Sudan University of Science and Technology
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Evaluation of Biosecurity Measures in Commercial Poultry Farms in River Nile State

تقويم إجراءات الامن الحيوي في مزارع الدواجن بولاية نهر النيل

By

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قَالَ تَعَالَىٰ:

﴿ وَعَلَّمَ ءَادَمَ ٱلْأَسْمَآءَ كُلَّهَا ثُمَّ عَرَضَهُمْ عَلَى ٱلْمَلَٰٓئِكَةِ فَقَالَ أَنۢبِـُٔونِى بِأَسْمَآءِ هَٰٓؤُلَآءِ إِن كُنتُمْ صَٰدِقِينَ ﴿٣١﴾ قَالُوا۟ سُبْحَٰنَكَ لَا عِلْمَ لَنَآ إِلَّا مَا عَلَّمْتَنَآ ۖ إِنَّكَ أَنتَ ٱلْعَلِيمُ ٱلْحَكِيمُ ﴿٣٢﴾ ﴾

صدق الله العظيم

(الآية 31&32 من سورة البقرة)

Dedication

I devote my study to :

my Parents

my kids Salwa & Ahmed

my sisters Sawsan & Asma and my brother Khalid

the soul of my sister Salwa

my self

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Abstract

A cross sectional study was conducted in 60 commercial poultry farms (38 open ,18 semi closed and 4 closed system) in River Nile State , distributed in 4 localities (Atbara , Aldamer , Shendi and Barber) included layer , broiler and grower farms . Data were collected by using structured questionnaire. The data were analysed using Descriptive Statistics Method and Chi Square .The practices and infrastructure observed in the farms were inconsistent with the three principle elements of biosecurity. Results showed that open system farms tend to have a less secured boundary than that of the close system farms. Most of farms in open system are at high density area (the distances to nearest farm are less than 500 meter) and there are no farms in closed system less than 500 meter. Level of knowledge about importance of biosecurity is overall insufficient, only 50% of the respondent understands the importance of biosecurity as disease prevention measures while 18% don't have any information about biosecurity. Partial knowledge about the component of biosecurity was noticed, 20% of respondent recognize isolation, while traffic control and sanitation were identified by 6.7 % and 3.3% of the respondent respectively. Regarding proper practice and awareness of biosecurity the study showed that 68.3% of farm owners were not trained about biosecurity practice. High cost and inconvenience are major constraints to practicing recommended biosecurity measures as well as insufficient knowledge of biosecurity measures and importance.

ملخـــص الأطـروحـــة

شملت الدراسة 60 مزرعة دواجن (38 شبه مغلق ، 18 مفتوح و4 نظام مغلق) في اربعة محليات (عطبرة ، الدامر ، شندي و بربر) ، تم جمع البيانات بزيارة المزارع والمقابلة الشخصية وملئ الاستبيانات وتم تحليلها باستخدام الاحصاء الوصفي ومربع كاي. اظهرت النتائج ان الممارسات في المزارع كانت متناقضة مع المبادئ الثلاثة للأمن الحيوي . وان مزارع النظام المفتوح تميل إلى امن حيوي اقل . و أغلبها في منطقة الكثافة العالية (المسافات إلى المزرعة الأقرب أقل من500 متر) اما مزارع النظام المغلق اكثر احتفاظا بالمسافة المأمونة . المعرفة بأهمية الامن الحيوي غير كافيه عموما، فقط 50 % من المستهدفين لديهم فهم بأهمية الأمن الحيوي بينما 18 % من المستهدفين لا يمتلك اي معلومات حول اهمية الأمن الحيوي. بينت الدراسة بان هنالك معرفة جزئية حول مكوّنات الأمن الحيوي ،20 % من المستهدفين يشيرون بان الامن الحيوي يتمثل في العزل فقط، بينما التحكم في الحركة والتطهير بنسبة6.7 % و3.3 % على التوالي.، 68.3 % من المستهدفين لم يتلقوا تدريبات في اجراءات الامن الحيوي. كما اظهرت الدراسة بان اغلب المعوقات في تطبيق الامن الحيوي في مزارع الدواجن بولاية نهر النيل هي التكلفة العالية بالإضافة لعدم المعرفة الكافية بإجراءات الامن الحيوي واهميته .

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Introduction

Biosecurity is a strategic and integrated approach to a nalysing and managing relevant risks to human, animal and plant life and health and associated risks to the environment. Interest in biosecurity has risen considerably over the last decade in parallel with increasing trade in food, plant and animal products, more international travel, new outbreaks of trans boundary disease affecting animals, plants and people, heightened awareness of biological diversity and greater attention to the environment and the impact of agriculture on environmental sustainability. (FOW Biosecurity Toolkit.,2007) .

Poultry industries in River Nile State are developing in the past ten years by private sector (Annual records., 2007-2017). River Nile state government has recently adopted a policy to improve poultry production in order to meet the increasing demand of the local markets for poultry products (ELGhali *et al*., 1995).

