these fields have an extremely promising future and that there was a place for me to practice my favorite topic**:** animal science. This program led me to an event that would change my life beyond my wildest dreams: The Global Youth Institute.

I attended the Global Youth Institute in 2013 as New Jersey's only laureate. My initial World Food Prize paper was on Uzbekistan's water insecurity issues. Writing that paper opened my eyes to the fact that food insecurity is a complex and multifaceted issue. I had previously assumed that fighting food insecurity was more of a humanitarian effort -- an effort that did not involve animal sciences. The Global Youth Institute showed me that I was wrong. I met many inspiring people there who worked in the animal science field and who were significantly impacting the world through their work. A sense of empowerment came over me during those three life changing days in Des Moines. I left determined to make a difference in the lives of others by helping with food security through my passion for animal science.

On the last day of the Global Youth Institute, I saw colorful posters and students dressed in clothing from other cultures. These were the Borlaug-Ruan International Interns of 2013. As they explained the amazing opportunities and experiences they had as interns, I knew that this would be a once in a lifetime opportunity for me. I instantly resolved to apply for an internship. I wanted to try something new in a foreign environment, learn about animal science in a hands on way, and push my own boundaries farther than before. I had never studied abroad on my own, yet going out into the world by myself with the mission of doing my part in the fight against food insecurity sounded like a dream come true. Nine months later, I boarded my flight to Costa Rica. I was eager to go out, explore the world, become self dependent, and make a change in the same way Dr. Norman Borlaug did.

III. Research Introduction

3.1 EARTH University

EARTH University in Guacimo, Costa Rica. EARTH stands for for *Escuela de Agricultura de la Región Tropical Húmeda* which translates to the School of Agriculture in the Region of the Humid Tropics. This private institution nestled in Costa Rica's Central Valley that is dedicated to tropical agriculture and sustainability. The university was established by the Costa Rican government in 1986 with financial assistance from the US Agency for

International Development and the W.K Kellogg Foundation. EARTH is dedicated to teaching students from around the world ways to use their natural resources wisely and farm sustainably through their agronomy program. EARTH University encourages its students to use the knowledge and hands on experience they gained while attending the institution and apply it once they return to their home countries.

3.2 Research Background

For my Borlaug-Ruan International Internship I was advised by Professor Jose Moro Mendez DVM, one of EARTH's Animal Production and Lactation professors With Professor Moro's guidance I chose to work on dairy cattle welfare. I worked on the Finca Pecuaria farm from Wednesdays to Saturdays. During my research I participated in "Sistemas Pecuarios Integrados" which is a work experience class taken by second year EARTH students every Wednesday and Saturday in order collect more data and hands on experience for my research project. When I was at EARTH I worked alongside EARTH Finca Pecuaria staff, fourth year students, and second year students doing farm chores such as feeding the animals, assisting in the lechería, recording milk yields, and assisting in commonplace medical procedures, all while researching my chosen objective.

3.3 Chosen Objective: Dairy Cattle Welfare

The topic of dairy cattle welfare is significant in the fight against food insecurity due to the significant impact a herd's welfare has on the milk and meat they produce. Past studies have shown that an increased welfare status benefits milk production in dairy cattle, which is a key aspect of food security. For the dairy cattle welfare aspect of the program, the goal was to develop a system that accurately quantify the welfare of dairy cattle within an individual herd through several detailed indicators that is tailored for tropical dairy operations, such as lecherìas tropicales. This assessment was split up into 4 important aspects of dairy cattle welfare: milking, environment, behavior, and health. The assessment was divided into these parts for management and research purposes. They are all interconnected and each topic is significant. Each of these aspects had a series of detailed questions and a few sub-rubrics in order to ensure thoroughness. Documents such as a dairy cattle welfare assessment sheet and a standard milking protocol were created. In the tropics, animal welfare is only starting to become a significant value for farmers. There are very few tools available to tropical farmers that would enable them to accurately assess their dairy herd's welfare status. Due to this, the developed system was adapted from several other sources. The majority of these sources originated from the northern hemisphere, so the information needed to be adapted to the needs of tropical dairy systems. Data was recorded and spreadsheets, rubrics, and other forms of documentation were created in order to keep track of the findings. In order to accurately determine which factors should have been included there was need for field inspections to

assess what kind of indicators could accurately be measured. EARTH's herd was monitored over the course of seven weeks and indicators were chosen during those interactions. Lecherías are farms where cows are milked without calves, give concentrates, and even with crossbred cattle they can reach a production rate of 12-15 kilograms per cow per day, milking twice a day. EARTH's lechería is more of a dual purpose farm since they have calves and use less technology compared to the real "lecherías tropicales", however the indicators can be used and applied to any tropical dairy farm. These indicators were selected due to easy visualization, easy access to measurement, easily determined functional traits, and relevance to milk yield and health. When the indicators were chosen, EARTH's lecheria and dairy operation was evaluated.

IV. Data Analysis

4.1 Milking

Milking is a process of high relevance within the operation of tropical dual purpose herds. Dairy cows are in the dairy parlor at least once a day. If the milking parlor, milking process, or milking equipment have any significant issues this could significantly lower the welfare status of the herd and lower the milk production and milk quality as a result.

