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Analysis of Rwandan Smallholder Poultry Farmer Needs in Production Manuals

Holly Henry

University of Arkansas

Introduction

Global population is continuing to grow and is expected to reach 9 billion by 2050 (Godfray, Beddington, Crute, Haddad, Lawrence, Muir, Pretty, Robinson, Thoman, & Toulmin, 2010). Over the past fifty years there has been an increase in food production and a population that has doubled in size. Despite the increased level of food production one in seven people still lack protein in their diet, and even more are food insecure (Godfray et al., 2010).

Smallholder poultry production is an important aspect of agricultural production in developing countries. Smallholder production is characterized by small backyard enterprises owned by a family. They typically have lower production than commercial systems but make an impact for families in developing countries. Smallholder poultry systems are usually made up of approximately fifteen birds per flock with various ages.

Poultry products are an example of a great source of protein which comes at a low price. Many diseases and deficiencies which come from malnutrition could be avoided by increasing protein consumption. Slow mental development, stunting, and wasting are all characteristics of children suffering from energy deficiencies in developing countries (Smith & Wiseman, 2007). Staple foods like rice are a major part of many diets in developing countries, but lack many essential fats, vitamins, and minerals (Farrell, 2013). Poultry products have almost all nutrients required by the body and contain all essential amino acids (Farrell, 2013). This means that not only is poultry a great source of protein, but poultry production at the village level can contribute to many nutrient deficiencies.

Many families in developing countries own poultry because chickens are a low-cost investment and are easy to raise. Poultry are socially acceptable as they do not conflict with any religious views, and production can be improved through low cost investments. Poultry production has been shown to help alleviate poverty in developing communities and is sustainable as local resources can be utilized without a large environmental impact. In addition to being a source of protein and income for local families, poultry is also beneficial in pest control and manure output for other agricultural projects a family may have (Mack, Hoffman, & Otte, 2005). When comparing smallholder flocks to commercial poultry production it is clear that smallholder production systems are not only efficient, but also a viable option for low income families. In comparison to commercial systems, smallholder flocks require less input, materials, and labor while being more adaptable and having a lower environmental impact. Smallholder flocks do produce lower outputs and have more problems with disease, though (Copland & Alders, 2005).

Several efforts have been made in different countries to introduce smallholder poultry flocks to developing communities. The Network for Poultry Production and Health is one organization that has focused on alleviating poverty through smallholder flocks. The goal of the Network for Poultry Production and Health organization is to introduce one million smallholder flocks per year through a three-part plan of human resources, research development, and planning and implementation of projects (Mack et al., 2005). The problem with these smallholder flocks is a lack of long-term guidance. "Lack of accessibility to literature, such as documents, guidelines, manuals, etc. is a major constraint of poultry development practitioners (Mack et al., 2005)." Smallholder poultry production practices in developing countries are varied based on many different factors, but a basic guideline on poultry production would benefit smallholders as a whole. This type of manual could be used by smallholders as a starting point for information during the beginning of production.

Rwanda is a country in East Africa which has seen growth over the past five years in the poultry sector. AgDevco recently invested 3 million dollars in Uzima Chick an Ethiopian poultry company. The Rwandan government transitioned this into the national hatchery to reduce dependency on foreign aid. Currently Rwanda depends on Uganda's more mature poultry sector for inputs, but this dependency is expected to decrease in coming years. The Democratic Republic of the Congo has become a large market for poultry produced in Rwanda. The growing markets and investment have set Rwanda up for growth, but a major challenge is a support system for farmers. To develop a successful poultry value chain, it is important to strengthen the skills and management of individual farmers. Lack of trained and skilled workforce is one of the existing gaps East Africa is currently facing. In order to strengthen the poultry sector in East Africa it is recommended to focus on practical hands on training, vocational training, higher education, and University education. These sectors will cater to farmers, farm workers, extension agents, students, and teachers. In addition to education and training there are other factors which can improve the poultry sector. These are policy development, food safety, strengthening suppliers, and farmers associations (Vernooij, Masaki, & Meijer-Willems, 2018).

Purpose

The purpose of this study was to describe methods of raising smallholder poultry in developing countries and determine topics which should be included in a general management guide, as there are no widely available guidelines for this type of production system.

Objectives

1. Investigate smallholder farmer needs in a production manual which will be practical for use in Rwanda.
2. Describe methods of small-scale production commonly utilized.

Limitations of the Study

This study aimed to gather data that could guide the production of a manual, which will be usable by smallholders in Rwanda. The survey sampling method included a convenience sample of Rwandan smallholder farmers. The results of the study cannot be generalized statistically to any larger population. In addition, the recruitment of these subjects was performed by a collaborator in Rwanda who worked in the poultry industry in Rwanda. The subjects he recruited were all connected in some way to the feed mill where the collaborator worked. Many of them had visited the feed mill seeking information about production practices. Therefore, the results are especially unique to this group of participants who could be categorized as especially motivated to educate themselves about poultry production. Also, the needs assessed were limited contextually to the northern region of Rwanda. Still, readers of this study may find similarities to other regions and populations, and the findings regarding proposed educational content for Rwandan producers may lead to further research on similar subjects in other developing regions.