River Nile state have been regarded as a disease free area, characterized by middle position between a large markets Khartoum, Port Sudan, kassala and Elgadaref. And connected with the main roads that encouraged establishing a poultry projects in the state (Annual record., 2017). Although of all these characteristics there are some problems threatened the projects.

Different viral, bacterial and parasitic in addition to deficiency diseases of poultry were reported in the state (ElGhali *et al*., 1995; EL Hussein *et al*., 1998 and annual record., 2017).

Infectious agents of poultry are a threat to both human and poultry health and have significant social and economic implications. In poultry production, especially under intensive

conditions, prevention is the most viable and economically feasible approach to the control of infectious agents (OIE.,2017).

Biosecurity is the cheapest way of disease control and the most effective as prevention is less expensive than treatment.(zienab.2019).

Benefits of an effective Biosecurity program include optimized animal health and welfare, improved animal productivity, reduced production and inputs costs, and enhanced value of the herd due to freedom from certain disease causing pathogens (Merck vet manual., 2010). Biosecurity protocols should be developed and applied in objective manner with the focus on pathogens and disease process that are economic relevance to livestock producers (Merck vet manual., 2010) . A disease control program should be formulated and then recognized and implemented, preventing the entry of pathogens and suppressing the activity of existing pathogens require effort and cooperation by all on the farm. (Merck vet manual., 2010).

Problem Statement or Justification:

- Circulation of some controllable poultry diseases that threaten poultry industry in the State.
- Lack of knowledge and interest about preventive and control program.
- Difficult to application of biosecurity due to the high cost.

Objectives of the Study

Main Objective:

- To evaluate the application of biosecurity measures in poultry farms in River Nile State.

Specific Objectives:

-To compare biosecurity practices in different types of poultry Husbandry systems in River Nile State.

-To identify the problems facing the adoption of Biosecurity in poultry farms in River Nile State.

- To identify Farmers knowledge about biosecurity in River Nile State.

Chapter One

Literature Review

1.1 Definition of Biosecurity

The word **Biosecurity** Bio=Life, Security=Protecting. Bio-security means Protecting Life (Trainee guide., 2011).**B**iosecurity has multiple meanings and is defined differently according to various disciplines. The original definition of biosecurity started out as a set of preventive measures designed to reduce the risk of transmission of infectious diseases in crops and livestock, quarantined pests, invasive alien species, and living modified organisms.

(https://en. wikipedia.org/wiki/Biosecurity).

Biosecurity was also defined as "Freedom from danger represented by biological agents". The biological agents that present "danger" to the poultry industry are those microscopic organisms that include pathogenic viruses, bacteria and parasites. Particularly those required the avian species as a host (BC association Poultry Biosecurity Reference Guide, 2006).

William (2015) stated that Biosecurity is the means by which you keep infectious diseases off your farm or in the event that you have a disease problem, how you can keep it from spreading to your neighbours**. B**iosecurity is also define by Siekkinen *et al* (2008) as the exclusion, eradication, and effective management of risks posed by pests and diseases to the economy, environment and human health. Recently the term biosecurity has been used widely in the debate on avian influenza (FAO., 2004a).

1.2 Component of Biosecurity

Biosecurity consists of a set of management practices, which when followed collectively reduces the potential for the transmission and spread of disease-causing organisms such as the Avian Influenza virus onto and between sites, animals and humans(Halifa ., 2007).

There are two categories of biosecurity namely **bio containment** involving quarantine and other measures designed to keep diseases virus on infected farm or area and **exclusion biosecurity** aimed at keeping the virus out of disease free farms or area (Abah *et al* .,2017).

Biosecurity is the normal way to avoid unnecessary contact between animals and microbes, infected animals and healthy ones. Biosecurity also applies to public health measures that will reduce the contact between animals and humans (Halifa ., 2007).

Ali *et al*(2014) mentioned that Biosecurity practices cover a broad range of measures. These have been divided into three categories, **conceptual** that including the choice of location of farms. **Structura**l, covering the physical facilities to protect against entry of wild birds**. Operational**, covering the work procedures that farm staff and visitors adopt. Poultry health management is the emerging issue.

1.3 Levels of Biosecurity procedures

1.3.1 Routine biosecurity procedures:

These procedures should be implemented and followed on a daily basis. They give a high degree of assurance that diseases and pathogens will not be carried into poultry production areas and will reduce the risk of transmission between production areas. These should be seen as a minimum requirement (National Farm Biosecurity Manual Poultry production.,2009).

1.3.2 High risk biosecurity procedures

High risk biosecurity procedures will be implemented In the occurrence of an outbreak of an emergency disease or serious endemic disease (National Farm Biosecurity Manual Poultry production.,2009).

1.4 Benefits of Biosecurity

Poultry diseases are controlled by biosecurity, veterinary health care, complete vaccination programs, high-quality diet, enclosed housing, and high standard of farm and bird management. Disease can occur if a flock is challenged with a new strain of a virus, bacteria, and parasite or if there is a breach in biosecurity .The first step to disease prevention is protection from exposure to disease agents (Nebraska Poultry Biosecurity Guidebook.,2010). Bio-security is an effective and relatively low-cost disease prevention option which can control multiple infectious diseases through the application of a standard set of measure (Trainee guide., 2011). Maisa and Hayfa (2017) stated that Better farm biosecurity can improve overall flock health, cut the costs of disease treatment, reduce losses and improve farm profitability.

