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Using Poultry to Enhance Food Security in Stann Creek, Belize

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Abstract

Food insecurity is a growing issue in developing and developed countries alike, and in countries like Belize, the prevalence of hunger has soared in recent years. Not having access to diets with sufficient calories and nutrients leads to a host of developmental issues, including stunting and cognitive delays. The purpose of this work was to create an all-encompassing manual for small-scale broiler production, with the intention of another honors student overseeing the implementation of the ideas set forth in the manual, in order to provide nourishment for the students and staff of a school in Belize. After determining that the best way to meet the school's needs was through dual-purpose birds, background research was conducted to determine small-scale poultry facilities in developing countries. This involved designing the layout for the poultry houses (one for layers and one for broilers) given the space available, as well as sourcing materials both locally and abroad. The manual was written to include background information and step-by-step instructions for constructing the houses and caring for the birds. The researchers anticipate that this farm will positively impact the lives of the students and faculty of the school, in that they will have access to poultry meat and eggs, which will increase physical and cognitive performance, provide hands-on education, and incentivize students to finish their schooling rather than quitting to work to provide for their families.

Introduction

Background and Need

Food insecurity is defined as the state of being "unable to consistently access or afford adequate food," and this is a global problem (Merriam-Webster, 2020). Although this term was first used in the late 1970's, food insecurity has undoubtedly been a challenge that mankind has faced for all of its existence. According to the Food and Agriculture Organization of the United Nations (FAO), the global number of undernourished people in 2018 was 821.6 million, which is the highest it has been since 2010 (FAO, 2019). It has been predicted that the world population will increase to nine billion people by 2050, which is approximately a 35% increase from the current population (Foley). As this global population continues to increase, demand for sustainable food sources will proportionally increase as well.

Although Belize is a country where many people from Guatemala, Honduras, and El Salvador come for refuge and to escape the violence of their own countries, a different problem awaits immigrants there—food insecurity, which continues to increase due to the influx of immigrants to the region. In fact, the magnitude of caloric deficiency has surged from 150 calories to more than 400 calories below the recommended amount per day (Linford, 2017). The long-term effects of food insecurity, especially on minors, have been studied extensively. Researchers have determined that when children do not consume diets rich in the necessary nutrients, including protein, that they have worse overall health, poorer academic performance, less social skills, and even suppressed immune system function (Thomas, 2019).

The poultry industry is a major source of employment in Belize, with around 2,500 citizens employed in some aspect of poultry production (Habet, 2009). As further evidence of the importance of poultry in the daily lives of Belizeans, the per capita consumption was nearly 100

pounds of meat and 115 eggs in 2007. Compared to the American average, which was 103 pounds of poultry consumed per capita in 2007, it is evident that poultry is a crucial aspect in the lives of Belizeans, much like it is in the United States (National Chicken Council, 2019). Although the per capita consumption of poultry meat in Belize is nearly the same as the U.S., poultry represents nearly 80% of the animal protein consumed in Belize, while it represents less than 47% of total meat consumption in the United States, which emphasizes the crucial role of poultry in meeting the nutritional needs of Belizeans (National Chicken Council, 2019; Habet, 2009). Even so, poultry meat is less accessible in poorer parts of the country, usually due to price being higher than many families can afford. For this reason, the most popular dish in Belize is the same as the majority of other Central-American countries: rice and beans (Farrell, 2013). Rice and beans are relatively low-cost and easy to prepare, which makes this meal the most sensible choice and thus is considered a staple for many families in second-world and third-world countries (Farrell, 2013).

To combat this global crisis, many nonprofit organizations and initiatives to reduce food waste have been formed. In addition, several groups of young adults have reached out to offer their technical knowledge to create sustainable farms and sources of nutrition to support these communities and ensure that the citizens do not go hungry. Furthermore, several young adults and college groups have worked to make resources available for those that live in these poverty-stricken areas. For the purposes of this study, work performed and manuals created by students from the Stann Creek Agriculture Department, business students from the University of Arkansas, and the Dangriga Neighborhood Chicken Association were referenced as a guide. Because these manuals were not written with the technical knowledge of those who are formally trained in poultry science, the goal of the study was to update the information for the residents so

that they will be able to have the most productive and healthy flocks possible. In addition, the student-created manuals did not include sufficient biosecurity measures, so practices that would eliminate the potential spread of infectious diseases had to be included.

The central focus of this research was to create a small-scale poultry facility for Saint Matthew's in Pomona Valley, which is a school in Stann Creek, Belize. This school was started by members of the Anglican Church in the United Kingdom (St. Matthew's). Students from the University of Arkansas have previously volunteered at this school to create a school garden to provide produce for the school's canteen. Because of the success of this project, the school requested a poultry farm to add a sustainable source of protein to their menu. The school currently has about 300 students and 11 faculty members, but it is challenging to keep students in school due to the price of education and because families often need their children to help them work in the orchards as a source of income (St. Matthew's). To combat this, creating a smallholder poultry farm is an effective way to teach students valuable skills about raising birds and animal husbandry, so that eventually the students will be able to create their own farm as a source of income and nutrition for their families and themselves if they choose to do so, while also providing meat and eggs to meet their immediate nutritional needs.

Problem Statement

Because there is such a high prevalence of food insecurity in Belize, it is necessary that those with resources utilize what they have available to help others meet their daily needs and eliminate the vast calorie deficit (Linford, 2017). Those associated with the poultry industry who have the necessary technical knowledge of properly raising chickens ought to help those in developing countries so that the citizens will be able to raise flocks and manage them in the most efficient ways possible. Although individuals from other disciplines have written manuals to help

the citizens of Belize with poultry production, the manuals utilized as a guide for this study were missing technical information that is crucial to poultry production. The gaps that were observed in the other manuals provided a starting point to improve and add information to further assist St. Matthew's of Pomona Valley as the school seeks to add sustainable protein to their students' diets.

Purpose and Objectives

The purpose of this study was to update and expand upon the manuals provided by the other various organizations, and then apply the best practices to implement a school farm for Saint Matthew's in Belize. This study sought to explore the availability of resources in Belize and create a small-scale poultry production facility to provide nourishment for the students and staff. This was accomplished through the following objectives:

- Objective 1: Analyze existing small-scale poultry manuals and edit them to include necessary technical information and biosecurity practices, as well as relevant background information about poultry.
- Objective 2: Create a step-by-step guideline to construct two fully-functioning small-scale poultry production houses for dual-purpose birds.
- Objective 3: Create a step-by-step guideline to train students and staff on proper animal husbandry practices and poultry basics.

Definitions

- All-in, all-out: A production system in which poultry are raised in single-age groups, so as to minimize the risk of transmitting diseases.

- Biosecurity: Procedures intended to protect animals against disease or harmful biological agents. Common biosecurity practices include footbaths, proper disinfection and sanitation, and limiting traffic onto the farm.
- Evaporative cooling pads: The process of using pads (generally cardboard) as a means of cooling a poultry house by pulling air through the pads as water runs and evaporates off of the pads.
- Feed Conversion Ratio (FCR): The amount of feed required to gain one unit of weight. In commercial operations, the FCR is approximately 1.6 units, meaning that for every 1.6 pounds of feed consumed, the bird will gain one pound of weight.
- Negative pressure: When an enclosed area has lower pressure than the outside, it is said to have negative pressure. Negative pressure environments are preferred in poultry operations because it allows for near complete control over the environment, which allows proper temperature and ventilation to be maintained.
- Net Protein Utilization (NPU): Ratio of amino acid mass converted to protein that can be utilized by the body compared to total mass of amino acids available.
- Tunnel Ventilation: A type of ventilation that utilizes two exhaust fans at the end of the house and air inlets along the side walls to pull air through the house at high velocity, creating a wind chill effect. This ventilation system is commonly used for maximum ventilation as birds grow.

Literature Review

As the poultry industry continues to innovate, better genetic strains have been created, nutrition requirements of the birds have become better understood, and the industry has nearly mastered disease control, all of which culminates in more efficient poultry production

(Ravindran, 2013). Through genetic selection and by understanding the bird's nutritional requirements, nutritionists have been able to formulate diets that maximize feed conversion, which allows the broilers to grow to their full potential in almost half the time. This allows poultry production to be more cost-effective, which makes poultry products increasingly available in both the foreign and domestic markets. Ravindran (2013) predicts that both poultry production and demand will increase in developing countries over the next two decades, due to various reasons including economic growth, urbanization, and higher household incomes.

Food Insecurity

The Food and Agriculture Organization of the United Nations (FAO) claims that "more than 820 million people do not have enough to eat" (FAO, 2019, para. 6). Although this statistic is startling, this is the daily reality for nearly one billion people. Although food insecurity is generally associated with third world countries, it is still prominent in first and second world countries as well. Belize is one of these afflicted countries, and it has been documented since the 2000s that "Belize has had trouble ensuring adequate nutrition for its people," which is partially due to the influx of refugees and poor quality of the food that is available (Linford, 2017, para. 3). There have been extensive studies on the effects of food insecurity on children's overall health and well-being, which include asthma, depressive symptoms, poorer academic performance, less developed social skills, and other general acute and chronic health problems, as concluded by Thomas, Miller, and Morrissey (2019) in their study, which included 35,651 children between the ages of two and seventeen. In addition, stunting and wasting are other health effects that are observed in children who do not consistently consume enough protein (Farrell, 2013).

The Role of Poultry in Human Nutrition

Poultry meat is known to be one of the greatest providers of amino acids, vitamins, and minerals, and the nutritional content of poultry meat allows it to positively contribute to individuals with restricted incomes, as it is generally more affordable and accessible than other meats (Farrell, 2013).

Because the entire purpose of eggs is to sustain life until hatch, eggs contain all of the essential vitamins, minerals, and amino acids that are necessary for vertebrates in one convenient package. Furthermore, poultry is an excellent source of protein, which is generally lower in grains. One method of describing the amount of protein available to the consumer is net protein utilization (NPU). Farrell defines NPU as "an index of protein quality, calculated by multiplying protein digestibility by biological value" (Farrell, 2013, p. 5). To support the statement that poultry meat is an excellent source of protein compared to other common foods, Farrell states, "rice has an NPU of about 60% and a protein content of about 7.5%, whereas poultry meat has an NPU of 87%" (Farrell, 2013, p. 5). As Belize is one of the many countries that relies heavily on grains like rice because of affordability, it is important to note that grains may give individuals the sensation of being full, but that certainly does not always correlate with nutritional benefits. The definition of food security is two-fold, meaning that individuals must not only have access to food, but that the food is *adequate* as well. Considering that rice is not a good source of protein or other nutrients, consuming rice alone does not contribute to lowering rates of food insecurity.

By consuming 36 grams of eggs and 22 grams of chicken meat per day, a child will receive "all the critical amino acids and vitamin K she needs, 30 percent of the RDI for folate, 66 percent for vitamin B12, 30 percent for biotin and 29 percent for iodine" (Farrell, 2013, p.5). Of

all the minerals, iron is considered one of the most essential, as it is required by every cell to carry oxygen via hemoglobin (in red blood cells) and myoglobin (in muscle cells) (MedlinePlus Medical Encyclopedia, 2019). MedlinePlus (2019) also states that young children and pregnant or menstruating women are more prone to becoming iron deficient, or anemic, if they go for extended periods of time without intaking sufficient levels of iron, which can lead to side effects that range from headaches and weight loss to shortness of breath and dizziness.

Another important vitamin is B9 or folate, and the more common synthetic version is folic acid. This vitamin is vital for pregnant women, as it prevents many serious birth defects, including neural tube defects, which lead to "defects of the brain and spinal cord, stillbirths, and early child mortality" (Farrell, 2013, p.5). Individuals often argue that vegetables are a more sustainable source of essential nutrients than animal protein, and although leafy vegetables do contain good amounts of folate and other important vitamins, a large percentage of these nutrients are lost once the produce is cooked, which is not a problem for poultry meat, as it retains its nutritional content even after being properly cooked.

According to the National Chicken Council, in 2011 the U.S. had an average per capita consumption of 99.3 pounds of poultry meat and the national per capita consumption of eggs was about 250 eggs (NCC, 2019; United Egg Producers, 2018). During this same year, Belizeans had an average per capita consumption of 109 pounds of poultry meat and only 141 eggs, which is over 100 less eggs than what were consumed in the U.S. (Belize Poultry Association, 2012). Although poultry is now more readily available than it was when the country relied on importing most of its poultry protein, there is still room for improvement that would have monumental effects on the overall health of the citizens of Belize. With the difference between the protein consumption in the United States versus that of Belize, it is evident that there is a deficit, which

leaves the citizens of Belize utilizing other forms of food, like rice, to meet their daily needs, but many of these foods are lacking crucial amino acids, vitamins, and other nutrients.

Housing

There are three main sizes of production operations- large, medium, and small. Although the large-scale farms have the potential to produce a large economic profit, this is often not feasible in developing countries, usually due to lack of financial resources, time required, or availability of resources to take care of the flock (i.e., food and water). Pym & Glatz concluded that because of "the lower construction and running costs, medium- and small-scale commercial housing is popular in developing countries" (Pym & Glatz, 2013, p. 25). These smaller flocks allow for the growers to properly manage and care for the flock, ensure that the birds are all healthy, and that they will be able to afford this endeavor. Even though the flock is not commercial-size, it is generally sufficient to feed the grower and their family, and often there will be excess meat or eggs that can be sold to bring income to the family, which in turn helps pay for the needs of the flock. Individuals wishing to start a flock in developing countries often utilize local materials, such as bamboo, to construct the chicken houses, which allows the farmers to lower the overhead costs (Glatz & Pym, 2013).