Literature Review

Hunger Development

As human population continues to grow and the demand for food, specifically protein, increases in developing countries, there is concern for the ability of world agriculture to provide a sustainable amount of food (Upton, 2000). Food security is defined as all people having sufficient access to safe and nutritious food that will meet dietary requirements at all times. Food

insecurity is the condition where people lack essential nutrients and energy required to live productive lives (Kryger, Thomsen, Whyte, & Dissing, 2010). Important issues when considering development are increasing food security, generating income, and improving nutrition (Alders, Spradbrow, & Young, 2009). No single activity can have a global impact on hunger, but poultry have shown to provide a practical first step in alleviation of rural poverty (Mack et al., 2005).

Global consumption of poultry products has continued to increase in the past and is expected to see continued growth in the future (Ravindran, 2013). In 2009 the Food and Agriculture Organization of the United Nations estimated a population of over 18 billion chickens and 1 billion ducks. This indicates that at that point poultry represented the largest domestic animal stock in the world (Conan, Goutard, Sorn, & Vong, 2012). The largest growing component of global meat consumption within developing and transition economies has been poultry meat which has had a major impact on poultry expansion (Mack et al., 2005). One study found that poultry meat and eggs made up 20% of protein consumed in developing countries. They also found that poultry production contributes to 70% of production in developing countries (Branckaert et al., 2000).

Different types of production systems contribute to total production of a country. In most developing countries there are both a commercial poultry industry and scavenging based smallholder flocks. The commercial industry typically provides for the urban community, while scavenging poultry support rural village families (Pym, Bleich, & Hoffman, 2006). A Kenya-based study concluded that both backyard and commercial production systems were important for meeting the growing demand for animal products in Kenya. Backyard poultry was believed to be a supplementary income for individual families which provided extra protein and income (Upton, 2000). Ethiopia is an example of a country that has utilized poultry production on a small scale to help alleviate food insecurity. Ninety percent of the country's poultry meat and egg production comes from small flocks of local chickens with a flock size of 5-6 chickens with little to no extra inputs (Dana, Duguma, Teklewold, & Aliye, 2006).

Smallholder agriculture is already practiced by over 650 million farmers around the world. The importance of increasing production in developing countries of all agricultural products is paramount as global consumption increases. Developing countries are generally net importers of livestock products, but the gap between local consumption and production increasing could have major implications on imports. This makes increasing production within countries of even more importance (Upton, 2000). It is predicted that developing countries will show the most increase in poultry production in the next few decades. The reasons for this are rapid economic growth, urbanization, increased household income, and increased demand for animal products (Ravindran, 2013). Agriculture expansion is essential for the development process. Expansion will allow for additional food for a growing population and give opportunities for people to make a supplementary income through production (Upton, 2000).

Human Nutrition

Poultry meat and eggs are one of the best sources for quality protein that is needed by many living in developing countries. Malnutrition and undernutrition are closely associated with poverty in sub-Saharan Africa and South Asia (Farrell, 2013). Smith and Wiseman found that in a study of several countries in South Asia and Sub Saharan Africa, 34% of people in South Asia and 59% of people in Sub Saharan Africa suffered from a severe energy deficiency (Smith & Wiseman, 2007). In Sub Saharan African countries many children under five years old have

shown stunting and wasting along with slow mental development. Children from poor families made up 80% of those affected. In Sub Saharan Africa the average person only receives 8% of their dietary energy from animal protein. In comparison, developing countries typically get 17% of energy from animal protein and China's average is 28% (Farrell, 2013).

Rice is the staple food for two billion people around the world. Most of this rice is white rice that lacks most essential fats, B complex vitamins, and minerals which contributes to nutrient deficiencies (Farrell, 2013). Grain and rice are major parts of the diet in many developing countries but can lack quality protein content. Net protein utilization (NPU) is a measure of protein quality based on digestibility of protein and biological value. Most grains have a NPU that is less than 40. Rice has a higher NPU at around 60 while an egg has an NPU of 87. This indicates that eggs offer a higher protein value in comparison to grain or rice (Farrell, 2013).

Poultry meat and eggs are a great source of many nutrients, vitamins, and minerals in addition to providing quality protein (Farrell, 2013). Lysine, threonine, methionine, and cysteine are important amino acids for the human diet, but most cereals lack them. Eggs and poultry meat are a good source of all these amino acids (Farrell, 2013). Several metabolic diseases that are associated with mineral, vitamin, or amino acid deficiencies have been shown to decrease with the addition of poultry products to a diet. Poultry products are rich in all essential nutrients apart from vitamin C (Farrell, 2013).

Many deficiencies which can have severe negative effects on human health could be prevented through additional poultry meat consumption. Folic acid is an important factor in nutrient poor diets of developing countries. A deficiency in folic acid can cause neural tube defects which cause severe defect of the brain and spinal cord, stillbirths, and increased childhood mortality. Fruits and vegetables can be a good source of folic acid, but half of the folic acid content is lost during the cooking process. Eggs are a good alternative for folic acid because they do not lose much nutrient content during cooking. Another nutrient which can affect women in developing countries is iron. Meat has a high amount of available iron which can combat iron deficiencies (Farrell, 2013). Overall additional poultry consumption can help combat many different deficiencies people in developing countries face.

Poultry products are typically lower in fat than other sources of animal protein. Around half of the fat in chicken is monounsaturated fats which are healthy and necessary in the diet. Poultry meat also has a high level of polyunsaturated fatty acids like omega-3 fatty acids. Omega-3 fatty acids are important to human health as they can protect against some forms of cancer, several diseases, and other health conditions. Specifically, consumption of polyunsaturated fatty acids have shown a decreased risk for heart disease, brain development conditions, reduction in inflammatory diseases like arthritis and has shown an increase in learning ability (Farrell, 2013).