During an outbreak, Biosecurity measures also limits the spread of disease both on and off premises and decrease the costs of disease treatment and reduces losses, leads to improve profitability (Biosecurity and preventing welfare impacts in poultry and captive birds.,2018;Trainee guide., 2011).

Poultry Diseases does not only increase mortality, but also could cause slower growth, lower egg production rates, reduce product quality and lower customer satisfaction, which all lead to enormous financial losses to producers and could be reflected in price increases to the consumers (Ajewole *et al* .,2014) .

Most of the poultry industries in the world have developed biosecurity measures to maintain the safety of poultry from biological

hazards and be used for protection and disease control of the poultry (Alsaffar., 2015).

Biosecurity must be practiced at all times. All farmers and workers should have a documented biosecurity training. A biosecurity checklist should be posted or kept on each farm (Nebraska Poultry Biosecurity Guidebook.,2010).

1.5 The Principles of Biosecurity

Biosecurity principles include simple procedures and practices which when applied prevent entry of disease agents into a farm or the exit of the disease agent from infected premises (Nyaga., 2007).

Ajewole *et al* (2014) mentioned that to achieve desired impact from biosecurity programs a comprehensive biosecurity programs must be developed. In general a comprehensive biosecurity program should include three major elements: isolation, traffic control, and sanitation.

Biosecurity can be broken down into three elements ,isolation refers to time, distance, and physical barriers that reduce or prevent entry onto the farm and/or into the poultry houses, traffic control includes restricting human, equipment, and animal movement onto the farm, and movement patterns on the farm, while sanitation refers to the cleaning and disinfection of poultry houses, people, materials, and equipments (Guidance for Industry-Prevention of *Salmonella Enteritidis* in Shell Eggs During Production, Storage, and Transportation.,2011).

1.5.1 Isolation

Isolation of premises and poultry from sources of infection. This include the following practices, keeping different bird species separately; preventing exposure of birds to potential sources of disease; preventing introduction of new birds from live bird markets

or neighbours into an old flock; quarantining new birds for a period of time before joining an older flock; quarantines in the event of a disease outbreak in a farm; birds that selected for sale or show should not return back to the flock houses. Trays that went to the market should be decontaminated before use again .Identifying clean and dirty operations in the farm and starting with the clean and ending with the dirty operations; identifying dirty and clean operations in the slaughtering process and preventing contamination of the final product from the dirty operations; preventing wild birds and animals or domestic pets from contacting the flocks. All these measures lead to both bio-exclusion and bio-containment of disease agents thus preventing spread of disease (Nyaga.,2007).

1.5.2 Controlling traffic

Flow in and out of susceptible areas to limit exposure. This would include fencing, gates, human and vehicle controls within the farm and into the farm; notifying the visitors that flock areas are out of bound to outside visitors; controlling movement of equipment and products to and from the farm (Nyaga.,2007).

1.5.3 Sanitation

Sanitation of equipment, housing, protective clothing for poultry workers, and sustaining personal hygiene that will lead to destruction of disease agents. This would involve the washing of hands; using fresh or dedicate clothing exclusively for the chicken house for sector three and four cases; using personal protective equipment like coveralls, gum boots, headwear; cleaning and disinfection of vehicles, houses and equipments; using showers and fumigation and frequent washing of hands before and after handling poultry or their products (Nyaga.,2007).

1.6 Biosecurity hazard

Biosecurity systems are primarily concerned with preventing, controlling or managing hazards to life and health (Infosan., 2010).

There are various descriptions in the different biosecurity sectors as to what constitutes a hazard. **Food safety is any** biological, chemical or physical agent in, or condition of food with the potential to cause an adverse health effect .**Zoonoses which are** a biological agents that can be transmitted naturally between wild or domestic animals and humans. Regarding **Animal health** any pathogenic agent that could produce adverse consequences on the importation of a commodity. **Plant health** any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products. **Plant health quarantine** a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.

1.7 Sources of avian diseases

Humans, whether as visitors' neighbors or farm workers, can be a major source of disease transmission. Equipments that moves between farms. Replacement flocks carries or infected with vertical transmitted poultry diseases, wild birds may carry and transmit disease to commercial poultry flocks. Birds of different age or species are all possible sources of contamination. Poor sanitation also can cause disease problems .once a site is contaminated, carry over from previously infected flocks may become reoccurring problems. Disease outbreaks are influenced by the general condition of the flock. Condition caused by poor management can reduce the flocks resistance to infection (Jeffre.,1996).