The most common practice is to have separate houses for each age group of broilers and to run an "all-in, all-out" production system, because this lowers the likelihood of infectious diseases being spread among the flock (Glatz, 2013). Although this system is the preferred way to raise birds, it often is not practical in developing countries, especially for smaller operations with limited space. In such scenarios where birds of different ages must be raised in the same house, they must be, at a minimum, in separate rooms divided by age.

In commercial operations, growers prefer to have closed-wall houses, then use evaporative cooling pads combined with tunnel ventilation, which utilizes exhaust fans to pull air through the house and maintain negative-pressure (Glatz & Pym, 2013). This system is the most common, as it allows for nearly complete control over the environment of the chicken house. However, this is not practical in developing countries, because commercial houses are costly to build and often electricity is not reliable enough, which would lead to the fans shutting off and suffocating the birds in the house. Instead, smallholder operations tend to employ open-sided houses so that natural breezes can cool the birds, which is referred to as natural ventilation. This system is the most effective when the longest side of the house is from east to west, as this will help to avoid heating the sidewalls, which would increase the temperature throughout the entire house (Glatz & Pym, 2013). It is also important to note that for the house to use natural ventilation, there must not only be adequate room for air flow, which can be achieved through open-sided houses with chicken wire, but there also must be a curtain of sorts that can cover the openings in case of severe rain or other unfavorable weather conditions.

Feed and Water Quality

For poultry growers throughout both commercial and small-scale production systems, the main financial concern is feed, as it represents approximately 70% of the entire expense of raising birds in commercial operations, and upwards of 80% in small-scale operations (Ravindran, 2013). One of the reasons that feed cost is such a large proportion of total cost is because broilers, for example, can store enough feed for two to four hours in their crops, meaning that they will eat every two to four hours as needed. For this reason, it is not only important that the birds are fed a high quality food, but also that they constantly have access to the food so that there will be no gaps in metabolization, which would lower productivity and

feed conversion rate. In commercial systems, emphasis is placed on ensuring that the exact nutritional requirements of the birds are met at each stage of life, and commercial operations often use three or four different diets throughout the flock's lifetime to maximize efficiency. In smaller operations, however, the focus is shifted to maximizing overall profitability rather than production, and this is achieved through using locally-sourced feeds, which are cheaper than imported feeds (Glatz & Pym, 2013). Ravindran (2013) states that there are three typical feeding strategies for those operating semi-commercial systems, which include on-farm mixing local feed ingredients, mixing commercial feeds with local ingredients, or adding local grains to a concentrated mixture. According to Ravindran (2013), the ten essential amino acids for poultry are arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine, because the birds' bodies cannot synthesize these amino acids and they must be supplemented in feed. Macro-minerals such as calcium, phosphorus, sodium, potassium, chloride, sulfur, and magnesium must also be supplemented through feed in amounts greater than 100 mg/kg, as they are extremely important for bird development (Ravindran, 2013). Various trace minerals, which often function as coenzymes in various physiologic reactions must be fed in small amounts as well to ensure that the birds reach optimum growth.

The body of a chicken is made up of approximately 80 percent water, reflecting its importance to the species, although it is often neglected. Although water is an essential nutrient, the daily requirement has not been determined, although it is estimated that birds drink nearly twice as much water as the amount of feed that they consume (Subcommittee of Poultry Nutrition, 1994). Many farmers do not consider water quality to be an important factor for raising flocks, as proved in the study performed by Carpenter. When asked if he was able to test water quality, one farmer responded, "I have pH testers, but I do not see the need in testing the

water" (Carpenter, 2019). Water is crucial for nearly every physiological process, including feed digestion, nutrient absorption, waste excretion, temperature regulation, and growth (Ravindran, 2013). If birds do not consume sufficient amounts of water, they will not eat, thus lowering production rates substantially.

Biosecurity

In order to raise a healthy flock, it is necessary that the growers adhere to a strict biosecurity program to limit and prevent the spread of infectious diseases. In commercial operations, biosecurity is achieved through strict restrictions on visitors, attire, sanitation, and accessibility. Entry is also typically restricted to one entry point per barn, with a footbath at the entrance and an area to change into disposable booties so that microorganisms will not be transferred between houses. It is paramount to prevent the domestic birds from coming in contact with wild birds, as many diseases are spread among fowl species. Many of the expected commercial-scale biosecurity practices are not feasible in the small-scale setting, especially when multiple homes have backyard flocks in a close vicinity (Bagust, 2013).

In order to combat some of the challenges that face those involved with poultry production in developing countries, Bagust (2013) reports that creating extension services to train farmers on proper programs and improving the services performed at the hatchery (such as vaccinations) will contribute significantly to increasing the overall health of flocks by protecting the chicks against certain diseases, such as Fowl Cholera and Newcastle Disease, which pose a major challenge in Belize (Bagust, 2013). There are four major pillars to an effective biosecurity program: quarantine, hygiene and disinfection, vaccination, and eradication. Quarantine has been used since Roman times, and is now applied in poultry by keeping new birds separated from the existing flock for at least one week to ensure that the new birds do not have any preexisting

diseases that they may spread to the entire flock. Before placing each flock and in between flocks, it is crucial that there is adequate down time (time in between flocks in which there are no birds in the house, which reduces the number of pathogens as a result of half-life). In this time period, the barn also must be disinfected with antimicrobials. The goal of disinfection is not to reach complete sterility, as this is impossible in commercial production, but the goal rather is to reduce the number of organisms to below the infectious dose level that would cause disease in the flock (Hargis, 2020). Vaccination, although extremely important, cannot be relied on as the sole method of protection for a flock. When combined with the other three pillars, vaccination effectively reduces likelihood of birds contracting diseases by building up anamnestic immunity and increasing the challenge dose required to cause disease. Finally, eradication is used under extreme circumstances and with outbreaks of extremely virulent diseases, like High-Path Avian Influenza (HPAI) (Bagust, 2013).

As poultry scientists continue to innovate and learn how to maximize the productivity of the birds, poultry protein availability will proportionately increase domestically and abroad, which allows it to provide a sustainable source of nutrition for those in developing countries. Through implementation of biosecurity programs, smallholder farmers will be able to maximize the productivity and health of their flocks, allowing them to provide for their families and communities. Once training programs and manuals are developed for developing countries, the citizens who desire to raise poultry will be able to understand the nutritional requirements of the birds and how to properly care for them to ensure the longevity of their flocks, which results in individuals receiving the adequate daily nutrition necessary to avoid all of the adverse effects of malnutrition and food insecurity.

Development Plan

Through the innovation that has been created in the poultry industry, it has also been noted that these advantages could be extremely beneficial when one considers the undernourishment often observed in developing countries. Those affiliated with the poultry industry have a responsibility to use their technical knowledge and expertise to help solve the global problem of food insecurity. This project addresses one way that poultry scientists can use their knowledge to fulfill this duty to fellow humans across the globe—through the creation and implementation of a cohesive manual and training program for small-scale poultry production in Belize. To accomplish the stated research objectives, the following steps were followed throughout the development of the project:

1. Identify a population in need.
2. Determine how to best meet the specified population's need.
3. Gather relevant existing manuals and do necessary background research.
4. Improve upon the existing manuals and use previous research and surveys to determine what the target population will need the most guidance with, then use that information to write a new manual that encompasses all of the necessary information.
5. Develop a step-by-step guide to teach faculty members of the school (St. Matthew's of Pomona Valley) how to properly care for the birds.
6. Design the layout for the poultry housing facility, based off of the space available at the school as well as desired number of birds.
7. Using the planned layout, determine what materials would need to be purchased, and compare this amount to the estimated cost sheet that was included in the *Backyard*

Poultry and Vegetable Garden Manual (University of Arkansas Business Students, 2019).

8. Print copies of the manual, record sheets, and biosecurity signage to give to the faculty of the school.

Due to travel restrictions from the COVID-19 pandemic, the implementation and continuation of this development plan, outlined below, will be led by another Bumpers Honors student.

1. Travel to Belize.
2. Set up the house and ensure that it will be suitable and safe for live birds. This includes sourcing the materials, constructing the roof, adding chicken wire to the windows, and preparing the litter.
3. Provide the manuals to the faculty, then train and prepare each member individually for what would happen over the next few days, including bird arrival.
4. Place supplemental feeders and waterers, and then fill them to ensure that the feed and water would reach the proper temperature before bird placement.
5. Set up the final biosecurity measures, including footbaths and disposable booties.
6. Place birds.
7. Perform more training, this time more focused on animal husbandry, animal welfare, and how to care for the birds on a day-to-day basis as well as the importance of observation to determine animal well-being.
8. Work alongside the locals for a couple of weeks to ensure that they are properly caring for the birds and fully understand the importance of biosecurity.
9. Hold an informational session to address any questions that the faculty may have about caring for the birds before returning to the United States. Provide faculty with contact

information of local groups that would be able to promptly answer any questions that may arise.

The first step in this process was identifying a population in need, and Dr. Lisa Wood of the University of Arkansas pointed out that Saint Matthew's of Pomona Valley in Stann Creek, Belize was the ideal candidate, as they had requested a small-scale poultry farm to provide a source of protein for the school canteen. The school currently has about 300 students enrolled and 11 staff members. Although the school is successful, as shown by the 100% passing rate from primary school, officials state that it is difficult to get students to complete high school because many families need their children to work to provide additional income for their families (St. Matthew's). It was determined that this population would benefit from the addition of an on-site poultry farm because it would not only provide a sustainable and affordable source of protein for those affiliated with the school, but also because it would be a practical way to introduce students to animal husbandry, which could serve as a potential source of income for the students and their families in the future.

To write a manual that encompassed all of the necessary factors of poultry production, various manuals including *Guide to Starting Your Own Poultry Business in Dangriga, Belize C.A.*, *Manual on Improved Best Practices in Rearing Free Range Chickens,* and *Backyard Poultry and Vegetable Garden Manual* were referenced, and important features were then complied into one comprehensive end product (Dangriga Neighborhood Chicken Association; Stann Creek Agriculture Department; U of A Business Students, 2019). Crucial technical information was added from scholarly sources and colleagues in the poultry industry to ensure that the growers in Belize would be able to grow flocks to their full potentials and that the flocks' health would continually be of the utmost priority.

As the manuals were missing large amounts of information regarding biosecurity, that was the main concern addressed in the writing process. Responses adapted from the survey utilized in B. Carpenter's *Observations and Applications of Husbandry Methodologies on a Backyard Poultry Farm in Dangriga, Belize* pertaining to various aspects of flock management was conducted among various members of the Stann Creek region in Belize, with subsections that included Feed and Water Quality, Biosecurity, House Set-Up, and Temperature Regulation, which served as a gauge of the farmers' grasps on these vital concepts and guided the direction of the manual's formation (Carpenter, 2019). Based on the results of the questionnaire, it was determined that the citizens surveyed struggled most with biosecurity, water quality, and feed quality, meaning that these aspects of production would take priority and receive the most emphasis in the manual.

After all necessary prior research was conducted and the manual was written and reviewed, copies were printed along with posters and record sheets to take to Belize so that the school members would have continued access to these invaluable resources. The next step was to begin designing the layout of the house. As the school had a fairly large plot of land available, it was determined that two houses would best suit the needs of the school. The possibility of dual-purpose birds was explored, and it was determined that by sexing the chicks and raising them in sex-separate houses, they would be able to be raised as "broilers" and "layers," which would provide a diverse protein source for the school, as they would produce both eggs and meat. It was determined that it would be beneficial to create a hybrid housing system for the hens by allowing access to outdoor runs, as this would allow birds to forage, which will reduce the amount of feed that must be purchased for the flock. As layers have longer productive lives than broilers, the first flock of both "layers" and "broilers" would be sexed, while subsequent flocks

of “broilers” would be raised straight-run, or not sexed. This eliminated the need to cull male chicks in a layer operation, while also minimizing costs and the amount of down-time that the school would face between flocks. A materials and cost sheet was included in the *Backyard Poultry and Vegetable Garden Manual*, which was used to determine where supplies could be purchased and to create a budget, although the referenced materials list was for a much smaller house. A step-by-step guide was also developed to ensure that those involved with the care of the school farm would know how to properly raise the flocks, with the intention of it being presented to the faculty before chicks were placed to ensure that they would have the opportunity to ask any pertinent questions.

The third phase of the project, implementation and application of all of the plans that had been made, was postponed due to COVID-19 and the inability to travel internationally and will be overseen by another student in May and June 2022. The largest component of the third phase will be building the facility and setting up the house and ensuring that it will be suitable and safe for live birds. This will involve sourcing the materials, constructing the roof, adding chicken wire to the windows, and preparing the litter for bird arrival. Before birds are placed, locals will be trained on the next steps of the process and guided through what the next days will look like. Supplemental feeders must be placed and waterers must be filled to ensure that they reach the proper temperature before bird placement. The final biosecurity measures will then be set up on the farm, including preparing footbaths at the entrance of the houses. Once the birds are placed, more training will be performed, this time more focused on animal husbandry, animal welfare, and how to care for the birds on a day-to-day basis as well as the importance of observation to determine animal well-being.

Through the guidance of the steps described above, the research objectives were accomplished, resulting in the creation of a manual to construct a fully-functional small-scale poultry production facility for the members of St. Matthew's of Pomona Valley in Stann Creek, Belize. Upon the final completion of this project, a sustainable source of nutrition will made available to the faculty and students at the school and their families, thus increasing the level of food security for the surrounding communities.

Design Process and Creative Works

Through extensive research, the attached manual was created to outline the steps required to build a small-scale poultry production facility consisting of two houses, as well as step-by-step instructions for placing chicks and their daily care. The manual includes background information, such as the importance of feed and water quality, so that the school faculty and others who may be interested will understand the importance of each facet of poultry production and be less likely to skip steps. Furthermore, the manual includes valuable information and resources, such as record logs, biosecurity posters, charts to determine chick health, and phone numbers to call and websites to visit for additional questions. This manual is attached in the appendix at the end of this document.