The lechería's dairy protocol is the first indicator of a good welfare status. Although it is common for tropical dairies to not have written milking protocols, it is advised that dairy protocol be posted in writing, visible, and accessible from the lechería. The proper training of employees on milking protocol is essential in order to ensure that cows are milked properly, in a hygienic and safe environment. If there is a clear dairy protocol in place there is less room for error, employees are more likely to follow protocol, and it shows potential investors and consumers that the milk they are consuming is collected in a safe and healthy way.

Another important indicator of welfare status in the milking process is the sanitary conditions of the lechería. Sanitization is of utmost importance in the milking process. Cows need to be milked in a clean environment with clean equipment, clean facilities, and milking unit cleaning. For this aspect of the assessment there are options where the evaluator can determine what type of sanitization is used on the machinery, how many times a day the parlor is cleaned, what cleaning solution is used, and there is a rating system from 1 to 5 for an overall milking area cleanliness.

Employee cleanliness is also evaluated in the assessment since it is not only an important aspect of food safety, but also to the health of the cow. Three options given on the assessment include wearing gloves, wearing smocks, and washing hands after every milking. If an employee's hands are unclean bacteria can be transferred from the employee to the udder which can cause health issues such as mastitis. Wearing gloves during milking is extremely preferred, however in the case of a smallholder farmer who cannot afford gloves, washing hands after every milking will suffice. Employees should also be encouraged to wear a smock in order to keep their clothes clean and to prevent the possible spread of illness between cows due to waste matter.

How long cows wait to be milked can also play a role in dairy cattle welfare. Cows are stimulated by the sound of a milking parlor, so the longer they wait the reflex to let milk down will be lost. The quicker the cows are processed through the lecheria the more milk will be produced. In addition to this, the longer cows wait in line to be milked the more pressure there is on their hooves, since they are most likely standing on a concrete surfaces. The more pressure there is on their hooves, the more likely the cows will develop hoof issues such as laminitis.

The last aspect of the milking process measured is the use of the milking unit during disconnection. The milking unit is a vacuum that pulls on the teats to express milk in a quick and efficient way. Vacuums absolutely must be turned off before the unit is removed. If vacuums are not turned off before they are removed, the teat structure will slowly deteriorate due to the strong suction of the vacuum combined with the force of the milking operator's pull.

4.2 Milking Protocol

The milking process plays a large role in the behavioral, emotional, and physical health of dairy cattle. Some cows can become stressed during the milking process when the system is not routine and or uncomfortable for the cows. Negative stimulus such as pulling on the teats when the milking unit is attached to the udder makes the cow associate milking with pain. If the milking takes too long cows become anxious and are more likely to kick off the milking unit. Changes in the routine can also affect the cows behavior since these herd animals are animals of habit. By perfecting a milking system we keep cows comfortable, meeting cleanliness expectations, and producing a good amount of milk.

The main objectives of the milking process include producing more milk of the highest quality quickly and doing so in a way that is healthy for the cow. In standard milking procedures there are steps taken to stimulate milk production and sanitize the teats before the connection of the milking unit (NMC or Canadian Mastitis Network). EARTH University student Jenny Cordoba along with Professor Moro Mendez modified a standard North American dairy protocol and transformed it for EARTH University's lecheria, based off of techniques the Canadian Bovine Mastitis Research Network recommends. In the tropics, dual purpose cattle are almost always milked without protocols, so the introduction of a common protocol into these herds is a novel, but critical, step. The protocol should have some form of sanitization of the teats and test for mastitis. The common dairy protocol in tropical lecherias has seven steps: Forestripping (hand milking each teat), California Mastitis Testing, Suckling (when calves are allowed to suckle and stimulate further milk let-down), Pre-dipping (sanitizing each teat), Drying, Unit Connection, and Unit Disconnection. It is often advised to have an eighth step, post dipping, at the end of the milking process to decrease the risk of infection, however this step was left out of the research product since after milking, calves go to suckle with their mothers for a short time before they are separated. The aspect that sets the tropical lecheria protocol apart from the northern system is the suckling step. In tropical dairies, the parlors

have a lane next to the milking cows where the calves are placed. Mothers are reunited with their calves during the process. There are windows by the udder that are opened by operators to allow calves to suckle before unit connection. This part of protocol stimulates further milk let-down, feeds the calf, and keeps the mother calm. Suckling is one of the aspects that makes the developed welfare assessment sheet unique. The current welfare assessment systems available do not include any evaluations pertaining to suckling.

The recommended time spent on the process of forestripping to drying is 60 seconds to 90 seconds (Dufour, S. 2011). This series of techniques stimulates the milking process, causing more milk to be let down from the glands. The peak of milk production is between 60-90 seconds. The quicker this process is completed the more milk will be produced. Once the 90 second mark is passed, the amount of milk produced by the stimulation decreases exponentially. Not only does this short timeframe yield more milk, but it also encourages workers to be quick and proficient, lessens the amount of milking time for each cow, all while simultaneously ensuring that proper sanitization methods are upheld.

The recommended time for milking in itself is 5 to 7 minutes (Dufour, S. 2011).This timeframe is appropriate because it does not over milk the cows, allows the teat structures to quickly recover, and assures that there will be enough milk leftover for the calves to consume once the cows are released from the dairy parlor. Milking cows longer than 7 minutes leaves the cow prone to mastitis, ruins the teat structure, and stresses the cow.

