5-2019

Observations and Applications of Husbandry Methodologies on a Backyard Poultry Farm in Dangriga, Belize

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A proposal submitted in partial fulfillment
of the requirements for the
Honors degree in Animal Science

By

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May 2019
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Abstract

This study explores the husbandry methodologies on a backyard poultry farm in Dangriga, Belize, with the purpose of producing a set of guidelines for backyard poultry growers that have limited resources in similar regions. The majority of data collection occurred through survey questions approved by the IRB, necropsies approved by IACUC, and general observations. There has been a steady increase in poultry production in developing regions due to its positive effects on income and relative nutrition. However, due to a lack of accessible communication and education regarding effective and safe poultry production, these operators typically see poor productivity and/or profitability in their operations. Data was collected over biosecurity, vaccination protocol, water quality, feed quality, temperature regulation, housing set-up and preparation, and behavior for broilers and layers. Overall, the major factors that appeared to have the greatest impact on the birds were low biosecurity measures, low levels of clean available water, and consistently high temperatures experiences in the broiler pens. The results for each factor are discussed and suggest if small adjustments be made, the birds could experience better health and therefore increased productivity. Additional studies regarding E. *coli* presence in water sources, trends in broiler weights, nutritional make-up of feed, and trends in necropsies should be conducted.

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Introduction

The United States poultry industry has developed its commercial operations to the point of near perfection. According to a report generated by Marin Weaver, the US "is the largest poultry producer in the world, accounting for approximately one-quarter of global poultry production during 2006–12" (Weaver, 2014). Therefore, it has become integral that production processes for broilers and laying hens be optimized to uphold the utmost level of efficiency. Because of this standard set for poultry management around the world, the United States has become a major player in exports to countries such as China, Canada, Mexico, Indonesia, and Thailand (Weaver, 2014). In addition to this, the US has also become the natural reference point to developing countries, such as Mozambique, that need to increase the level of nutrition in the diet and kick-start a stagnant economy through the production of chicken.

After spending just one month in Nampula, Mozambique, a general theme for developing countries became apparent: there is an increasing reliance and significance on poultry. One Egg, a company ran by Johnwayne Kennedy in Nampula, teaches people in the community that one egg a day can prevent severe malnutrition, an issue that seems to be prevalent in the children of developing countries. This concept of increasing protein in the diet is one that should be presented and stressed to all societies struggling to meet minimal standards for quality of life. Many individuals throughout these countries have in fact begun to produce chickens in their own backyards; however, it has come at a larger cost due to a lack of training and education.

Mr. Derek Jones, a resident of Dangriga, Belize, is a trailblazer in the production of backyard poultry in his community. He has been working with the University of Arkansas for several years now in an attempt to improve certain aspects of his community, but not yet on his own business. Mr. Jones produces and sells both broiler chickens and layer hen eggs, but he has recently seen a decline in his productivity. Based on what he has shared with me, there is a rising prevalence of disease along with a subsequent rise in mortality and morbidity, which appears to be a direct result of improper management protocols.

The problem Mr. Jones is facing is likely similar to those also attempting to produce chickens in their own backyard. Instead of simply giving individuals from growing countries compensation to produce more birds, it would be much more practical to provide these communities with useful instructions and proper education regarding poultry husbandry. Education would include topics such as biosecurity, vaccination/disease prevention protocols, egg temperature regulation, water quality, feed quality, and chick-housing preparation. Because the United States, and even more specifically Arkansas, is a leading producer of poultry, it only makes sense that we produce an instruction manual that can be accessible to those who have never before grown chickens. Not only will this manual seek to establish a stronger foundation for Belize, but if translated across several borders, it will also act to bridge the gap between the first and third-world countries.

Literature Review

As the countries throughout the world attempt to align with one another in economic and social prowess, poultry production becomes a rising industry all over. Because "poultry are able to adapt to most geographical areas and conditions, are never expensive to buy, have rapid generation time, have a high rate of productivity, and do not require large areas of land", they serve as a sustainable source of protein in the diet of those in developing countries (Marangon 2006). However, it has become apparent that individuals in these developing countries are primarily facing losses in backyard poultry because they are unaware of the necessary costs that should be spent for maximum productivity. To lower these losses, there are five major factors of methodology that should be evaluated and adjusted in light of available resources and type of environment. These factors include biosecurity, vaccination/disease prevention protocol, egg temperature regulation, water quality, feed

quality, and chick-housing preparation. Based on past experience and education, careful monitoring and regulation of these topics is integral to preventing onset of endemic diseases present in the area and acquisition of the most efficient form of production.

I. Biosecurity

By definition, backyard poultry production is that by which small flocks are managed through the use of low biosecurity measures (Conan 2012). Biosecurity encompasses everything an individual does to prevent the chance that disease enters a farm, while also preventing the chance that disease leaves a farm (USDA, 2007). This includes all methods of sanitation before, during, and after exposure to a flock, control of vectors, preventing exposure to other flocks, and maintaining an effective vaccination protocol. Failure to follow these methods of biosecurity for any given farm may subsequently "result in high levels of baseline mortality" (Conan 2012). This high level of mortality may subsequently result in a loss of income and nutrition for the family in which the backyard operation supports.

a. Personnel Sanitation

For those planning to work consistently on a backyard poultry operation (or any for that matter), consistent sanitation is necessary. Thus, owners/workers of a backyard poultry operation should wash their hands thoroughly with antibacterial soap before handling birds of all ages. If there are multiple flocks on the premises, hands should be washed each time one moves from one flock to another. Because flocks have different "sets" of microflorae, which are considered "the totality of microorganisms normally associated within a given environment or location" (Singleton, 2006), it is important to prevent any cross exposure between flocks. Additionally, there should be designated clothes and shoes that are only worn in the coop or on the premise to insure no pathogenic agents are carried in from off the farm. This will also increase the likelihood that diseases will not be taken off the farm to infect other flocks as well. Because chickens are constantly pecking at the ground for scraps, this form of transmission could easily pose a substantial threat to the health of one's birds. The common poultry diseases that could be transferred via fomites, which are inanimate objects capable of spreading infectious organisms (Mifflin, 2015), are Airsaccultis (Table 3.1), Avian Newcastle (Table 3.2), Coliform Septicemia (Table 3.3), and Fowl Cholera (Table 3.4). Though there are several other diseases of poultry capable of spreading via fomites, these pose the largest concern in an area such as Dangriga, Belize.

b. Disinfection of the Environment

According to a pamphlet designed by the USDA, *Cleaning and Disinfecting Checklist for Backyard Poultry Owners,* thorough cleaning of the chicken coop is necessary when transitioning a new flock of birds into the environment. To ensure the environment is clean of any pathogenic agents left behind by the old flock, the individual needs to apply both "dry" and "wet" cleaning methods. Dry cleaning consists of removing/scraping any excessive layers of feathers, manure, dirt, or other substances. Wet cleaning is simply scrubbing the recently scraped areas with water and disinfectant (USDA, 2015). The disinfectant that should be used on these surfaces is Commander (Clark, 2018), which is a bleach product. A homogenous mixture containing ten-parts water to one-part bleach is optimal when applying for disinfection. This will safely disinfect the environment, but will not pose a threat to any of the birds that may find themselves pecking at the newly cleaned surfaces later. The area should be thoroughly rinsed post-dry/wet cleaning, and. Left to dry through the use of ventilation and/or sunlight (USDA, 15). In addition to cleaning the physical space the birds will be housed in, it is also recommended one cleans the food and water pans. Because several diseases listed in Appendix I can be transmitted via the fecal-oral route- and because the food and water is in close proximity to the litter- it is very easy for foreign flocks to leave behind their diseases for other birds to peck at. That being said, feed and water trays should undergo the same dry/wet cleaning procedure as the housing, and should be set in the sun to dry. Sunlight can have a direct and indirect effect on the inactivation of microorganisms living in an environment (Carratalà, 2015). Through direct

inactivation, sunlight in the light range of (290-320 nm) can cease the replication of microorganisms by damaging their DNA or RNA genomes. Additionally, a light range greater than 320nm to form highly reactive oxygen species, which are capable of causing damage to some of the biological structures housed by the infectious organism (Carratalà, 2015). After exposure of these materials to ultra-violet radiation, they can be placed back in the pen and should be rinsed once a day with clean water after the new flock arrives.

c. Vector Control

Disease vectors are those species that are capable of transmitting a pathogen to another species. For example, rodents, cats, and pigs can serve as reservoirs to transmit Pasteurella *multocida*, which is the bacterium responsible for causing Fowl Cholera (Kraemer, 2012). The environment, infectious agent in question, and host's capability of developing an immune response against the agent, determines which vectors (if any) are going to transmit disease. Because the presence of a vector within a specific geographical location largely depends on the relative environment (food availability, climate, and predatorial influences, the vectors of one species can change with a change in location. Therefore, in environments experiencing subtropical climates, the probable vector species for poultry are mosquitos, rodents, wild birds, opossums, and iguanas (Johnson, 2016).

There are two broad classes of vectors that exist: biological vectors and mechanical vectors. Biological vectors transmit pathogens that have multiplied within their body to a new host. This usually occurs via a bite, or other mode of transaction between bodily fluids (More, 2017). Mosquitos are well known for this ability, because they can transmit a disease, if they are carrying it, when consuming the blood of their host. Mechanical vectors are simpler in that they essentially "pick up" the pathogen on the outside of their bodies and transmit the disease through physical contact (More, 2017).

Maintaining a secure farm is essential for keeping vectors away from and off the birds, and will subsequently decrease the overall prevalence of disease. Essentially, the best way to do this is to remove the features of an environment that are conducive to vector habitation. For instance, because mosquitos lay their eggs in still water, the operator of a farm should make sure to empty water-filled containers, clear pool and pond edges of emergency vegetation, drain swampy areas, and fill low areas that collect water (Philips, 2016). This will ultimately steer the mosquitos away from the area and encourage them to find another place to reside and reproduce. Similarly, with rodents or other animals that are considered scavengers, one should be sure to keep the premises securely closed off and hold any feed in thick, closeable containers (Clark, 2018). If it is not possible to secure the farm from all vectors, traps and poisons can be used to further prevent those animals from returning. Furthermore, the basis behind vector control is all about restricting the environment in such a way that restrains the vector's ability to reside there, and such restrictions should also be considered on any kind of production farm.

d. Vaccination

Because commercial flocks are constantly at risk for exposure to disease causing agents, "disease prevention by vaccination is an integral part of flock health management protocols" (Sharma, 1999). In this study, vaccination protocol will be considered a sub-category of biosecurity because vaccination is the process of exposing an organism, such as a chicken, to a pathogen that has been weakened or killed to stimulate the immune system. Vaccines are becoming increasingly essential in poultry production, as the level of antibiotics being used declines and the prevalence of microbes and parasites remains a constant battle (Moyle, 2007). With vaccines, it is possibly for immunity against such infectious agents can be accomplished. Immunity, which "can be described as the ability of the body to recognize the presence of material normally within the body ("self"), and to eliminate foreign ("non-self") materials" (Moyle, 2007). Thus, with the development of pathogenic immunity in

addition to other biosecurity measures, the health and production of the bird can be optimized. It is important to emphasize that vaccines are *not* an alternative to all other biosecurity methods and should not be done in lieu of other biosecurity protocols.

The way in which vaccines work is rather simple. Essentially, they induce the body to think that it is being invaded by a specific organism, and the immune system goes to work to destroy the invader and prevent it from infecting the bird again" (Moyle, 2007). Furthermore, if that organism *actually* attacks in the future, the bird's body is already equipped with an immune response in the form of antibodies. This immunity development is similar to that of a natural infection, which occurs when the bird comes into unaided contact with the pathogen in the environment. Contrary to what some may believe, natural immunity is not preferred over vaccine-induced immunity, because the bird may *not* develop a strong enough immune response to rid the body of the pathogen, which could result in reduced productivity and/or mortality. Therefore, vaccines provide a safer development against disease-causing agents, and subsequently encourage optimal production and decreased mortality in the future.

II. Water Quality

Water has been defined as the single most important nutrient in all biological systems, and more specifically, in poultry production. Because water is essential for physiological functions such as digestion, [nutrient] absorption and transport, thermoregulation, and development, its absence will depress animal performance more quickly than any other nutrient deficiency (Ibotoye et al., 2013). Therefore, it is vital to track water quality provided for the birds from the moment they hit the ground to the moment they are harvested. When assessing water quality, it is important to consider three variables: level of availability, source of water, and presence of pathogenic organisms. Level of availability simply refers to how much water is provided and how consistently it is replaced for the birds. There should always be water on the ground when chicks hatch and that availability must be maintained throughout their life. The source of water primarily goes hand-in-hand with presence of pathogenic organisms. Sources of water include sealed water tanks, pure rain water, rain water that reached the birds from a run-off source (i.e. a gutter), or surrounding bodies of water. Ideally, the birds would be able to avoid the threat of disease by only drinking clean water from sealed tanks. However, because that may not be the case, it will be important to test for the common pathogenic organisms that attack poultry. After meeting with Dr. Fred Clark, a veterinarian with a Ph.D. in pathobiology, he stated that the most common diseases in poultry caused by pathogenic organisms would be Newcastle Disease, Avian Infectious Bronchitis, Fowl Typhoid, Marek's Disease, and Fowl Cholera. Controlling exposure of these organisms to the birds through water will greatly reduce the disease challenge they face and therefore increase their overall productivity.

III. Feed Quality

The greatest cost incurred by those in the poultry industry comes from the feed (Tahir, et al., 2012). Therefore, it is vital that the producer knows the content of his or her feed to determine which feed has the lowest cost with relation to nutritional content and to enhance levels of feed efficiency. Feed efficiency is the ability of an animal to gain more weight through the ingestion of less food. Because of this, select levels of nutrients in the feed have made the difference between your average backyard poultry and the chicken developed by companies like Tyson or KFC. In a study regarding the aspects of selection for feed efficiency, W. O. Willems claims that feed efficiency in poultry has been improved through the utilization of optimum temperature regulation, lighting, bird densities, and genetic selection (Willems et al., 2013). Though few of these factors are probably regulated in backyard poultry, the producer can still focus on the most important thing: the content of the feed itself, which changes in response to the location of cultivation, the growing conditions, and the quality of the soil (Tahir, et al., 2012). Therefore, it will be important for farmers to evaluate the location and protocol by which they purchase their feed in order to decrease costs while improving productivity.

IV. Temperature Regulation

The optimal growth temperature for a chick, which is defined as that required to achieve max hatchability, is approximately 38 degrees Celsius. Dr. N.A. French, a scientist who studied the effects of varying incubation temperatures on embryonic development and egg size, states that small derivations from this optimum can have a major impact on the hatching success and embryo development (N.A. French, 1997). In the United States commercial poultry industry, temperatures of the eggs are kept within a narrow range immediately after the hen lays them. Essentially, the eggs are dropped onto a conveyer belt, sent to a cooling room, and maintained in dormant state until 'x' amount of eggs are available to fill the incubator. This ensures that all of the eggs hatch at the exact same time and all of the chicks are given the necessary attention at moment of hatch. Because this practice cannot be achieved yet in a country like Belize, there have to be adjustments to account for lack of resources. Because Belize has an overall higher temperature scale than the US and backyard growers do not have intricate cooling systems or incubators, it's vital to their success that the eggs be kept as cool as possible if being used for replacement birds.