Conclusions and Discussion

As previously discussed, undernutrition leads to a host of chronic and acute health issues, including both physical and cognitive developmental delays, especially during the crucial years of childhood. As the nutritional and environmental needs of poultry have become better understood, they are an increasingly efficient source of protein that can be grown with less space and time than other livestock. Due to these factors, among others, poultry meat is often more affordable and accessible than other meats, which makes poultry the ideal candidate to combat

food insecurity within the school community. The attached manual was created with the most up-to-date information available, including information from recent small-scale poultry production manuals, industry guidelines, and poultry scientists in academia. The manual discusses the importance of feed and water quality in poultry production, as this is one of the factors that surveyed farmers in Belize generally believed was relatively unimportant—although it significantly contributes to the health, wellbeing, and productivity of the flock. Likewise, referenced materials lacked sufficient information on proper biosecurity practices, so this information was included to ensure that the proper steps are taken to care for the health and safety of the flock. The manual and the plans contained therein, which include step-by-step guides for constructing the poultry houses as well as daily care and management of the birds, will be used in the near future to implement a small-scale poultry farm for Saint Matthew's of Pomona Valley. The manual explores various housing types and production sizes, from large-scale, closed-wall houses to small-scale, open-sided and hybrid houses, and highlights benefits of each system before concluding that a small-scale operation would be more cost-effective while still sufficient for the needs of the school. This will provide a sustainable source of nutrition for the students and faculty members of the school, with a long-term goal of providing meat and eggs on a rotational basis for students to take home to their families. This will not only provide nutrition for the students, but also for their family members, which will significantly reduce the need for students to drop out of school to pursue full-time work, allowing them to reap the benefits of formal education. Above all, this project will significantly enhance food security in the region of Stann Creek, Belize.

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Appendix

Small-Scale Poultry Production
For Saint Matthew's of Pomona Valley

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For Saint Matthew's Anglican School of Pomona Valley. Thank you for your willingness and for letting us develop this program for you. I hope that it will be of the utmost assistance and will serve as a fruitful way to combat food insecurity within the school community and the surrounding neighborhoods, and that it will provide a way to teach students about animal husbandry, thus providing them with skills that may keep the students in school through to high school completion.

Preface

This broiler production manual is the result of combined technical knowledge taught at the University of Arkansas Poultry Science Department with other poultry production manuals, including *Guide to Starting Your Own Poultry Business in Dangriga, Belize C.A.*, *Manual on Improved Best Practices in Rearing Free Range Chickens,* and *Backyard Poultry and Vegetable Garden Manual*. Although these manuals are great resources, each presented its own problems, whether they be bias, false information, or lack of sufficient technical information. This manual was written with its primary purpose being to assist the faculty members of Saint Matthew's of Pomona Valley to create and run an efficient and sustainable small-scale poultry production facility to provide nourishment in the school's canteen.

This manual provides step-by-step instructions for setting up a poultry house and maintaining a flock of dual-purpose birds, reared as layers and broilers. In this manual, the focus is a flock of 200 birds total, split between two houses, but numbers can easily be adjusted based on individual needs and desires. At the end of the manual, a list of resources, both local and abroad, is included, so that if any issues arise that are not directly addressed in the manual, there will be easy access to the appropriate assistance.

1. **INTRODUCTION**
    a. **Broilers Vs. Layers:** Broilers are chickens that are raised for meat production. These birds have been selected for the highest possible rates of feed conversion, making them the ideal candidates to efficiently provide nutrition to the school population. As broilers are used for meat consumption, the safest way to rear birds is in small pens with bedding rather than in cages, where their legs would become damaged. They require constant access to clean, safe feed and water for optimum performance and general animal welfare. In commercial operations, broilers are usually a cross between a Cornish hen and a White Plymouth Rock rooster, and are typically raised to six to eight weeks of age, depending on consumer preference. This also means that up to six flocks can be raised in one year, depending on the age of the birds at slaughter. Commercial Broilers have an excellent feed conversion ratio of about 1.6, meaning that for every 1.6 pounds of feed consumed, the bird gains one pound. Layers, on the other hand, have much longer productive lives, meaning that they are more susceptible to diseases. The commercial layer strain is typically White Leghorns, which are well adapted to living in cages. Layers are known for their high productivity rates, nearing almost an egg per day. This is in part due to greater knowledge of the birds' nutritional requirements, greater management, and genetic selection.
    b. This manual will be targeted toward rearing dual-purpose birds for meat and egg production, and for this task we aim to use a suitable dual-purpose breed, such as Barred Plymouth Rock, Rhode Island Red, or Leghorns, although the breed ultimately used at the school farm will depend upon its availability in Dangriga and/or ability to be shipped to the school.
2. **BUILDING DETAILS**
    a. **Determining Space Needed:** Before you can begin construction on your poultry house, it is important to rationally think about how many birds you will be able to properly care for. Seeing as the school has just above 300 members, including students and staff, it is reasonable to desire 100 birds as a starting point. The recommended stocking density for smaller birds is 0.67 square feet per bird. However, since we will be constructing an open-sided house, we would like to allot 1.5 square feet per bird to ensure proper air flow and to allow potential flock expansion. In this case, we will need a house that measures approximately 150 square feet (100 birds X 1.5 ft/bird). If there are any areas that the birds will not be able to access, such as the walls of the house and the space that equipment

takes up, that space will need to be subtracted from the area. Providing adequate space ensures that the birds will not trample over each other, that there will be adequate ventilation, birds will not become heat stressed, and that animal welfare will be maintained.

b. Small-Scale Housing Systems Options: In developing countries, it is often impractical and near impossible to use a commercial housing system, due to electricity problems, material availability, and construction costs. In such cases, it is important to carefully assess the needs of the individual farmer and compare those needs with small-scale housing options. Choosing the right type of housing for your flock can be a crucial aspect to flock success. No matter what type of housing is chosen, it is also important to consider building the house facing east and west, if possible, which will help keep the house cooler and reduce temperature variation throughout the day by eliminating as much direct sunlight as possible.

- **i. Open-sided houses:** This housing system employs houses that have open side-walls, which allows wind to provide the ventilation that is required to keep the birds healthy. In addition, the natural daylight in tropical regions is generally sufficient for the birds and artificial lighting is not required. These houses must have, at a minimum, chicken wire covering the windows so that birds cannot escape and predators cannot enter. The wire ought to have a covering of sorts, like curtains or shutters, so that the walls can be closed up in the case of a tropical storm, cold nights, or other conditions that could potentially harm the birds. If the curtains are closed, stir fans need to be used so that air will still be circulating and the birds will have access to fresh air and not become too hot.
- **ii. Free-Range:** This housing system is becoming increasingly popular and is seen as an option that increases the birds' overall wellbeing. Free-range systems allow the birds to freely roam within a fenced area. This option is relatively low-cost and requires minimal materials. However, birds are more susceptible to predation in this system because there is relatively no protection from predators. There is also a greater risk for disease spread from wild birds to domestic birds, or from other vectors such as rodents and insects.
- **iii. Hybrid:** This system combines characteristics from the free-range system and the open-sided system. The birds' primary location will be within the house, but birds have access to runs, or fenced areas, that allow them to go outside as they please. This option is a good middle-ground because the birds will have a safe shelter to stay in at night, but they are also allowed to forage and explore during the day, which makes this the option with the highest perceived overall animal wellbeing, although it also requires the most space and materials.

3. **MATERIALS NEEDED:**
    a. **Determining Needed Materials:** Purchasing the appropriate materials to construct your poultry house will present a large overhead cost, but this can be reduced greatly by gathering local or recycled materials, such as wood or bamboo, to use to construct the house. We will further discuss materials needed in detail in the next few sections.
        i. **Floors and Litter:** It is important that the house either has packed dirt flooring or concrete flooring, which will make cleaning the house between flocks easier. Litter goes on top of the floor to provide insulation, cushion for the birds, and to absorb moisture from drinkers and bird feces. In commercial operations, pine shavings or rice hulls are often used, depending on their availability in the area. When selecting a litter material, the three main criteria that the litter must meet are: a) locally available; b) absorbent; and c) safe. Examples of cost-effective litter materials that are available in Belize are wood shavings, chopped dried grasses, rice hulls, or even newspaper strips, although these do not wick away moisture as efficiently. Litter should be placed in a 5-10 centimeter deep layer to ensure adequate insulation, cushion, and moisture absorption.
        ii. **Slats for Droppings:** Although less common in pens than cages, housing can be built with slats on the floor to allow feces to pass through, which provides a cleaner environment for the birds. As long as an appropriate litter material is used and is properly cleaned, there is no need for slatted flooring.
        iii. **Roof**: Aside from protecting the house from direct sunlight and other weather conditions, the roof ought to be properly insulated, which will help keep the house cool when it is hot outside (and keeps the birds warm if it becomes too cold outside). The insulating material is measured in R-values, and the minimum insulation ideally should be 20 R. Examples of insulation include cellulose, fiberglass batting, and polyurethane foam. You must select the appropriate insulating material based upon availability, price, and effectiveness.
        iv. **Curtains**: When using open-sided housing systems, it is important to install curtains to help regulate house temperature. You must make sure that there are no holes or leaks, as this will result in improper ventilation and difficulty controlling temperature. A tarp is the minimum amount of coverage needed for curtains. An alternative to curtains is metal sheets, similar to what may be used as roofing. These sheets must have a pulley or manual system that allows them to be opened and closed.
    b. **Sample Materials List and Costs**: Based on the number of birds that we desire to raise and the size of house needed to do so, an example list of materials that will be needed, as well as the estimated quantity of each, cost, and where they can be purchased, has been included in the appendix at the end of this document. I

have also included page 286 from the Reimer's Feed Mill catalog (below) because it includes poultry equipment that will need to be purchased for the flock.

4. HOUSE MANAGEMENT

a. Litter Management: Litter quality is crucial for broiler production. If the litter becomes too wet, unhealthy levels of bacteria will grow and infect the birds, cause foot sores, and increase ammonia levels, thus potentially causing respiratory damage or eye burns. If the litter becomes too dry, dust particles can cause air quality issues and damage the birds' respiratory systems. For this reason, finding the proper balance of litter moisture is extremely important to the overall health and productivity of the birds. In general, the best litter material is wood shavings of some kind, as they are absorbent while also soft enough to provide bedding that will not damage the birds' paws.

b. **Ventilation:** Ventilation is the air movement through the house, which provides birds with fresh air, cools birds down when it is hot, and helps control litter moisture and ammonia content. Unlike humans, birds are unable to sweat, so the only way that they can control their body temperature is through panting, which adds moisture to the air. An adequate amount of ventilation is required to help birds maintain the appropriate body temperature so that they do not become heat-stressed, which is both a welfare issue and a hinderance to productivity. In summer months or when the birds are reaching maturity, commercial operations use tunnel ventilation, which employs a negative pressure system to ensure that the air is flowing at the appropriate rate throughout the house. These houses utilize a mixture of fans, air vents, and evaporative cooling cells to achieve the appropriate air flow. However, this type of ventilation system may not be achievable for small farms because of the high cost and electricity requirements. To combat this issue, open-sided housing is a popular choice for small farms or farms in developing countries. An easy way to change the amount of ventilation is by adjusting the side curtains to let in more air as needed. If natural ventilation will be used, a reflective roof is a good option, and it is recommended that the roof hangs 5 feet/1.5 meters past the sidewalls. In houses using natural ventilation, it is important to consider removing feed during the hottest portion of the day, which will keep birds cooler as they are not consuming and digesting feed, which produces metabolic heat.
    i. **Curtain ventilation**- During the first 14 days of life, the goal of curtain ventilation is not cooling the house, but rather air exchange and controlling the amount of CO_2 and ammonia in the air. To accomplish this, the curtains should be opened minimally. As the birds age, the curtains can be adjusted more to account for cooling the house and proper air flow.
    ii. **Consider stir fan installation**- Even in naturally ventilated houses, it is important to consider installing stir fans, which ensure air mixture and help maintain air quality and temperature. Fans do not need to be used during the first 14 days of life, but are beneficial thereafter.

c. **Lighting:** Lighting is important for bird activity and will influence how much the birds eat and drink, which impacts how well they grow. Furthermore, lighting directly corresponds to egg production, and hens will only lay eggs if they are receiving adequate photostimulation. The World Poultry Foundation recommends installing solar powered lighting if electricity is not dependable or readily available. Amount of lighting recommended also will change drastically as the birds grow. In commercial operations, lighting is almost universally controlled through the use of electricity. Small-scale operations, however, often rely on natural daylight. Layer programs would benefit substantially from supplemental lighting.
    i. **Lighting programs**- On the day that broiler chicks are placed in the house, they will need 24 hours of light to ensure that they can familiarize themselves with the house and be able to find feed and water. After the

first day, birds can be introduced to the dark period, which will gradually be increased as birds grow. Birds need at least six hours of darkness to ensure that their immune system will be able to function properly, among other important systems and bodily processes. This darkness allows the birds to rest, contributes to their welfare, reduces mortality, and increases flock uniformity. In an open sided house with curtains, lighting can be controlled by opening and closing the curtains to provide the appropriate amount of natural daylight. Below are a few examples of lighting programs used for Cobb broilers, according to desired finished weight (Cobb-Vantress, 2021, page 42).