In order to accurately determine if the dairy protocol at EARTH fit these recommendations, a rubric was created to collect the time it took for each step to occur. Once the cows enter the parlor the person recording the data notes each cow's identification number located on the left ear tag. After cows enter the milking parlor the recorder monitors and writes down when each step of stimulation and sanitization begins on each cow. This rubric factors in milk yield and any extra variables in order to get a full understanding of how time spent milking and techniques used during milking effects the milk yield and behavior of the cows.

Figure 1: Dairy Protocol Assessment

	Annotate the actual time in which each step is performed							Milk yield (kg)	Comments
Cow ID	Fore stripping	CMT	Suckling	Pre-dipping	Dry	Unit connection	Unit disconnection		

4.3 Health

The health of a dairy herd is the most important aspect of a dairy business. The judging system that was designed has several detailed variables in order to properly assess the health of the herd.

Body condition scoring is one of the most commonly used assessments used to determine the health of a herd. This system developed by Edmunson et al., (1989) is a visual assessment of the weight and body condition of individual cows. The scale goes from 1 (very lean) to 5 (overweight). Cows are scored off the amount of fat present on their hips, flanks, and tops of their tails. Cows with low body condition scores are often extremely ill and likely to die. At farm level, the percentage of very lean cows was positively associated with mortality rate of calves (Sandgren et al., 2009). By calculating the body condition scores of the herd, a farmer can see whether or not additional nutrients need to be provided and monitor extremely thin cows. The higher the overall body condition score of a herd, the better the welfare.

Teat condition was chosen as a welfare indicator since the teats can show whether there is something wrong with the milking process, cleanliness, or breeding. When there are stretch marks on the majority for the herd's teats this could indicate an issue with the milking unit or it could show that employees are pulling on the unit. If a specific teat on a cow is constantly infected then there might be a cleanliness issue within the milking process.

Mastitis is one of the biggest health issues in the dairy cattle industry. This type of bacterial infection affects the mammary glands and causes them to become inflamed. This is painful for the cows and often leads to other health issues down the line. Infected cows need antibiotics and other costly medicines in order to recover, which could be a long and costly process. In addition to harming the cow and adding additional costs, this infection severely affects the dairy herd's production rates. Cows with mastitis cannot produce consumable milk. Should a large percentage of a herd contract this infection, milk production rates will severely decline which can mean disaster for a farmer who relies on dairy production for his or her main income. The amount of cows with mastitis indicates the welfare of the herd extremely well because it relates to other indicators of welfare. Mastitis can be caused when the dairy protocol is flawed, the environment is unclean, or when the cow is unclean. If mastitis is especially prevalent in a herd, this could indicate that one or more of the previously mentioned indicators needs to be evaluated and fixed.

Diarrhea was also included as a welfare indicator. The stool of the cow is a good indicator of the animal's welfare because the waste shows how well the cow is being fed and if it has any

possible illnesses. In addition to this, diarrhea also lowers the milk yield significantly. As Bareille stated, “Diarrhea was associated with a 35.6-kg-lower cumulated milk yield from the day of onset to the day of recovery.” (Bareille et al., 2003).Also, Hugues (2001) argues that there is a relation between the consistency of the fecal matter and the cleanliness grade of the animals.

Cleanliness is key to good health and is one of the most obvious indicators of welfare status. The cleanliness assessment focused on 5 parts of the cow’s body.

1. Udder
2. Hind Legs
3. Flanks and Hips
4. Genetalia

These areas of the body are more likely to cause health problems when dirty. A dirty udder often causes cows to contract mastitis and other infections. In other studies there has been a correlation between dirty hind legs, genetalia, flanks and hips and stillbirths, which is a huge red flag on the herd’s welfare status.(M. de Vries et al., 2014).

Lameness is one of the main assessment factors due to the several issues lameness causes and the countless ways lameness can occur. Lameness can be due to an animal's genetic disposition, an environment that does not allow access to clean floors or grounds, poor foot care, or a poor diet. When a dairy cow is lame they tend to produce less milk, are difficult to handle, become thin, and have a high fatality rate. The higher the amount of lame cows there are in a herd, the lower their welfare status is. Farm hands often underestimate the amount of lame cows in a herd so this factor has to be measured extremely carefully in order to assure accuracy(Whay H R et al., 2003).

4.4 Behavior

Behavior is essentially the window into the mind of an animal that allows humans to understand it. According to the Brambell Committee, “Welfare is a wide term that embraces both the physical and mental well-being of the animal. Any attempt to evaluate welfare, therefore, must take into account the scientific evidence available concerning the feelings of the animals that can be derived from their structure and functions and also from their behaviour.” (Brambell Committee, 1965). It is difficult to truly determine when a cow is happy, and happiness is hard to define in any sense, so it is much more efficient to determine when an animal is stressed through their behaviors.

An animal’s flight zone is a commonly used indicator of animal welfare. Herd animals, such as dairy cattle, have a determined area around them that, when breached, will cause them to flee. One way to test an animal’s flight zone is through a proximity test. de Vries et al. (2011)

proposed a simple tool: the handler approaches and attempts to put a hand to the muzzle of the cow. According the distance from the hand to the muzzle at the moment when the animal gets apart a scale is applied: 1 indicating that the cow allows the handler to put their hand upon the muzzle, 2 indicating that it the animal allows the handler to get close to them but does not allow them to be touched, and so on until 4, which indicates that the animal does not respond well to having its flight zone invaded. The closer one can get to an animal, the shorter its flight zone is and the less human based fear the animal has. Dairy cattle with a shorter flight zone have a better welfare status, since these cows are conditioned to being handled by humans and do not fear their handlers.To evaluate the flight zone, a rubric determining the flight zone was added into the assessment.