V. Housing Set-Up and Preparation

Because the first three days of a chick's life are the most important, proper housing set-up is critical for their survival, growth, and development. Chickens should be maintained in an area that provides warmth, shelter from adverse weather conditions, dry litter on the ground, and constant access to food and water. Stress, which is the primary catapult for overgrowth of infectious agents and development of disease, is directly related to any defects in the above listed specifications. Avoiding stress can be done when backyard producers decrease the level of wind draft in the housing area, monitor the soiled litter by replacing it when the volume of feces becomes too high, and constantly checking food and water availability. In previous research conducted in Nampula, Mozambique, the out-growers saw a direct correlation between the quality of their housing (based on these variables) and the death of the chicks at days 3, 5, and 10 (Johnson et al., 2016). Therefore, in order to optimize productivity and decrease mortality, it is absolutely essential to reduce the level of stress through proper housing management techniques.

Materials

1. **Temperature Regulation**

   Lascar EL-USB-2-LCD USB Data Logger:

   Test Equipment Depot
   Fotronic Corporation
   99 Washington Street
   100 Melrose, MA 02176-6024

2. **Necropsy Kit**
3. **Survey Questions**
4. **Scale**

Methods

Disease Prevention Protocol: Biosecurity and Vaccination

This topic was predominantly addressed by observing the general layout and surroundings of the farm, and by interviewing Mr. Jones. He was asked a series of questions regarding vaccination, treatment for disease, diagnostic testing, control of vector species, offal disposal, and approaches to sanitation. See below for the survey questions Mr. Jones was asked about general biosecurity and vaccination.

Survey Questions Regarding Biosecurity

a. Are you exposed to more than one flock of birds at a time? (note: flock of birds are differentiated by different dates of delivery to your farm)
b. Do you shower between exposures to each flock?
c. Do you take any other measures (other than taking showers) between flocks of birds? I.e. changing clothes, cleaning shoes, having disposable shoes, washing hands, etc.
d. Do you keep flocks separate? If so, How?
e. Do you integrate birds from separate flocks?
f. What is your protocol for offal disposal?
g. What is your protocol for managing dead birds?
h. What is your protocol for managing diseased birds? For example, are they quarantined, treated with medication, or culled?
i. Are there any obvious vector species on your property? If so, what species are present?

Survey Questions Regarding Vaccination

a. Do you understand the purpose behind vaccinating?
b. Do you use any vaccinations for the birds?
c. If so, what vaccinations do you use and what diseases do they act to prevent?
d. What is your method for vaccination?
e. Do you have help with vaccinations? If so, by whom?
f. Do you observe any direct deaths due to vaccination type or technique?
g. Have you observed any deaths that *may* be related to a vaccination type or technique? If so, can you describe the symptoms leading up to death and the post-mortem observations?
h. What indications did you observe that lead you to associate the deaths with the vaccinations?
i. What is your biggest challenge while vaccinating?
j. Are there any changes in methodology that you believe could overcome these challenges?
k. If you are not vaccinating, why? For example, is it an issue with cost and time?
l. Do you know anyone else in the community with a backyard poultry farm who vaccinates their birds?

Water Quality:

Evaluation of water quality was predominantly based off observations and an interview with Mr. Jones. I also checked for the prevalence of slime layers by scraping the inside wall of each of the water storage units. See below for the series of survey questions Mr. Jones was asked regarding the maintenance of his chickens' water source and quality.

Survey Questions Regarding Water Quality

a. Do you consider water quality a factor that affects production of poultry?
b. Do you have any means of testing water quality?
c. How many sources of water are available for consumption by the broilers?
d. What are the sources of water available to the layers and rooster?
e. Are there any nearby (natural) sources of water that could possibly contaminate the water consumed by your birds? If so, where and what is the source?
f. Have you ever tested the water for presence of pathogenic organisms? If so, when and what did you find?
g. Did you do anything with the results when you tested the water quality?

Feed Quality
In order to determine the relative effectiveness of the feed the chicks were receiving, I weighed the chicks on their day of arrival, and on days three, five, and ten. Each bird was weighed individually using a scale (with a basket placed on top), with the weight of the basket being subtracted from the total weight. To distinguish between flocks of birds, I color-coded them by marking the tops of their heads with a different colored marker. An average of the entire flock's weight was taken for comparison against other flocks. These weights were then used to evaluate if any changes needed to be made in Mr. Jones' feeding protocol and/or type of feed used. During this time, I also observed and recorded how often food was added to the feeders in each flock's housing unit. Additionally, see below for the series of survey questions Mr. Jones was asked regarding feed quality.

Survey Questions Regarding Feed Quality

a. What feed are you providing for both the broilers and the laying hens?
b. Where do you purchase your feed?
c. How often do you feed?
d. Is feed consumption regulated? If so, what are your means for monitoring that regulation?
e. Are the birds capable of consuming anything other than the generic feed?
f. Do you monitor weight gain as a direct correlation to feed type and regulation? If so, how?
g. Are there competitors to the feed you buy?
h. Is there a reason you buy the food that you currently do?
i. Do you know the nutritional value of the feed you buy, or that of the competitors?
j. Are there antibiotics present in the feed?

Temperature Regulation:
The protocol for determining the temperature the environment was reaching was similar to the research I conducted in Mozambique, Africa. On the evening prior to each day, I used the data logger software on the computer to set a time in the morning in which the loggers would begin to collect data. Temperature (in degrees Celsius) was collected in intervals of one hour throughout each day that was spent for data and observations. During the first week of data collection, the positions of the loggers were determined based on the consistent locations that the hens and broilers resided. The positions of these loggers were maintained for the entirety of the study. See Tables 2.1-2.4 be for the position of each logger throughout Mr. Jones' farm. The loggers were placed first thing in the morning, around 9:00am, and picked up later that afternoon
. The data from the loggers was then uploaded to the computer using the data logger software, and graphs were produced to further evaluate the data. In addition to collecting raw temperature data, a set of survey questions were asked to Mr. Jones to determine his general protocol for egg temperature regulation. See below for the set of questions asked.

Survey Questions Regarding Egg Temperature Regulation

a. How often are eggs collected from laying hens?
b. How many eggs do you pick up per collection?
c. How do you store the eggs once you've collected them? I.e. are they placed in a freezer, refrigerator, or just on a shelf?
d. Do you have any means for cooling the eggs? If so, do you implement them?

Housing Set-Up and Preparation
During the first week of arrival, Mr. Jones was asked how often he received his day-old chicks, as well as when the next arrival would be. I then monitored his protocol for preparation of the chick housing before delivery and paid close attention to the type of feed present and the level of availability, water availability, temperature of the chick house, and type of bedding. When the chicks were delivered, I counted how many were originally present and how many (if any) were dead at days three, five, and ten. I also observed the type of housing available to the layers and roosters and recorded this data by taking notes and pictures of the farm.

Additionally, see below for the series of survey questions Mr. Jones was asked regarding preparation of the bird houses before a new set of chicks arrived.

Survey Questions Regarding Housing Set-Up and Preparation

a. Is the temperature regulated and monitored? If so, how?
b. If any, what is the bedding provided for the chicks?
c. How often is the bedding replaced?
d. How many chicks are housed together?
e. What is the size of the housing provided for the chicks (in square footage)?
f. Are water and feed available for the chicks upon arrival? If so, how much?
g. How often are water and feed levels monitored, if at all?
h. Who is responsible for monitoring the chick housing?
i. Have you ever noticed any direct correlation between dead birds and quality of chick housing? If so, describe any clinical symptoms leading up to death and/or post mortem observations

Necropsy Methodology[1]

To determine the possible prevalence of disease, or any other issues related to stunted growth and mortality, eight necropsies were performed. As per instructed by my thesis mentor, Dr. F.D. Clark, I performed each necropsy in the same manner as a means to develop a consistent approach with each bird. The exact steps taken for each necropsy were as follows:

- **Steps for External Evaluation[2]**
  1. Observe the feathers of the bird and look for presence of small, black specks and/or off-white moving specks.
  2. Observe the scales of the pelvic limbs, and look for dried, tan specks.
  3. Observe the nails- Determine if they are relatively long or short, and if any are missing.
  4. Observe the head of the bird
     - Evaluate the color of the comb- it should be bright red.
     - Check the eyes and eyelids for any abrasions or lacerations. Additionally, evaluate the relative clearness of the eye and if any ulcers appear to be present.
     - Evaluate the nostrils and check for the presence of a clear, thick discharge coming out of the them, or for evidence of a dried, brown exudate from past discharges. If there is a discharge present, check the feathers on the shoulder for the same past discharge.

- **Steps for Internal Evaluation[2]**
  1. Open up the bird by first using poultry sheers to make an incision in the skin between the legs and the body.
  2. Tear the skin with fingers on both sides and connect the incisions.
  3. Tear the skin back towards the head to expose the underlying muscles.
  4. Pop both hip joints out to lay the bird down flat.
     - When doing this, look for the head of the femur bone and determine if it is fully intact or if it has sheared off during the dislocation.
  5. Evaluate the breast muscle.
     - Observe the carina bone of the sternum, which divides the breast in left and right parts. Determine if the carina is "S"-shaped, in order to evaluate the level of calcium in the bird's diet.
  6. Break the tibiotarsus of the femur bone in each leg to determine level of calcium in the bird's diet.
  7. Pull the skin of the chest further up to expose all of the chest cavity. While doing this, evaluate the level of fat storage.
  8. Make an incision at the tip of the sternum.
  9. Using the poultry sheers, cut along and through the ribs. Pull back the sternum and attached breast muscle to expose the internal organs.
  10. Evaluate the color and the relative sharpness of the edge of the liver.
  11. Evaluate the color of the heart and the level of fat surrounding it.
  12. Locate and evaluate the relative transparency the air sacs in the thoracic cavity.
  13. Pull the organs away from the left side of the lower abdomen to gain a clear view of the gonadal structures- One ovary is in the female while two testes are in the male.
      - If female is in production, there may be a follicular hierarchy to observe.
  14. Take out the proventriculus and the ventriculus (the gizzard) by pulling on them with a mild amount of force. Observe the outside of both of these structures for any evidence of change and/or for a slightly green appearance, which could indicate leakage of bile. Set the two structures aside for later evaluation.
  15. Remove the intestinal tract by pulling it with mild force from the thoracic cavity. Be careful not to tear open the gall bladder, which is located ventrally to the liver. Lay the intestines aside to be observed later.
  16. Observe the cloaca, which is the located in the caudal-most portion of the thoracic cavity. Determine if it has its characteristic triangular shape.
  17. Locate the bursa of fabricius, which is a pear-shaped structure usually found in birds less than eight weeks of age and contains many folds when cut into. The bursa fabricius is dorsal to the cloaca.
  18. Evaluate the color of the lungs. A normal color is an orangey-pink.
  19. Evaluate the three divisions of the kidney (cranial, medial, and caudal), and observe their color to determine level of dehydration. Also, locate the ureters and observe for urates in them (toothpaste-like composition).
  20. Separate the muscles of the proximal pelvic limb and look for the ischiatic nerve. Observe its relative smoothness to determine prevalence of Marek's Disease. Marek's would be indicated by a knobby, somewhat grey-colored nerve.
  21. Using the sheers, cut through the stifle joint in the legs and observe the clearness of synovial fluid to determine possible prevalence of viral arthritis.
  22. Cut the breast muscle along the carina bone and observe any green tinting to determine the possibility of green muscle disease.
  23. Using the sheers, cut through the lateral aspect of the mouth in line with jaw, and extend the cut to the crop. Using small scissors after making the initial cut.
  24. Observe the jugular vein on the right side of the bird.

25. Observe the roof of the mouth and evaluate the relative conical appearance of the papillae for possible indication of a respiratory disease. These are usually more rounded when the bird is infected by a respiratory disease.
26. Using the small scissors, cut through the glottis and follow this by cutting through the trachea. Look for evidence of increased mucus.
27. Cut open the crop and observe level of food present.
28. Cut a cross section of the beak to evaluate the scroll-shaped structures. Squeeze the nostrils to observe how much mucus is ejected and how thick it is, if any is present.
29. Cut through one of the sinus cavities and observe the level and thickness of mucus.
30. Open up the proventriculus and the ventriculus (the gizzard) to observe the level of sand and rocks. Evaluate the koilin, which is the lining of the gizzard, and look for possible erosions and/or ulcers.
31. Evaluate the intestinal tract by cutting open the duodenal loop, the small intestines, the large intestines, and the ceca in that exact order. Observe the relative thickness when cutting through the intestinal tract, and look for prevalence of stripes, hemorrhages, ulcers, and/or worms.[3]

[1]Refer to Appendix III for a glossary of medical terms utilized throughout the text.
[2]Appendix II offers further explanation regarding certain post-mortem symptoms/lesions and their corresponding (possible) causes.
[3]Refer to Table 4.2 in the appendix for further information regarding intestinal parasites and their defining characteristics.

Data Collection and Observations

Biosecurity

The level of biosecurity available to the layers, roosters, and broilers was mainly determined by asking Mr. Jones a series of survey questions. See Table 1.1 for the responses given. There was no "true" separation of flocks from one other, other than a layer of chicken wire. Additionally, the day-old chicks would be placed with the week-old chicks when they first arrived on the farm, and were then joined by a new flock of day-old chicks for another week. Mr. Jones claimed he intermingled the day-old chicks with the birds that were one-week-old, because he felt that the younger birds need to be taught the basic functions of survival. He did not shower, wash hands, change clothes, or switch shoes between handling different flocks. Because the birds on his farm did not usually experience disease (to his knowledge), he had no specific protocol for managing the birds that did show symptoms of illness. Additionally, he claimed he has observed rats, mice, tarantulas (Figure 1), opossums, and iguanas on the farm. The rats were a major problem in the past, but have declined since he started setting out rat poison around the farm- location of the rat poison was never determined. On two occasions he had witnessed an opossum stealing eggs from the nest of the layers, but never attacking the layers themselves. During the study, an iguana was spotted in the layer pen almost every day, and one had been caught inside the broiler coop as well.

Figure 1- Tarantula in Mr. Jones' yard.

Table 1.1: Survey Questions Regarding Biosecurity

Survey: Biosecurity	
Question	**Response**
Are you exposed to more than one flock of birds at a time? (note: flock of birds are differentiated by different dates delivered to your farm).	Yes.
Do you shower between exposures to each flock?	No.
Do you take any other measures (other than taking showers) between flocks of birds? I.e. changing clothes, cleaning shoes, wearing disposable shoes, washing hands, etc.	No.
Do you keep flocks separate? If so, how?	The flocks are all kept in one coop, but separated by a waist-high layer of chicken wire. The day-old chicks are kept with the week-old chicks for one week, and then placed with a new flock of day-old chicks for another week.
Do you integrate birds from separate flocks?	The birds from week zero remain with the week one birds for one week. The purpose behind this is to have the younger birds taught by the older birds.
What is your protocol for offal disposal?	The heart, lungs, liver, and kidney are fed to the dog. The intestines, gall bladder, and trachea are thrown in the compost pile and often consumed by the layers.
What is your protocol for managing (unexpectantly) dead birds?	Cutting up the bird and giving it to the dog after it has been cooked.
What is your protocol for managing diseased bird? For example, are they quarantined, treated with medication, or culled?	There is no specified protocol.
Are there any obvious vector species on your property? If so, what species are present?	Yes: Rats, mice, opossums, tarantulas, and iguanas.

Vaccination Protocol

Broilers

Figure 2- Injection marks on the neck of a recently delivered chick.