Standard Lighting program - Option 1

Slaughter weight: <2.5 kg (5.5 lb)

Age (days)	Hours of dark
0	0
1	1
130 to 180 g	6
Five days before processing	5
Four days before processing	4
Three days before processing	3
Two days before processing	2
One day before processing	1

Standard Lighting program - Option 2

Slaughter weight: <2.5 kg (5.5 lb)

Age (days)	Hours of dark
0	0
1	1
130 to 180 g	6
21	5
28	4
35	3
Two days before processing	2
One day before processing	1

Standard Lighting program - Option 3

Slaughter weight: 2.5 kg to 3.0 kg (5.5 to 6.6 lb)

Age (days)	Hours of dark
0	0
1	1
130 to 180 g	8
21	7
28	6
35	5
42	4
49	3
Three days before processing	3
Two days before processing	2
One day before processing	1

Standard Lighting program - Option 4

Slaughter weight: >3.0 kg (6.6 lb)

Age (days)	Hours of dark
0	0
1	1
130 to 180 g	10
22	9
28	8
35	7
42	6
49	5
Five days before processing	5
Four day before processing	4
Three days before processing	3
Two days before processing	2
One day before processing	1

Pullets, or layer chicks, have similar needs throughout the brooding and growing phases, but require a longer photoperiod (more light) as they reach sexual maturity and begin laying eggs. As light stimulates egg production, supplemental lighting is extremely useful. Below are two options for lighting programs for layers from the Poultry Site (Winchell, 2005).

Lighting Options	Flock Age		Light Intensity lux (foot-candles)	Photo Period (hours of light per day)
Option 1	**Pullets**			
	Brooding	(1 - 3 days)	20 (2)	23
	Growing	(4 days - 19 weeks)	5 (0.5)	9 to 11
	Laying	(20 - 72 weeks)	10 - 30 (1 - 3)	Increase by ½ hour per week to maximum of 16 - 17 hours.
Option 2	**Pullets**			
	Brooding	(1 - 3 days)	20 (2)	23
	Growing:	(4 days - 2 weeks)	5 (0.5)	23
		(2 - 3 weeks)	5 (0.5)	21
		(3 - 4 weeks)	5 (0.5)	19
		(4 - 5 weeks)	5 (0.5)	17
		(5 - 6 weeks)	5 (0.5)	15
		(6 - 7 weeks)	5 (0.5)	13
		(8 - 9 weeks)	5 (0.5)	11
		(9 - 20 weeks)	5 (0.5)	11
	Laying	(20 - 72 weeks)	10 - 30 (1 - 3)	Increase by ½ hour per week to maximum of 16 - 17 hours.

ii. **Light intensity**- In commercial operations, the goal is to have a light intensity of 25 lux at chick height in the darkest section of the house, which is then decreased gradually after the first week of life to approximately 5-10 lux. This allows chicks to become familiar with the house, find food and water, and results in proper development during the most crucial phase of their life. The decreased lighting later in life helps keep the birds calm. In addition, research suggests that birds are able to see a different portion of the light spectrum than humans can, meaning this darker lighting is still sufficient for them to adequately see.

iii. **Light sources**- There are many common lighting sources to choose from, although all may not be available in the small grower setting. Examples of light bulbs requiring electricity are LED bulbs, fluorescent bulbs or tubes, incandescent bulbs, or halogen bulbs. Although these may not be available in areas where electricity is not reliable, some may be available with solar power. If this is not a feasible option, you can rely on natural lighting if you have an open sided house, although it is recommended that you install lighting to use in case of a storm or prolonged darkness. If the birds are not in a lit environment, they will perceive night, and will sleep rather than eat, drink, grow, and exhibit other natural behaviors.

d. Temperature and Humidity: During the first few days of life, chicks are poikilotherms, which means that they cannot regulate their own body temperature and are extremely sensitive to any environmental changes. For this reason, it is important to ensure that the house is at the proper temperature (33°C) at chick level before the chicks arrive (see “Brooding and Temperature Schedule” section below). After this initial period, it is important to maintain building temperature and humidity for a variety of reasons, including to uphold litter and air quality, to ensure that the birds are comfortable in their environment, and to keep the birds healthy so that they can optimally grow.

Heat will need to be provided to the birds during this sensitive time period and in the event of cooler than normal weather. Charcoal units or infrared lamps can be used to warm the birds, depending on dependability of electricity.

5. **INCUBATION AND BROODING** As we will be purchasing chicks rather than hatching our own, this section is purely informational and will not relate to the school farm.
    a. **Collecting Eggs for Hatching:** When collecting eggs to be used for hatching, eggs are inspected to ensure that there is not excess foreign material and that the eggs are not cracked or damaged in any way. Eggs can be candled to determine if they are fertile. If they are fertile, they will appear red or you may be able to see a blood spot. If eggs are infertile, blood will not be visible and you will just see the dark yolk and the air sac at the wide end of the egg.
    b. **Egg Storage:** Commercially, eggs are often stored in cooling rooms below 60°F (generally 53-59°F), as this pauses the embryonic development. Once a sufficient number of fertile eggs has been collected, eggs can be transferred to the incubator, where the environment will be controlled to ensure proper growing conditions for the embryo. This ensures that the eggs will not be at different stages of development, which would cause issues during incubation and hatching.
    c. **Incubation:** Eggs generally remain in the incubator for 18 days, in which all of the organs and external structures are formed. During incubation, temperature is held at 100.5°F and relative humidity is held at 50-55%. Eggs are turned, manually or automatically, every few hours to ensure the chick does not stick to the egg, which could cause deformities. There are various types of incubators that can be purchased, so it is important to select one that meets the needs of the flock. For example, some are more mechanized and are larger to accommodate commercial operations.
    d. **Hatching:** On day 18, eggs are often transferred to hatchers, which are still climate controlled. Temperature in the hatcher is generally 98-98.5°F. Hatchers, however, do not utilize the turning mechanism and have a solid or slatted bottom that the chicks will be able to walk on. It is important to monitor the hatcher, as you do not want the chicks that hatch first to spend too much time in this environment, as they may become dehydrated. Likewise, some chicks may hatch more than 24 hours later, which could lead to other problems as well, or they may not dry properly before being removed from the hatcher.
    e. **Brooding:** The term *brooding* refers to the period of time during the first week of a chick's life, in which the bird is extremely responsive to environmental changes and must be kept warm to foster growth. There are several options for brooding, including whole house brooding, partial house brooding, and brooding chambers. As brooding chambers are most common in curtain-sided housing, that is what this section will focus on. In each of these systems, monitoring temperature at bird level is crucial.
        i. **Whole house brooding-** In whole house brooding, the entire house is heated and prepared for chick arrival. This method uses more energy, and you must ensure that the heat is uniformly distributed throughout the house. This option is well-suited for houses that have solid side walls and are well insulated.

ii. **Partial house brooding**- Partial house brooding reduces the amount of energy required to heat the house, as birds only have access to a portion of the house and the other parts of the house are blocked off by curtains or fences.

iii. **Brooding chambers-** Brooding chambers are more practical for houses that are poorly insulated, such as curtain-sided housing. These brooders often consist of a cardboard ring around the birds, which keeps them confined to the specific area that will be heated and prepared appropriately for chicks. Feeders and waterers are placed inside of the ring and there is a heat lamp above the ring.

f. **Characteristics of Healthy Chicks:** Chicks should be monitored closely in the first few hours following placement. Chicks should be observed eating, drinking, playing, and sleeping in roughly the same distribution. Healthy chicks will appear alert and will have fluffy, dry down feathers; bright, round eyes that respond to stimuli; healed navels; bright, waxy legs that do not appear red or injured; and will be without deformities. Below is a picture of what a healthy chick should look like. Note that the chick in this picture meets all of the characteristics of healthy chicks that were mentioned above. In the appendix, there is a chart that shows characteristics of healthy and unhealthy chicks that can be used to evaluate your chicks upon arrival. If chicks have major deformities, they must be humanely culled.

g. **Brooding and Temperature Schedule:** Chicks should be checked two hours after placement to ensure that they are properly distributed throughout the house and have acclimated to the environment. Birds should be observed spread out throughout the entire brooding ring, which means that the temperature is comfortable for the birds. If the birds huddle underneath the brooder, it is too cold and the temperature and/or height of the brooder should be adjusted. If the birds are lining the edge of the brooding ring, the temperature is too hot and should be

adjusted, or the brooder should be raised. If birds are huddled on one side, there may be a draft. An easy way to check the chick's temperature is to place their feet against your cheek. If their paws are cold, the house is too cold, and likewise, if their paws are hot, the house is too hot. Placing a thermometer at chick level is a small step that will make monitoring the flock much easier, as well as providing a way to quickly check if the temperature is appropriate. When the birds are placed, temperature in the house must be at least 84°F, while the brooding area must be between 90°F and 94°F, although up to 100°F is also acceptable. House temperature should be decreased by 4°F each week until it reaches normal day temperature.

6. **FEED QUALITY**
    a. **Nutritional Requirements:** The six classes of nutrients are protein, carbohydrates, fat or energy, vitamins, minerals, and water. Chickens, like many other living organisms, require a balanced diet comprised of the appropriate amounts of nutrients from each of these categories. Birds are typically fed at least three different diets throughout their lifetime, which ensures that the nutrient requirements are met at each stage of life for optimum growth and performance. The three diets used for broilers are Broiler Starter, Broiler Grower, and Broiler Finisher, all of which can be purchased at Reimer's Feed Mill. The Starter feed costs $3.65 for a five-pound bag; Grower feed costs $25.45 for a 50-pound bag; Finisher feed costs $22.75 for a 50-pound bag. Starter feed is nutrient-dense and is typically fed to birds from the day of hatch to two weeks of age. This feed is specifically designed to provide chicks with the required nutrients for growth and skeletal development, as the first few weeks of life are extremely important and set the pace for the rest of the birds' lives. This feed is often more expensive, as it contains more micronutrients, but is vital to the overall performance and health of the birds. Birds are then switched to the Grower diet from three weeks to five weeks of age, which contains more protein and less fat than starter diets. This ensures that the birds produce lean muscle rather than fat. Finally, the birds are switched to Finisher feed for the rest of the production period. This diet is cheaper than the other diets since it contains less nutrients, although birds will eat more of this diet than the other two formulations. Similarly, laying hens are fed three different diets throughout their lifespan as well, for the same reasons. Layer diets are rich in nutrients such as calcium, which are crucial for egg production. These feeds also can be purchased at Reimer's Feed Mill.
    b. **Feeder Space:** It is important to provide enough feeders so that each bird has equal opportunity to access the feed. The recommended feeder space per bird is 1.0 – 2.75 inches per bird. So for 100 birds, between 100 and 275 inches of feeder space is required. The same amount of space is required for drinkers. A typical round feeder with 22-pound capacity will have a circumference of 52.6 inches, while 3-gallon drinkers typically measure 40.8 inches. With that being said, about five feeders and six drinkers per house would be required to meet the needs of our

flock. It is important to measure the dimensions of the selected feeders and drinkers, as they may vary between stores.

c. **Feeder Height:** Feeders should be level with birds' backs. To accomplish this, a system of adjustable feeders should be used. In commercial operations, equipment is used that can adjust the feeders to the programmed height, but in the small-scale setting, feeders will be manually adjusted. Chains may be attached to the ceiling of the house using strong carabiner clips, which may be raised as the birds grow.
d. **Importance of Constant Access to Feed:** As this manual is focused on raising broilers, it is of the utmost importance that the birds are fed *ad libidum,* meaning that they have constant access to feed. To ensure that the birds never run out of food, feeders should be checked at least twice a day—at morning and evening. Layers, however, are often fed rations that are measured out to ensure that birds receive the appropriate amount of feed and do not overconsume, which could negatively impact egg production. Layer operations often feed the birds once or twice per day.
e. **Feed-Conversion Ratio:** Feed-Conversion Ratio (abbreviated "FCR") is used to determine how effectively the birds convert feed into body mass. Currently, commercial broilers have a FCR of approximately 1.6, meaning that for every 1.6 pounds of feed consumed, the bird will gain 1 pound of weight.
f. **Feed Safety:** It is important to monitor the quality of the feed and ensure that it has not gotten wet or been contaminated by pests or rodents. If the feed gets wet, it must be thrown out, as wet feed can grow mold, which is an aflatoxin that can cause severe respiratory disease in the birds. If pests have gotten into the feed, that is a biosecurity risk because they could have come in contact with other birds or could be serving as a vector for various pathogens. For this reason, it is important to ensure that the feed is properly stored and that feeders are being checked on a daily basis.
g. **Feed Storage:** As previously mentioned, the safety of the feed is important, which means that feed storage is also crucial. Feed must be stored somewhere dry that is also not accessible by rodents or pests. Examples of sufficient storage include metal trashcans, which have lids that tightly seal and prevent water or pests from contaminating the feed source. Only one bag of feed should be opened at a time, to keep the feed as fresh as possible and ensure that older feed is getting used first. Unopened bags of feed should be stored off of the ground, for example, on a shelf or stacked on top of cinder blocks.

7. WATER QUALITY

a. **Importance of Water:** The effect of water and water quality has been studied immensely, and it has been found that birds drink an average of twice as much water as they eat. Much like humans, birds are picky with the water that they drink, as a subtle change in taste or temperature can deter the birds from drinking, and in turn, the birds will not eat nor grow. For example, if there are increased levels of iron or manganese, birds perceive an unpleasant bitter taste that leads to

reduced water consumption. Birds prefer to drink water that is between 50-55°F. It is also important to ensure that water is filtered and free from microbial contamination, as there are many water-borne diseases that have adverse effects on bird health. A water filter with a 40-50 micron mesh will adequately filter out most problematic microbes as long as it is cleaned weekly and properly maintained, although these filters may not be affordable or available for small farms. The table below shows average daily water consumption in gallons for 100 birds, depending on age and weather (University of Kentucky Agricultural Extension). Rows related to broilers and layers are highlighted, as that is the most relevant information for this flock. This table shows the importance of having access to clean water, as mature birds drink large quantities of water, especially in hot weather.