1.7.1 Factors contributing to disease occurrence

Poor disease control strategies and low or inadequate biosecurity measures result in high levels of baseline mortality due to infectious diseases (Tabidi *et al*., 2014). Factors that can contribute to disease occurrence include management, environment and the chickens:

1.7.1.1 Management factors

Poor-quality food and water, Poor hygiene and inadequate cleaning programme, Leaking water bowls, rodent and fly problems, Overcrowding of chicks, multi age rearing together, uncontrolled movement of people and animals within and between chicken farms are the major factors .

1.7.1.2 Farm Environment

Temperature and humidity conditions, Wet litter, Dusty bedding, high build-up of chicken droppings, No air circulation and Sharp wires in the cages.

1.7.1.3 Chickens

Source of chicks is crucial, weak second-grade chicks, with low protective maternal immunity are always susceptible to different diseases. (poultry.,2000).

1.8 Major Routes for Disease and Pathogen Transmission

Introduction of replacement flock which might be carries or at incubation period, improper disposal of dead carcasses which is consider as an important source of diseases in the farm. domestic and wild birds, feral and domestic animals, including other livestock pets, insects and rodents .

Wild birds play an important role in disseminate diseases not only between farms in the same areas but even between countries

.Disease can be transmitted by farm personnel and family members living on site; contractors, maintenance personnel, neighbours, visitors ,service person(debeakers, vaccinators, sprayers, burners,).in addition to Feed Trucks, Product & waste collection vehicles .contaminated feed and water (Nyaga .,2007).

1.9 Prevention and Control of diseases in poultry farms

Strict biosecurity measures in addition to vaccinations, are strategic prevention and control policies adopted to control some contagious poultry diseases as vaccinations alone are not enough to control them under field conditions and the good husbandry practices such as adequate feeding, housing and stocking to avoid overcrowding, good ventilation, proper disposal of wastes, cleaning and disinfection of poultry premises help to keep out infections and their spread. (Zeinab., 2019). Understanding how diseases are transmitted is an important factor in developing a biosecurity program (Butcher *et al*., 2018).

1.10 Biosecurity procedures in poultry production

A set of recommendations regarding Biosecurity procedures in poultry production including recommendations on the location and construction of poultry establishments and recommendation applicable to the operation of poultry establishment were clearly mentioned in OIE (2018).

1.11Access Management

Preventing the introduction of pathogens into poultry flock is the first step. It is essential to follow proper protocols for movement of people, equipment and birds onto and within the farm. The best approach is to create two zones, an outer area commonly referred to as Controlled Access Zone (CAZ), which include the entire area where poultry are kept or handled.

The Restricted Access Zone (RAZ) is a more restricted area, located inside the CAZ, to which access is more tightly controlled. Each access point to the CAZ or RAZ is referred to as a Controlled Access Point (CAP).These entrances are used by all traffic, such as workers, equipment, feed trucks (Biosecurity recommendation in Ontario., 2016).

1.12 Poultry Industry in Sudan

World Poultry production has been steadily rising at the rate of 4% annually. The productivity of poultry has almost tripled in the last 100 years through genetic selection, improved feeding methods, implementation of modern technology, improved housing, better disease control and excellent management in addition to processing and improved storage of products (Abdelbasit *et al*., 2016).

Poultry industry in Sudan began since 1926 by enter a group of Yandotte Chicken from England ,followed by a central poultry farm in Khartoum Bahri in 1951 this was starting point of government investment in the field of poultry farming. In 1958 Makelmenjeri was published a first version of a book on behalf of poultry (poultry farming in the Sudan). Late in 1963 the American Aid Programme established Kuku Poultry Farm. Breeds such as White Leghorn, Fayoumi, Rhode Island Red, New Hampshire and Light Sussex were introduced into the Sudan (Hayat., 2014).

During the period from 2001 - 2005 a significant increase in the number of farms were noticed, as a result of growing demand and an improvement in selling prices, especially after the increase in population steady in the state of Khartoum.

According to field survey in 2009 the production of broilers was 17.3 million chick, and the poultry factories in Khartoum state, were about 10 factories of the poultry broilers production with capacity of

25000 tons / hour (Hayat., 2014). The Kuwaiti Investment Fund made the first investments in poultry integrations in Sudan in the 1979 and in 1984 the Arab Authority of Agriculture Development and Investment launched a second project. These two pioneering projects started with closed systems and state of the art feed mills, and was set as an example to follow for the private sector (Nabil., 2017).The major source of chicken meat and eggs in the Sudan was produced from a population estimated in 1975-1976 to be about 22 million bird yielding 1.3 million kilograms of meat (Hayat., 2014).

Poultry production has become one of the most popular and visible enterprises in Sudan. Profitable poultry industry is always characterized by quick body gain and high egg production with less utilization of feed (Abdelbasit *et al*.,2016) .

Poultry industry in Sudan reveal considerable development in the last 10 years, with production increasing from 5 million broilers in 2006 to close to 90 million in 2017. Several factors contributed to this increase, the two most important were the government decision to stop imports of frozen poultry in 2006 and the increase in red meat prices. Other factors that contribute to increase of poultry meat consumption are, urbanization, change in food habits, rising income and population growth (Nabil., 2017) .