Data regarding vaccination protocol was primarily collected through survey questions and observations. See Table 1.2 for the responses Mr. Jones gave to a series of survey questions regarding the quality of the feed on his farm. Based on his responses and my own observations, the day-old chicks were not being vaccinated *consistently* before being shipped out to the growers. Though one flock of chicks all had injection marks on their necks, thus indicating they had probably been vaccinated (Figure 2), the majority of the other flocks did not have these same marks. Furthermore, the birds that showed no signs of vaccination (Figure 3) were also larger, on average, than the birds that had been vaccinated. Dr. F.D. Clark, poultry veterinarian at the University of Arkansas, believed those birds that had been vaccinated were likely being protected against Marek's disease. However, this hypothesis was never confirmed.

Figure 3- A recently delivered chick with no obvious signs of vaccine injection.

Table 1.2: Survey Questions Regarding Vaccination Protocol

Survey: Vaccination Protocol	
Question	**Response**
Do you us any vaccinations for birds?	No
If so, what vaccinations do you use and what diseases do they act to prevent?	N/A
What is your method for vaccination	N/A
Do you have help with vaccinations? If so, by whom?	It's possible that the people at Spanish Lookout vaccinate the birds before they're shipped out to the growers.
Do you observe any direct deaths due to vaccination type or technique?	No.
Have you observed any deaths that *may* be related to a vaccination type or technique? If so, can you describe the symptoms leading up to death and post-mortem observations?	N/A
What indications did you observe that lead you to associate the deaths with the vaccinations?	N/A
What is your biggest challenge while vaccination?	N/A
Are there any changes in methodology that you believe could overcome these challenges?	N/A
If you are not vaccinating, why? For example, is it an issue with cost and/or time?	It's possible that the Mennonites are vaccinating the birds before they send them out so I don't want to double vaccinate.
Do you know anyone else in the community with the backyard poultry farm who vaccinates their birds?	No
Would you be willing to vaccinate in the future if it meant improving your production and profits?	Yes.

Water Quality

Broilers

As previously mentioned, each broiler pen contained one Plasson Breeding Drinker for the water source. The drinkers were located directly next to the feeders and were hung at the same level in all of the pens, regardless of the age of bird that housed it. The birds 0-1 week of age would reach up for the water, while those birds that were older than three weeks would have to bend their neck down to do so. Throughout the entire time of the study, it was observed that each drinker contained a thick layer of mahogany shavings (Figure 4) where the birds would otherwise be able to access the water. The water from each waterer came from a fifty-five-gallon tank just located on the outside of the coop, except for the waterer on the western-most end, which was sourced by rain-water. The opening to the tank was covered by a piece of mesh that could be opened and closed easily when the owner needed to access it. It was filled using a hose, which pulled from a source containing municipal water, and was only filled up when the tank was completely empty.

Figure 4- Plasson Breeding Drinker filled with bedding in broiler nursery pen.

Mr. Jones added one packet of OTC Plus to the main water source, which is a water-soluble powder containing vitamins and antibiotics. He added one packet to the fifty-five-gallon tank, thus diluting the solution 20%. The OTC Plus could be used as a means for prevention of disease, as well as for treatment. However, Mr. Jones claimed he only used it for vitamin purposes rather than for the antibiotics, because he believed the dilution of the solution would only negatively affect the benefits that antibiotics would provide for the birds.

Layers and Roosters

There were four main water sources provided for the layers: two 1,000-gallon tanks, one fifty-five-gallon tank, and an old fish nursery. The two 1,000-gallon tanks were filled directly with rain water, while the fifty-five-gallon tank was connected to gutter system that collected rain from the roof of the broiler coop. That rain then flowed through a pipe at the bottom of the barrel and filled a "pan" made from a barrel that was cut a fourth of the way up from the bottom. The smaller tank was also similar to the one that supported the coop's waterer, in that it could be closed off using a mesh. For the majority of the study, water was not collected by this gutter system because there was not a lot of rain fall during that time. The larger tanks did not drain into a water source closer to the ground, and only a few chickens were ever observed drinking from them. The water in each of the larger tanks appeared green and housed living tadpoles throughout the entire duration of the study. The fish nursery seemed to be the

Figure 5- Fish nursery serving as a water source for the layers and roosters.

major source of water for the layers and roosters to drink from (Figure 5). It was covered on the top and was not supplied by rain water, and instead contained water that had been added to it about one year previous to the study. Similar to the 1000-gallon tanks, it had also appeared green and housed tadpoles in it for the duration of the data collection period.

There did not seem to be any direct source for newly hatched chicks to receive water from. Due to the height of the water pan, 1000-gallon tanks, and fish nursery, the chicks were not able to reach water from these sources until they were at least three-weeks-old. Because there were some small "scrap" items laying in the yard, the chicks would sometimes drink from their surfaces when water collected in/on them. However, this was completely dependent on the level of rainfall, which was not very much or often during the study.

See Table 1.3 for the responses Mr. Jones gave to a series of survey questions regarding the quality of water on his farm.

Table 1.3: Survey Questions Regarding Water Quality

Survey: Water Quality	
Question	**Response**
Do you consider water quality a factor that affects the production of poultry?	No
Do you have any means of testing water quality?	Yes; I have pH testers, but I do not see the need in testing the water
How many sources of water are available for consumption by the broilers?	One waterer per coop
What are the sources of water available to the layers and roosters?	There are two one-thousand-gallon tanks filled with rain water and sometimes used for the chickens. There is also a tank that uses a gutter to collect rain water by the broiler coop.
Are there any nearby (natural) sources of water that could possibly contaminate the water consumed by your birds? If so, where and what is the source?	There is a river located north of the farm about 200 yards away.
Have you ever tested the water for presence of pathogenic organisms? If so, when and what did you find out?	No
Did you do anything with the results when you tested the water quality?	N/A

Feed Quality:

Broilers

The broiler feed was sourced from Spanish Lookout Mennonite Community, a privately-owned facility based in Belize City, Belize. Mr. Jones purchased three types of feed and fed the different kinds based on the age of the birds. "Broiler Starter" was given to nursery birds between zero days and two weeks of age, "Broiler Grower" was given to birds between three and five weeks of age, and "Broiler Finisher" was given to birds six to seven weeks of age. For information regarding the contents of the Broiler Grower and Broiler Finisher, refer to Table 6.1 in Appendix IV. Due to a lack of information available, the nutritional makeup of the Broiler Starter was not determined. When owners of Spanish Lookout were asked about the antibiotics

present in the feed, they would not disclose the information. The nursery birds were fed with a five-pound bag of starter for the entire week. If they ran out of feed, the feeder would not be refilled until the start of the next week when a new bag was purchased.

Typically, all of the feeders were checked (and possibly filled) around 9:00am each day and would not be checked/filled again until the subsequent morning. There were three recorded instances in which one flock went an entire day without access to any feed (Figure 6), and there were several other instances where some of the flocks went at least five hours without feed. Because the feeding regimen was inconsistent with the growers and finishers, the amount of feed administered per week was not determined.

Layers and Roosters

The feed for the layers and roosters, which was called “Laying Mash”, was also sourced from Spanish Lookout Mennonite Community. For information regarding the contents of the Laying Mash, refer to Table 6.2 in Appendix IV.

In a similar fashion to that of the broilers, Mr. Jones would feed the layers around 9:00am and administer a three-pound scoop of laying mash in the single feeder. When observing feeding time, it was noted that the majority of birds never actually received any of the laying mash; most of it was taken up by the roosters or larger hens. A fifty-pound bag was purchased at one time, so it lasted about sixteen days until a new one was purchased. On the days when Mr. Jones would butcher his seven-week-old broilers, the offal would be eaten by the layers when thrown in the compost pile. The layers would also dig up decomposing birds in the compost and eat whatever parts remained.

See Table 1.4 for the responses Mr. Jones gave to a series of survey questions regarding the quality of the feed on his farm.

Table 1.4: Survey Questions Regarding Feed Quality

Survey: Feed Quality	
Question	**Response**
What feed are you providing for both the broilers and the laying hens?	The laying hens eat whatever is in the compost or on the ground, in addition to daily laying mash and old cafeteria food. The broilers are on broiler feed.
Where do you purchase your feed?	Spanish Lookout in Belize City, Belize.
How often do you feed the laying hens?	Twice a day; the laying mash is in the morning and food waste from the local elementary school is thrown out in the afternoon.
How often do you feed the broilers?	Once every day if their feeder is empty.
Is feed consumption regulated? If so, what are your means for monitoring that regulation?	Feed consumption is not regulated closely.
Are the birds capable of consuming anything other than the generic feed?	The laying hens and roosters are capable of picking up any scraps in the yard or anything in the compost.
Do you monitor weight gain as a direct correlation to feed type and regulation? If so, how?	No
Are there competitors to the feed you buy?	No.
Is there a reason you buy the food that you currently do?	It's the only product available.
Do you know the nutritional value of the feed you buy, or that of the competitors?	The contents are listed on the back of the bag, but they do not disclose everything, such as the antibiotics present in the feed.

Temperature and Humidity Data:

Table 2.1: Temperature and Humidity Data for Logger #1

Logger #1						
Date	**Max Temperature**	**Min Temperature**	**Average Temperature**	**Maximum Humidity**	**Minimum Humidity**	**Average Humidity**
6/12/18	31.0C at 3:48pm	25.5C at 6:22pm	29.3C	77.0% at 7:45pm	60.0% at 4:00pm	68.7%
6/13/18	31.0C at 4:00pm	26.0C at 8:30pm	28.8C	74.5% at 8:48pm	68.5% at 5:00pm	72.0%
6/18/18	37.5C at 4:00pm	28.0C at 2am	31.3C	83.0% at 10:10am	69.5% at 5:13pm	77.5%
6/19/18	36.5C at 11:58am	31.0C at 9:30am	34.2C	74.0% at 9:50am	63.5% at 7:06pm	68.4%
6/20/18	34.5C at 1:15pm	31.0C at 11:15pm	32.5C	73.0% at 11:15pm	67.0% at 2:10pm	69.8%
6/21/18	31.5C at 9:00am	28.0C at 6:30am	29.8C	83.5% at 7:00am	70.5% at 3:15pm	77.5%
6/22/18	37.0C at 2:45pm	29.0C at 7:30pm	32.4C	77.5% at 11:20pm	61.0% at 2:40pm	72.1%
6/23/18	36.5C at 1:25pm	28.5C at 2:50am	31.2C	80.0% at 3:45am	62.5% at 1:50pm	72.3%
6/24/18	38.5C at 7:40am	28.5Cat 12:10am	26.1C	74.5% at 4:35am	58.0% at 8:45pm	66.1%
6/26/18	35.5C at 1:45pm	30.0C at 8:45pm-12:00am	32.2C	70.5% at 9:40am	60.5% at 2:33pm	65.7%
6/27/18	37.5C at 1:52pm	29C at 3:38am	31.7C	80.0% at 5:47am	63.5% at 2:38pm	69.5%
6/29/18	37.0C at 2:59pm	30.0C at 4:12pm-11:12pm	33.4C	77.0% at 11:57am	64.5% at 1:57pm	69.3%
6/30/18	38.5C at 6:57pm	29.5C at 5:27am	34.0C	76.0% at 8:38am-	60.5% at 3:05pm	69.9%
7/1/18	38.0C at 7:56am	29.0C at 11:48pm	33.8C	75.5% at 11:40pm	58.0% at 5:56am	68.8%

Logger 1 (Table 2.1) was located in the large nest box in the middle of the yard. The nest box contained three dividers that were used to form four "sections" for the hens to lay. This logger was placed in the eastern-most section, which was typically inhabited by one to four hens at a time (Figure 7). A total of fourteen recordings were taken, with temperature and humidity being the point of focus. The highest temperature was 38.5C (101.3F) while the lowest was 25.5C (77.9F). The average maximum and minimum temperature recorded was 35.8C (96.4F) and 28.0C (82.4F), respectively. The highest humidity was 83.5%, while the lowest was 58.0%. The average maximum and minimum humidity level recorded was 76.9% and 63.4%, respectively.

Figure 7- Layers in a nest box of the main coop.

Table 2.2: Temperature and Humidity Data for Logger #2

Logger #2						
Date	**Max Temperature**	**Min Temperature**	**Average Temperature**	**Maximum Humidity**	**Minimum Humidity**	**Average Humidity**
6/13/18	33.0C at 1:09pm	26.0C at 5:52pm	28.9C	68.5% at 9:38pm	60.5% at 9:22am	64.6%
6/18/18	31.5C at 12:00pm	28.5C at 8:30pm	29.6C	79.5% at 8:00pm	70.0% at 12:00pm	74.7%
6/19/18	32.5C at 10:00am	29.0C at 11:00pm	31.1C	73.5% at 11:20pm	65.5% at 3:09pm	69.2%
6/20/18	33.5C at 6:00pm	28.5C at 10:30pm	30.6C	79.0% at 11:30pm	68.5% at 6:00pm	75.4%
6/21/18	32.0C at 9:00am	28.0C at 2:12am	29.8C	81.0% at 6:00am	65.0% at 3:00pm	73.6%
6/22/18	31.0C at 5:40pm	28.5C at 7:50pm-11:55pm	29.8C	86.5% at 11:21pm	76.0% at 2:43pm	81.2%
6/23/18	34.0C at 11:49am	28.0C at 4:17am	30.4C	93.0% at 6:30am	70.5% at 5:53pm	80.1%
6/24/18	33.0C at 12:44pm	28.0C at 12:25am-4:47am	30.4C	79.5C at 4:23am	67.5% at 12:31pm	74.8%
6/26/18	32.0C at 10:42am-2:41pm	29.0C at 7:43pm-10:41pm	30.6C	78.5% at 10:41pm	67.0% at 12:34pm	71.5%
6/27/18	31.0C at 11:52am	29C at 5:42am	29.7C	78.0% at 6:45am	72.0% at 12:49pm-3:45pm	75.1%
6/28/18	32.5C at 11:14am	29.5C at 10:52pm	31.1C	91.5% at 9:28am	66.5% at 12:58pm	71.5%
6/29/18	33.5C at 12:58pm	29.0C at 9:53pm	31.3C	76.0% at 11:45pm	63.0% at 1:54pm	69.8%
6/30/18	33.5C at 11:04am	28.5C at 12:58am-5:00am	30.5C	78.0% at 5:00am	60.5% at 12:53pm	70.6%
7/1/18	33.0C at 8:57pm	28.0C at 4:38am	30.7C	78.0% at 4:51am	65.5% at 10:48am	72.3%

Logger 2 (Table 2.2) was located in the nursery pen, which was the most central section within the broiler house. There were sixteen birds between zero days and two weeks of age at all times. The logger was placed next to the broilers' feeder. A total of fourteen recordings were taken, with temperature and humidity being the point of focus. The highest temperature was 33.5C (92.3F) while the lowest was 26.0C (78.8F). The average maximum and minimum temperature recorded was 32.6C (90.7F) and 28.4C (83.1F), respectively. The highest humidity was 93.0%, while the lowest was 60.5%. The average maximum and minimum humidity level recorded was 80.0% and 67.0%, respectively.