Type of poultry	Normal ambient temperature (68°F/20°C)		Hot weather (89.6°F/32°C)
	Average (growing)	Mature birds	Mature birds
Layer pullets	2.64	3.43	5.28
Breeder pullets	3.17	4.23	6.60
Layer hens		5.55	10.57
Broiler breeders		7.93	15.85
Broiler chickens	4.23	6.60	13.21
Roaster chickens	5.28	7.93	15.85
Broiler turkey	7.66	14.27	26.42
Heavy female turkeys	10.04	16.91	31.70
Heavy male turkeys	14.53	26.42	47.55

b. **Biologic Information:** Similarly to humans, water is crucial for nearly all of the bird's metabolic processes, such as digestion, respiration, and temperature regulation. Furthermore, 68-76% of a bird's body is water. If birds do not have access to clean water, birds will stop eating, which will negatively impact growth and performance.

c. **Watering Systems:** There are many factors that must be considered when selecting the type of watering system for your house, such as cost, cleanliness, and accessibility.

   i. **Bell Drinkers**- These drinkers are often more affordable, but can leak more than other options and lead to litter quality issues. As these drinkers are open and the water is exposed to the environment, it is easy for the birds to contaminate the drinkers with feed, litter, and waste, and the drinkers must be cleaned daily to prevent illnesses. Although bell drinkers become dirty faster than water lines, they are much easier to clean and

require less technology to do so. It is recommended that there is at least one-quarter inch of space per bird to drink, although we will provide our flock with 1.0-2.75 inches of space per bird, just like feeder space, to ensure they have sufficient access. Bell drinkers should be installed level with the bird's back, and it is suggested to install the drinkers from lines that can be adjusted as the birds grow. Bell drinkers can be filled by hand each day as needed.

ii. **Nipple Systems**- Nipple drinkers are more costly, as they require more equipment such as a pump system to ensure adequate water flow. These drinkers create a drop of water at the nipple which draws the bird's attention. Nipple systems should be installed above the bird's beak level and there should be 10-12 birds per nipple. These lines also must be installed in a way that can be adjusted as the birds grow. Although these lines will not need to be cleaned daily, they will need to be thoroughly cleaned between flocks, as a biofilm may build up inside of the lines, which can lead to infection and sickness. Nipple systems also need to be monitored to ensure that all nipples are working. Some nipple systems may be equipped with cups or trays below the nipples to collect water that leaks out and provide birds with an alternate place to drink from.

d. **Washing and Sanitizing Drinkers:** Bell drinkers are slightly easier to sanitize than water lines with nipples, as it is easier to access every surface and bell drinkers can easily be disassembled. Drinkers ought to be cleaned thoroughly with water and mild soap each time they are filled or if there is noticeable buildup of algae, litter, or other waste. Furthermore, the drinkers should be sanitized at least once a week, or more often if needed. Plastic drinkers can be sanitized using a solution of apple cider vinegar or liquid bleach and water. Each solution should be made of 1 tablespoon of cleaning agents per 1 gallon of clean water.

e. **Testing Water:** As a general rule of thumb, water should be tested if the color or odor changes, if it has recently flooded near the water source, if water pressure becomes significantly lower, or if birds have been diagnosed with a water-borne disease. Along with testing for microbial contamination, it is important to monitor pH, as birds are sensitive to pH and often will not drink water above a pH of 8.0, as it tastes bitter. The table below gives the maximum acceptable levels of several water quality factors that must be monitored (Cobb-Vantress, 2021, page 51). A previous study found that water from the Rio Bravo Conservation Area in Belize in 2009 had no significant contaminants that would harm humans, although the phosphorus levels were high, they were within safe levels (Rostocil, 2009). It was also determined that the water was hard, although these minerals do not cause issues in poultry.

i. If the water test provides unsatisfactory bacterial counts, chlorine or hydrogen peroxide may be added to the water. A **Chlorine ORP meter** can be used to measure the amount of chlorine in the water, and 700-750

is sufficient to kill bacteria. Some ORP meters also measure pH. Alternatively, chlorine test strips could be used.

ii. If it is determined that chlorine will need to be used to control bacterial levels, a 15-gallon barrel could be used to mix the bleach each morning. The maximum acceptable level of bleach is four ounces per gallon of water. If necessary, juice from citrus fruits (limes/lemons) can also be added to the water to further decrease the pH, as a pH under six works best for bleach to efficiently kill bacteria.

Contaminant, mineral or ion	Level Considered Average	Maximum Acceptable Level	Comments and Treatments
Bacteria Total bacteria	0 CFU/ml	100 CFU/ml	Total Bacteria is an indicator of system cleanliness, high numbers do not indicate harmful bacteria are present but it increases the risk of pathogenic organisms. High bacteria levels can impact taste of water resulting in reduced consumption by birds.
Coliform bacteria	0 CFU/ml	0 CFU/ml	Presence of any fecal coliform means water is unfit for consumption by poultry or humans.
Acidity (pH)	6.8 to 7.5	7.6	pH below 5 can be harmful to drinker equipment by causing corrosion to metal components (long term exposure). pH above 8 impacts the effectiveness of water sanitizers and is also associated with high alkalinity which may cause reduced water consumption in poultry due to "bitter" taste.
Total hardness (Ca and Mg)	60 to 180 mg/L	See comments	Hardness causes scale which can reduce pipe volume and make drinkers hard to trigger or leak. Hardness of water is classified as follows: 0 to 60 mg/L - soft water; 61 to 120 mg/L - moderately hard water; 121 to 180 mg/L - hard; and >180 mg/L - very hard.
Naturally occurring elements Calcium (Ca)	60 mg/L	N/A	No upper limit for calcium, birds are very tolerant of calcium. If values are above 110 mg/l may require water softener, polyphosphates or acidifier to prevent scaling.
Chloride (Cl)	14 mg/L	250 mg/L	When combined with high sodium levels, creates saline water that can act as a laxative causing flushing. Salty water can promote the growth of *Enterococci* which may cause enteric issues. Saline water can damage reproductive tract in breeder birds causing shell quality issues. Treatment- reverse osmosis, lower dietary salt levels, blending with non-saline water. Keep water clean and use daily sanitizers such as hydrogen peroxide or iodine to prevent microbial growth.
Copper (Cu)	0.002 mg/L	0.6 mg/L	
Iron (Fe)	0.2 mg/L	0.3 mg/L	Birds tolerant of iron metallic taste but high iron causes leaking drinkers and promotes the growth of *E. coli* and *Pseudomonas*. Treatment includes oxidation with chlorine, chlorine dioxide or ozone followed by filtration.
Lead (Pb)	0	0.02 mg/L	Long term exposure can cause weak bones and fertility problems in breeders.
Magnesium (Mg)	14 mg/L	125 mg/L	Higher levels of Mg may cause flushing due to laxative effect particularly if high sulfate levels are present.
Manganese (Mn)	0.01 mg/L	0.05 mg/L	Can cause black grainy residue on filters and drinkers. Manganese can promote bacterial growth. In the bird, manganese may interfere with copper uptake and utilization. Treatment includes oxidation with chlorine, chlorine dioxide or ozone at a pH of 8 followed by filtration. Green sand filtration is an option.
Nitrate	10 mg/L	25 mg/L	If nitrates convert to nitrites, poor growth and feed conversion can occur due to the nitrites binding blood hemoglobin. Presence of nitrates may indicate fecal contamination so also test for bacteria. Can be removed with reverse osmosis.
Sodium (Na)	32 mg/L	50 mg/L	When combined with high chloride levels, creates saline water that can act as a laxative causing flushing. Salty water can promote the growth of *Enterococci* which may cause enteric issues. Saline water can damage reproductive tract in breeder birds causing shell quality issues. Treatment- reverse osmosis, lower dietary salt levels, blending with non-saline water. Keep water clean and use daily sanitizers such as hydrogen peroxide or iodine to prevent microbial growth.
Sulfate	125 mg/L	250 mg/L	Sulfates can cause flushing in birds. If rotten egg odor present in water, then hydrogen sulfide producing bacteria are present and system will require shock chlorination as well as the establishment of good daily water sanitation program. Sulfates can be removed by aerating water into a holding tank, treatment with hydrogen peroxide, chlorine or chlorine dioxide then filtration. With elevated sulfate levels, hydrogen peroxide is preferred since it requires an almost 2 to 1 ratio of sanitizer to sulfate for oxidation.
Zinc	N/A	1.5 mg/L	No known issues.

f. Water Medications: Many medications can be administered through the water, such as Amprolium for Coccidiosis and Tetracyclines or Norfloxacin for Fowl Cholera. Administering medications through water is less labor intensive than vaccination, as well as being available for more diseases. When adding medications to the water, it is crucial to follow supplier instructions and correctly dilute the dosage.

g. **Minerals in Water:** Certain minerals can be toxic to the birds if they are consumed in quantities above healthy levels. Birds not only consume minerals through the feed, but also through the water, which could potentially cause problems. Total Dissolved Solids (TDS) can be measured in water, with levels

under 1000 ppm being considered perfectly safe, and levels under 3,000 ppm being safe but potentially leading to watery droppings. It is important to also check the water for minerals such as zinc, mercury and lead which can become toxic for the birds. Minerals such as iron and copper can produce an unpleasant taste and odor if they are present in high concentrations in the water.

8. **BIOSECURITY**
    a. **Definition and Importance:** Biosecurity is defined as "procedures intended to protect humans or animals against disease or harmful biological agents." Biosecurity is of the utmost importance when raising birds, as it ensures that the birds are safe, healthy, and able to grow without any disease challenges.
    b. **Downtime Between Flocks:** A downtime of at least 7-10 days is recommended between flocks, although two weeks is encouraged. This time allows for cleaning, sanitation, and the reduction of the bacterial load. This will ensure that the growth of the next flock is not hindered by any pathogens that were present in the previous flock.
    c. **Signage:** To help ensure that proper biosecurity practices are followed, signs should be placed around the farm and by the entrance. Some examples of signage noting bio-secure practices will be attached in the appendix.
    d. **Footbaths:** Footbaths are disinfectants that are stepped in before entering a poultry facility. They should be placed at the entrance of the poultry house to ensure that any potential contaminants will not be transmitted between different flocks. Remember- footbaths are chemicals that are dangerous to the birds and should not be placed where birds will have access. A common ingredient for footbaths is bleach, although plastic booties are an alternative. These booties can become costly and are not environmentally friendly. To use bleach as a footbath, it should be diluted to 1% sodium hypochlorite to maintain safe levels that still sanitize effectively.
    e. **Designated Farm Clothing:** The safest option is to use disposable suits and plastic booties each time you enter the farm, but another alternative is to have clean clothes and a designated pair of boots and that are for farm-use only. However, these disposable suits should still be available for guests to use.
    f. **Guest Log:** Everyone who enters the farm should write their name and number in a guest log, which should be placed at the entrance. In the case of a disease outbreak, the log will allow you to track down the source of the infection and warn other visitors that have been in contact with the flock when it potentially was infected but not yet showing signs. A template for a guest log is included in the appendix.
    g. **Controlling Traffic:** It is important to limit the number of guests that are allowed onto the farm property and to ensure that each guest has not been around any other poultry species for 72 hours. Furthermore, poultry houses ought to be at least 65 feet (20 meters) away from existing poultry facilities to reduce the spread of pathogenic organisms. It is also important to consider placing a lock on the door of the barn, which will prevent unwanted visitors and theft. Ideally, a fence

can be constructed around the entirety of the poultry farm to further reduce unwanted visitors and potential theft.

9. DISEASES

a. **Causes of Diseases:** The three most common diseases etiologies, or causes, are bacteria, viruses, and fungi. Each agent has its own set of signs that can help lead to diagnosis. For example, bacterial diseases are characterized by pus and petechial hemorrhages due to the endotoxins and exotoxins that the bacteria secrete. On the other hand, you will never find pus or hemorrhage by a simple viral infection unless it has been complicated by a bacterial secondary infection.

b. **Treatment for Diseases**: Diseases caused by bacteria may be treated using antibiotics, assuming that the pathogen responsible for the disease has not developed resistance to available antibiotics. Antibiotics are not transmitted through the poultry meat to consumers, so long as the recommended withdrawal period has been followed. Furthermore, hormones and antibiotics are not administered to poultry for growth reasons—hormones are never added for any reason, while antibiotics are only used to treat the birds when they are sick. Viruses cannot be treated with antibiotics, so prevention is usually the focus, which can be achieved through vaccination and proper biosecurity measures. Coccidiostats, or medicine to treat coccidiosis, may be administered through the water. Dewormers are commonly injected, administered topically, or given orally.

10. VACCINATION

a. **Vaccination Program:** Raising a healthy flock begins with having an effective vaccination program in place. Vaccines provide the birds with either living or killed organisms that protect the birds from future illness caused by those organisms. Vaccines may be administered inovo (into the egg), subcutaneously (into the neck or muscle of the chick), or orally (generally through a powder sprayed onto the chicks, which they then peck off of each other). A typical vaccination program includes two to three rounds of vaccinations. This ensures that both the chicks with strong maternal immunity and those with weak maternal immunity build up immunity to the targeted pathogen, whether that be a virus or a bacterium. Only trained individuals should administer vaccines, and all instructions should be followed.

b. **Common Diseases in Belize:** Newcastle, Fowl Cholera, and Marek's Disease are common in poultry in Belize. Vaccines for Newcastle disease are available from the Agriculture Department, BAHA, and BPA. Medications such as Tetracyclines or Norfloxacin may be administered through the water to treat Fowl Cholera, but vaccines are also available. There is no treatment for Marek's disease, as it is caused by a retrovirus, so prevention is the only option. Commercially, chicks are often vaccinated inovo, or while they are in the eggs before hatching.