One other benefit of eggs on top of protein quality and nutrient content is the fact that one egg is a meal which if boiled can last for a period of time and easily be taken by children to school or by adults to work. Poultry products are widely available, inexpensive, and can help alleviate deficiencies in nutrition of impoverished people (Farrell, 2013).

General Smallholder Information

One characteristic of food consumed in developing countries is that the bulk is supplied through small scale household farmers. Most producers are smallholders who produce products of both plant and animal origin. It has been estimated that smallholders own around 90% of

livestock in developing countries. One study based in Kenya found that of smallholder farmers 72% of the farmers surveyed kept cattle with an average herd size of 7.4, and 65% of producers kept poultry with an average flock of 13 birds (Upton, 2000). Nearly all families in village settings of developing countries are owners of poultry (Mack et al., 2005). One study found that 90% of rural African households keep some type of poultry (Gueye, 2000).

Village poultry or smallholder poultry contributes significantly to poultry production in developing countries. In Kenya backyard poultry production makes up 75% of all chickens raised in the country. The difference between backyard systems and commercial systems is that backyard systems are characterized by small indigenous flocks while commercial systems typically use hybrid breeding systems (Upton, 2000). Backyard systems also use birds of varying age and species while commercial systems raise same species and same age flocks (Conan et al., 2012). Almost all commercial production in Kenya takes place near the capital city and Central Provinces. In the past 30 years Kenya has seen a 2.8% increase in annual production of poultry (Upton, 2000). Another example of a developing country with growing agricultural practices is Mozambique. Mozambique now has 80% of its population involved in agriculture and poultry production. The main reason for growth in this sector is the ability to contribute to the protein consumption of low-income families (Oliveira et al., 2015).

Smallholder farming is very diverse, but most systems have commonalities. Typical small-scale poultry production is characterized by rural settings in which the production is a household enterprise. Family members provide labor needed for upkeep and production decisions are based on family needs (Upton, 2000). Typical smallholder poultry production is made up of indigenous scavenging flocks (Upton, 2000). These flocks also generally have low biosecurity measures (Conan et al., 2012). The average size of a smallholder's flock is around ten to twelve layers with one to two males (Glatz, 2013). One benefit of indigenous flocks is that they are typically better able to cope with harsh living conditions and disease which is important given the low biosecurity measures (Glatz & Pym, 2013).

Household Usage

Smallholder flocks provide much needed protein as well as income to families in developing countries which can boost food security (Farrell, 2013). The protein provided from smallholder flocks can be consumed or sold to meet family needs. These needs can include medicine, clothes, and school supplies. In addition to added income and protein, small poultry flocks are also beneficial in pest control, providing fertilizer, and for use in festivals and traditional ceremonies (Alders & Pym, 2009). Most of the eggs are hatched to use as replacements for birds going out of production, eaten by the household, or given or exchanged with neighbors. Typically, few eggs are sold by smallholders (Upton, 2000).

Economic Impact

Village poultry require low investment to start or maintain which allows it to be a good supplementary activity (Alders et al., 2009). In addition to requiring few investments, poultry in village settings do not compete for scarce resources which makes them a good option as a supplementary income provider. Backyard flocks typically involve few costs as birds feed mostly through scavenging. They receive little to no supplementary feed and no veterinary care. These low inputs allow for supplemental income and protein (Upton, 2000). This supplemental income can provide families with the ability to pay for education, health care, or clothes for the household (Alders et al., 2009).

In comparison to other smallholder livestock production, poultry is the least costly and has the highest return on investment. The return on capital for backyard flocks is typically over 100% due to the number of offspring produced and fast reproductive rate (Upton, 2000). Improving production is also feasible as low-cost technology can be used to considerably impact production levels (Upton, 2004). Village poultry production is considered a supplementary activity, but it makes an important contribution to the income of villagers and the amount of protein they consume (Mack et al., 2005). Smallholders who own poultry may also begin to climb the “livestock ladder” and become involved in other types of livestock production (Alders et al., 2009).

The impact of increasing smallholder poultry production is not just economical. One program in Asia, Africa, and Latin America found that the implementation of village poultry production resulted in not only an increase in number of poultry, but in increased purchasing power for smallholder households, increased consumption of poultry products, and increased decision making for women in smallholder households (Dolberg, 2003; Alders, 2004).

Egg production and sales typically vary depending on the farmer. In rural areas smallholders typically keep over 50% for hatching, while the rest are consumed or sold. Hatching and rearing offers a much higher return than consumption but has added risks. Hatching chicks has a high risk for loss due to unpredictable mortality (Upton, 2000). One survey asked respondents the purpose of their smallholder poultry flocks. In response to the survey 87% answered the sale of live birds and 3% answered sale of eggs. In addition to sales, 82% of respondents consumed poultry meat while 19% consumed eggs. Smallholder poultry products that are sold contribute to around 15% of a smallholder’s household income (Alders et al., 2009).

Poultry Diseases

Inadequate management and disease control strategies result in high levels of mortality due to predators or infectious disease (Conan et al., 2012). Due to natural selection indigenous breeds of poultry have become more disease resistant than commercial strains of poultry. This is important due to the increased risk of disease in village settings (Pym, Bleich, & Hoffman, 2006).