Headbutting is another good indicator since it is one of the most common behavioral indicators that something is awry. When cattle are inclosed in a stressful environment, they are more prone to headbutting and getting into other altercations with different members of the herd. Cows that headbutt more than ten times an hour are more likely to be experiencing extreme stress. If a large percentage of the herd is on the high end of the headbutting rubric, the lower their welfare status. A rubric regarding headbutting was also created and added into the assessment.

Other stressed behaviors include kicking off milking unit, laying down outside designated area, and colliding with stall components. These behaviors are commonly shown in stressed cows with a lower welfare status. These behaviors are problematic because they can often injure handlers, the individual cow, the herd, and milk yield. (Breuer et al., 2000;Bertenshaw et al., 2008)

Breathing was also chosen as an indicator since it is an important yet subtle tell-tale sign of stress. When a cow has an increased respiratory rate it is a common indicator of stress, specifically heat stress. Some cows do not show their stress in the behaviors previously stated, but they tend to breathe quickly or have uneven breathing patterns. These cows are stressed, but are often unrecognized due to the subtleness of their stressed behaviors.This biological sign of stress is easy to recognize when looked for. A rubric was also inserted to the assessment for this indicator.

4.5 Environment

Another important aspect of animal welfare is the environment surrounding the cow. One of the biggest indicators of good welfare is the animal handling, amount of available food, and cleanliness of the cattle’s surroundings.

The management practices of the lecheria are key in the keeping of a high welfare status. One

big malpractices in the dairy industry is the hitting of cows. In theory, cows should not be hit at all. They can easily be moved through the use of visual aids and vocalizations, however it is common practice to strike cows with a stick or use a cattle prod. This practice has an extremely negative effect on the herd. Cows that are hit often have a lower quality of welfare behaviorally and physically. Cows that are hit are proven to have a larger flight zone (C Arraño et at., 2007). These cows are afraid of humans due to the connection between humans and pain, thus making the cattle hard to work with. These cows are also extremely stressed and tend to produce less milk because of that stress. A rubric was created for this issue due to its significance.

Clean water and mineral salts determine welfare status pretty clearly. If there isn't enough clean water present the herd is more likely to be dehydrated, have parasites due to the consumption of dirty water, and have a higher mortality rate. If a lecheria has several areas where clean water is present and accessible, the better the welfare status of the cattle. If there are not any mineral salts present, then the cows are not receiving the minerals and nutrients they need to maintain a good weight or keep them healthy. The more mineral salts there are available, the higher the welfare status of the herd.

Pasture condition and the use of a grazing system can also determine the welfare status of a lecheria operation. In the tropics, pasture is a standard aspect of any lecheria. Grazing is a simple and cost effective way to feed a herd. System with access to pasture had lower culling rates than zero- grazing systems, so the use of a grazing system greatly increases the welfare status of a herd. (Washburn et al., 2002; White et al., 2002). Using a grazing system, such as a rotational grazing system, can ensure that farmers have enough pasture to feed the herd. The condition of the pasture is positively associated with herd welfare. If the pasture has little to no brown, wet, or bare spots, the welfare of the herd will be better than that of a dairy operation where the pasture is extremely bare.

Cleanliness of the environment is extremely important. If the operation has several areas where there is an excess of filth such as manure, mud, or filthy hay, there will most likely be an increase in health issues. Cows will become dirty when they are in a filthy environment, so an unclean environment is correlated to an unclean cow.

V. Discussion

5.1 Milking

The milking aspect of EARTH's lecheria operation is relatively good, however there is certainly room for improvement.

Equipment: Milking unit cleaning before the workday is extremely thorough. The units were placed in a tub full of water with a chlorine cleaning solution which was also pumped through

the tubes. However, unit cleaning is extremely quick and haphazardly done in between individual milking. The standard cleaning is a quick spray with the hose, however it is common for this step to be overlooked.

Management: Employee cleanliness is an issue at EARTH University's lecheria that is being addressed. Workers do not wear gloves during the milking process and only wash their hands by spraying them with water and drying them quickly with a paper towel.

Animals: Cows often wait around 5 minutes or so to be milked. While these cows are waiting to be milked they are often stimulated while they wait, which is essentially causing the operation to lose money.

Process: Vacuums are often turned off before the unit is removed, however there are still occasions when the vacuum is pulled off the udder while the power is still on. This action is usually done by a student, however, experienced employees occasionally forget.

5.2 Milking Protocol

Spreadsheet: Data was edited, evaluated, and placed into a Microsoft Excel spreadsheet. (See figure 1)

Data collection: Data was collected over the course of 4 milkings and placed into the dairy protocol assessment on site.