11. SIGNS TO WATCH FOR IN YOUR FLOCK

a. **Monitoring the Flock:** A good flock manager should spend time simply observing the flock each day. They will then become familiar with the normal behaviors of the flock and will likely be able to spot abnormal behaviors, which

could end up saving the flock. Some signs may be less obvious than others, so a few common indicators of disease are described below. Record keeping will be discussed later, and this will also help you identify any changes that may be potential signs of disease. If you notice any of the following signs in your flock, it is recommended that you call a veterinarian or someone from the Ministry of Agriculture immediately so that you may prevent your flock from as much loss as possible.

i. **Drop in Feed Consumption:** When birds are sick, they may become anorexic and not feel like eating. Chickens, especially broilers, enjoy eating and make multiple visits to the feeder per day, so it is generally a cause of concern if the birds do not want to eat. You may notice that birds are not spending time at the feeders, or when you fill up the feeders, you may notice that there is more food leftover than normal.
ii. **Change in Water Consumption:** If you notice a decrease in water consumption, it is possible that the birds are sick. Conversely, if birds begin excessively drinking, it may be due to increased stress or an infection.
iii. **Sneezing/Rales/Dirty Shoulders:** These signs indicate that the flock is suffering from a respiratory disease. If the birds have excess mucus and drainage, they will often rub their beaks against their wings, like little kids rub their runny noses. The mucus on the wings sticks to dust and litter, thus giving the shoulders a dirty appearance. Although sneezing can be normal if the litter is dusty, the flock should be monitored if sneezing persists.
iv. **Diarrhea:** Diarrhea can be caused by a variety of pathogens, such as *E. coli* and *Campylobacter jejuni*. If not properly treated, diarrhea can lead to dehydration, as well as causing litter quality issues. Furthermore, if the birds have diarrhea, they are not properly absorbing nutrients, which will lead to decreased productivity.
v. **Increase in Mortality:** Each day, the flock manager must pick up the dead birds and record the number that died. If there is a sharp increase in mortality, this could point to a disease within the flock.

12. PROCESSING

a. Processing the birds to produce edible meat is a process that must be handled with care. In addition, birds must be treated with respect. Slaughter must be done quickly and efficiently to ensure that the birds do not feel pain. Feed must be taken away from the birds approximately 8 hours before slaughter to ensure that their digestive tract will not contain any feces when processing begins, which would contaminate the meat. In commercial operations, birds are hung upside down on shackles, where their heads then go through a water bath with an electric current. This stuns the birds and renders them unconscious so that they do not feel pain. After this, each bird's jugular vein in the neck is cut so that the blood can drain from the carcass. Carcasses then go through a hot water tank in a process

called scalding. Scalding softens the feathers, which makes removing the feathers in the next step easier. After feathers are removed, birds' necks and paws are cut off, then the organs are removed carefully to avoid contamination. While some organs can be washed and kept for later consumption, the gall bladder is full of bile, which contains bacteria and stinks, so care must be used not to rupture it. Carcasses then should go through a chilling process to lower their temperature to below 44 degrees Fahrenheit to reduce bacterial load and keep the meat safe for consumption. The most common methods for chilling are with air or with water tanks. After reaching the appropriate temperature, carcasses are ready to be deboned or cooked.

b. For the purposes of this flock, the school has reached an agreement with the Agricultural and Natural Resources Institute (ARNI), so processing will be handled by those associated with this vocational school.

13. OTHER IMPORTANT CONSIDERATIONS

a. Record Keeping: Record keeping is an important aspect of any poultry operation, despite its size. Accurate records allow the manager to keep track of feed conversion and flock efficiency, feed and water consumption, flock uniformity, and many other important factors, including finances. Records also allow the manager to make informed decisions that are crucial to the health of the flock. By monitoring changes in feed consumption and flock productivity, for example, diseases can be easily detected. By monitoring the amount of water consumed, the manager can determine how much water the flock typically consumes so that the proper amount will always be available and because decreases in water consumption can point to various health issues within the flock. Vaccinations should be recorded, including the type of vaccine, date administered, expiration date, cost, and route of administering the vaccine. If there is a disease outbreak, you should record dates that birds were sick, medicine given, mortality, and any signs that you notice of the disease. Sample record sheets are included in the appendix which may be used or adjusted to meet the needs of your flock. Printed record sheets will also be given in a binder once the house is built.

14. RESOURCES:

a. Locally:

i. Belize Poultry Association: (501) 822-3221 | belizepoultry@yahoo.com | https://www.belizepoultry.com/

ii. Reimer's Feed Mill: (501) 823-0105 | sales@reimersfeed.com | http://www.reimersfeed.net/

b. Abroad:

i. University of Arkansas System Division of Agriculture: +1(501) 686-2500 | division.uaex.edu

ii. Cobb Broiler Management Guide: https://www.cobb-vantress.com/assets/Cobb-Files/045bdc8f45/Broiler-Guide-2021-min.pdf

iii. World Poultry Foundation Training Videos: http://worldpoultryfoundation.org/videos/

15. CONCLUSION

a. Although starting your own poultry farm may be a daunting task, this manual will serve as a baseline to provide you with the necessary information to do so. Remember that the bird's health and well-being are of the utmost priority and must be ensured throughout the entire process. Spending time observing your flock is an invaluable tool that will allow you to understand their normal behaviors, so that if there is any deviation you will be aware and able to take the appropriate steps to heal the flock before it is too late.

INSTRUCTIONS FOR STARTING THE FARM

1. Constructing the house:

a. Gather all of the building materials (see list in the appendix).

b. Gather necessary equipment such as feeders, drinkers, brooding rings, thermometers, etc.

c. Measure the designated area for the flock (8' X 25') and begin digging up or tilling this area. We want to create a flat surface, as well as having dirt to create the packed dirt flooring. Additional bags of dirt can be purchased if necessary.

d. Dig a trench along the perimeter of the marked area. It should be 6 inches deep, or the height of one cinderblock.

e. Place cinderblocks all along the trench. This step will provide stability, as well as making it more difficult for predators to dig under the house and enter.

f. Three to four layers of cinder blocks can then be added on top of the base. Concrete or grout will be needed to secure the blocks and prevent pests from entering. Rebar can also be placed through the cinderblocks to provide additional stability to the structure of the house.

g. 2X4 wood planks should then be nailed along the top of the concrete to provide stability for the remaining wood structure.

h. Wooden 4X4 planks can then be nailed into the 2X4 at each of the four corners, as well as every 5 feet along the side walls of the house to provide additional support. Thick local wood logs could be used in place of the 4X4s. These planks should be 7 - 10 feet tall.

i. Add 4X4s along the top perimeter of the building.

j. After the wooden supports are secured, chicken wire may be secured around the length of the building using nails or a staple gun to secure it to the bottom 2X4

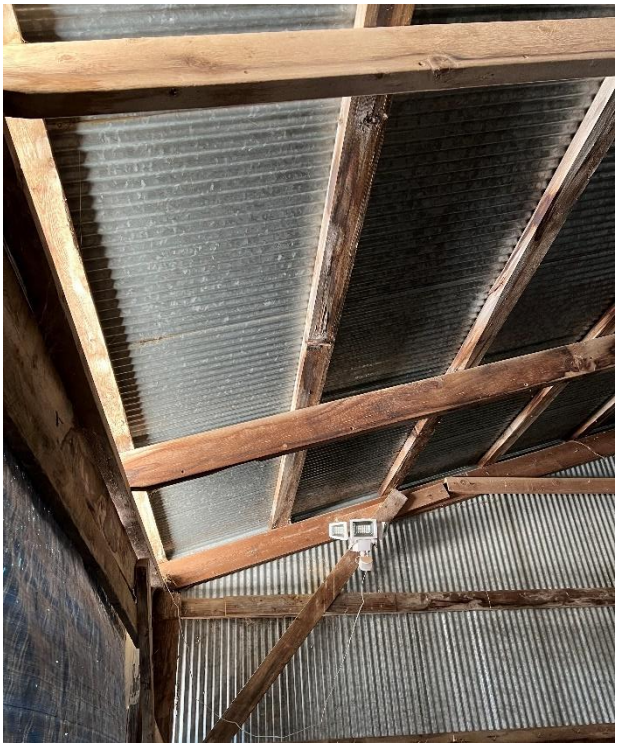
and the 4x4 support beams. It will likely take two layers of chicken wire to cover the entire height of the walls. Be sure to not leave any gaps where birds could escape or predators could enter.

k. For the short side wall opposite of the door, screw metal sheeting (like what was used for the roof) into the wooden support beams.
l. To build the door, take two 2X4s and nail 3' long 2X4s to the top, middle and bottom of the 2X4s to connect them and form the door. Then staple chicken wire (or metal sheeting) on one side of the door. Below is an example of a simple door.


m. For the short side wall with the door, measure the width of the door and then nail a 2X4 the appropriate distance from the left support beam to attach the door to. Attach the door using hinges at the top and bottom of the door. On the right edge of the door, screw a latch into place. The latch must be able to lock. Use chicken wire or metal sheeting, depending on your preference, to enclose the remainder of the side wall.
n. The typical roof slope of a conventional house is 4:12 – 9:12. As the width of our house is 8 feet, we would want about a 2.5-foot peak. Using Pythagorean theorem, we can determine the roof needs to be about 8.38 feet long. However, we must leave wooden overhangs of 1.5 feet on each side to provide additional shade and to attach the pulley system. With the roof height calculated above (8.38 feet) plus the 3 feet of overhangs, we now need a roof that is 11.38 feet wide.
o. Take a 2X4 that measures 2 feet long and nail it to one corner of the top of the building. Repeat this step in 5-foot increments, to match the support beams, along the length of the house.

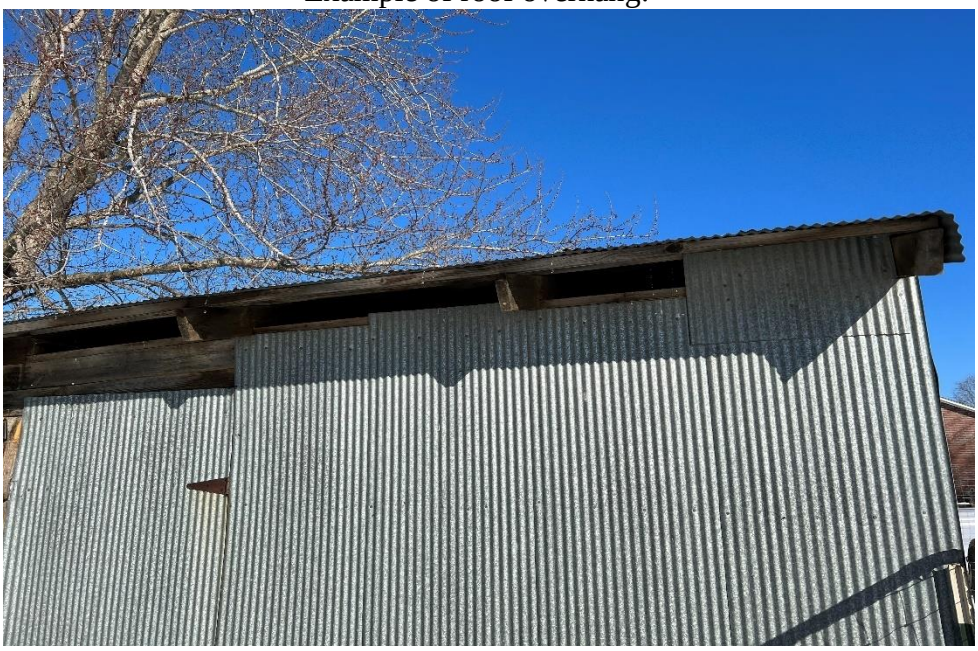
p. A 2X4 plank should be added along the peak of the roof throughout the length of the house.
q. At the center of the short side of the house, a 1.25’ beam should be added. This step should be repeated in 5-foot increments, to match the support beams, along the length of the house, just like the peak of the roof was built.
r. Alternatively, one long side of the house may be built with taller 4X4s to create the needed slanted edge and replace steps o – q.
s. The metal roof can then be nailed into the support beams.

Example of roof support beams:



t. On each of the roof overhangs, one pully should be nailed or screwed into the beam to attach the pully.
u. Drill holes into the two lower corners of each sheet of metal siding. Hook the pulleys appropriately.

Example of roof overhang:



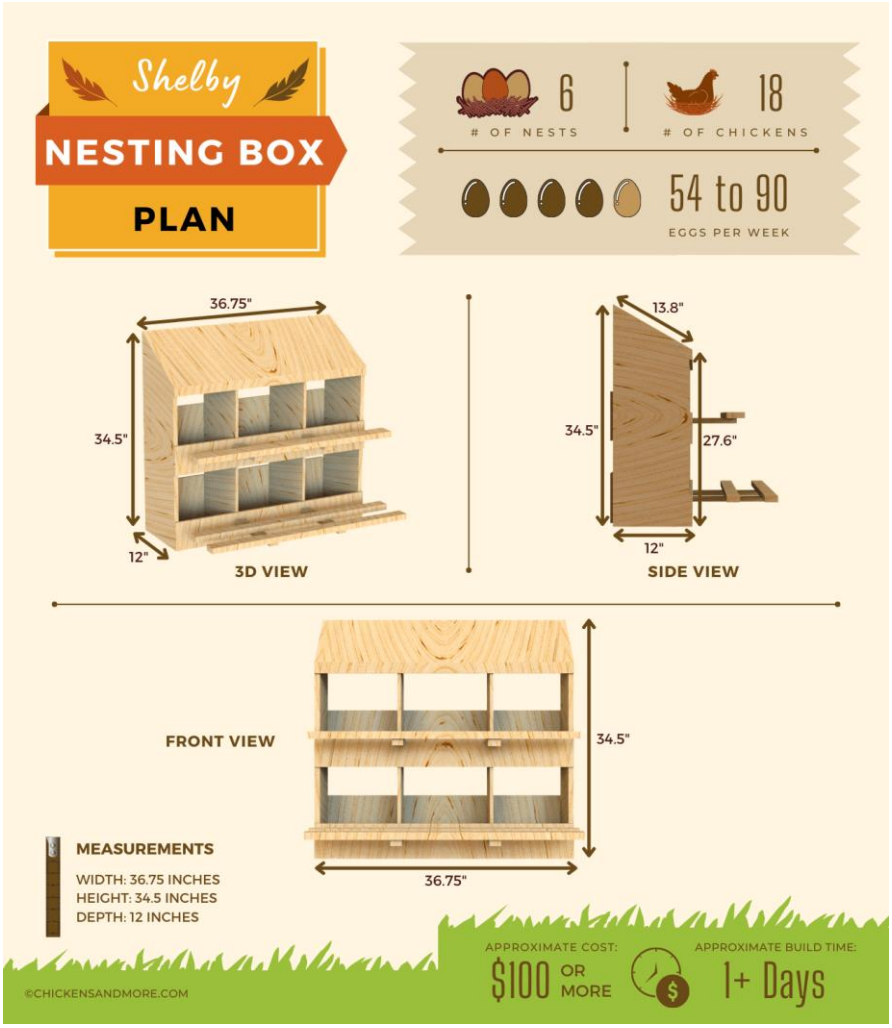
v. Attach chains to the ceiling of the house using carabiners. Although feeders and drinkers will be placed on the ground for chicks, they must be raised as the birds grow. This system will allow for easy adjustment.