Table 2.3: Temperature and Humidity Data for Logger #3

Logger #3						
Date	**Max Temperature**	**Min Temperature**	**Average Temperature**	**Maximum Humidity**	**Minimum Humidity**	**Average Humidity**
6/12/13	32.5C at 11:50am	26.0C at 5:45pm	30.0C	78.0% at 9:30am	59.5% at 4:15pm	67.3%
6/13/18	33.0C at 2:00pm	26.0C at 6:45pm	29.1C	75.5% at 10:45pm	70.0% at 6:45pm	72.5%
6/18/18	32.5C at 2:33pm	28.0C at 9pm-6am	29.5C	85.0% at 2:30pm	74.0% at 11:30am	81.0%
6/19/18	31.5C at 11:53pm	29.0C at 10:00pm	30.4C	86.0% at 11:00pm	72.5% at 3:08pm	78.6%
6/20/18	32.5C at 12:22pm	28.5C at 8:00pm-11:30pm	30.6C	87.5% at 12:00pm	80.0% at 1:30pm	83.9%
6/21/18	31.5C at 11:52am	28.0C at 1:09am-5:59am	29.7C	93.5% at 6:59am	74.5% at 4:00pm	82.7%
6/22/18	32.0C at 7:37pm	29.5C at 11:52am	30.4C	93.5% at 10:37pm	82.0% at 11:38am	88.1%
6/23/18	33.0C at 2:42am	28.5C at 5:34pm	30.4C	93.5% at 11:30pm	78.0% at 3:45pm	85.5%
6/24/18	32.5C at 12:37am	29.0C at 5:39am	30.7C	88.5% at 1:46am	71.5% at 11:50am	79.4%
6/26/18	32.5C at 9:45am-11:41am	29.0C at 8:27pm	30.6C	84.5% at 11:37pm	70.0C at 10:15am	76.4%
6/27/18	31.0C at 9:02am	29.0C at 12:00am-5:30am and from 7:09pm-11:36pm	29.5C	91.5% at 9:49pm-11:59pm	84.0% at 1:45pm	88.5%
6/28/18	33.5C at 11:03am	28.5C at 9:25pm	30.6C	100.% at 9:20am	67.5% at 1:07pm	77.4%
6/29/18	34.0C at 11:21am	28.0C at 10:03pm	30.7C	84.0% at 8:58pm	64.0% at 10:56am	75.0%
6/30/18	33.0C at 12:09pm	27.5C at 4:54am	29.8C	84.5% at 4:54am	64.5% at 10:56am	76.1%

Logger 3 (Table 2.3) was Located in the eastern-most pen within the broiler house. There were eight birds in this section during the entirety of the data collection period. A total of fourteen recordings were taken, with temperature and humidity being the point of focus. The highest temperature was 34.0C (93.2F) while the lowest was 26.0C (78.8F). The average maximum and minimum temperature recorded was 34.8C (94.6F) and 30.2C (86.4F), respectively. The highest humidity was 100.%, while the lowest was 59.5%. The average maximum and minimum humidity level recorded was 87.5% and 72.3%, respectively.

Table 2.4: Temperature and Humidity Data for Logger #4

Logger #4						
Date	**Max Temperature**	**Min Temperature**	**Average Temperature**	**Maximum Humidity**	**Minimum Humidity**	**Average Humidity**
6/13/18	34.5C at 2:15pm	25.5C at 6:19pm	29.9C	76.0% at 10:00pm	64.0% at 3:18pm	69.5%
6/18/18	32.0C at 12:15pm	27.5C	29.1C	87.0% at 1:30am	76.5% at 9:30am	82.9%
6/19/18	31.0C at 10:06am	28.0C at 8:00pm-11:59pm	29.3C	86.5% at 11:40pm	80.0% at 9:46am	84.1%
6/20/18	34.0C at 1:02pm	29.0C at 8:30pm-11:59pm	31.2C	92.5% at 10:11pm	81.5% at 10:02am	87.9%
6/21/18	31.5C at 9:06am	28.0C at 5:37pm	29.8C	83.5% at 7:02am	70.5% at 3:08pm	77.6%
6/22/18	30.5C at 8:44am	28.0C at 7:30pm-10:00pm	28.9C	88.5% at 11:21pm	82.5% at 2:36pm	85.5%
6/23/18	32.5C at 12:45pm	28.0C at 12:00am-5:52am	29.5C	90.0% at 5:52am	79.5% at 1:51pm	84.6%
6/24/18	31.0C at 11:47am	28.0C at 12:00am-6:35am	29.3C	86.0% at 6:35am	78.5% at 4:42pm	83.0%
6/26/18	32.5C at 11:37am	28.5C at 8:57pm-11:59pm	30.4C	85.0% at 11:24pm	75.0% at 10:04am	80.2%
6/27/18	30.5C at 9:10am, 12:00pm, and 3:22pm	27.5C at 5:51am	29.1C	91.0% at 9:14pm	84.0% at 9:30am	87.2%
6/28/18	34.0C at 4:12pm	28.5C at 10:47pm	31.3C	95.5% at 9:38am	66.5% at 4:08pm	77.7%
6/29/18	34.0C at 4:00pm	28.5C at 10:19pm	31.5C	82.0% at 11:42pm	66.0% at 3:57pm	73.8%
6/30/18	34.5C at 3:53pm	28.0C at 5:34am	30.6C	83.5% at 5:02am	64.0% at 4:03pm	74.8%
7/1/18	34.0C at 3:57pm	27.5C at 4:45am	30.3C	82% at 5:58am	66% at 3:56pm	75.10%

Logger 4 (Table 2.4) was located in the western-most pen within the broiler house. There were eight birds in this section during the entirety of the data collection period. A total of fourteen recordings were taken, with temperature and humidity being the point of focus. The highest temperature was 34.5C (94.1F) while the lowest was 29.0C (84.2F). The average maximum and minimum temperature recorded was 32.6C (90.7F) and 27.9C (82.2F), respectively. The highest humidity was 95.5% while the lowest was 64.0%. The average maximum and minimum humidity level recorded was 86.4% and 73.9%, respectively.

Housing Set-Up and Preparation:

Broilers

Mr. Jones built one large coop that was divided into five pens lined up East to West, with each one (except for the middle) housing a different flock. Each flock was made up of eight birds and consisted of four males and four females. The outermost pens were 31.5 square feet, the pens just deep to the outermost pens were 38.5 square feet, and the middle pen was 24.5 square feet. The outside of the entire structure was made up of wooden posts and chicken wire. Additionally, a thick sheet of tin was utilized for the roof. Each pen was divided by a waist-high layer of chicken wire and each had its own door that lead to the inside. In order to actually reach the individual flocks, one had to go through a “master door” that lead into a walkway in front of all of the pens. The middle pen consistently held the two-week-old birds that would be joined by a new shipment of day-old chicks seven days later, while the four other pens were on a rotation system. Thus, those four pens did not house the same age groups throughout the time of the study. When the oldest flock of birds reached seven-weeks-old, they would be removed for butchering and the two-week birds in the middle would be translocated to the newly opened up pen. Mr. Jones’ rationale behind placing the day-old birds with the week-one birds so that they could be taught the basic tools for survival. To gain a better understanding of the basic layout at one point in time, see Figure 8 for an example.

The floors of the chicken houses were filled with twelve inches of sand, with a two-inch layer of mahogany wood shavings on the top. Before the owner would translocate the two-week old flock to the newly opened up pen, he would add a thin layer of lime on top of the mahogany shavings. The lime was used as a means to soak up the excessive moisture within the shavings, and therefore decrease the prevalence of mold growth. He did not clean out/change the litter because he wanted it to be concentrated before adding it to his compost pile, which was used in place of soil for his vegetable garden. Each pen also contained a Plasson Breeder Drinker that hung from the ceiling, as well as a feeder.

<table>
<tr><td><u>Birds 6-7 Weeks</u>

31.5 Sq. Ft.</td><td><u>Birds 5-6 Weeks</u>

38.5 Sq. Ft.</td><td><u>Birds 0-1 Week</u>
&
<u>Birds 1-2 Weeks</u>

24.5 Sq. Ft.</td><td><u>Birds 3-4 Weeks</u>

38.5 Sq. Ft.</td><td><u>Birds 4-5 Weeks</u>

31.5 Sq. Ft.</td></tr>
<tr><td colspan="5">Common Walkway</td></tr>
</table>

Figure 8- A screenshot of the basic layout of Derek Jones' broiler coop one point in time. Included in this graphic is the layout of the pens and the common walkway, the size of the pens, and the age-groups of the birds.

Layers

Mr. Jones' farm housed three roosters and forty layers for the majority of the time that data was collected. In the last two weeks of the study, three chicks had hatched, but the sex of those birds had never been determined. The layers and roosters were free to roam the entire premises, including the wood-carving workshop, the front yard, and anywhere in the back-yard enclosed with chicken wire. The entire area available to these birds was 4800 square feet. Shade for the birds was provided by three large coconut trees and one large dragon fruit vine that hung across the entirety of the backyard. Pieces of chicken wire, cut-up barrels, and other small metal materials were found all over this space and remained there until three weeks before the conclusion of the study (Figure 9).

Figure 9- A view of the main yard/ space provided for the layers and roosters.

There were four main sources of water, which are discussed in further detail in the section titled "Water Quality". There was one feeder available to the layers and roosters, and this was placed in a central location in the backyard portion of the farm. The layers were provided with two large egg coops, which were completely enclosed and contained dividers between the individual nests. Mr. Jones had also designed a structure out of old tree branches for the birds to roost on throughout the evening.

See Table 1.5 for the responses Mr. Jones gave to a series of survey questions regarding the housing set-up and preparation on his farm.

Table. 1.5 : Survey Questions Regarding Housing Set-Up and Preparation \

Survey: Housing Set-Up and Preparation	
Question	**Response**
Is the temperature regulated and monitored? If so, how?	No, it is not regulated
If any, what is the bedding provided for the chicks?	Twelve inches deep of sand with two inches of mahogany shavings on top
How often is the bedding replaced?	It is replaced once annually
How many chicks are housed together?	Eight chicks are kept in one pen. There are a total of forty-eight birds in the coop at one time.
What is the size of the housing provided for the chicks (in square footage)?	See Figure 1.1
Are water and feed available for the chicks upon arrival? If so, how much?	Water and feed are available. A three-pound scoop is used to put the broiler starter in the feeder.
How often are water and feed levels monitored, if at all?	Every two-three days
Who is responsible for monitoring the chick housing?	Derek Jones
Have you ever noticed any direct correlation between dead birds and quality of chicken housing? If so, describe any clinical symptoms leading up to death and/or post mortem observations	No

Necropsy Observations:
During the two months on Mr. Jones' farm, there were eight necropsies conducted. Six of the birds were broilers, and were chosen to be necropsied because of their inadequate size or possible sign of illness. The other two birds were layers and were chosen due to an accident on the farm that left them incapable of survival among the flock. Using the guide outlined in the literature review, a thorough necropsy was performed on each of these birds and notes were taken on the internal and external structures.

Necropsy on 6/8/18 (1)- This bird was a broiler and was delivered on 05/18/18, and was about three weeks of age. Weight of bird was unknown. The owner noticed and chose this bird to be necropsied because it was fairly smaller than the rest and seemed to not be using its left wing. The owner euthanized the specimen via cervical dislocation.

External Observations:
- **Wings**: No obvious breaks in the wings when they were extended.
- No evidence of northern fowl mites or scaly leg mites or lice
- All nails were present and of normal length
- No evidence of eye notch syndrome and no evidence of brown discharge coming from the nasal cavities or on the shoulders.

Internal Observations

- **Head of femur:** Popped out fully intact when hip joints were dislocated.
- **Legs:** Snapped cleanly and did not bend before they were fully broken.
- **Liver:** Edges of liver were sharp and the liver was a dark brown-reddish color.
- **Heart:** The heart contained a small amount of fat around the top part of it.
- **Air Sacs:** They appeared clear and not congested.
- **Gonadal Structures:** Specimen was a male with two normally-shaped testicles.
- **Proventriculus:** No obvious leakage of green bile when removed from the specimen.
- **Gastrointestinal Tract:** The intestines had no evidence of parasitism.
- **Bursa:** The bursa was an off-white color and appeared to be of normal shape and size.
- **Lungs:** The lungs were an orange-pink color and of normal appearance.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break- the synovial fluid was clear and mildly viscous.
- **Breast Muscle:** The muscle located underneath the breast bone was of normal appearance.
- **Roof of Mouth:** Normal, conical papillae.
- **Glottis and Trachea:** Was of normal appearance.
- **Crop:** The crop was of normal appearance. There was no food inside when it was cut open.
- **Nostrils:** When cut and squeezed, normal levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers.

Necropsy on 6/8/18 (2)- This bird was a broiler and was delivered on 05/23/18, and was about two weeks of age. The owner noticed and chose for this bird to be necropsied because it was fairly smaller than the rest, had incomplete patches of feathers, and was thus dubbed a “throw-away”. The weight of the bird was unknown. The owner euthanized the specimen via cervical dislocation.

External Observations:

- **Wings:** No obvious breaks in the wings when they were extended (Figure 10).
- No evidence of northern fowl mites or scaly leg mites or lice.
- All nails were present and of normal length.
- No evidence of eye notch syndrome and no evidence of brown discharge coming from the nasal cavities or on the shoulders.

Internal Observations

- **Head of femur:** Popped out fully intact when hip joints were dislocated.
- **Legs:** Snapped cleanly and did not bend before they were fully broken.
- **Liver:** Edges of liver were sharp and the liver was a dark brown-reddish color.
- **Heart:** The heart contained a small amount of fat around the top part of it.
- **Air Sacs:** They appeared clear and not congested.

Figure 10- Left Wing from 6/8/18 (1) Necropsy

- **Gonadal Structures:** Specimen was a male with two normally-shaped testicles.
- **Proventriculus:** No obvious leakage of green bile when removed from the specimen.
- **Gastrointestinal Tract:** The intestines had no evidence of parasitism.
- **Bursa:** The bursa was an off-white color and appeared to be of normal shape and size.
- **Lungs:** The lungs were an orange-pink color and of normal appearance.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break- the synovial fluid was clear and mildly viscous.
- **Breast Muscle:** The muscle located underneath the breast bone was of normal appearance.
- **Roof of Mouth:** Normal, conical papillae.
- **Glottis and Trachea:** Was of normal appearance.
- **Crop:** The crop was of normal appearance. It was full of food when cut open.
- **Nostrils:** When cut and squeezed, normal levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers.

Necropsy on 6/12/18- This bird was a broiler and was delivered on 05/23/18, and was about three weeks of age. The owner noticed and chose for this bird to be necropsied because it was fairly smaller than the rest, had incomplete patches of feathers, and was thus dubbed a "throw-away". The weight of the bird was unknown. The owner euthanized the specimen via cervical dislocation.

External Observations:
- **Wings**: No obvious breaks in the wings when they were extended.
- No evidence of northern fowl mites or scaly leg mites or lice.
- All nails were present and of normal length.
- No evidence of eye notch syndrome and no evidence of brown discharge coming from the nasal cavities or on the shoulders.

Internal Observations
- **Head of femur:** Popped out fully intact when hip joints were dislocated.
- **Legs:** Snapped cleanly and did not bend before they were fully broken.
- **Liver:** Edges of liver were sharp and the liver was a dark brown-reddish color
- **Heart:** The heart contained a small amount fat around the top part of it.
- **Air Sacs:** They appeared clear and not congested.
- **Gonadal Structures:** Specimen was a male with two normally-shaped testicles.
- **Proventriculus:** No obvious leakage of green bile when removed from the specimen.
- **Gastrointestinal Tract:** The intestines had no evidence of parasitism.
- **Bursa:** The bursa was an off-white color and appeared to be of normal shape and size.
- **Lungs:** The right lung was an orange-pink color and of normal appearance. The left lung appeared grayer in color and had several black specks throughout its surface.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break- the synovial fluid was clear and mildly viscous.
- **Breast Muscle:** The muscle located underneath the breast bone was of normal appearance.
- **Roof of Mouth:** Normal, conical papillae.
- **Glottis and Trachea:** Was of normal appearance.
- **Crop:** The crop was of normal appearance. It was full of food when cut open.
- **Nostrils:** When cut and squeezed, normal levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers. The outer membranous layer was very difficult to remove and would not come off in one piece.