Actual time of event

Cow ID	Forestripping	CMT	Suckling	Pre-dipping	Dry	Unit Connection	Unit disconnection	Milk yield	Time from forestripping
93400	8:41	8:42	8:42	8:43	8:43	8:44	8:48 -2t 8:52-2t	8	
32402	8:37	8:37	8:41	8:43	8:44	8:45	8:49-2t 8:51-2t	6.6	
91810	8:36	8:37	8:41	8:42	8:42	8:43	8:50-2t 8:51-2t	6	
02850	8:36	8:37	8:41	8:43	8:43	8:44	8:51-2t 8:52-2t	5.6	
52404	8:50	8:51	8:51	8:53	8:53	8:54	8:59	6.2	
91806	8:47	8:47	8:51	8:53	8:53	8:54	8:56	3	
42100	8:47	8:48	8:51	8:53	8:53	8:54	8:57-2t 8:59-2t	3.8	
15100	8:47	8:49	8:51	8:53	8:53	8:54	8:57-1t 9:01 -3t	5.2	
21404	8:57	8:57	8:59	9:00	N/A	9:01	9:04-2t 9:08-2t	6.4	
41000	8:58	8:58	8:59	9:00	N/A	9:01	9:04-2t 9:09-2t	6	
05418	8:56	8:56	8:59	9:01	9:01	9:01	9:06-2t 9:11-2t	8	
63104	8:56	8:57	8:59	9:02	9:02	9:02	9:10	2.6	
33106	9:06	9:08	9:10	9:11	N/A	9:12	9:15-2t 9:20-1t 9:21-1	4	
64106	9:05	9:06	9:10	9:11	9:12	9:12	9:19	4.4	
71800	9:05	9:06	9:10	9:11	9:12	9:12 -2t	9:19	5	
4410	7:40	7:40	7:41	N/A	7:43	7:43	7:48-2t 7:51-2t	7.8	
84406	7:41	7:42	N/A	7:44	7:45	7:45	7:51	3.8	
93412	NS	NS	7:51	7:53	7:53	7:55	8:00	8	Not enough information
3230	NS	NS	7:51	7:53	7:53	7:53	8:00-2t 8:05-1t 8:07-1	7.8	Not enough information
73402	NS	NS	NS	7:50	7:50	7:51	7:56	1.4	Not enough information

Figure 1: Milking Protocol Data Recorded in One Day

Descriptive analysis: A series of histograms were created for each milking using the information in the spreadsheet; one for the time from forestripping to unit connection, one for unit connection to disconnection, and one that shows the correlation between time spent milking and the amount of milk produced. With these graphs several conclusions have been made about the milking procedure at EARTH University's lecheria. These graphs were created from the data collected at the last milking.

Number of Cows	Time (minutes)
0	1
2	2
8	3
6	4
6	5
10	6
2	7
4	8
1	9
0	10

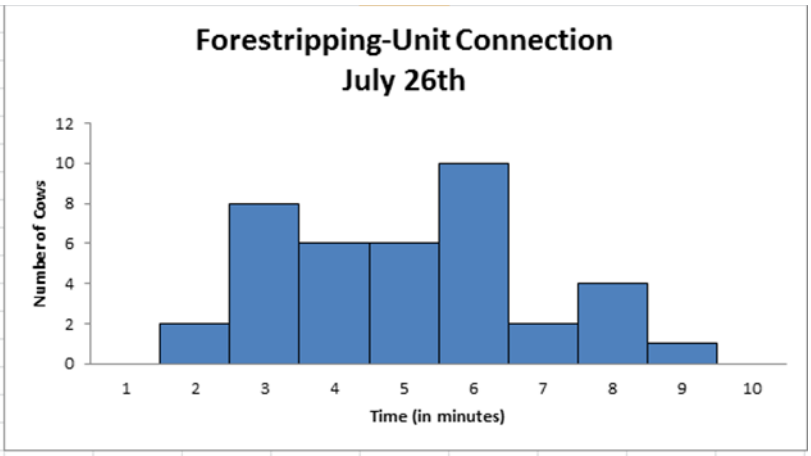

Figure 2: Time taken from Forestripping to Unit Connection

Number of Cows	Time (minutes)
0	1
0	2
2	3
6	4
5	5
6	6
3	7
8	8
5	9
1	10
1	11
1	12
0	13

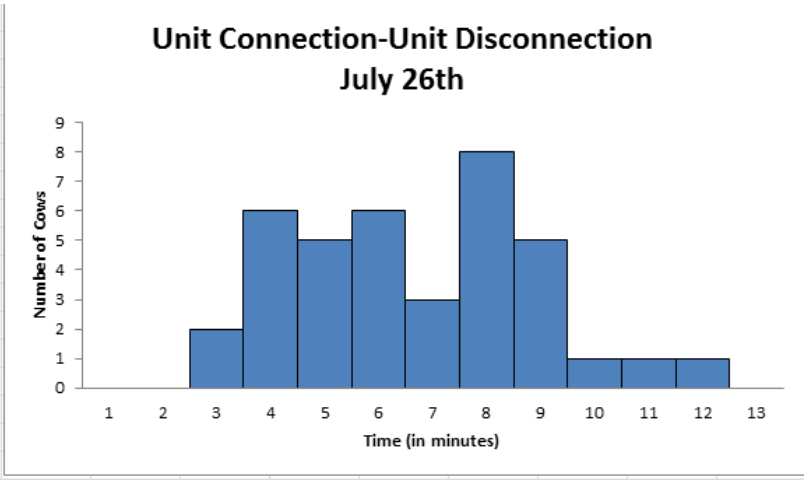

Figure 3: Time between Unit Connection and Unit Disconnection

Milk Yield (kg)	Time (min)
0	1
0	2
2.5	3
3.3	4
4.58	5
4.8	6
5.73	7
5.2	8
6.68	9
5.6	10
10.2	11
2.6	12
0	13