Many diseases can affect poultry, but one of the biggest disease threats to production is avian influenza. All birds are susceptible to avian influenza, but wild birds carry the disease with no clinical signs (Permin & Detmer, 2007). The potential risk of avian influenza to backyard flocks near water lands or migration paths is therefore higher due to proximity to water fowl and wild birds (Conan et al., 2012). Avian influenza can also be transmitted through movement of birds between farms, contaminated equipment, feed, or cages. Highly pathogenic avian influenza is characterized by sudden onset of disease, rapid spread, and a mortality rate of up to 100% in the first few days. The disease can be transmitted to people in extreme cases (Permin & Detmer, 2007).

It is important to act promptly if disease signs are noticed. If there is a disease outbreak in a flock, sick birds should be kept in a separate place to reduce risk of transmission to healthy birds. Dead birds should be buried or burned (Conan et al., 2012). Eating meat or eggs from a bird with disease can cause increased risk of infection in humans (Permin & Detmer, 2007). To decrease risk of disease in a flock, biosecurity measures should be implemented such as; isolation, traffic control, and sanitation. Restricting movement of people around a flock reduces risk of introducing infectious agents to the farm. Another risk factor for spread of infectious

disease is the practice of trading poultry. It is advised that owners of poultry not visit poultry trading markets, but this practice continues in many developing countries. If new birds are purchased they should be quarantined for two weeks before joining with the rest of the flock (Conan et al., 2012). Culling sick animals is practiced in the United States, but this is not practical in developing countries (Conan et al., 2012).

Biosecurity

Biosecurity is defined as the implementation of measures to reduce the risk of disease spread (Conan et al., 2012). Biosecurity is made up of two principles; bio exclusion and biocontainment. Bio exclusion involves preventing infectious agents from entering a flock while biocontainment involves preventing infectious agents from leaving. Some important parts of these principles are isolation, traffic control, and sanitation. Isolation is important because it ensures there is no contamination from housing and equipment. Traffic control restricts movement of products and people. Limiting the number of people who are around birds, especially people who also have poultry, greatly limits the risk of contamination. Sanitation is also important for cleanliness and disinfection. Clean surroundings reduce the risk of infection for a flock (Conan et al., 2012).

There are many actions that can be taken to reduce the risk of disease. It is recommended to separate poultry based on species and age to reduce transmission, but this is something not adopted by most smallholders who have multi-age flocks (Conan et al., 2012). Predation is one of the biggest threats to scavenging flocks, and confinement can reduce the risk of losses from predation (Alders et al., 2009). Predators include birds, reptiles, mammals, and even other people (Bell, 2009). The average mortality rate for chicks in a smallholder system ranges from 40% to 60% during the first two months. Most of these losses come from predation and could be avoided with additional confinement (Upton, 2000). Another recommendation to help decrease predation is building fences and limiting scavenging area. This will decrease predation, but also increases supplementary feed necessary for the flock. The increase in feed supplementation will make most smallholders unlikely to adopt the practice due to added long term costs (Conan et al., 2012).

Litter Quality

Another important aspect of poultry management is litter quality. Litter should be light, absorbent, and cheap. Common materials used for poultry litter are wood shavings, chopped straw, sawdust, shredded paper, and rice hulls. Other similar materials may be used depending on availability (Glatz & Pym, 2013). Proper litter management is crucial to bird health and performance. If the litter is too hard birds can develop lesions on the breast. If litter is too wet lesions on bird feet are common and ammonia levels can cause respiratory problems (Glatz, 2013).

Feed

The limited availability of suitable feed for poultry is one of the major constraints on improving productivity, especially for hens and young chicks (Ravindran, 2013). Village poultry are typically allowed to roam freely around the house and scavenge for food which leads to low production and survivability (Alders et al., 2009). Scavenging areas are generally over scavenged due to large amounts of poultry in the same area (Ravindran, 2009). Poultry can usually scavenge enough energy during grain harvest season, but not during other times of the year. The

rainy season is also suitable because birds are able to find abundant animal protein through insects and worms. Energy is the main limiting nutrient for scavenging poultry because most of the food they scavenge is made up of crude fiber (Alders et al., 2009).

Feed supplementation is an option for increasing energy in backyard poultry. Scavenging alone cannot provide enough energy for growth and egg production. Body weight and egg production can be significantly increased with supplementary feed (Ravindran, 2013). One study found that a supplementation of as low as eight grams of feed per day increased body weight gain of scavenging poultry (Alders et al., 2009). In Kenya 80% of smallholders did not provide supplementary feed, but many producers in urban areas fed maize or grain supplements. It has been suggested that a priority option for improving production is to improve nutrition through supplementation (Upton, 2000). A study in Asia found that a typical household produces between 200 and 500kg of dry matter food waste which could be used to supplement nutrients for poultry. This amount would be sufficient for supplementing around five birds (Upton, 2000).

The four traditional feed ingredients in poultry production are maize, soybean meal, fishmeal, and meat meal. It is becoming evident that there is a continuously growing gap in supply and demand for the traditional ingredients. This makes exploration of new ingredients even more critical (Ravindran, 2013). Smallholder poultry have a variable diet depending on season. During harvests of grain and rainy seasons scavenging poultry can fulfill dietary needs more easily. The dry season is the period of the most concern. Strategic supplementation during periods where scavenging is unable to meet nutrition requirements can increase production and decrease mortality (Ravindran, 2009).