Necropsy on 6/16/18- This bird was a broiler and was delivered on 06/13/18, and was three days old. The owner chose this bird to be necropsied because it died between 5:00pm on 6/15/18 and 9:00am 6/16/18. The weight of the bird was unknown. The owner euthanized the specimen via cervical dislocation.

Figure 11- Bare ventral body and thin legs from 6/16/18 necropsy

External Observations:

- **Wings**: No obvious breaks in the wings when they were extended.
- The skin around the legs was thin, tough, and appeared very dry (Figure 11).
- The ventral aspect of the body was lacking down. The parts of the body that were covered with down were wet and matted (Figure 11)
- No evidence of northern fowl mites or scaly leg mites or lice.
- All nails were present and of normal length.
- No evidence of eye notch syndrome and no evidence of brown discharge coming from nasal cavities or on the shoulders.
- The navel appeared to be infected (Figure 12).

Figure 12- Infected navel from 6/16/18 necropsy

Internal Observations

- **Head of femur:** Popped out fully intact when hip joints were dislocated.
- **Legs:** Snapped cleanly and did not bend before they were fully broken.
- **Liver:** Edges of liver were sharp and the liver
- was a dark brown-reddish color
- **Heart:** The heart contained a small amount fat around the top part of it.
- **Air Sacs:** They appeared clear and not congested.
- **Gonadal Structures:** Specimen was a male with two normally-shaped testicles.
- **Proventriculus:** No obvious leakage of green bile when removed from the specimen.
- **Gall Bladder-** Partially transparent with an orange tint (Figure 13).
- **Gastrointestinal Tract:** The intestines had no evidence of parasitism.
- **Bursa:** The bursa was an off-white color and appeared to be of normal shape and size.

Figure 13-Gallbladder from 6/16/18 necropsy

- **Lungs:** The right lung was an orange-pink color and of normal appearance. The left lung appeared grayer in color and had several black specks throughout its surface.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break- the synovial fluid was clear and mildly viscous.
- **Breast Muscle:** The muscle located underneath the breast bone was of normal appearance.
- **Roof of Mouth:** Normal, conical papillae.
- **Glottis and Trachea:** Was of normal appearance.
- **Crop:** The crop was of normal appearance. It was partially filled when opened.
- **Nostrils:** When cut and squeezed, normal levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers.
- Koilin also pulled away in one piece and rather easily.
- **Urinary Tract:** Both ureters were filled with a thick, white substance (Figure 14).

Figure 14- Ureters from 6/16/18 necropsy

Necropsy on 6/20/18- This bird was a broiler and was delivered on 05/02/18, and was exactly seven weeks of age. The owner noticed and chose this bird to be necropsied, because it was much smaller than the other seven in its flock when they were ready to be butchered. The live weight of the specimen was 3.5 lbs. before it was euthanized. The owner euthanized the specimen via decapitation.

External Observations:

- **Wings:** No obvious breaks in the wings when they were extended.
- No evidence of northern fowl mites or scaly leg mites or lice.
- The majority of the feathers were missing on the ventral aspect of the body.
- All nails were present and of normal length.
- No evidence of eye notch syndrome and no evidence of brown discharge coming from the nasal cavities or on the shoulders.

Internal Observations

- **Head of femur:** Popped out fully intact when hip joints were dislocated.
- **Legs:** The leg bones were difficult to snap and were slightly bendable.
- **Liver:** The liver was light brown and had an irregular shape to it. It was globular in appearance and there were no sharp edges (Figure 15).
- **Heart:** The heart contained a cloudy film around it that was not observed in any of the other birds. It also had a heavy layer of fat around the dorsal aspect.
- **Air Sacs:** Air sacs were slightly cloudy.
- **Gonadal Structures:** Specimen was a male with two normally-shaped testicles.

Figure 15- Liver from 6/20/18 Necropsy

- **Proventriculus:** A small amount of green bile was scattered throughout the abdominal cavity.
- **Gastrointestinal Tract:** The intestines had no
- evidence of parasitism.
- **Bursa:** The bursa was an off-white color and appeared to be of normal shape and size.
- **Lungs:** The lungs were an orange-pink color and of normal appearance.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break- the synovial fluid was mostly clear and contained a small amount of blood. It was not determined if this blood came from the joint or if it came from an unclean break during the necropsy.
- **Breast Muscle:** The muscle located underneath the breast bone was of normal appearance.
- **Roof of Mouth:** Normal, conical papillae.
- **Glottis and Trachea:** Was of normal appearance.
- **Crop:** The crop was of normal appearance. It was full of food when cut open.
- **Nostrils:** When cut and squeezed, relatively low levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers. Koilin also pulled away in one piece and rather easily.

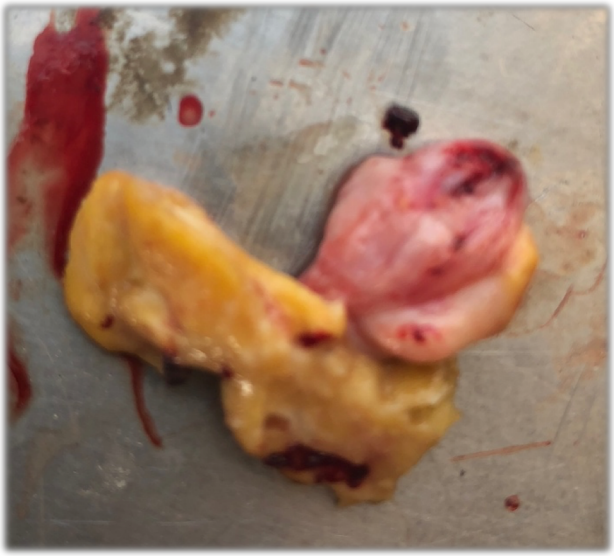

Figure 16- Caseous Exudate from 6/20/18 Necropsy

Additional Notes

- The organs were much harder to remove from the bird during the necropsy.
- Mr. Jones had emailed me about a yellow-white substance he had found in a few of his broilers before the study began. Two small samples (Figure 16) were found in the abdominal cavity of the specimen being necropsied. The texture of the substance felt similar to that of a packing peanut.

Necropsy on 6/27/18 (1)- This bird was a layer and was about two years old. The owner noticed and chose this bird to be necropsied, because it was being pecked at and attacked by the other layers in the flock. It was found hiding under chicken wire and walking with a limp on its right leg. The weight of the bird was unknown. The owner euthanized the specimen via cervical dislocation.

External Observations:

- Because the owner put the bird in hot water and removed its feathers before the necropsy, effective analysis of the external appearance of the bird could not be conducted. Additionally, the medial aspect of the left thigh was torn apart.

Internal Observations

- **Head of femur:** Popped out fully intact when hip joints were dislocated.
- **Legs:** Very strong and snapped cleanly when broken.
- **Liver:** The liver was a light brown color, but had fairly sharp edges. There were a few dark spots on the superficial aspect.
- **Heart:** The heart contained a thick yellow band of fat around the dorsal aspect.

Figure 17- Tapeworm from 6/27/18(1) Necropsy

- **Air Sacs:** Air sacs could not be observed.
- **Gonadal Structures:** Specimen was female with several small follicles.
- **Proventriculus**: A small amount of green bile was scattered throughout the abdominal cavity.
- **Gastrointestinal Tract:** The intestines had several tapeworms (Figure 17) and were present everywhere except the cecum.
- **Bursa:** There was no bursa.
- **Lungs:** The lungs were an orange-pink color with a thick, dark blood clot surround them.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.

Figure 18- Leg Joint from 6/27/18 (1) Necropsy

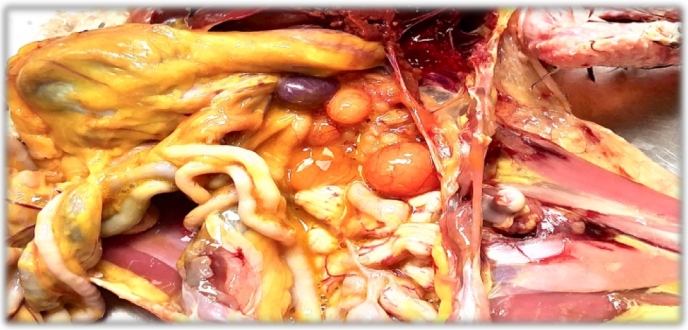

Figure 19- Broken Yolk Sacs from 6/27/18(1) Necropsy

- **Leg Joint:** Cutting through the joint in the leg produced a clean break; the joints were fairly dry and there was little to none synovial fluid within (Figure 18).
- **Breast Muscle:** The muscle located underneath the breast bone was slightly green in color.
- **Roof of Mouth:** Had conical papillae that were smooth to the touch.
- **Glottis and Trachea:** Was of normal appearance.
- **Crop:** The crop was of normal appearance. It was completely empty when cut open.
- **Nostrils:** When cut and squeezed, relatively low levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers. Koilin also pulled away in one piece rather easily.

Additional Notes

- The fat deposits were a golden yellow color and much thicker than in the broilers.
- There were several broken yolk sacs within the body cavity (Figure 19).
- There were several blood clots (Figure 20) found throughout the abdominal cavity of the bird.

Figure 20- Blood clots from 6/27/18 (1) necropsy

Necropsy on 6/27/18 (2)- This bird was a layer and was about two years old. The owner noticed and chose this bird to be necropsied, because it was killed by his dog earlier that morning. The weight of the bird was unknown.

External Observations:

- Because the owner put the bird in hot water and removed its feathers before the necropsy, effective analysis of the external appearance of the bird could not be conducted.

Internal Observations

- **Head of femur:** Popped out fully intact when hip joints were dislocated.
- **Legs:** Snapped cleanly when broken.
- **Liver:** The liver was a light brown color, and was very globular in appearance. There was no uniform structural appearance.
- **Heart:** The heart contained a thick yellow band of fat around the dorsal aspect.
- **Air Sacs:** Air sacs could not be observed.
- **Gonadal Structures:** Specimen was female with several small follicles and one fully developed egg (including the shell).
- **Proventriculus:** No obvious leakage of green bile when removed from the specimen.
- **Gastrointestinal Tract:** The intestines had several tapeworms and roundworms (Figures 21, 22) throughout the lumen. They were present everywhere except the cecae.
- **Bursa:** There was no bursa.
- **Lungs:** The lungs were a dark red color and were slightly torn apart.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break; the joints were fairly dry and there was little to none synovial fluid within.
- **Breast Muscle:** The muscle located underneath the breast bone was slightly green in color (Figure 23).
- **Roof of Mouth:** Normal, conical papillae.
- **Glottis and Trachea:** Was of normal appearance.
- **Crop:** The crop was of normal appearance. It was completely full of food, which was mostly grass.
- **Nostrils:** When cut and squeezed, relatively low levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers. Koilin also pulled away in one piece and rather easily.

Figure 21- Roundworm from 6/27/18 (2) Necropsy

Figure 22- Roundworms (red) and Tapeworms(blue) from 6/27/18 (2) necropsy

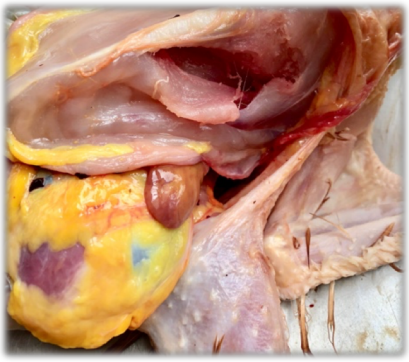

Figure 23- Torn breast muscle and yellow fat deposits from 6/27/18 (2) necropsy

Additional Notes

- The fat deposits were a golden yellow color and much thicker than in the broilers (Figure 23).

Necropsy on 7/19/18 (1)- This bird was a broiler and was delivered on 05/23/18, and was about eight weeks of age. The owner noticed and chose for this bird to be necropsied because it was fairly smaller than the rest, had incomplete patches of feathers, and was thus dubbed a "throw-away". The live weight of the specimen was 2 lbs., 3oz before it was euthanized. Mr. Jones placed these broilers in the same pen as the layers two days before the necropsy was performed. The specimen was euthanized via cervical dislocation.

External Observations:

- **Wings**: No obvious breaks in the wings when they were extended.
- No evidence of northern fowl mites or scaly leg mites or lice.
- All nails were present and of normal length.
- No evidence of eye notch syndrome and no evidence of brown discharge coming from the nasal cavities or on the shoulders.

Internal Observations:

- **Head of femur**: Popped out fully intact when hip joints were dislocated.
- **Legs:** Both legs appeared strong. Though they did not bend, they did not produce a clean snapping sound when attempted to be broken.
- **Liver:** Edges of liver were sharp and the liver was a dark brown-reddish color
- **Heart:** The heart contained a small amount of fat around the top part of it.
- **Air Sacs:** They appeared clear and not congested.
- **Gonadal Structures:** Specimen was a male with two normally-shaped testicles.
- **Proventriculus:** no obvious leakage of green bile when removed from the specimen. The proventriculus was full of food.
- **Gastrointestinal Tract:** The intestines had no evidence of parasitism.
- **Bursa:** There was no bursa present.
- **Lungs:** The lungs were an orange-pink color and of normal appearance.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break- the synovial fluid was clear and mildly viscous.
- **Breast Muscle:** The muscle located underneath the breast bone was of normal appearance.
- **Roof of Mouth:** Normal, conical papillae. There was a thick layer of saliva in the mouth.
- **Glottis and Trachea:** Was of normal appearance. There was a thick layer of saliva in the glottis and trachea.
- **Crop:** The crop was of normal appearance. It was full of food when cut open.
- **Nostrils:** When cut and squeezed, normal levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers. Koilin also pulled away in one piece and rather easily.

Necropsy on 7/19/18 (2)- This bird was a broiler and was delivered on 05/23/18, and was about eight weeks of age. The owner noticed and chose for this bird to be necropsied because it was fairly smaller than the rest, had incomplete patches of feathers, and was thus dubbed a "throw-away". The live weight of the specimen was 1 lb., 13oz before it was euthanized. Mr. Jones placed these broilers in the same pen as the layers two days before the necropsy was performed. The specimen was euthanized via cervical dislocation.

External Observations:

- **Wings:** No obvious breaks in the wings when they were extended.
- No evidence of northern fowl mites or scaly leg mites.
- All nails were present and of normal length.
- No evidence of eye notch syndrome and no evidence of brown discharge coming from the nasal cavities or on the shoulders.

Internal Observations:

- **Head of femur:** Popped out fully in-tact when hips were broken outward
- **Legs:** Both legs appeared strong. Though they did not bend, they did not produce a clean snapping sound when attempted to be broken.
- **Liver:** Edges of liver were sharp and the liver was a dark brown-reddish color
- **Heart:** The heart contained a small amount of fat around the top part of it.
- **Air Sacs:** They appeared clear and not congested.
- **Gonadal Structures:** Specimen was a male with two normally-shaped testicles.
- **Proventriculus:** no obvious leakage of green bile when removed from the specimen. The proventriculus was full of food.
- **Gastrointestinal Tract:** The intestines contained a small number of roundworms.
- **Bursa:** There was no bursa present.
- **Lungs:** The lungs were an orange-pink color and of normal appearance.
- **Ischiatic Nerve:** Both appeared smooth and of normal appearance.
- **Leg Joint:** Cutting through the joint in the leg produced a clean break- the synovial fluid was clear and mildly viscous.
- **Breast Muscle:** The muscle located underneath the breast bone was of normal appearance.
- **Roof of Mouth:** Normal, conical papillae. There was a thick layer of saliva in the mouth.
- **Glottis and Trachea:** Was of normal appearance. There was a thick layer of saliva in the glottis and trachea.
- **Crop:** The crop was of normal appearance. It was about halfway filled with food, but also appeared gaseous.
- **Nostrils:** When cut and squeezed, normal levels of clear mucus came out.
- **Gizzard:** Koilin was of normal appearance, and contained no erosions, no discoloration, and no ulcers. Koilin also pulled away in one piece and rather easily.