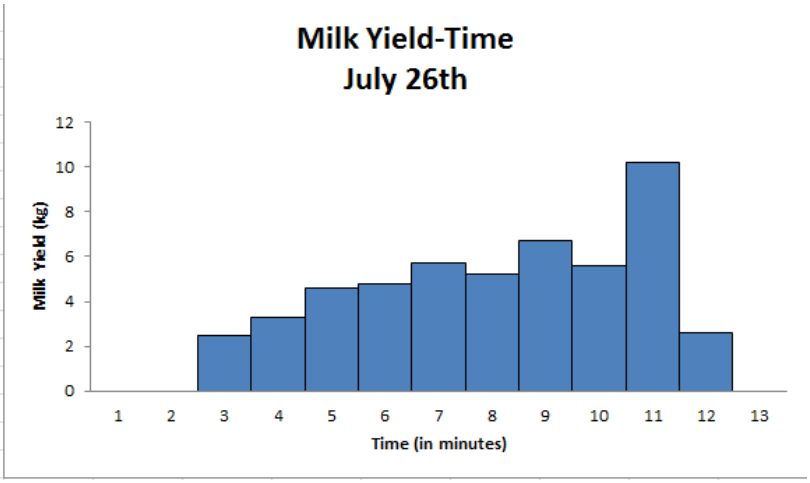

Figure 4: The correlation between time milked and milk yield

Conclusions: Our first conclusion is that we are spending too much time on the procedures before unit connection. Workers in EARTH's lecheria system usually tend to four cows or so whenever students are not present the process is much slower. Two cows on one side of the parlor are tended to first and are usually connected to the milking unit first. The cows on the other side are usually forestripped and tested while the cow across from them is being milked. This is a bad process because

Our second conclusion is that we over-milk the cows. As stated previously, the advised milking time is 5 to 7 minutes. Based on the information collected and presented in the second graphic, only 47% of the cows milked are milked within the advised time frame. The longest milking time recorded during these assessments was thirteen minutes. These times do not include the time from forestripping to unit connection. The cows that are milked for longer than 5 to 7 minutes tend to be in worse health.

Our final conclusion is that the amount of time milked doesn't necessarily reflect on the amount of milk produced. Of course the cows that are milked longer usually have a higher milk yield to time percentage, however this is mostly due to the productivity of individual cows. In addition, over milking cows is a bad business investment for farmers. By over milking these cows the farmer ruins the teat structure, prevents the cow from producing as much milk as it could, and stresses the cow.

5.3 Health

Cleanliness: The cleanliness at EARTH varied based on the weather. The cows are in the pasture for the majority of the day so when it rains the cleanliness rating decreases due to the increase of mud and other filth buildup. Cows with deeper udders were more likely to score higher on the udder cleanliness rating due to the constant kicking of the udder.

Teat Condition: The teat condition of the dairy herd was substandard at best. Several of the highest producing cows have stretch marks, lesions, and other deformities. The majority of these are caused by over milking, pulling on the teats, and a practice where the workers put a hand sized stone on the unit during the milking. Workers have been informed of the consequences of these practices; however they still continue to use stones and pull on the units to collect more milk. This is extremely detrimental to the welfare of the cows who suffer through these practices regularly. In order to improve the welfare and health of the herd, EARTH University's lecheria staff needs to stop this practice.

Figure 2: Stretched Teats

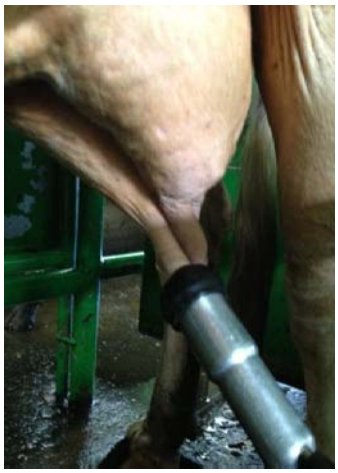

Figure 3: Stretching the teats

Body Condition Scoring: Body condition scores were taken during several stages of lactation The BCS of the cows of EARTH's lecheria varied. 15% of the herd had a body score lower than 2, 36% of the herd had a body score between 2 and 2.5, 48% of the herd had a body score greater than 2.5 but lower than 3, and now cows received a score of 3 or above. This indicates that the herd has a severe problem and needs to be monitored. EARTH University can improve the body condition scores of their herd by improving the diet of the cows, adding more nutrients and increasing the volume of food consumed by the cows daily.

Number of Cows	Body Score
5	<2
12	2-2.5
16	>2.5<3
0	>3-3.5
0	>3.5

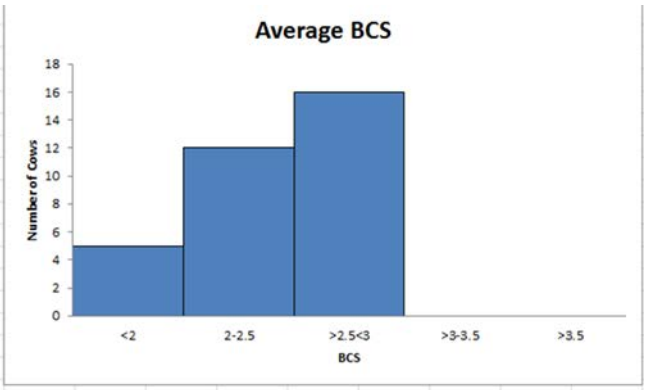

Figure 4: Average Body Condition Score

Diarrhea: During the evaluation of EARTH University's lecheria there have been several occasions where a majority of the herd has had severe diarrhea. This indicated that the pineapple that the workers were feeding to the cows were affecting their digestive systems.