A wide range of local materials can be used as supplementary feed sources. Insects are a great source of supplementation because they are a source of protein. The protein content of insects is typically 40 to 75%. Common types of insects consumed by poultry include; grasshoppers, crickets, termites, aphids, beetles, caterpillars, flies, fleas, ants, along with many more (Ravindran, 2013). Some examples of plants used for supplementation are herbs, leaves from plants like cassava, or aquatic plants like water hyacinth or duckweed. Banana peels can also be sun dried and milled into a supplement. Green materials have a high dry matter content which can be fed directly to birds. Green materials also have high vitamin and mineral content in addition to protein content which make them a great supplement. Cassava peels are ten percent of the weight of the plant but are not used for human consumption. This makes them an economically efficient option for poultry supplementation. They must be sun dried before consumption to remove toxic levels of cyanide (Ravindran, 2013). Small or damaged tubers and roots of cassava, sweet potatoes, and yams could be used as a supplement if they are not used for human consumption. Slicing and sun drying, or grinding is recommended to make these into a supplement for poultry feed (Ravindran, 2013). Many options exist as low-cost alternatives for feed supplementation.

The possible benefits of supplementation are more successful if poultry are housed. Housing allows for reduction of waste and better supplement management (Upton, 2000). In addition, supplementary feed should not be given during the hottest part of the day. One of the main factors that decreases food consumption is high temperatures (Glatz, 2013).

Housing Management

Raising poultry indoor is recommended, but this can be difficult in a village setting. It is therefore recommended that poultry be kept indoors at least during the night (Conan et al., 2012). A study in Kenya conducted a trial on confinement of chicks in pens. The significant reduction

in losses was sufficient to cover costs of pen construction. Upon conclusion of the trial many local farmers adopted the practice as it was financially viable (Upton, 2000). Smallholders are aware of losses due to predation and difficulty in locating eggs of scavenging layers.

It is possible to create a low-cost shelter for poultry through using bush materials and building in a way that is similar to a villager's home. It is also recommended to make separate rooms within the structure to keep older birds away from chicks (Alders et al., 2009). Materials for construction of poultry houses can include wood and leaves from local trees or bushes, mud, bricks, and bamboo. Houses can be of various shapes and sizes depending on flock size and available materials (Glatz & Pym, 2013). When building shelters villagers typically use leftover iron for roof material, but a thatch roof made from leaf material is better for insulation from extreme temperatures. A well-insulated roof reduces heat loss during cold weather, and leaves attract less heat during warm weather compared to iron (Glatz, 2013). Temperatures are easier to control in a small area, so small houses are not a downfall (Glatz, 2013).

Most poultry smallholders own multi-age flocks which is not typically recommended. Best practice is to raise all birds at the same age together, but this is not feasible for village production (Glatz, 2013). It is recommended to have different areas in a house designated for hens to lay eggs and brood. Nest boxes, feeders, and drinkers can be added to a house to increase production. Nest boxes encourage laying within the house, and one nest should be big enough for around four birds to nest in (Glatz, 2013). These nests may be constructed of woven leaves or other similar materials that are available (Pym, 2013). If supplementary feed is given feeders should be included in the house. Sufficient feeder space allows for uniform growth rate. Feeders should be level with the back of the bird to reduce spillage (Glatz, 2013). Drinkers can be made from many different materials such as bamboo or water bottles. Water containers should be refilled daily and kept clean. They should also be kept away from direct sunlight to avoid heating which will decrease water consumption (Glatz, 2013). It is important to keep all housing, equipment, and surroundings clean. This will improve health, limit parasites, and reduce pest and fly populations (Glatz & Pym, 2013). Providing sufficient space for birds is important as lack of space can lead to leg problems and other injuries (Glatz, 2013).

Natural ventilation is the most common ventilation practiced by smallholders (Glatz & Pym, 2013). Natural ventilation comes from breezes entering and leaving a poultry shelter. It works best in houses where the longest side runs east to west which stops sidewalls from overheating during sunrise and sunset (Glatz & Pym, 2013). Proper ventilation is important for good air quality (Glatz, 2013).

Once housing has been adopted and set up by smallholders the only addition to caretaking is daily release and penning of birds. Afternoon release is typical because at this point in the day most hens have laid eggs in the house; this will save time for the smallholder in not having to search for eggs. Return to the house generally happens around sunset when poultry are naturally looking for a place to roost (Alders et al., 2009).

Chicks

Upon placement or hatch chicks should be active. Chicks can typically use body reserves to survive for the first 72 hours of life, but the supplementation of feed and water within 24 hours greatly enhances survival rates (Glatz, 2013). The first two weeks of life are critical for future growth and development in chicks (Glatz, 2013). It is extremely important to provide a uniform environment free from fluctuation in temperature. This is more difficult in village settings than in commercial systems (Glatz, 2013). Chicks that have just hatched are not able to completely

control their body temperature and it is recommended to add supplementary heating for the first few days (Glatz & Pym, 2013). If an ideal temperature is provided, chicks will spread uniformly throughout the area. If they are cold they will crowd together in groups and will be close to any source of heat. If the temperature is too high chicks will spread out and panting and wing spreading can be observed (Bell & Weaver, 2001.)

In addition to proper temperature, good air quality is important for healthy chicks. Chicks are more susceptible to things like ammonia than older birds. Unhealthy ammonia levels have been proven to decrease body weight by 20 percent (Glatz, 2013).

It is recommended that chicks be provided with feed supplementation for the first two weeks of life (Glatz, 2013). Supplements could include chick starters from a feed mill or products made by the smallholder. If supplementation is given it is important to observe birds to make sure they can successfully use feeders and waterers (Glatz, 2013). Crop size is a good indicator of if the chicks have been eating and drinking (Glatz, 2013). The crop is located near the base of the neck and will be fuller and rounder after feed consumption. Chicks have a higher risk of mortality than older birds, so it is important to monitor them. Farmers should check chicks at least four times a day to observe behavior (Barnett & Glatz, 2004).