More than 60% of the broiler production is produced in integration. Farmers produce the remaining 40%, with farms ranging in size from 10,000 birds to 100,000 birds (Nabil., 2017).

Both Sudan’s growing population (estimated at 2.5% per year in 2016) and growth of gross domestic product (GDP) income are contributing factors to the increase in demand for protein. This is reflected in the current per capita consumption estimated at around

2.7kg. Amongst Arab countries, Sudan has the lowest per capita chicken consumption. (Nabil., 2017).

1.13 Poultry Production in River Nile State

Until 1983, the northern region lacks poultry industry. Local breeds are not known and no statistics for them, types of Hisex and Fayoumi breeds have entered through public sector farms and the poultry production system is the traditional system (small farms). The consumer gets Eggs and chicken from government units, which were originally established as service extension and not productive units. Governmental production units in River Nile state were distributing in Shendi, Atbara and Aldamer, they are established in 1954, 1958 and 1972 respectively in addition to the farms of the private sector. (https://aoad-app.org/linked_studies).

Commercial poultry production in the state categorised into open system, semi closed system and closed system (Annual record., 2017) .They differs in capital investment, operating cost, and efficiency.

1.13.1 Open system poultry farms

Considered to be the least costly of all systems, this system is usually used by small and medium size farmers. The poultry house will have open sides with curtains and no insulation. There are no controls for the environment. The internal environment will depend on external temperature and winds. This type of housing gives no control on temperatures. Farmers tend to stop production in cold winter period and hot summer periods to avoid high mortality. Maximum density is around 10 birds per square meter (Nabil., 2017) . Open system farms were widely distributed in the state which reach up to 105 farms in 4 localities Shendi , Atbara, Aldamer and barber (Annual record.,2017)

1.13.2 Semi-Closed System poultry farms

This system is with open sided window and curtains. Fans are typically installed at the end of the house and are equipped with a climate control equipment for adjustment of temperature and humidity. The farmer will have an acceptable control on the house temperature, plus or minus 5 to 7 degrees. Best practices put the maximum density at 14 birds per m2 (Nabil., 2017). Total of farms in this system are 18 farms in state. (Annual record.,2017) Table (1).

1.13.3 Closed System poultry farms

In this system, the environment is completely controlled. The house has small windows, fans, and sensors connected to an environmental control system that manages the internal climate of the house including temperature and humidity. This system provides optimal conditions for the birds to grow. Internal temperatures can be up to 20 degrees lower inside the house.

This system requires a higher investment, but will produce a higher return with lower mortality. Best practices put the maximum density at 20 birds per m2 (Nabil., 2017) .There are only 6 farms in State in closed system. (Annual record.,2017) Table (1).

Table (1) Distribution of Poultry Farms in River Nile State

Husbandry system	Type of rearing	Locality	No of Farms
Open	layers	Shendi	5
		Atbara	60
		Aldamer	9
		Barber	9
		Total	**83**
	Broiler	Aldamer	4
		Atbara	17
		Barber	1
		Total	**22**
Semi closed system	layer	Shendi	2
		Atbara	4
		Aldamer	1
		barber	-
		Total	**7**
	Broiler	Shendi	-
		Atbara	11
		Aldamer	-
		barber	-
		Total	**11**
Closed system	Layer	Shendi	3
		Atbara	-
		Aldamer	-
		Barber	-
		Total	**3**
	Broiler	Shendi	2
		Atbara	-
		Aldamer	-
		Barber	1
		Total	3
Total of farms		**129 farm**	

1.14 Problems threaten poultry industry in Sudan

Poultry diseases can cause serious losses in the poultry industry. Diseases occur due to lack of proper care and management, inadequate nutritious feeding and some other factors (Hussein., 2017).Diseases are a main challenge to poultry production in Sudan. Prominent viral diseases present are infectious Bronchitis (IB), infectious Bursal disease (IBD) and Newcastle disease (ND) (Nabil ., 2017). Prevalence of infectious diseases, predators and lack of veterinary services and health care were considered to be the major constraints facing the Sudanese native chickens keeping under extensive system. (Ibrahim *et al* ., 2015) .

Common infectious diseases of poultry such as coccidiosis, infectious laryngotracheitis and Marek's disease pose constant challenges to poultry producers and can chronically lower flock performance. (Maisa and Hayfa.,2017) .

In September 2006, Sudan joined the list of nations seeing a resurgence of bird deaths due to avian influenza H5N1.The disease had severe impacts on the poultry industry, high mortality rates in farms range from 7% up to 80%. The prevalence of these diseases increases production cost and in turn has a negative impact on the sector in general. Campaign for awareness promotion and improvement of the biosecurity and restructuring of poultry production was launched (Maisa and Hayfa., 2017; Nabil., 2017).

Infectious agents of poultry are a threat to poultry health and, at times, human health and have significant social and economic implications. In poultry production, especially under intensive conditions, (OIE ., 2017). Sudan has always had great potential in the poultry and agriculture sectors in general. It is recognized as one of

the countries in the region with the potential to produce competitively priced poultry for export. Although the country is far from achieving this stage due to low productivity caused by diseases and sector mismanagement, there is opportunity for many improvements. (Nabil., 2017).