5.4 Behavior

The status of the behavior at EARTH was overall very uniform.

Flight Zone: The flight zone at EARTH for most of the cattle was less than average. Cattle were often unwilling to be approached closer than a few yards away and some cows even threatened to charge when a person came too close.

Headbutting: Headbutting was not a significant issue at EARTH, however there were a few cows who exhibited this behavior more than five times.

Stress behaviors: There were one or two cows that tended to lay outside of the area, so it was not a big issue. The biggest behavior issue at EARTH is the constant kicking of milking units. This was most likely caused by the severe issues with the milking process, especially when the units are weighted down by the rock.

5.5 Environment

The environment at EARTH is average.

Mineral Salts: There are mineral salts available in the corral and there are clean water barrels in several areas of the pasture and corral.

Pasture Condition: The pasture condition depended on the weather, however the pasture overall was spectacular. There were little to no brown areas thanks to the rotational grazing system used at the finca pecuaria.

Cleanliness: The cleanliness varied based on the weather as well. EARTH's herd and lecheria were monitored during the rainy season, so there were many days where the environmental cleanliness score varied.

5.6 Conclusion

At the end of our research program we discovered that the biggest challenges facing EARTH's lecheria were: milking procedure, health, and environment. Now that this information has come to light and there is a significant amount of data backing up our results, EARTH's lecheria staff can use our research to better their operation. Once they change what needs to be adjusted, the welfare of the herd will increase, the quality and quantity of milk production will increase, students will learn the proper milking protocol, and the farm will benefit extremely.

VI. Personal Reflection

I knew that this internship experience would change my life, but I did not fully grasp how much I would grow from this program until it reached its end.

I was thrust into a situation that I was not fully comfortable in. I left the few months I had left of childhood behind to work towards a goal that plays a small part in the killing of the massive monster that is food insecurity. It was a struggle at first that really forced me to adapt in an environment that was extremely different from my own. I needed to become extremely independent and willing to adjust to anything that was presented to me, whether it was something as simple as mucking out pig stalls or as difficult as giving a speech in a different language. I had to overcome my anxiety and put myself in situations that I was not comfortable in. Luckily I adapted to these challenges quickly. I developed innovative ideas to tackle different agricultural issues, improved my spanish significantly, and I became an independent individual. I believe that this internship made me a stronger person.

Coming to EARTH made me realize that there are multiple avenues for us to take in the fight against hunger. Here at EARTH professors and students value environmental sustainability and sustainable farming. There are several farming systems used to teach different innovative forms of agriculture. EARTH's integrated organic farm, peri urban farm, banana plantation, and integrated animal systems farm are just a few areas where students learn about agriculture. Students here develop a multitude of useful skills that can be used outside of the university, in local communities, and across the world. From etymology to agribusiness, animal production to topography, and from mathematics to work experience, students of EARTH learn how to become successful agronomist who will lead the world into a better and greener future through hard work, creativity, and persistence.

During my internship at EARTH I earned the pleasure of developing relationships with some of the students here. With students from over 35 different countries EARTH is teeming with cultural diversity. I discussed Middle Eastern politics with a student from Bolivia named Andres, learned about Ramadan through a student from Africa named Fatumah, attempted to dance the bachata with the assistance of my Costa Rican roommate Marcela, practiced my

spanish with my two friends, Kalem and Jhoselyn, both from Ecuador, and much more. Each of these students had different stories to tell, however they all strived for the same goal: to make the world a better place through sustainable agricultural practices. I know that during my time here I have met people who can, and will, help our world.

VII. Bibliography

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VIII. Appendix

Milking Procedure			
Is there a clear dairy protocol in place?			
Posted in the lecheria	Yes	No	
Posted in the break room	Yes	No	
Other (Please state below)	Yes	No	
Milking area cleanliness			
1 (No manure, dirt, or other filth present)			
2 (Small amount of manure, dirt, or other filth)			
3 (Moderate amount of manure, dirt, or other filth)			
4 (Mild amount of manure, dirt, or other filth)			
5 (Severe filth and possible health risks present)			
How are the milking units cleaned?			
Sprayed down with a hose			
Dipped into a sanitizing solution			
Wiped down with a sanitized cloth			
Other (Please state below)			
Do employees follow dairy protocol?	Yes	No	
How long are the cows milked?			
3 minutes or less			
4-6 minutes			
7-9 minutes			
10 minutes or more			
How often are cows milked?			
Once a day			
Twice a day			
More than twice a day			
How often are the milking units cleaned?			
After every cow			
After every other cow			
Only when manure is on the unit			
Rarely			
At the end of the day			
Employee cleanliness			
Employees wash hands after every milking		Yes	No
Employees wear gloves		Yes	No
Employees wear smocks while milking		Yes	No
How long do cows wait to be milked?			
Less than a minute			
1-2 minutes			
2-3 minutes			
More that 3 minutes			
		Yes	No
Are vacuums turned off before removing the unit?			
Other comments:			