2. Constructing nesting boxes:

a. Nesting boxes must be constructed for the house. Nesting boxes are typically made out of wood, with hay or shavings inside, for hens to lay eggs. This will keep eggs cleaner, as they will not be laid on the ground. Nesting boxes are generally elevated above the ground and connected to the wall or built onto a shelf-like structure. Each box should measure 12”X12”X12” and can be used by about three hens. Building 20 nesting boxes is a good starting point.
The nesting box that we will be building is shown below, although other options can be found at https://www.chickensandmore.com/chicken-nesting-boxes/. This example is for a structure of 3X2 nesting boxes, but we will modify it to have 5 rows and 3 columns of nesting boxes, with a flat top so another perch can be added.
b. On the first sheet of plywood, measure and mark every 13 inches on the longer side. On the short side, measure and mark every 12 inches.
c. Cut the second sheet of plywood into seven pieces that each measure 4’X1’.
d. From the third sheet of plywood, cut four pieces that are 3”X4’ each and eight pieces that are 6”X2”.
e. Nail the 4’X1’ pieces where you marked on the first sheet of plywood to form the bottom for each row of nesting boxes and the top of the top layer. Clamps can be

used if needed to hold the pieces in place. After the five horizontal pieces have been nailed into place, nail the two side pieces vertically to create side walls.

f. Now 1'X1' dividers can be nailed into place along the markings. There will be three dividers per row, which will create four nesting boxes per row.
g. The 3"X4' pieces of wood can now each be nailed to the bottom edge of each of the rows of nesting boxes to prevent hay from coming out.
h. Two 6"X2" pieces can be nailed onto the lip of each row of the nesting boxes. Above this piece, nail a 4' long 2"X2" plank of wood or local log on each row to serve as a roosting space for birds to perch or sleep. An additional perch can be nailed to the roof of the boxes.
i. This nesting box structure can be nailed directly into the wooden support beams of the house or may be placed on top of two stacked cinderblocks on each side.
j. Add hay or straw to each of the nesting boxes.
k. Birds like to roost or perch when they sleep. Roosting poles can be added down the length of the house to allow birds to express this natural behavior. Local logs can be used for this purpose.



3. **Build the outdoor runs for the layer house:**
    a. First, measure the correct dimensions of the space (16'X8' for example). Dig a trench along these measurements that is the depth of one cinder block (6"). Fold chicken wire under each block to secure in place to prevent predators from digging under the fence. Place the metal stakes or local logs every four feet to secure the wire. Attach a flat metal roof to protect the birds from predators. Additional 2X4 planks or local logs may be needed to support the middle of the roof.
4. **Optional additions:**
    a. Depending on the availability of electricity, light bulbs can be installed on the roof support beams in one or two rows along the length of the house, spaced two feet apart. Someone trained in electricity must install the wiring and lightbulbs to ensure safety.
    b. Depending on the availability of electricity, stir fans can be installed on the ceiling of the house. Someone trained in electricity must install the wiring and fans to ensure safety. At minimum, two fans will be needed, spaced approximately ten feet apart.
5. **Final steps:**
    a. Once you are satisfied with the appearance of the house, evaluate it for any areas where predators would be able to enter. Fix these areas so that birds will be safe.
    b. Hang up all necessary biosecurity signage.
6. **Preparing the house and brooding space:**
    a. Clean and disinfect the house to remove any existing pathogens.
    b. At least 24 hours before birds will arrive at the house, the house needs to be set up and ready for chick placement.
        i. Place litter in a 2–4-inch (5-10-centimeter) layer covering the entire floor.
        ii. Set up the brooder. Cardboard rings should be used to confine the chicks to a small portion of the house around the heat lamp to ensure they stay warm. Make sure that the rings do not have any corners, as birds could pile on top of one another.
        iii. Fill feeders, extra feed pans, and drinkers. Paper should be placed under the feed pans to attract chicks during the first few days. Water must reach room temperature before chicks arrive.
        iv. Check and closely monitor the temperature of the house at chick or floor level to maintain proper chick body temperature. The temperature at the floor needs to be at least 84°F (29°C) inside the brooding rings. This temperature must be maintained for the first week of the chicks' lives.
        v. Open the curtains slightly so that there will be enough ventilation to regulate carbon dioxide and moisture levels.
        vi. If supplemental lighting will be used, check and make sure that all lights are working properly and that you are able to see clearly.
        vii. Check the house and ensure that it is safe for the birds and that predators will not be able to enter.

c. Prepare a footbath outside of the house. This will be done by filling a tub with disinfectant. Disinfectant should be prepared according to package instructions. **Note:** The solution will be toxic to birds. The footbath must be placed in an area that birds will not be able to access.

7. Chick Placement:

a. Once the house has been prepared and determined to be sufficient for the chicks, they can be purchased from a local hatchery or may be shipped internationally to the farm, if available. Communicate with the hatchery and determine if the chicks have been vaccinated. If they have, you may proceed with placement. If not, you must vaccinate them or call a trained individual such as a veterinarian to do so.
b. Chicks can then be transported to the farm and unloaded by carefully dumping the chicks out of their boxes and into the brooder rings. Alternatively, you may take 10 chicks at a time, place them in a bucket on a scale, and record the weight before placing them in the brooder ring. Repeat this for all of the chicks so you can monitor their growth.
c. Chicks should be evaluated according to the Cobb broiler chick chart (see appendix). If they have unhealed navels, extremely dehydrated legs, or any physical abnormalities or deformities, the bird should be humanely culled by cervical dislocation. Record any issues and the number of culled birds.
d. After all chicks have been placed, step back and allow the birds to get accustomed to their new home. You may have to leave the house and come back in a maximum of two hours to see how they are adjusting.
e. Before you reenter the house, quietly look inside without disturbing the birds. Are they huddled together? If so, they may be cold and the heaters need to be adjusted. You can pick up a chick and place its paws on your cheek, as this is a simple way to check their temperature. If the paws are cold, the bird is too cold.
f. You should be able to observe the chicks eating, drinking, playing, and sleeping in roughly the same distribution. You should also be able to hear them chirping.
g. 12 hours after placement, feel the crops of several chicks. This is an organ that stores feed, and is located on the neck of the bird. If it feels empty, the bird likely is not eating enough. If the crop feels hard, the bird may not be getting enough water.

8. Daily Management:

a. The farm manager needs to check on the birds at least twice each day. He or she will be responsible for recording various items:
    i. Record house temperature, and make adjustments if necessary.
    ii. Record the number of dead birds and remove them promptly. If the cause of death is known, record it. If there is a large increase in number of dead birds, consider calling a veterinarian to perform a necropsy and determine if there is a disease outbreak.
    iii. Check drinkers. Record the amount drank. Fill and clean drinkers if necessary. Drinkers also need to be sanitized weekly. Water from the

water source also should be tested weekly and the results from this test should be recorded.

iv. Check and fill feeders. Record the amount eaten. Remove feed if it is wet or contaminated with feces, and record this amount as well.

v. Observe bird behavior. Take notes so that the normal behavior of the flock can be compared to abnormal behavior.

vi. Once birds reach sexual maturity, hens will begin laying eggs. Eggs must be collected every day and records should be kept.

b. As birds grow, at least once a week, feeder and drinker height should be adjusted to suit the majority of the birds. The lip of bell drinkers and standard feeders should be even with the bird's back.

c. Birds should be weighed once a week. This can be done using a bucket, as was done on the first day, although birds will have to be weighed individually or in smaller groups. It will not be possible to weigh every bird, so take a good sample of birds (at least 10%) and calculate an average.

d. Once it begins to get dark outside, if you are using natural daylight, close up the doors to the runs so that birds will be protected from predators.

9. Bird processing:

a. After approximately 8-10 weeks, or when birds reach the target weight, it will be time to slaughter.

b. Remove feed from the birds 8 hours before transport to the processing plant, and remove water 4 hours prior.

c. Carefully catch birds by their shanks and place them into transportation crates. Be careful not to overcrowd the birds, cause excess stress, or damage their legs.

d. Once birds arrive at the processing facility, carefully unload them according to plant procedures. Dispose of any dead birds.

e. Processing will be handled by the ANRI.

f. Make sure carcass temperature is compliant with food safety rules (keep the meat below 40°F) and then refrigerate or freeze until ready for use.

10. House Cleanout:

a. Remove all feeders, drinkers, and other equipment from the house.

b. Remove all of the litter, including any old feed, feathers, insects, or anything remaining on the floor. Litter can be placed in bags to be used as fertilizer. This will ensure that the house is able to be cleaned and disinfected properly.

c. Thoroughly inspect the house to ensure that there are no holes in the roof, walls, curtains, or in the chicken wire. If there are issues, fix them appropriately to make the house safe for the next flock.

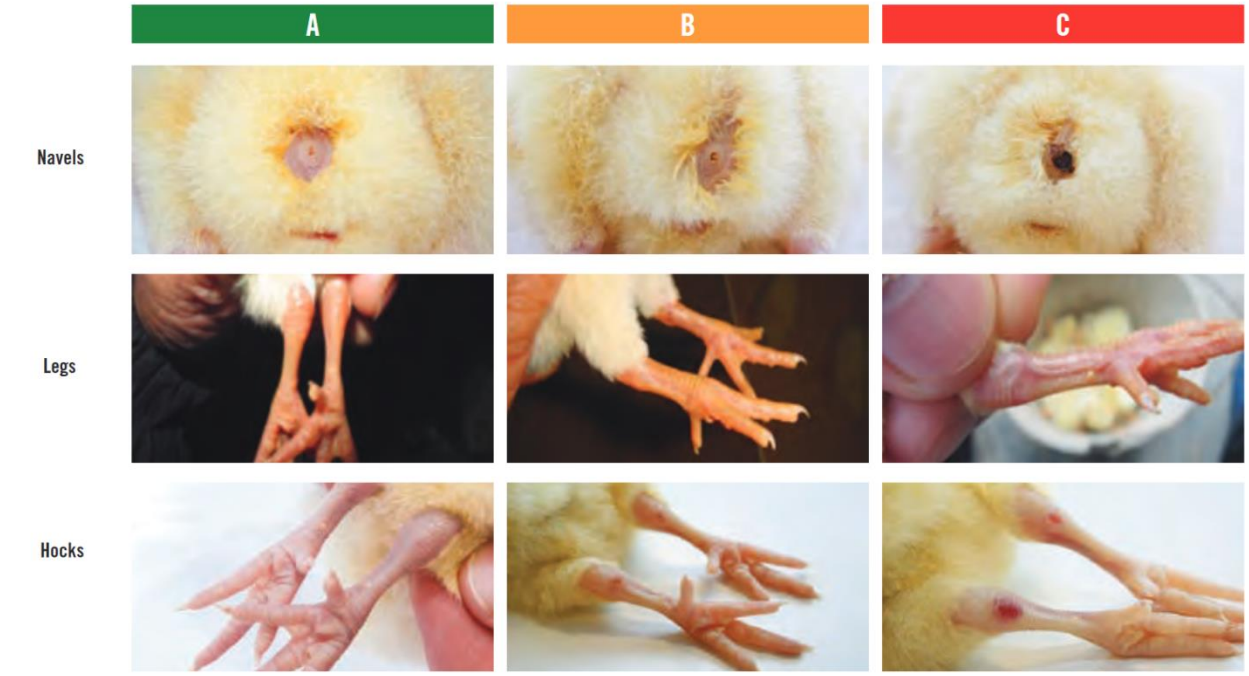
d. Wash the house with water and soap.

e. Clean the entire house with disinfectant. Make sure that the disinfectants are mixed according to the package directions. Take appropriate safety measures to protect yourself from the chemicals. You should wear gloves, boots, and clothing that covers as much of your skin as possible.

f. The house must then be allowed to rest for one to two weeks, which is known as "down time." Close all house curtains and the door to allow the house to naturally heat up, which helps kills off viruses and other bacteria that would be harmful to the next flock of birds. Down time crucial as it helps prevent illness in the future flock.
g. After the down time is complete, begin preparing the house for chicks to arrive once again.

APPENDIX

- **Cobb broiler chart comparing healthy and unhealthy chick characteristics:**



Characteristic	A Excellent	B Acceptable	C Cull
1. Reflex	Chick can flip over within 3 seconds	Chick flips back over between 4-10 seconds	Over 10 seconds or fails to flip over
2. Navel	Clean and well healed	Closed but slight abrasiveness	Not closed/string/button attached or discolored
3. Legs	Clean, waxy legs	Some dryness/pale	Dehydrated with vein protruding
4. Hocks	Clean, no blemishes	Slight blushing	Red color/heavy blushing
5. Defects	Clean, no defects	Minor defects (ex: yolk staining, feather coloration, etc.)	Missing eye/blind, legs with cuts/abrasions, spraddled legs, cross beaks, poor feathering, clubbed down

- **Examples of biosecurity signage:**

BIOSECURITY

...the things we do at our farm to prevent disease from entering or spreading.