1.15 Bodies involved in Application of biosecurity on farms

1.15.1 National stakeholders

The sector-specific government agencies have a primary interest in dealing with biosecurity threats, but industry, scientific research institutes, specialist interest groups, nongovernmental organizations (NGOs) and the general public, all have a vital role to play. Even within government, bodies responsible for the sectors usually associated with biosecurity – food safety, public health, agriculture, forestry, fisheries and the environment – play the primary role in a contemporary integrated approach to biosecurity. However, other parts of government responsible for sectors such as trade, customs, transport, finance and tourism may also become involved depending on national circumstances (Infosan .,2010)

1.15.2 International stakeholders

International standard-setting organizations, international bodies and international legal instruments and agreements constitute the governance framework for biosecurity. International standard-setting organizations and bodies like the Codex Alimentarius Commission (CAC), the World Organisation for Animal Health (OIE) and the Commission on Phytosanitary Measures (CPM) develop standards according to their mandates, which have become international reference points through the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary

Measures (SPS Agreement), 1995. Other relevant agreements include the Cartagena Protocol on Biosafety, the Codex Alimentarius, the Convention on Biological Diversity (CBD), the Food and Agriculture Organization of the United Nations (FAO), General Agreement on Tariffs and Trade (GATT 1947), the International Health Regulations 2005 (IHR, 2005), the International Plant Protection Convention (IPPC), the International Maritime Organization (IMO), the Organisation for Economic Cooperation and Development (OECD) and the World Health Organization (WHO) are the potentially most important and relevant global and regional agreements, soft-law instruments, international organizations and bodies that are associated with biosecurity.(Infosan .,2010) .

Chapter Two
Materials and Methods

2.1 Study Area

River Nile state is located between latitudes 16-22 north, and longitudes 32-35 south .the state was boarded by country and other four neighbours states. Arab republic of Egypt from the north, kassala and red sea states from the east, Khartoum state from the south and the northern state from west fig (1). It covers an area of about 124000 square KM. The State lies within the tropical area. It occupies the desert and semi desert zones .River Nile State is composed of seven localities namely Aldamer, Barber, Shendi, Elmatama, Atbara, Abohamed and Elbohira fig (2).

Fig (1) location of river Nile state (https://www.google.com/maps).

Fig (2) localities of River Nile State.

2.1.1 Selection of study Area

The current study was carried out in Four localities (Atbara, Aldamer, Barber and Shendi) , which were selected according to the distribution of poultry farms .The primary information and numbers of poultry farms were obtained from Ministry of Agriculture and Animal Resources (Annual Record .,2017) .

2.2 Design of study

A cross-sectional survey for assessment of biosecurity measures on commercial poultry farms in four localities in River Nile State was carried out. Questionnaire was prepared to get information about the biosecurity system in farms investigated.

2.3 Numbers and Types of Samples

A total of 60 Poultry farms of different husbandry system (closed ,semi closed and open system) and type of production(broiler , layer and grower) were investigated during the period January and April 2019 table (2) .Majority of Farms 56 (93%) were belonged to the small scale producers and only 4 (6.6%) were large companies.

Table (2) Distribution of investigated farms

location	open	semi close	close	T.N
Atbara	30	12	0	42
Aldamer	2	3	0	5
Shendi	0	2	3	5
Barber	6	1	1	8
Total	38	18	4	60

2.4 Sampling method

Samples were collected from all farms that were found working during the research period (January and April 2019) .Only 60 farms out of the 129 registered farm were investigated (total coverage method).

2.5 Questionnaire

Data were collected by means of pretested modified questionnaire FAO (2004a). Questionnaire included different types of actions related to biosecurity at the farm level.

2.5.1 Components of Questionnaire

Questions for biosecurity were grouped into the three main components of biosecurity as defined by FAO (2004a) which were isolation, traffic control and sanitation. The first part Basic information of poultry farms consisted of locality ,type of production, system of production ,Number of birds in squarmeter, Building materials, Distribution of feeder and water , source of chicken and Presence of keeping records. Second part was related to isolation (including location of the farm, distances to nearest farm, distances between houses, presence of fence and gate, keeping fence and gate locked when not in used). The third part related to traffic control (including presence of parking area, warning signs put upon gate, restriction of vehicle movement and disinfection before entering vehicle, restriction of people and animals movement, equipments share. The fourth part was related to sanitation. This part categorized to four component, cleaning and disinfection, pest control, disposal of manure and dead birds in addition to food and water source.

The fifth part diseases treatment and vaccination the sixth part was respondent knowledge about biosecurity measures. The seventh part was the problems facing the application of biosecurity consist problems and obstructions (Appendix1).

2.6 Data collection:

Data to evaluate biosecurity parameters, were collected by direct interview with poultry farm manager at the farm, Data were collected from all working commercial poultry farms at time of study.