Behavioral Observations

There were five times throughout the study in which observations of layer and broiler behaviors were made. The layers and roosters were always observed before the broilers, and there was often less information to report. The nursery birds (flocks between 0-1week and between 1-2 weeks- of age) were in the middle pen, the three-week-olds (between 3-4 weeks) were in the eastern-most pen, the four-week-olds (between 4-5weeks) were in the western-most pen, the five-week-olds (between 5-6 weeks) were between the middle and western-most pen, and the six-week-olds (between 6-7 weeks) were between the middle and eastern-most pen.

Morning of 06/18/18- Observations of the birds began at 9:30am. The layers and roosters had followed me closely all morning as I walked around taking notes and collecting the temperature loggers. There was no sign of feed in the feeder and there were no layers pecking at the ground around it (like there usually are). The nursery broilers were eating from the feeder, but they were also pecking at the wood that made up the structure of the coop. One bird was sitting on the ground breathing heavily with mouth open. The three-week-old birds were mostly standing and eating from

the feeder. All birds were breathing normally. Seven of the four-week old birds were standing, while one bird was sitting and breathing through its mouth. The water from this pen was moderately full, but was still murky in appearance. There were four birds from the five-week-old flock that were sitting, and four that were standing and eating from the feeder. Two of the four birds that were sitting were breathing through their open mouths. This pen had the least amount of water, as the waterer was almost completely filled with wood shavings. The six-week-old broilers were all sitting in the dirt and were more vocal than any of the other flocks. Two were breathing through their open mouths. The waterer in this pen was very low and filled with mahogany shavings.

Evening of 6/18/18- Observations of the birds began at 4:30pm. When I had arrived, all of the layers and roosters were crowded by the gate and had followed me around when I entered the pen. There were also seven birds digging holes in the ground and laying in them. None of the eggs from the layers had yet been collected. There were five of the nursery broilers that were breathing through their mouths and sitting. Two of the three-week-old birds were eating, while two of them were breathing through their mouths and sitting on the ground. The four-week-old birds were all breathing through their mouths as well and were also fairly vocal. None of these birds were eating from their feeder either. All of the birds from the five-week-old flock were breathing through their mouths and were fairly vocal. None of these birds were eating from their feeder. All of the birds from the six-week-flock were breathing through their mouths and sitting. The rest of birds in this flock were standing and wondering around.

Morning of 6/19/18- Observations of the birds began at 9:30am. The layers and roosters did not follow me around like they had on the morning of 6/18/18. Some birds were in the compost pile digging in it and pecking at the surface (Figure 24). One of the recently hatched layer chicks had died between the hours of 5:00pm the day before and 9:00am on this day. The chick had been eaten by the other birds of the flock, so cause of death was not determined. The nursery broilers had an empty feeder and all them were crowded towards the entrance of the pen. The feed was checked again at 12pm and it was still empty. Four of the birds from the three-week-old pen were standing and wandering around, two were eating, and two were sitting on the ground breathing through their mouths. None of the birds from the four-week old flock were eating, but all were crowded around the waterer near the entrance of the pen. Only one bird was actually observed consuming water. All birds from the five-week-old flock were breathing heavily through their mouths and crowded towards the entrance of the pen. Two of the birds were also eating in between their open mouth breathing. Two of the birds from the six-week-old pen were eating, while the other five were crowded towards the entrance and breathing through their mouths.

Figure 24- Birds digging and pecking in the compost pile, which contains old food scraps, offal, and used litter from the broiler pen.

Evening of 6/19/18- Observations of the birds began at 5:00pm. Most of the layers and roosters were being considerably aggressive towards each other and were following me around when I started my observations. At some point between the hours of 2:00pm and 5:00pm, plastic bags had been thrown in the compost pile. The eggs had been collected by Mr. Jones at 4:30pm. The nursery broilers had no feed in their feeder. When I entered the pen, they had followed me around while I took notes. The three-week-old birds were all standing and being fairly vocal. Two of these birds were breathing through their mouths and one bird was eating. Again, the four-week old birds were crowded by the waterer, sitting on the ground, and breathing through their open mouths. The five-week-old birds were all sitting and breathing with their mouths open. The six-week-old birds were all sitting and breathing with their mouths open.

Morning of 6/27/18: Observations of the birds began at 8:45am. According to Mr. Jones, the layers had been fed around 8:00am. A mother hen with her two chicks was trying to eat scraps from the feeders, but one of the roosters would chase her off if she got too close to the main food source. One rooster and layer were also observed breeding at this time. One hen had been killed by the owner's dog that morning, while another hen was being pecked at by the other birds in the flock. This layer was injured on the inside of its right leg, and when picked up it did not try to escape like most birds usually do. This bird was later euthanized for necropsy. Every flock in the broiler pen was crowded towards the southeast corner of their pen (towards the entrance). The flocks between the ages of five and seven weeks were all breathing through their mouths. Every flock had a full feeder. It was also noted that one chick in the nursery was standing in the waterer.

Discussion

Biosecurity:

Broilers

As mentioned previously, the flocks within the coop should be *completely* separated by the chicken wire from the ceiling to floor. This will prevent the possibility of the larger birds from jumping over and into a separate flock's pens. Additionally, because Mr. Jones has multiple flocks at one time, preventative biosecurity methods should be incorporated between the exposure to each one. When entering the premises, Mr. Jones should be wearing a different set of clothes and shoes that are only used for broiler operations. If available, disposable shoes or shoe coverings should be switched out each time a different flock is handled. At the very least, he and anyone else with multiple-flock-operations, should also wash their hands before moving on to a different flock of birds. This will avoid the mechanical transmission of diseases, should the birds develop any.

Layers

When Mr. Jones would harvest the broilers, he would dispose of some of the offal in the compost pile, which was accessible to the layers. This included the intestines, gall bladder, and trachea and therefore served as another source for disease transmission on the farm. Because parasites such as roundworms, cecal worms, and tapeworms reside in the intestines, the intestines should not be thrown in a space where other birds can reach them. Consumption of the intestines, and thus the parasite eggs, could result in transmission of the parasites into a new host, and therefore cause a decrease in egg production.

Broilers and Layers
When managing birds that start to show some of the symptoms related to the diseases in Appendix I, the operator should immediately separate them from the rest of the flock for treatment or culling. By keeping a close observation on one's birds and by being able to recognize the signs of disease quickly, the transmission of disease from one bird to another, or one flock to another, can be reduced. Thus, if one bird contracts an illness, it may not result in the entire flock contracting that same illness, which would ultimately cause a decrease in overall production.

Those living on separate properties and maintaining their own flocks of birds should not be allowed on one's premises. As mentioned above, each flock harbors its own flora, and could therefore disrupt the immune system of another flock should those flora come in contact with one-another. If another person growing their own flock *must* enter the area, they should shower thoroughly and change into the clothes and shoes provided by the owner of the property. Additionally, they should never come in direct contact with the layers or broilers on the farm.

As mentioned before, vectors are species that are capable of transmitting disease. The consistent vectors invading Mr. Jones' farm can be controlled through the use of rodenticides, chicken wire, and proper feed storage. However, should an individual choose to use rodenticides for control, it should be placed in an area inaccessible to the chickens to prevent them from consuming it. To assist in control of iguanas and opossums and other vermin on the farm, the chicken wire around the farm should be well kept. Storing the feed in thick, plastic/steel bins that can be securely closed will also help in preventing vermin contamination.

Vaccination Protocol

Broilers
The injection marks found on the necks of the birds are thought to be indicative of vaccination from Spanish Lookout's Hatchery. It is believed those that did not show any injection sites on the neck were not being vaccinated. Dr. F.D. Clark, poultry veterinarian and professor at the University of Arkansas, believes those birds being vaccinated were likely being protected against Marek's Disease. Furthermore, it is believed that the birds showing no signs of vaccination were consistently larger, because they were being shipped out on day-of-hatch and were reaching farms immediately, allowing them to consume food and water. Alternatively, the birds being vaccinated were kept at the hatchery for a couple of days without adequate levels of food and water, thus decreasing their growth rate in the first couple of days and for the rest of their production period. Therefore, it is extremely important that all birds have feed and water available when placed in the production facility.

In order to determine which vaccines need to be administered, and which ones are currently used, the vaccination protocol from Spanish Lookout needs to be investigated. Effective vaccination of the birds before they are shipped to the farmers could further improve levels of biosecurity, and therefore increase the overall productivity experienced by the flock(s). Preventative measures such as vaccinations can also decrease the economic and physiological loss incurred by the birds, and therefore make poultry production much more beneficial in the long-run (Moyle et. al, 2007).

Water Quality:

Broilers

Given the resources available in Belize, the Plasson Breeding Drinker is the best option available as a source of water in the broiler pens. The two most important principles to keep in mind with water are availability and cleanliness. Water should *always* be available to the birds, as it encourages efficient metabolism and therefore optimal production (Bell, 2002). Because Belize has such a hot and humid climate, the birds are likely to consume more water than they would in a cooler climate. To ensure enough is available, one water waterer should be provided for every ten birds, and should be sourced by a larger tank of water that is clean and secure from the rest of the environment. If rainwater is used, it should be filtered and disinfected before the birds can access it. In addition to maintaining a constant supply of water to the birds, it is also important to make sure that water is always clean. Keeping the water clean will prevent the development and transmission of bacterial agents, which could subsequently lead to disease (Bell, 2002).

A relevant factor in the cleanliness of water is the height of the waterers are from the ground. Raising the waterers to a specific level (based on the flock's overall age) prevents the birds from kicking chicken litter into them. Chicken litter/feces can be covered in infectious pathogens and/or parasites, and would therefore act as a very effective source for disease transmission. Refer to Appendix I for those disease capable of being transmitted through water sources. In addition to causing disease transmission, the chicken litter can also fill the waterers so much that there would not actually be any water in them. Thus, this leaves the birds unable to consume an adequate amount of water, and possibly lead to dehydration. If an individual has no way of measuring the actual height the waterers should be, they should do it based on how the birds orient themselves when they drink the water. If the birds are bending down to drink it is low enough for them to kick chicken litter into it. Instead, the waterer should be level with the line of their backs, causing them to reach up for a drink when they want it. Another way to insure high levels of feces are not filling the waterers is by changing it out twice a day. This can be accomplished by simply tipping them over to dump the older water out and letting it fill back up with new, clean water.

The waterers should also be cleaned once a week and between flocks of birds. This can be done by scrubbing them with soap/bleach and water, and by leaving them out to dry in the sunlight. The sunlight is a great and natural way to disinfect fomites, so this methodology could be translated to all cleaning processes involved in one's production practices (North, 1990).

The OTC Plus Mr. Jones uses is a great source of vitamins and antibiotics, however it is being administered at a diluted level and will not have a beneficial impact on his flocks. The purpose of OTC Plus is to treat and control a wide range of bacterial infections, including the treatment of Coliform Septicemia, Fowl Cholera, Fowl Typhoid, and control of secondary infections associated with chronic respiratory disease. The addition of these vitamins and antibiotics to the water system can decrease bacterial levels and assist in overall health. They would also assist in metabolism, which would make production much more efficient and maximize growth rates (Kraemer, 2012). To learn more about the individual vitamins and antibiotics added to OTC Plus, as well as the recommended solution levels, refer to Table 6.3 in Appendix IV. Furthermore, if an individual is planning to use a primary source for the waterers, a metal storage barrel would be preferred to prevent the development of bacterial slime layers. Bacterial slime layers can consume the vitamins in the water, thus decreasing availability to the chicks.

The constant maintenance and up-keep of water is crucial to the survival and successful production of broilers. Because Belize has such a hot and humid climate, dehydration is likely to be one of the most prominent causes, or contributing factor, of death. Thus, the individual operating the production should pay close attention to how much water is available to their birds at all times, as well as the relative level of cleanliness it possesses.

Layers
The same principles regarding water and relative production that were outlined for the broilers are just as important for the layers and roosters. Based on the observations made and the survey questions asked, there were no consistent sources of water provided for the layers on Mr. Jones' farm. Just like the broilers, there should be one hanging waterers for every ten birds, as well as a clean storage source in order for maximum production to take place. If the eggs are being used for hatching and thus flock replacement, some of the waterers need to be available for the younger chicks. This would prevent the problem of dehydration and subsequent mortality. Availability and cleanliness of waterers can contribute to better reproduction practices (Clark, 2018).

Feed Quality:

Broilers
Just like water, feed should *always* be available to birds from the day they hatch, to the end of the grow-out cycle. Feed is removed 12-18 hours prior to harvest, so there is a reduction in contamination of the carcass from intestinal contents (Clark, 2018). When the birds are constantly eating, they are also constantly growing. Thus, when Mr. Jones would leave some of his flocks without food (especially the chicks) for even a couple of hours, they were not growing in that time span. Overall, this lowered the rate at which his birds were growing and the final weight they would reach before harvesting. To insure the birds always have feed available to them, the feeders should be checked, every morning and every evening. If the feeder appears that it is about to run out of feed, the operator should fill it a little at a time. Because food should not be recycled/transferred to the next flock- this would be a breech in biosecurity- the operator should check the feeders more often and fill them in smaller amounts so that minimal feed is wasted. As per the labels for birds being grown to seven-weeks of age, birds between 0-2 weeks of age should be fed with Broiler Starter, birds between 3-5 weeks of age should be fed with Broiler Grower, and birds between 6-7 weeks of age should be fed with Broiler Finisher. This specific feed with these regimens can be bought at Reimer's Feed Store in Dangriga, Belize.

The feed should also be stored properly to prevent moisture build-up (which could result in mold formation) and rodent infestation. Stainless steel or thick plastic containers are typically rodent/wild-animal proof. This is not only important because vermin will consume the feed, but it is also important because they have the potential of transmitting disease-causing pathogens onto the farm. Which, as previously mentioned, can result in the death of one's birds if that agent causes severe enough symptoms.

Layers
Unlike the broilers, layers do not necessarily need to be fed *ad libitum*. Instead, they should be fed once in the morning and once in the evening, with one feeder available to every twenty birds. A three-pound scoop of Laying Mash should be used to fill each feeder in the pen, and if there are multiple feeders they should be spread out across the pen. This will increase the likelihood that the feed is distributed among the majority of the birds, rather than allowing a small portion of the flock to consume all of it. This constant and secure level of feed will improve the production of the layers, as well as the reproductive capacities of the roosters (source).

Additionally, layers/roosters should not be allowed to consume foreign objects or contents from the compost pile since dead birds can be sources of infectious pathogens. (Swayne, 2019). Thus, if one has a compost pile in their backyard, it should be sectioned off and protected from access by the birds.