Health				
Percentage of calves with BC scores				
1.0-2.0	#	%		
2.0-2.5	#	%		
3.0-3.5	#	%		
3.5-4	#	%		
Percentage of cattle with BC scores:				
1.0-2.0	#	%		
2.0-2.5	#	%		
3.0-3.5	#	%		
3.5-4.0	#	%		
Cattle with deformend teats				
Very rough ring	#	%		
Rough ring	#	%		
Compression ring	#	%		
Red or blue teat	#	%		
Lesions	#	%		
Stretch marks	#	%		
Chaps	#	%		
Hemorrhage	#	%		
Excessive canal dilation	#	%		
Cows with mastitis				
Trace	#	%		
Weak positive	#	%		
Distinct positive	#	%		
Strong positive	#	%		
Number of cows that have had mastitis within the last month				
Trace	#	%		
Weak positive	#	%		
Distinct positive	#	%		
Strong positive	#	%		
Cow cleanliness assessment				
Udder				
1	#	%		
2	#	%		
3	#	%		
4	#	%		
Hind legs				
1	#	%		
2	#	%		
3	#	%		
4	#	%		
Flanks and hips				
1	#	%		
2	#	%		
3	#	%		
4	#	%		
Teats				
1	#	%		
2	#	%		
3	#	%		
4	#	%		
Genitalia				
1	#	%		
2	#	%		
3	#	%		
4	#	%		

Cows with overactive mucous mebranes				
Ocular discharge	#	%		
Nasal discharge	#	%		
Vulvar discharge	#	%		
Cases of dystocia				
Within the past month	#	%		
Within the past year	#	%		
Cows with fly larvae				
No larvae present	#	%		
Mild (1-5 open sites)	#	%		
Moderate (6-10 open sites)	#	%		
Severe (More than 10 open sites)	#	%		
Cows with loose stool				
Solid stool	#	%		
Weak	#	%		
Mild	#	%		
Moderate	#	%		
Severe	#	%		
Miscarriages				
Within the past month	#	%		
Within the past year	#	%		
On farm deaths				
Within the last month	#	%		
Within the past year	#	%		
How many times are cows fed?				
Once a day				
Twice a day				
More than twice a day				
How many times are calves fed?				
Once a day				
Twice a day				
More than twice a day				
Are antibiotics used regularly?				
Yes, under the supervision of a vet or trained farmhand				
Occasionally used only when needed				
No, antibiotics are rarely used even when they should be administered				
Are cows up to date on their shots?				
Yes, all shots have been given and recorded				
Mostly, only missing a few shots or records				
No, long gaps between booster shots and records aren't kept				
Injuries				
Cows with open lesions	#	%		
Cows with infected lesions	#	%		
Cows with healed lesions	#	%		
Cows with visable scars	#	%		

Lameness				
1 (Normal gait)	#	%		
2 (Mildly lame)	#	%		
3 (Moderately lame)	#	%		
4 (Lame)	#	%		
5 (Severley lame, won't walk on one or more extremities)	#	%		
Cases of	Month	Month	Year	Year
Subacute Laminitis	#	%	#	%
Subclinical Laminitis	#	%	#	%
Chronic Laminitis	#	%	#	%
Number of vet visits per month				
One-Three				
Three-Five				
More than five				
Are records being kept?				
Yes, records are kept regularly and are used as a reference often				
Somewhat, there is missing information				
No, records are not kept or can't be found				
Other comments:				

Behavior		
Proximity test		
0-10 cm	#	%
>10-50 cm	#	%
>50-100 cm	#	%
>100 cm	#	%
Cows that exhibit stressed behaviors such as		
Lying outside lying area	#	%
Colliding with stall components	#	%
Kicking off the milking unit	#	%
Other comments:		

Average frequency of head butts per cow in 1 hour				
Cow ID	0	>0-5	>5-10	>10

Calculate bpm by watching the cow's ribs, count the number of times they move out on inspiration in 15 seconds and then multiply by 4				
	Below average	Average	Above average	Comments
Cow ID	<26 bpm	26-50 bpm	>50 bpm	(Struggling to breathe, wheezing, etc.)

Environment			
Is there clean water available in:			
The corral entrance		Yes	No
Pasture		Yes	No
Other (Please state below)		Yes	No
Are there mineral salts available 24/7?		Yes	No
Pasture condition			
1 (Pasture has few or no brown spots)			
2 (Empty patches are visable)			
3 (Not enough grass to feed cattle)			
What type of grazing system is used?			
Rotational			
Open pasture			
Other (please state below)			
Stall cleanliness			
1 (No manure, dirt, or other filth present)			
2 (Small amount of manure, dirt, or other filth)			
3 (Moderate amount of manure, dirt, or other filth)			
4 (Mild amount of manure, dirt, or other filth)			
5 (Severe filth and possible health risks present)			
Corral cleanliness			
1 (clean bedding and very little manure present)			
2 (Slightly dirty bedding and some manure present)			
3 (Moderately dirty bedding and some manure present)			
4 (Mildly dirty bedding and manure present)			
5 (Severe flith and possbile health risks present)			
Other comments:			

Animal Discipline Rubric					
Note: In theory, no animal should be hit. This assessment only applies to farms where workers hit the animals.					
	No problem	Moderate Problem	Mild Problem	Severe Problem	Comments
Cow ID	0 > 10 hits in a hour	>10-20 hits in a hour	>20-30 hits in a hour	More than 30 hits in a hour	(Hard, used sticks, etc.)