2.7 Data analysis

Data collected were analyzed with the descriptive statistics frequency and chi square. Data were analyzed using the SPSS statistical package of social science (SPSS) computer program (version 16.0.)

Percentages were used to describe the implementation of biosecurity parameter. Frequencies were used to enumerate the numbers of farms. Chi-Square values were used to measure the significances of dependency to comparing three systems of production significant 0.5.

Chapter Three

Results

3.1 Results

During this study the data was collected from 60 poultry farms. Farms were located in four localities at River Nile state namely Atbara, Aldamer, Barber and Shendi with the objective to evaluate biosecurity condition, to compare the biosecurity practices in different types of Husbandry systems (close, semi closed and open system), to identify the problems facing the adoption of Biosecurity in poultry farms in River Nile State. Also to identify Farmers knowledge about biosecurity.

3.1.1 The basic information in poultry farms

3.1.1.1 Location of the farms

Results showed that poultry farms in the study area distributed in different proportion Fig (3).

3.1.1.2 System of production

The majority of farms 38(63.3%) were identified as an open system farm Fig (4&5), While 18 (30.0%) and 4 (6.6%) of the visited farms were designated as semi closed and closed system respectively Fig (6&7) and Fig (8). Table (3).

3.1.1.3 Type of production

Layer farms were the major type of production, 45 (75.0%) followed by broiler 14 (23.3%) and 1(1.7) breeders farm, Number of birds in square meter were found 7 in 31(51.7%) of the visited farms Table (3).

3.1.2 Building Materials

The majority of housing is made from local materials such as mud or bricks, the roof is wood or zinc. The farms have open sides houses. The walls are low and constructed of bricks or mud and the rest is covered with mesh network .**B**uilding materials are bricks and cement with zinc roof in 29 (48.3%) farms Table (3).

3.1.3 Distribution of Feeders and water

Interestingly in 59(98.3%) farms feeder and water equipments are distributed in an ideal manner.

3.1.4 Source of chicks

The majority of chicks 41(70.0%) in the study area were bought by intermediary from Khartoum state breeders company Table(3).

Table (3) Basic Information about poultry farms

Item	Frequency	Percentage %
System of production		
Open	38	63.3%
semi closed	18	30.0%
Closed	4	6.7%
Type of production		
Layer	45	75.0%
Broiler	14	23.3%
Grower	1	1.7%
Building materials		
bricks and cement with wooden roof	17	28.3
muds with wooden roof	14	23.3
bricks and cement with zinc roof	29	48.3
Distribution of feeder and water		
Ideal	59	98.3
Not ideal	1	1.7
Number of birds in square meter		
10	14	23.3
7	31	51.7
8	13	21.7
Battery	2	3.3
Source of chicks		
Omat	3	5.0
Enma	11	18.3
Coral	4	6.7
Others (by intermediary)	42	70.0

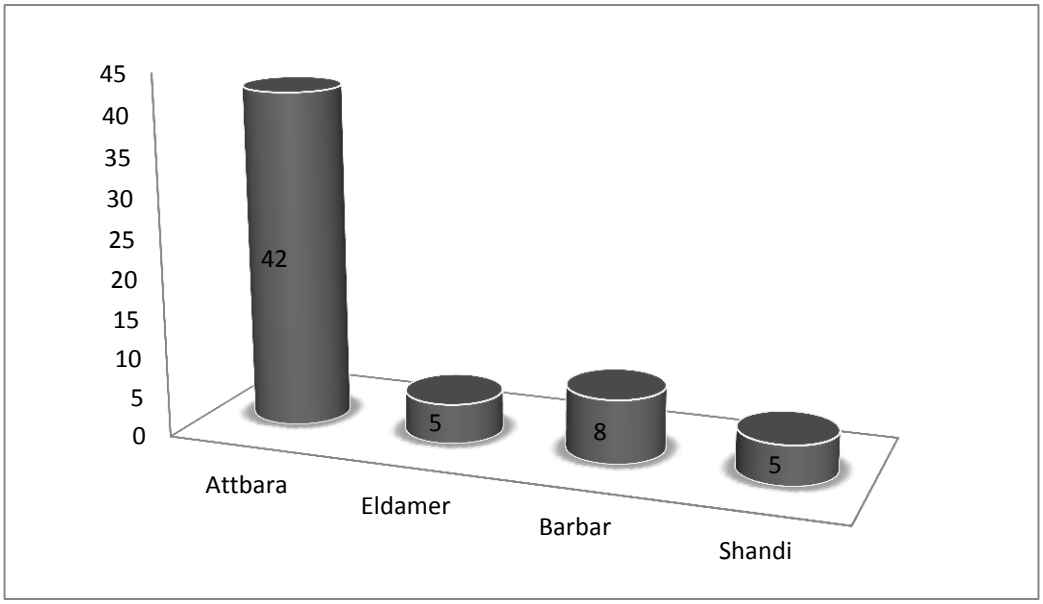

Fig (3) Distribution of evaluated farms in the study Area

Fig (4) Open system layer farms in Aldamer locality

Fig (5) Open system layer Farm in Atbara locality

Fig (6) Semi close broiler farm in Aldamer locality

Fig (7) Inside Semi close broiler farm showing automatic water nipple

Fig (8) Closed layer farm in shandi locality

3.2 Application of Biosecurity measures related to isolation

Twenty three of studies farms 23(38.3%) were located very far from main roads, while 20(33.3%) and 17(28.3%) were near main road. Distance less than 500 meter between farms was observed in 35(58.3%) farms. While the distances between houses in the farms less than 100 meter was noticed in 28(46.7%) farms. A total of 33(55.0%) poultry farms had fence and gate and about 3(5.0%) had only fence around the farms. on the other hand 27(45.0%) farms has no gate at all Table(4).