Brooding

During broody periods, hens prefer a dark, protected environment when sitting on eggs. Chicks hatch after 21 days of incubation, and the hen will begin caring for the chicks upon hatching (Gatz, 2013). Most indigenous breeds of hens are very good at incubating eggs and can generally hatch ten out of 12 eggs that are laid. The six-week survival rate from one clutch laid is usually five or less chicks due to malnutrition, disease, predation, and other factors (Pym, 2013). In village settings one hen can care for up to 15 chicks at a time. After they have hatched a hen will help regulate chick body temperature by letting them nestle under her. They will also learn to scavenge through following the hen around (Glatz, 2013).

Productivity of Village Poultry

Smallholder poultry production allows farmers to be less reliant on other sources for high quality animal protein (Alders et al., 2009). Hens are layers and brooders in smallholder systems so clutches of eggs are laid and brooded around two to four times per year. Typical egg production ranges from 30 to 60 eggs per year (Upton, 2000). Productivity is low due to few eggs being laid and hatched in addition to high mortality rates in village poultry systems. These systems do provide supplemental nutrition and income to smallholder families, though (Upton, 2000). Fertility of eggs also has an impact on productivity. Young flocks of breeders produce fewer eggs than those at peak age, and older birds have much lower fertility. Males generally have a decline in mating activity and sperm quality as they age (Glatz, 2013). Replacement of older hens or introduction of new males can help boost fertility and production.

Improvements for Smallholders

Improvement of smallholder poultry production has many constraints. Disease control, predation, feed, genetic improvements, training, and management are all areas that could increase production, but may not be feasible for smallholder farms. Another issue is lack of access to guidelines on poultry production for smallholder farmers (Mack et al., 2005). Some improvements that positively impact smallholder production are adding inexpensive houses, supplementing feed, and improving disease control measures (Upton, 2000). Simple changes in

management like nightly enclosures, daily watering, and feed supplementations can greatly improve production (Alders et al., 2009). The number of people engaged in agricultural activities is continuing to rise in developing countries which has contributed to rural poverty alleviation (Upton, 2000). Implementation of some or all these management strategies could increase the impact on overall poverty alleviation.

Methods

Design

The study design was a quantitative non-experimental survey, which was used to examine the educational needs of smallholder poultry farmers in Rwanda. Threats to validity include low response rates and inability to complete online questionnaires due to subjects' lack of internet access. In an effort to combat the latter, surveys were administered in hard copy form to smallholder farmers, and answers were recorded electronically upon completion.

Sampling and Participation

This study employed convenience sampling to survey smallholder poultry farmers in Rwanda. U.S. poultry genetics company Cobb-Vantress currently works with Zamura Feeds in Rwanda in an effort to increase poultry production in the country. Zamura Feeds helps train smallholder farmers to improve the farmers' production practices. The estimated number of smallholder poultry farmers in Rwanda who are engaged in Zamura's educational efforts who could possibly be reached was approximately 130 (D. Juenger, personal communication, April 2018). The actual response rate was 44 producers (33.8%).

Treatments and Instruments

This study involved a questionnaire that was administered with smallholder poultry farmers. The questionnaire included two matrix table questions, four multiple choice questions, and one open-ended question. Question one related to subjects' gender. Question two was used to determine whether or not participants thought a guide would be useful. Question three was used to determine what smallholder participants thought should be in the guide. This question included topics identified in the literature as important in the education of smallholder farmers in developing countries (Alders et al., 2009; Bell & Weaver, 2001; Conan et al., 2012; Glatz, 2013; Glatz & Pym, 2013; Mack et al., 2005; Permin & Detmer, 2007; Pym, 2013; Upton, 2009). Questions four, five, and six were used to determine if participants were currently implementing practices which have been recommended for improving backyard production, including housing, feeding, and biosecurity (Alders et al., 2009; Upton, 2000).

Data Collection

Data were collected through Zamura feeds between October and December of 2018. The questionnaire was administered by a translator working for Zamura. This person was a member of the service technician team who had access to farmers. The questionnaires were administered to smallholders on paper due to the lack of internet access for most of the population. The questionnaire required five minutes to complete as to not deter from the smallholders' daily tasks.

Data Analysis

Data collected through the smallholder questionnaire was analyzed for answers most frequently chosen by smallholders. Frequencies and percentages were reported. The results indicated whether or not smallholders would find a poultry production manual beneficial, and what topics they thought should be included in a production manual.

Results

Smallholder farmers in Rwanda were asked a series of questions to determine attitudes toward production manuals and what information should be included in a production manual. Participants were 34% female and 66% male. Study participants were asked if they would find a production manual beneficial and the result was a unanimous affirmative response. The following tables present data on perception of important topics and use of production practices including; housing, feeding, and biosecurity.

Participants were asked if they would find information on the following topics beneficial to them in raising poultry. The topics included; poultry housing, poultry diseases, biosecurity, egg management, chick management, supplemental feeding, environmental factors, and poultry management. The data in Table 1 indicate which topics should be included in a smallholder manual. Data are presented as affirmative responses.

Table 1.

Poultry Producers' Perceptions of Importance in Manual Topics (N=44)		
Topic	Frequency of Yes	Percentage
Poultry Housing	42	95.5%
Poultry Diseases	44	100%
Biosecurity	44	100%
Egg Management	44	100%
Chick Management	44	100%
Supplemental Feeding	43	97.7%
Environmental Factors	44	100%
Poultry management	44	100%

Affirmative responses indicated that respondents would find information on the given topic helpful in a manual. For diseases, biosecurity, egg management, chick management, environmental factors, and poultry management there were 100% "yes" responses. Poultry housing and supplemental feeding were the only two topics that received any "no" responses at all.