Temperature and Relative Humidity:

Depending on the age of bird, type of production, and stage of production, the optimal temperature range for poultry production is between 20.0C (68.0F) and 24C (75.2F) (Hulzebosch, 2005). Based on this, the temperatures on Mr. Jones' farm are too high for his birds to grow efficiently. The lowest average minimum temperature record by the logger was 27.9C (82.2F), which was located in the western-most broiler pen. Thus, on average, the birds were experiencing a climate at least 8.0C (14.0F) higher than recommended. As a consequence, when temperature rises above a bird's comfort level, they are no longer able to dissipate heat. Because of this, they will start to consume less feed, causing production to decrease as well (Bell, 2002). Additionally, it is possible that the weight of the eggs and the shell quality will be reduced, making it difficult for Mr. Jones to repopulate his layer flock. These losses in productivity are ultimately due to one major factor: stress. Heat stress in the birds should be accommodated by providing ventilation and ensuring cold water is *always* provided (Bell, 2002). Research shows that birds "will drink about twice as much water per day at 37.4C (100F) as they do at 21C (70F) (Bell, 2002). Thus, cool water will increase feed consumption, which can help to maintain normal production levels.

Humidity can also play a role in chicken productivity. Ideally, poultry should be raised in a climate with a relative humidity between 60% and 80% (Hulzebosch, 2005). Though there were several recorded instances of the humidity on Mr. Jones' farm falling within this range, the average maximum humidity either surpassed it or came close to doing so. Thus, it is important that Mr. Jones finds solutions to reducing the overall humidity on his farm, because it can result in water loss by the birds. This can subsequently result in an increase in heat stress, which will cause a decrease in feed consumption and therefore growth (Bell, 2002). High humidity levels can also affect the birds' environment by causing their litter to be too wet, which can result in an increase and ammonia levels, parasitic breeding, and coccidiosis. Therefore, if humidity is too high, the producer should provide ventilation (via fans or utilizing natural airflow) to decrease the negative effects that high humidity levels can have on poultry production. Additionally, cold water should always be provided to account for the birds' water loss that can take place in an environment with high humidity.

Housing Set-Up and Preparation:

Broilers

The broiler pens that Mr. Jones has built provide more than enough space for a flock of eight birds. Because each bird requires 1.5 square feet of space for an optimal production environment (Clark, 2018), a pen of eight birds should be no smaller than 12 square feet. Thus, these guidelines are adequately met on his farm. In regards to the location of the pens, which are arranged side-by-side from East to West, ventilation could be greatly increased by lining them up North to South. The wind predominantly comes from the east, especially as one moves closer towards the shore of the Caribbean Sea, resulting in a natural source of ventilation. Stress is from heat and lack of air-flow can result in decreased production capabilities (Bell, 2002). If an individual is not sure that their birds are overheating, they should observe them during the hottest part of the day, which is usually between 12:00-3:00pm. The birds will typically breathe through their mouths and pant excessively, and will likely be very vocal (Clark, 2018). If there is too much ventilation and the birds are actually cold, they will huddle together in a corner of the pen. Thus, the owner needs to decrease excessive air-flow by covering the front of the coop with some kind of tarp or wind-breaking material. If wind is not the issue, heat lamps may need to be added in the pens to keep the chicks warm.

The rotation system Mr. Jones had set up for his coop did not follow accepted biosecurity protocols. When dealing with multiple flocks, they should be completely separated, from ceiling to floor, by the chicken wire, and should never share the same pen. Because each flock carries their own set of flora and potential-disease-causing pathogens, it is very important that they do not interact with other groups of birds (Swayne, 2019). Additionally, each flock should remain in one pen during the entirety of their production. Translocating one flock of birds to another pen within the coop could result in the mechanical transmission of pathogens, which is the transfer of pathogens from an infected host to a susceptible host, where a biological association between the pathogen and vector is not necessary. This means that transmission of a pathogen took place when it would not have otherwise occurred, because there was some interference that initiated it. Therefore, when one flock of birds is moved across the coop, it could result in potentially destructive flora or pathogens reaching a new flock. Common diseases of poultry to look for are outlined in Appendix I, which lists the responsible pathogen(s), form of transmission, route of infection, signs and symptoms, post-mortem lesions, treatment regimen, control regimen, and prevention protocol. The better method of placing new birds is to wait until the oldest birds have been processed.

Before the new chicks arrive on the farm, a bit of preparation needs to take place for production to be as efficient as possible. First and foremost, there should be adequate food and water in the pen. The first three days of a chick's life are the most important and keeping these resources available at all times will result in healthy birds. In most cases, healthier birds are paralleled to bigger birds, making it crucial to maintain this kind of environment. To tell if the birds are eating, feel for the crop (the organ responsible for food storage) by placing a hand in the middle of the breast. A hard, sac-like structure should be easy to locate and palpate if it is full of food. If it is difficult to palpate, it may be indicative that the birds are not eating. Additionally, there should be about two inches of wood shavings on the ground. When a new flock is placed, a thin layer of lime should be sprinkled to soak up any moisture, and an additional two-inch layer of shavings should be added. Wood shavings are a great material to use for bedding because they absorb moisture, which reduces ammonia levels (Clark, 2018). Because too much ammonia can result in respiratory diseases, and in more severe cases result in mortality, it is important to find ways to keep these levels low. Hardwood shavings should be avoided, as they often cause problems in the birds due to contamination from the fungus Aspergillus (Swayne, 2019). Cedar wood shavings should also be avoided because they are known to cause dermatitis and respiratory problems in the birds (Swayne, 2019). Thus, the mahogany shavings Mr. Jones used were a good choice for poultry production.

Layers

The maximum ratio of layers to roosters on any farm should be about 10:1, to insure the rooster is not being overused or stimulated. Thus, based on the amount of birds Mr. Jones has, he should include one more rooster to insure optimal reproduction and egg production on his farm. Because the layers and roosters are free-ranged, the average sized yard in Belize should be sufficient for layer production (as long as the birds are not crowded). The yard should be fenced in with chicken wire to prevent other animals from killing/injuring them and to prevent the birds from escaping. The space should also be free of sharp, foreign objects, as the layers could have the potential for injury. Because poultry are conformist in nature, injured birds are more likely to be singled out and mauled by the rest of the flock, resulting in severe damage or even mortality (Clark, 2018). Adequate shade should also be provided for the birds, which can be done through the utilization of trees or man-made structures. Because Dangriga maintains a constantly hot and humid climate, it is very important these birds are able to cool down during the day, because it will ultimately keep stress levels low and egg production optimal (Bell, 2002). The shade can also be utilized by placing water sources under it, thus preventing the water from evaporating too quickly.

Next boxes should also be provided for the layers as a means of protection, temperature control, and comfort for the layers and their eggs. There should be enough space to lay eggs for all of the actively laying hens to reside there at one time. Additionally, if it is available, artificial lighting should be added to these nest boxes,

because it will keep the eggs warm and development consistent if the mother hen moves off of them. Hens will sometimes abandon their eggs, due to disturbances.

Roosting structures should also be added to the space in which the layers/roosters reside. A roost is a perch upon which birds will rest at night when they sleep, and avoid predators. Thus, enough space for roosting should be provided for all of the layers/roosters, should they desire to perch at night. Perches can be man-made and/or can be created through the use of tree-branches, such like the ones on Mr. Jones' farm.

Necropsy Evaluations[4]:

Necropsy on 6/8/18 (1)

- **Left Wing:** Dr. F.D. Clark speculates the bird suffered from a slipped tendon in the wing, which is commonly referred to as "helicopter syndrome". This was probably caused by trauma.
- **Crop:** Though the crop's overall appearance was normal, it was not full of food. This was probably because the bird was not getting up to eat due to its injured wing.

Necropsy on 6/12/18

- **Lungs:** The grey coloring and presence of black specks across the surface of the left lung are possibly due to small hemorrhages or clots.
- **Gizzard**: The difficulty of attempting to remove the koilin from the gizzard could be due to Koilin Dysgenesis. This is a malformation with formation of the koilin, which ultimately affects the chemical structure and therefore results in it being "flakey" or discontinuous.

Necropsy on 6/16/18

- **Ventral Body:** The lack of fur on the ventral aspect of the bird was probably due to the infection and inflammation caused by the open navel.
- **Infected Navel:** An infected navel can be a result of Omphalitis, which is a commonly referred to as "Mushy Chick Disease". It is a bacterial infection in which various bacteria may be involved, and it causes the yolk sac of the chick to become infected. Chicks with omphalitis typically die within the first week of life.
- **Thin, dry skin:** This is an indication that the bird was probably dehydrated and did not have the ability to reach the water source.
- **Gall Bladder:** The clear gall bladder is an indication that the bird never produced any bile, which is an indication that it did not eat or was not digesting food properly.
- **Urinary Tract:** When the ureters contain a thick, white substance, this is evidence of uric acid build-up and dehydration.

Necropsy on 6/20/18

- **Missing Feathers:** The feathers that were missing on the ventral aspect of the body could be due to heat stress and constantly laying in the dirt.
- **Legs:** Rubbery leg bones could be a result of an imbalance between calcium and phosphorus, or vitamin D in the diet; a condition known as rickets in young birds.
- **Liver:** The globular-shaped liver could be a result of fatty liver hemorrhagic syndrome.
- **Difficulty removing organs from the bird:** This could potentially be due to the age of the bird, the state of nutrition available, the type of bird, or dehydration.
- **Heart:** cloudiness around the heart could be indicative of bacterial septicemia.
- **Yellow-white Substance in body:** The presence of the white, caseous exudate is likely due to Airsacculitis. The caseous exudate was probably caused by E. *coli*, but further investigation and testing would need to be conducted to confirm this hypothesis.

Necropsy on 6/27/18 (1)

- **Liver:** The dark spots found on the superficial aspect of the liver were likely due to a subscapular hemorrhage. These are common in birds with fatty livers.
- **Heart:** cloudiness and changes in the fat could be indicative of bacterial septicemia.
- **Proventriculus:** The green bile throughout the body cavity probably came from the gall bladder, which could have been damaged when Mr. Jones put the bird in a hot water bath to remove its feathers.
- **Gastrointestinal Tract:** Numerous species of tapeworms can infest poultry. These are flat, ribbon-like, and segmented parasites utilize an intermediate host such as a beetle, grasshopper, etc. and compete for nutrients in the bird.
- **Lungs:** The small black clots on the lungs were likely due to Mr. Jones placing the bird in the hot water bath to remove its feathers.
- **Leg Joint:** The lack of synovial fluid in the leg joint was likely due to Mr. Jones placing the bird n the hot water bath to remove its feathers.
- **Breast Muscle:** The green bruising underneath the breast muscle is likely due to green muscle disease, which is practically characterized by the bruising of the supracoracoideaus muscle. This can occur as a result of poor handling or trauma.
- **Roof of Mouth:** Flattened, smooth papillae on the roof of the mouth are typically a result of a respiratory infection.
- **Crop:** Because this bird was injured and was being singled out by the rest of the flock, it was probably not allowed access to feed.
- **Fat Deposits:** Yellow fat deposits could be due to the level of fat in the feed, or age-related.
- **Dark Clots within body:** The blood clots throughout the body were probably due to hemorrhaging that occurred when Mr. Jones placed the bird in hot water to remove its feathers.

Necropsy on 6/27/18 (2)

- **Liver:** The yellow-tan appearance of the liver was likely due to fatty liver hemorrhagic syndrome. This can occur as a result of any level of trauma, and because the bird was attacked by the dog the liver was probably affected.
- **Gonads:** The dark clots around the egg were probably due to agonal hemorrhage, which occurred as a result of the trauma to the bird from the dog.
- **Gastrointestinal Tract:** Numerous species of tapeworms can infest poultry. These are flat, ribbon-like, and segmented parasites utilize an intermediate host such as a beetle, grasshopper, etc. and compete for nutrients in the bird. Roundworms are a common parasite which live in the lumen of the intestines and compete with the bird for nutrients.
- **Lungs:** The dark, red appearance of the lungs and their torn state were probably due to the trauma the dog inflicted on the body.
- **Breast Muscle:** The green bruising underneath the breast muscle is likely due to green muscle disease, which is characterized by the bruising of the supracoracoideaus muscle. This can occur as a result of poor handling or trauma
- **Fat Deposits:** Yellow fat deposits could be due to the level of fat in the feed, or age-related.

Necropsy on 7/19/18 (1):

- **Legs:** Weak leg bones could be a result of insufficient levels of calcium or vitamin D in the diet; a condition known as rickets in young birds.
- **Roof of Mouth:** Increased levels of saliva in the mouth could be a result of a respiratory infection.
- **Glottis and Trachea:** Increased mucus in the glottis and trachea could possibly be due to a respiratory virus such as Bronchitis or Newcastle Disease.

Necropsy on 7/19/18 (2)

- **Legs:** Weak leg bones could be a result of insufficient levels of calcium or vitamin D in the diet; a condition known as rickets in young birds.
- **Gastrointestinal Tract:** Roundworms are a common parasite which live in the lumen of the intestines and compete with the bird for nutrients.
- **Roof of Mouth:** Increased levels of saliva in the mouth could be a result of a respiratory infection.
- **Glottis and Trachea:** Increased mucus in the glottis and trachea could possibly be due to a respiratory virus such as Bronchitis or Newcastle Disease.
- **Crop:** This could be due to a bacterial or yeast infection, or post mortem autolysis changes.

[4]Evaluations and potential diagnoses of the necropsies were supported by advice from Dr. F.D. Clark (Clark, 2018).

Behavioral Evaluations:

Broilers

The broilers that were breathing with their mouths open were likely doing it because they were too hot and/or dehydrated. The relative level of open-mouth breathing is likely a direct correlation to the level of ventilation occurring in each pen. A decrease in ventilation towards the western end of the coop was evident, because these birds were the ones breathing the heaviest through their mouths. Alternatively, the birds on the eastern-most end of the coop were not breathing through their mouths at all when observed. It is also likely that the birds were dehydrated because the bells consisted of more wood shavings than water, making it hard for the birds to drink enough for high productivity. Though these optimal amounts differ with stage of production, the owner should just focus on making sure his/her waterers are always full with cool water, especially in hot and humid climates. Thus, the operator of the farm should clean out the waterers. The bells should also be raised higher if the birds are capable of kicking wood shavings into them. The overheating and probable dehydration were also indicated by the sounds the birds made. Louder, consistently vocal birds are typically expressing their discomfort and should be addressed by determining the part of the environment causing the distress. In addition to the discomfort and stress brought on by overheating and dehydration, the birds are less likely to consume feed, and will therefore not produce as efficiently as they could.

It was uncommon for the broilers to be crowded towards the entrance of the pen when I approached for observations. Because of that, it was obvious they had not been fed when this occurred. There was also no feed present in the feeders when I made these observations, so the hypothesis claiming the birds had not been fed was further supported. As mentioned previously, birds should *always* have feed available to them if a producer wants their production to be as efficient and as possible.

Layers

Because it was uncommon for the layers to follow me around when I walked through the pen or to be aggressive to each other, it was obvious that they had not been fed when this occurred. This hypothesis was further supported by the subsequent observation of the lack of Laying Mash in or around the feeder. The layers digging in the dirt and laying in it were taking a “dirt bath”, and they do this as a means to cool off and clean themselves. If an operator notices their birds are attempting to cool off like this, they should make sure

there is a location on the farm available for adequate ventilation, as well as shade. Just like the broilers, the layers will consume less feed when they are overheated, thus decreasing the relative level of egg production in the hens and reproductive capacities of the roosters. Though the deceased layer chick had not been found for necropsy, it is hypothesized that it died from dehydration and/or lack of feed. Because there was only one feeder available, it was difficult for all of the adult birds, let alone the chicks, to receive enough for the day. Additionally, there were a few, barely accessible water sources for the layers, while there were no water sources available to the chicks. An owner must provide sources of water and feed that are available to both the adult birds and the chicks.