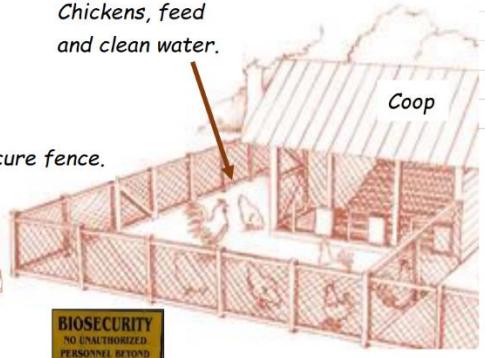
A BIOSECURITY SYSTEM FOR BACKYARD CHICKENS

Bury dead chickens with white lime before covering with earth.

Chickens, feed and clean water.

Coop

Secure fence.



Keep records of important events (e.g. debeaking, vaccination, deworming).

Always wash hands before and after handling chickens.

Use clean footwear dedicated for the chicken area.

Put up a biosecurity sign

Restrict access for people and vehicles.

Remove sick chickens and keep separate from main flock.

Quarantine new chickens at a separate location.

Keep different types of poultry separate.

Vaccinate your flocks against diseases like Newcastle Disease.

Protect Your Flock

Illustrations: Guide for the Prevention and Control of Avian Flu in Small Scale Poultry, FAO, 2006.

Belize Poultry Association

IICA Delegation in Belize

Funded by Australian Aid

BAHA

Ministry of Agriculture

POULTRY

BIOSECURITY

IS EVERYONE'S BUSINESS

Restrict access

Protect Your Flock

Keep it clean

Don't bring diseases home

Know the warning signs of sick birds

Protect Your Flock

Report sick birds to

- *Ministry of Agriculture*
- *Belize Agricultural Health Authority*
- *Belize Poultry Association*

Illustrations: United Stated Department of Agriculture, 2006 - Backyard Biosecurity: Practices to Keep Your Birds Healthy

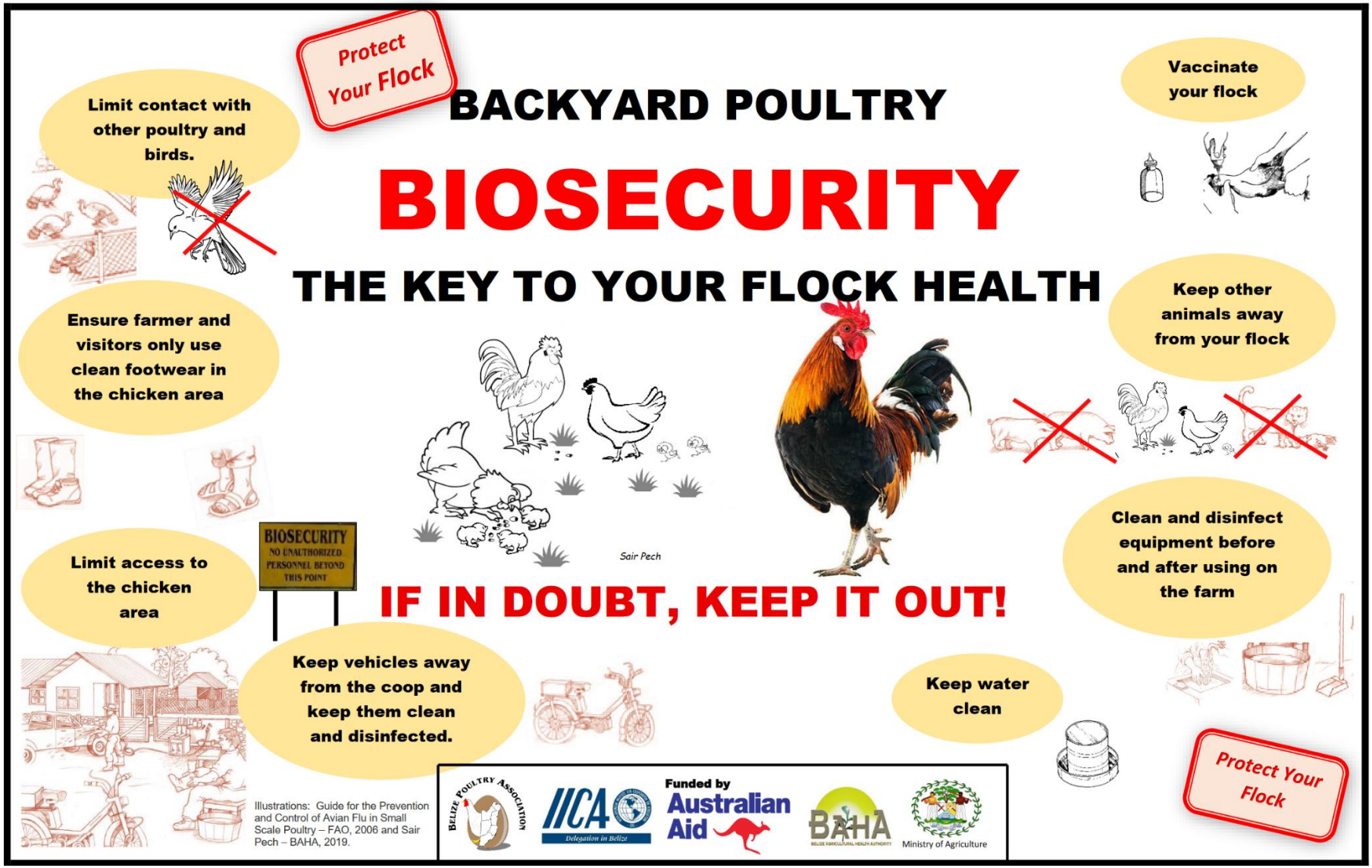
Belize Poultry Association

IICA Delegation in Belize

Funded by Australian Aid

BAHA Belize Agricultural Health Authority

Ministry of Agriculture


Protect Your Flock
BACKYARD POULTRY
BIOSECURITY
THE KEY TO YOUR FLOCK HEALTH
Limit contact with other poultry and birds.
Vaccinate your flock
Ensure farmer and visitors only use clean footwear in the chicken area
Keep other animals away from your flock
Limit access to the chicken area
BIOSECURITY
NO UNAUTHORIZED PERSONNEL BEYOND THIS POINT
Clean and disinfect equipment before and after using on the farm
Sair Pech
IF IN DOUBT, KEEP IT OUT!
Keep vehicles away from the coop and keep them clean and disinfected.
Keep water clean
Protect Your Flock
Illustrations: Guide for the Prevention and Control of Avian Flu in Small Scale Poultry – FAO, 2006 and Sair Pech – BAHA, 2019.
Belize Poultry Association
IICA
Delegation in Belize
Funded by
Australian Aid
BAHA
Ministry of Agriculture

- **Chick purchasing schedule:**

Chick Purchasing Schedule		
Month	**Day**	**Number of Chicks**
January	9	100 females (layers) 100 males (broilers)
March	20	100 straight-run (broilers)
May	29	100 straight-run (broilers)
August	7	100 straight-run (broilers)
October	16	100 straight-run (broilers)
December	25	Week off
Restart the flock January 1 or 9 and repeat the entire schedule.		

- **Record logs:**

House Conditions at Time of Chick Placement:						
Floor Temp.	**Air Temp.**	**Water Temp.**	**Air Humidity**	**Litter Moisture**	**Any Concerns in Water Test?**	**Additional Lighting being Used?**

Visitor Log—All Visitors Must Complete this Form.						
Date	**Name**	**Off-Site Poultry Contact in Last 72 Hours?**	**Reason for Visit**	**Time In**	**Time Out**	**Sign Out**

Egg Production Record Sheet					
Date	**# Good Eggs**	**# Bad Eggs**	**Total Eggs**	**Notes**	**Weekly Total**

Vaccine Record Log							
Name/Brand of Vaccine	**Purchased From**	**Purchase Date**	**Exp. Date**	**Dosage Given**	**Date Given**	**Mode of Delivery**	**Notes**

Feed Purchased / Consumed Record Log					
Date Purchased	**Item (Brand, # Lbs., Feed Type)**	**Date Fed**	**Lbs. Consumed**	**Feed Thrown Out, If Any, and Why**	**Notes**

Disease Record Log					
Date of Symptom Onset	**Symptoms**	**Vet Diagnosis**	**Steps Taken**	**# Mortality**	**Potential Transmission to Other Flocks?**

Water Consumption and Testing Record Log

Date	Water Consumed (Gallons)	Washed Drinker Today? (Yes/No)	Sanitized Drinker Today? (Yes/No)	Temp.	pH	Any Minerals Present Outside of Safe Zone?	Notes/ Steps Taken

House Environment Record Log									
Date	**Litter Moisture**		**Relative Humidity**		**Temperature at Bird Level**		**Air Temperature**		**Notes**
	#1	**#2**	**#1**	**#2**	**#1**	**#2**	**#1**	**#2**	

Mortality Record Log					
Flock Start Date:_____ Flock Total Mortality: _____					
Date	**Check #1**	**Check #2**	**Daily Total**	**Weekly Total**	**Notes/ Known Cause**

Expense Log						
Flock Start Date: _____ Flock Total Expenses: _____						
Date	Item Purchased	Qty	Purchased From	Price per Unit	Weekly Total	Monthly Total

Broiler Weight Record Log											
Date	**Wt. 1**	**Wt. 2**	**Wt. 3**	**Wt. 4**	**Wt. 5**	**Wt. 6**	**Wt. 7**	**Wt. 8**	**Wt. 9**	**Wt. 10**	**Flock Average Weight**
Week 1:											
Week 2:											
Week 3:											
Week 4:											
Week 5:											
Week 6:											
Week 7:											
Week 8:											
Week 9:											
Week 10:											
Week 11:											
Week 12:											

Feed Conversion Record Log (FCR = Lbs. Feed Consumed per Bird/ Avg. Weight Gain)						
Age	**Lbs. Feed Consumed**	**# Birds**	**Lbs. Feed Consumed per Bird**	**Avg. Bird Weight**	**Avg. Weight Gain from Last Week**	**FCR**
Week 1:						
Week 2:						
Week 3:						
Week 4:						
Week 5:						
Week 6:						
Week 7:						
Week 8:						
Week 9:						
Week 10:						
Week 11:						
Week 12:						

Materials needed for 2 houses, 8'X25' each (96" X 300")				
	Store/Location	**Qty**	**Unit price**	**Price total**
Wood 4X4	Hummingbird Distributors	24	$64.80	$1555.20
Wood 2X4	Hummingbird Distributors	16.5	$19.80	$326.70
Chicken wire	Hummingbird Distributors	2 rolls (150 ft. ea.)	$119	$238.00
Cinder blocks	Z-Best Blocks	500	$1.35	$675.00
Pulleys	TBD	20	TBD	TBD
Wire/chain for feeders/drinkers	Reimer's Feed Mill	22	$9.50	$209.00
Carabiners	Reimer's Feed Mill	22	$3.80	$83.60
Bell drinkers	Reimer's Feed Mill	12	$25.50	$306.00
Feeders	Reimer's Feed Mill	10	$35.00	$350.00
Chick drinkers	Reimer's Feed Mill	7	$12.95	$90.65
Chick feeders	Reimer's Feed Mill	7	$12.95	$90.65
Wax/brown paper	TBD	1 roll	$5.00	$5.00
Metal sheets for siding	Hummingbird Distributors	20	$4.30/ft	$86.00
R-Panel Roofing (8 ft)	Hummingbird Distributors	10	$28.40	$284.00
Litter (wood shavings)	Tropical Wood Carving	TBD	$0	$0
Local logs for roosting poles and outdoor run	Surrounding area	30	$0	$0
Charcoal and pots for brooder	TBD	4-8	TBD	TBD
Cardboard Brooder rings	TBD	4-8	TBD	TBD
Stir fans	TBD	4, if possible	TBD	TBD
Light bulbs	TBD	10-20, if possible	TBD	TBD
Materials for electric/wiring	TBD	If possible	TBD	TBD
Scale	TBD	2	TBD	TBD
Bucket for sanitizer	Reimer's Feed Mill	2	TBD	TBD
Feed scoop	Reimer's Feed Mill	2	TBD	TBD
Plywood (for nesting boxes)	Hummingbird Distributors	3	$48.32	$144.96
Concrete bags	Bull's Blocks Making	3	$7.00	$21.00
Tote for footbath	TBD	2	TBD	TBD
Sanitizer (Bleach)	Supermarket	As needed	TBD	TBD
Brush/rags to clean feeders/drinkers	Reimer's Feed Mill	2 brushes, or pack of rags	TBD	TBD

Temperature gun	Reimer's Feed Mill	1-2	TBD	TBD
Thermometers	Reimer's Feed Mill	8	TBD	TBD
Water tests	Amazon	1	$27.95	$27.95
CO2 meter	TBD	2, if possible	TBD	TBD
Gloves	Supermarket	As needed	TBD	TBD
Screws	Hummingbird Distributors	1 lb.	$10.76/lb.	$10.76
Hay for nesting box	Reimer's Feed Mill	1-2 bales	TBD	TBD
Staple gun	Hummingbird Distributors	1	TBD	TBD
Staples	Hummingbird Distributors	3 boxes	$3.85	$11.55
Nails	Hummingbird Distributors	3 lbs.	$3.86/lb.	$11.58
Hinges for doors	Hummingbird Distributors	4	$2.22	$8.88
TOTAL ESTIMATED COST:			$4536.48	