Table 2 displays the number of participants using housing and/or feeding on a regular basis at the time of the study. Data are presented as affirmative responses.

Table 2.

	Frequency of Yes	Percentage
Housing	43	97.7%
Feeding	44	100%

According to the data 97.7% of respondents were housing their chickens at the time of the questionnaire. In addition, 100% of respondents were feeding their poultry as opposed to allowing their birds to scavenge.

Table 3 displays the extent of biosecurity measures common among these Rwandan poultry producers. Participants were asked whether or not they practiced foot bath use, restricted access, or hand washing. Data are represented as affirmative responses indicating the participant did practice the given measure at the time of the survey.

Table 3.

Biosecurity Measure	Frequency of Yes	Percentage
Foot Bath	21	47.7%
Restricted Access	2	4.5%
Hand Washing	1	2.3%

Less than half of respondents were using foot baths, and less than 5% of participants were using restricted access or hand washing.

Conclusions

Regarding objective 1, this study was able to determine topics of interest to these smallholder farmers in Rwanda. According to the data, all topics listed in the questionnaire were determined to be important based on participant responses. This may indicate that the smallholder farmers are receptive to any type of guidelines or information about production. This information may be valuable to the smallholder farmers based on its ability to help them make informed decisions in raising poultry and improve current production practices. Information on housing and feeding did receive multiple “no” responses, but the data indicate the information was still important to the majority. Overall, the data indicate that the smallholder farmers find any information available helpful to them in their production.

In regard to objective 2, this study was able to describe production methods utilized by the smallholders, including housing, feeding, and biosecurity. Table 2 and Table 3 represent the production practices of housing and feeding, and biosecurity. The majority of respondents were housing and feeding their poultry, which may indicate a higher level of investment in production than would normally be expected in smallholder flocks in Rwanda (Alders et al., 2009). This level of investment may also be a reason why participants would find the topics included in the survey important. Biosecurity measures were not commonly used among these participants. The

most common method of biosecurity was foot bath use, which was utilized by less than half of participants. So, while the majority of participants were investing in housing and feeding, they were not focused on biosecurity. This is important because biosecurity was one of the topics with a unanimous affirmative response, meaning smallholders wanted more information about biosecurity. Therefore, biosecurity should be a topic with detailed information in a manual due to the perceived importance of the topic and the lack of experience of the farmers with biosecurity.

Discussion

Researchers found in 2005 that lack of literature including documents, guidelines, and manuals was a major constraint on poultry production in smallholder flocks in developing countries. This came after a three-part study involving human resources, research and development, and planning and implementation. The researchers also hoped that the creation of guidelines would serve as a starting point for smallholder farmers (Mack et al., 2005). The current study recognized the need for guidelines and sought out information which should be included in such a manual. Through the administration of a questionnaire, this study was able to determine that the smallholder farmers in Rwanda who participated in this study were interested in a production guide. When asked if a guide would be beneficial to their production 100% of participants indicated that they would be interested. The study was also able to outline important topics which should be included in a guide. The topics of importance to smallholder farmers in Rwanda include poultry housing, poultry diseases, biosecurity, egg management, chick management, supplemental feeding, environmental factors, and poultry management. All of these topics were perceived as important by the majority of participants in this study and had been previously identified by other researchers (Alders et al., 2009; Bell & Weaver, 2001; Conan et al., 2012; Glatz, 2013; Glatz & Pym, 2013; Mack et al., 2005; Permin & Detmer, 2007; Pym, 2013; Upton, 2009).

Previous studies have made recommendations on methods of raising poultry in developing countries. These recommendations could be compiled into a manual for smallholder farmers. Housing is one topic that has been addressed by several different studies. Research has shown that village poultry producers are willing to switch to confinement when shown the benefits. These benefits include a reduction in bird loss significant enough to cover building costs (Upton, 2000). Manual information could include building materials and design (Alders et al., 2009). Information on housing could also include details comparing different building materials. For example, one study outlined how using a thatch leaf roof versus tin could decrease the internal temperature of a house (Glatz, 2013). This research also describes placement of equipment within the house as important, including the location of nest boxes, feeders, and drinkers (Glatz, 2013). Instruction on internal set up could be beneficial to the smallholder farmers. Another important aspect of housing and environmental factors is ventilation. Natural ventilation can be created by using strategic house orientation with houses facing east to west to reduce overheating during sunrise and sunset. Ventilation is also important for good air quality (Glatz & Pym, 2013).

Egg, chick, and poultry management were all topics that the smallholder farmers indicated they would want in a production guide. Information should be included in a guide which would inform a farmer how to care for a chicken throughout its lifecycle. Also, Glatz & Pym (2013) have already recommended that smallholders should learn methods of providing supplemental heating for chicks. Methods of observing temperature could also be included in a guide. An example is, if the temperature is correct chicks will spread uniformly, but if it is too

cold chicks will huddle together, and if it is too hot chicks will spread out and pant (Bell & Weaver, 2001). Other small ways of determining chick health, like the fact that crop size can indicate feed intake, should also be included (Glatz, 2013).