Appendix I: Recognizing Common Diseases of Poultry

Table 3.1 (Swayne, 2019)

Airsacculitis	
Causative Agent	*Mycoplasma gallisepticum* and *Mycoplasma synoviae*
Transmission [7]	Trans-ovarian, direct contact with infected birds, direct contact with exudates, aerosolized, and indirect contact through fomites.
Pathogenesis	Incubation Period: 6-10 Days.
Signs and Symptoms [7]	Coughing, nasal and ocular discharge, sinuses below the eyes swollen, inappetence, leg problems, slow growth.
Post-Mortem Lesions [7]	Air sacs are filled with thick white or yellow caseous material, pericarditis, peri-hepatitis, swollen infraorbital sinuses.
Treatment	Tetracyclines, fluoroquinolones, tilmicosin, tylosins, spiramycin. Dust build-up should be reduced and secondary bacterial infections should also be prevented.
Control	Isolate infected bird(s) from the rest of the flock, disinfect all water and feed dishes, replace cage shavings, change clothing and wash hands after handling infected birds and when handling new flocks.
Prevention	Practice good biosecurity [5] and maintain low levels of stress related to production[6].

Table 3.2 (Swayne, 2019)

Avian Newcastle	
Causative Agent	Avian Paramyxovirus Type 1
Transmission [7]	Aerosolized, direct contact with infected birds, consumption of contaminated poultry products, indirect contact through fomites.
Pathogenesis	The paramyxovirus targets and replicates in the epithelial cells of the respiratory system, and then spreads to other essential tissues.
Signs and Symptoms [7]	Torticollis, circling, paralysis, depression, inappetence, respiratory signs, reduced egg production, and death within 2-6 days of infection.
Post-Mortem Lesions [7]	Airsacculitis, tracheitis, necrotic plaques in proventriculus, intestines, and cecal tonsils, hemorrhage in proventriculus.
Treatment	None; Can administer antibiotics to control secondary bacteria.
Control	Isolate and euthanize all birds of the infected flock, test other flocks on the same farm and euthanize if test positive, disinfect all water and feed dishes, and replace cage shavings.
Prevention	Quarantine infected birds, practice good biosecurity [5], all-in/all-out production, vaccinate once in day-old chicks and a second time at day 14.

Table 3.3

Coliform Septicemia	
Causative Agent	*Escherichia coli,* an opportunistic bacterium.
Transmission [7]	Aerosolized, ingestion of contaminated poultry products, contact with fomites, infected water sources.
Pathogenesis	Incubation Period: 3-5 Days.
Signs and Symptoms [7]	Respiratory signs- coughing and sneezing, snick, dejection, reduced appetite, poor growth, omphalitis.
Post-Mortem Lesions [7]	Airsacculitis, pericarditis, peri-hepatitis, hepatomegaly, splenomegaly, peritonitis, salpingitis, omphalitis, synovitis.
Treatment	Broad-spectrum antibiotics- amoxicillin, tetracyclines, neomycin (if showing intestinal activity), sulphonamides, fluoroquinolones.
Control	Isolate infected bird(s) during treatment, disinfect all water and feed dishes, replace cage shavings, change clothing and wash hands after handling infected birds and when handling new flocks.
Prevention	Reduce exposure to predisposing factors, such as viral infections and high stress situations [6], practice good hygiene in the hatchery, sanitize and disinfect bird houses, feed, and water, insure the embryo is well nourished and optimal incubation takes place to maximize day-old viability.

Table 3.4 (Swayne, 2019)

Fowl Cholera	
Causative Agent	*Pasteurella multocida*
Transmission [7]	Direct contact with nasal exudates, feces, contaminated soil, equipment, and people. Rodents, cats and sometimes pigs can serve as reservoirs to transmit the bacterium.
Pathogenesis	Incubation Period: 5-8 Days
Signs and Symptoms [7]	Dejection, ruffled feathers, inappetence, Diarrhea, coughing, nasal and ocular discharge, swollen and cyanotic wattles and face, swollen joints, lameness, sudden death.
Post-Mortem Lesions [7]	Enteritis, yolk peritonitis, focal hepatitis, cellulitis of face and wattles, purulent arthritis, sometimes none at all.
Treatment	Broad-spectrum antibiotics: Sulphonamides, tetracyclines, erythromycin, streptomycin, penicillin. This disease can persist long-term, so may have to consider euthanasia or periodic medication.
Control	Isolate infected birds and practice good biosecurity [5].
Prevention	Administer bacterins at 8 and 12 weeks of age, maintain low levels of stress

	related to production [6], practice good biosecurity [5], control rodent exposure.

Table 3.5 (Swayne, 2019)

Fowl Typhoid	
Causative Agent	*Salmonella enterica* serovar Gallinarum
Transmission [7]	Trans-ovarian infection, fecal-oral contamination, and/or egg eating.
Pathogenesis	
Signs and Symptoms [7]	Dejection, ruffled feathers, inappetence, thirst, yellow diarrhea, reluctance to move.
Post-Mortem Lesions [7]	Bronzed hepatomegaly with small necrotic foci, and/or congestion.
Treatment	Broad-spectrum antibiotics: Amoxicillin, Sulfonamide, Tetracyclines, Fluoroquinolones
Control	Isolate infected birds, test recovered birds for carriers, practice good biosecurity [5].
Prevention	Administer bacterins and live vaccine, maintain low levels of stress related to production [6], practice good biosecurity [5].

Table 3.6 (Swayne, 2019)

Marek's Disease	
Causative Agent	Alpha Herpes Virus
Transmission [7]	Aerosolized. Shed in the feces and feather dander.
Pathogenesis	Viral replication occurs in the lungs and invades the immune cells. It then spreads to the organs, peripheral nerves, and feather follicles.
Signs and Symptoms [7]	Neurologic- paralysis of legs, depression, lethargy, sudden death.
Post-Mortem Lesions [7]	Lymphomatous lesions in nerves and organs.
Treatment	None.
Control	Isolate and euthanize all birds of the infected flock, test other flocks on the same farm and euthanize if test positive, disinfect all water and feed dishes, and replace cage shavings.
Prevention	Vaccinate for Marek's *in ovo* or in day-old chicks. Maintain low levels of stress related to production [6].

[5]Refer to Page X for instructions regarding "good" biosecurity maintenance.
[6]Refer to Page Y for instructions to reduce levels of stress related to production management.
[7]Refer to Appendix III for further explanation of the medical terms used.

Appendix II: Necropsy Lesions and Intestinal Parasites

Table 4.1- Necropsy lesions/ symptoms and their probable causes (Clark, 2018).

Lesion	Possible Cause
Black specks on and underneath the feathers	Northern Fowl Mites
Dried, tan crusty specks in between the scales of the pelvic limbs	Scaly Leg Mites
Cut Eyelid	Eye Notch Syndrome- due to respiratory infection or too high of ammonia levels in the environment
Foggy eyes with ulcers	Ammonia levels are too high in the environment
Dried, brown nasal discharge	Respiratory infection
Head of femur bone is sheared off when popped out of place	Femoral Head Necrosis
“S”-shaped carina bone	Insufficient levels of calcium or calcium imbalance
“Rubbery” bones	Rickets (in chicks) or osteoporosis (in adults)- Due to insufficient levels of calcium or vitamin D. Rickets could also result from an imbalance of calcium.
The edges of the liver are not “sharp”/well-defined	The liver may be congested
Petechial hemorrhage or excessive fat around the heart	Bacterial septicemia
Foggy air sacs	High levels of dirt and/or ammonia. It could also be due to a bacterial infection
Green appearance around proventriculus and ventriculus	Leakage of bile
Stripes, hemorrhages, or ulcers on the mucosa (lining) of the intestinal tract	Coccidiosis
Black coloring of the bursa	Bursal disease
Tan-brown coloring to the kidneys, with white specks present	Dehydration
Lumpy ischiatic nerve	Marek’s Disease
Blood-tinged synovial fluid	Viral arthritis
Green coloring of the breast muscle	Green muscle disease/poor handling/trauma
Flattened, non-conical papilla on cleft pallets	Respiratory infection
Increased mucus in the glottis and trachea	Bronchitis
Thick mucus ejecting from nasal cavity	Respiratory infection
Erosions in the koilin/lining of the ventriculus	Gastrointestinal trouble or hemorrhages
Ulcers in the koilin/lining of the ventriculus	Fungal infection

Off-white, grey, or yellow moving specks in the feathers and on the skin.	Lice

Table 4.2- Intestinal parasites that could be found during a necropsy and their defining characteristics.[5]

Intestinal Parasite	Characteristics
Roundworms	Will appear in the duodenum or jejunum of the intestinal tract. Take on a tubular-shaped appearance and are large in size (4+ inches).
Cecal Worms	Will appear in the cecum of the intestinal tract. Take on a “C”-shaped appearance and are small in size.
Tapeworms	Will appear anywhere in the intestinal tract. Take on the appearance of small ribbons

Appendix III: Glossary of Medical Terms

Table 5.1- Glossary of medical terms throughout the text.

Term	Definition
Aerosolized	Referring to a form of transmission in which the infectious agent transfers hosts through the air and is inhaled by the susceptible host.
Airsacculitis	Inflammation of the air sacs.
Bile	A blue-green liquid produced by the liver to help with the digestion of fat.
Bronchitis	Inflammation of the mucosal layer of the bronchioles.
Cecal Tonsil	Lymphoid tissue located at the junction of the cecae and intestines.
Caudal	Towards the tail of the body.
Cellulitis	Inflammation of the subcutaneous layer of tissue.
Coelom	The body cavity.
Cranial	Towards the head of the body.
Cyanotic	A situation in which the host's skin turns a bluish tint due to lack of oxygenated blood.
Dejection	A depressed state; lethargic.
Dorsal	Towards the topline of the body.
Ectopic	In an abnormal place or position.
Exudate	A mass of cells and fluid that has seeped out of blood vessels or an organ, especially in inflammation.
Focal Hepatitis	Inflammation of the liver.
Fomite	An inanimate object capable of transmitting an infectious agent.
Hemorrhage	An escape of blood from a ruptured blood vessel.
Hepatomegaly	Enlargement of the Liver
Laceration	A deep cut in the skin
Lateral	Away from the median plane of the animal.
Lymphomatous	Containing lymphocytes.
Medial	Towards the median plane/middle of the animal.
Necropsy	A postmortem examination of an animal or bird body.
Offal	The internal organs or entrails of the animal that are usually thrown away after the butchering process.
Omphalitis	Inflammation of the navel, especially in newly hatched chicks.
Pelvic Limb	The hind limb

Pericarditis	Inflammation of the pericardium (of the heart).
Perihepatitis	Inflammation of the serous peritoneal coating of the liver.
Peritonitis	Inflammation of the peritoneum, which is the lining of the abdominal cavity.
Proximal	Towards the trunk of the body.
Purulent Arthritis	A form of arthritis in which a pus-like substance is produced around and/or in the affected joint.
Salpingitis	Inflammation of the oviduct.
Snick	A condition in which chickens will cough softly or sneeze.
Splenomegaly	Enlargement of the spleen.
Synovitis	Inflammation of the synovial membrane, which lines the cavities of highly moveable joints (e.g. the knee, elbow, or hip joint).
Thoracic	Referring to the thorax.
Torticollis	A condition in which the head becomes persistently turned to one side.
Tracheitis	Inflammation of the trachea.
Trans-ovarian	Referring to a form of disease transmission in which the infectious agent transfers hosts through the ovaries. The ovary becomes infected and the infected eggs are produced.
Ulcer	A disintegration of the surface of the skin or a mucus membrane resulting in an open sore that may heal very slowly.
Ventral	Towards the ground/underneath the animal's body.
Yolk Peritonitis	A condition in which an infection establishes in the coelomic cavity of the hen, which is caused by the presence of an ectopic yolk in the coelom.

Appendix IV: Feed/Water Contents of Broilers and Layers

Table 6.1: Broiler Feed Contents

	“Starter”: 0-2 Weeks	**“Grower”: 3-5 Weeks**	**“Finisher”: 6-7 Weeks**
Feed Bag Label			
	TBD	"This feed contains coccidiostat for prevention of coccidiosis."	"This feed contains coccidiostat for prevention of coccidiosis."
	TBD	"BROILER GROWER MEDICATED"	"BROILER FINISHER MEDICATED"
Nutritional Breakdown			
Crude Protein	TBD	21.0%	19.0%
Crude Fat	TBD	6.0%	6.9%
Crude Fiber	TBD	2.9%	3.0%
Ingredients			
	TBD	Ground Yellow Corn	Ground Yellow Corn
	TBD	Grain By-Products	Grain By-Products
	TBD	Soybean Meal	Soybean Meal
	TBD	Animal By-Products	Animal By-Products
	TBD	Soybean Oil + Vitamins & Minerals	Soybean Oil + Vitamins & Minerals
Recommendations			
	TBD	"Recommended for Broiler ONLY"	"Recommended for Broiler ONLY"

Table 6.2: Layer and Rooster Feed Contents

"Laying Mash": Hens and Roosters	
Nutritional Breakdown	
Protein	17.0%
Fat	3.0%
Fiber	4.5%
Calcium	3.1%
Ingredients	
	Ground Yellow Corn
	Grain By-Products
	Soybean meal
	Soybean oil + Vitamins & Minerals
	Animal By-Products
Recommendations	
	"Recommended for Layers ONLY"

Table 6.3: OTC Plus Supplement Contents (Kraemer, 2012)

Substance	Amount	Description
Oxytetracycline HCl	60mg	A broad-spectrum antibiotic that shows bacteriostatic activity at normal doses; active against Mycoplasma *synoviae*, M. *gallisepticum*, M. *meleagridis*, Hemophilus *gallinarum*, Pasteurella *multocida*.
Vitamin A	3mg	A fat-soluble vitamin essential for embryonic development, growth, reproduction, immune function, and vision.
Cholecalciferol (Vitamin D3)	3mg	Responsible for maintaining normal circulating levels of calcium and phosphorus in the intestine, as well as maintaining bone health and immune function. Deficiency can lead to rickets.
Alpha-tocopherol acetate (Vitamin E Acetate)	3mg	Functions as a chain-breaking antioxidant that protects polyunsaturated fatty acids in membranes and plasma lipoproteins against the propagation of free radical reactions.
Menadione nicotinamide bisulphate (Vitamin K)	6.364 mg	Essential for blood clotting and coagulation, as well as bone formation, metabolism and mineralization.
Thiamine hydrochloride (vitamin B1)	0.5mg	A water-soluble vitamin that plays an essential role in the metabolism of carbohydrates and branched chain amino acids. Deficiency can lead to Beri-Beri disease.
Riboflavin (Vitamin B2)	0.3mg	A water-soluble vitamin that is an essential coenzyme for redox reactions in many different metabolic pathways.
Cyanocobalamin (Vitamin B12)	2.5ug	Plays an essential role in amino acid and fatty acid metabolism and in DNA synthesis as a cofactor for methyl malonyl CoA mutase and methionine synthetase.
Ascorbic Acid (Vitamin C)	12mg	A water-soluble vitamin that is essential for the biosynthesis of collagen, carnitine, and catecholamines. It is also a strong antioxidant that protects molecules from oxidative damage.
Calcium Pantothenate	3mg	A component of CoA, which is a cofactor involved in fatty acid metabolism.
Folic Acid	0.1mg	Plays an important role as a coenzyme for single-carbon transfers in the synthesis of nucleic acids and amino acids. Deficiency can lead to anemia.
Choline L-bitartrate	12mg	An essential precursor for acetylcholine, phospholipids, and betaine, and is closely associated with folate, vitamin B12, and methionine metabolism.
Excipients (“Excipient”, 2015)	1mg	A usually inert substance (such as gum arabic or starch) that forms a vehicle (as for a drug).

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