Another topic of importance to smallholders in this study was disease. Information on common diseases and how to recognize and treat them should be included in a manual. One of the biggest threats to village poultry is avian influenza, which is especially common because unconfined birds have contact with other chickens as well as with wild birds (Permin & Detmer, 2007). Avian influenza is characterized by sudden onset, rapid spread, and a high mortality rate (Permin & Detmer, 2007). Due to the seriousness of diseases like avian influenza, information on preventative actions would be very beneficial to smallholder farmers. Avian influenza is just one disease that affects poultry though, and other common diseases should be outlined as well. Research recommends acting promptly at any sign of disease. Sick birds can be kept separately to decrease transmission of disease to healthy birds, and infected birds that die should be buried or burned (Conan et al., 2012). Smallholders should also be made aware of the risks to their health when dealing with sick birds or eating meat and eggs from a sick bird (Permin & Detmer, 2007). Preventative measures for disease control include implementing biosecurity practices of isolation, traffic control, and sanitation (Conan et al., 2012). Common disease management tactics such as isolation and traffic control are possible based on the findings in this study because the majority of farmers were already housing their poultry.

Regarding biosecurity, researchers have found that smallholder flocks generally have low levels of biosecurity in place (Conan et al., 2012). The current study validates these findings, as the majority of survey participants were not using the three biosecurity practices included in the questionnaire. The most common practice followed was foot bath usage, with 47.7% of participants indicating they use a foot bath. Less than 5% of participants used restricted access or hand washing practices. Research has shown that indigenous breeds are more durable when it comes to disease, which is a benefit given low biosecurity measures. This higher resistance is valuable because village poultry are at a higher risk for disease (Pym et al., 2006). The current study did not focus on breed and therefore no determination can be made on durability. The data in this study do indicate that smallholders are receptive to learning about biosecurity. Receptiveness to learning about biosecurity is important because implementation of these practices can lead to healthier chickens. One study recommends isolation, traffic control, and sanitation as measures to prevent spread of disease. Restricted access of people and poultry prevents introduction of pathogens to a flock. One of the main reasons this is not practiced in developing countries is because of the market systems, where the presence of live chickens is common (Conan et al., 2012). The current study does support this research in the fact that over 95% of participants did not restrict access to their flocks, but no relationship to the market system can be determined through the data. Sanitation in terms of foot bath use and hand washing was evaluated in this study, but not in depth. While foot bath use was more common than hand washing, neither were practiced by the majority of smallholder farmers, and both could be areas of improvement through education. Information outlining the importance of these practices should be included in a guide.

In this study, 97.7% of smallholders were housing their chickens. According to previous research, predation is one of the biggest threats to flocks but can be reduced with confinement. Alders found that 40-60% of mortality in the first two months was due to predation (Alders et al., 2009). Because smallholders in this study practiced housing, predation may not have been an important issue to them. Researchers recommend the practice of confinement but recognize the

need to increase feeding as a result (Alders et al., 2009). Researchers also recommended confinement but believed that the necessity of supplemental feeding would make smallholders averse to housing due to additional long-term costs (Conan et al., 2012). This study found that 97.7% of the smallholders in the current study were housing and 100% were feeding their chickens. This indicates that the Rwandan smallholders in this study acted differently than the expectations of the previous studies mentioned.

The majority of smallholder farmers in this study were feeding their poultry. The study did not analyze the method of feeding whether it be full feeding or supplemental. Scavenging poultry are at a disadvantage because scavenging cannot meet the energy requirement of the bird. Supplemental feeding can significantly increase body weight and egg production (Ravindran, 2013). Because the majority of smallholders in the current study are feeding their birds may be meeting more of their nutritional requirements. Information on feed ingredients, where to buy feed, and how to mix feed would be beneficial in a production manual.

Recommendations

Based on the data, it is recommended that production manuals be created for smallholder farmers. Topics of importance according to this study include; poultry housing, poultry diseases, biosecurity, egg management, chick management, supplemental feeding, environmental factors, and poultry management. Each of these topics was perceived to be important by 95% of the participants. The majority of the participants were feeding and housing their poultry, but the majority were not practicing biosecurity. Due to the lack of practice and 100% perceived importance, information on biosecurity should be thoroughly addressed in a manual.

Additional studies similar to this one would be beneficial to gather more knowledge. Rwanda is a small country, so much could be gained from recreating this study in different environments. Needs of farmers will differ greatly by region and climate, so the data in this study may not be suited for farmers in other locations. In recreating this study, it would be beneficial to have a larger sample size. More information on specific location, flock size, breed, access to electricity, bought versus mixed feed, and size of farm would also be beneficial. This could help in determining why some topics are important while others are not. It may also be helpful to have farmers rank topics based on what they think would be the most important rather than asking if a topic is important or not. This would give a clearer outline of which topics should be discussed in depth versus which could be briefly outlined in a manual. A more in-depth picture of production practices could be gained through asking about brooding practices, flooring, access to water, vaccination protocol, veterinary care, disease prevalence, and type of housing. This information could be used to make recommendations to smallholders such as ways to brood, types of litter for flooring, ways to collect water, vaccination and veterinary care options, and different types of housing.

Another study which would be beneficial is a study on the success rate of smallholder farmers in Rwanda. This study found that the majority of participants were housing and feeding. This goes against previous data which shows that smallholder farmers are not receptive to the idea of housing and feeding (Conan et al., 2012). The main reason for this is the additional cost. A cost benefit analysis of the farmers in Rwanda could be used understand the level of success the farmers in Rwanda are experiencing. If it was determined that the systems are cost effective the farmers could be used as an example to encourage these practices in other locations.

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