Table (4) Biosecurity measures related to Isolation

Item	Frequency	Percentage
Location of farms		
near main road	17	28.3
Far from main road	20	33.3
Very Far from main road	23	38.3
Distance to nearest farms		
Less than 500 m	35	58.3
More than 500 m	19	31.7
500m	6	10.0
Distance between houses		
less than 100m	28	46.7
more than 100m	5	8.3
100m	10	16.7
One houses	17	28.3
Presence of fence and gate		
Yes	33	55.0
No	24	40.0
Only fence	3	5.0
Do you keep gate locked when not used		
Yes	22	36.7
No	11	18.3
No gate	27	45.0

3.3 Application of Biosecurity measures related to traffic control

Only 14 (23.3%) farms had parking area. None of the farms visited had Warning signs put upon gate. In 27(45%) farms movement of vehicles were restricted, only 8 (13.3%) of them were adopted through washing and disinfection of the vehicle before entering. Out of 60 poultry farms 34 (56.7%) showed restriction in the movement of visitors. In majority of the farms 24 (40 %) only vet and employees were inter the farm while in 13(21.7%) farms other visitors such as friends and consumers were allowed to enter. The majority of the farms 54 (90 %) did not share Equipments with neighboring farms. Thirteen (21.7%) farms had an open access to wild birds. Species other than chicken were found in about 5 (8.3%) farm Table (5).

Table (5) Biosecurity measures related to traffic control

Item	Frequency	percentage
Presence of parking area		
Yes	14	23.3
No	46	76.7
Presence of warning sign		
Yes	0	0.0
No	60	100.0
Movement of vehicle restricted		
Yes	27	45.0
No	33	55.0
Vehicle subjected to washing and disinfectant		
Yes	8	13.3
No	52	86.7
Movement of visitors restricted		
Yes	34	56.7
No	26	43.3
Who enter the farm		
vet and employee	24	40.0
owner and employees	3	5.0
vet and owner and employees	20	33.3
others(consumer and visitor)	13	21.7
Equipment share		
Yes	5	5.0
No	54	90.0
Sometimes	1	1.7
Entering of other animals in farm		
no	13	21.7
Yes goat, cats and dogs	29	48.3
Birds	13	21.7
Rearing with other animals	5	8.3

3.4 Application of Biosecurity measures related to sanitation

3.4.1 Cleaning and disinfection

The employees of about 32(53.3%) of the farms evaluated washes their hands by water and soap before entering and leaving the farm ,and have a clean work clothes which disposed before leaves premises. whereas only 19(31.7%) of employees disinfected their hands before entering poultry houses. The majority of poultry farms 46(76.7%) were not using disinfectant in footpath Fig (9). In 29(48.3%) of the farms investigated equipments were washed with water and soap every morning. Table(6).

Table (6) Cleaning and disinfection

Item	Frequency	Percentage (%)
Cleaning and disinfection		
Visitors and employees wash hands by water and soap before entering		
Yes	32	53.3
No	27	45.0
if visiting other farm	1	1.7
Employees have clean work clothes		
Yes	33	55.0
No	27	45.0
Hands disinfected before entering the poultry houses		
Yes	19	31.7
No	41	68.3
Using disinfected in footpath		
Yes	9	15.0
No	46	76.7
used two shoes (out and inter)	5	8.3
Decontamination of equipment		
as routine	23	38.3
after out break	1	1.7
washing by water and soap in morning	29	48.3
washing by water only after some days	1	1.7
beginning of the patch	6	10.0

Fig(9) antiseptic sink at the main entrance of a close system farm in shandi locality

3.4.2 Pests control

Out of 60 farms ,52 (86.7%) were blocking holes ,and 46 (76.7%) farms were looking usually for evidence of rodents while only 6 (10.0%) farms were keeping out rodents by using control program as routine Table(7).

Table (7) Pests control

Item	Frequency	Percentage (%)
Pest control		
Look usually for evidence of rodent		
Yes	46	76.7
No	14	23.3
Block holes and trap rodent and wild birds		
Yes	52	86.7
No	8	13.3
Do you keep out rodent by using control program		
Sometimes	17	28.3
As routine	6	10.0
No	37	61.7

3.4.3 Manure and dead birds disposal

Most farms 35(58.3%) used manure as fertilizer. About 90% of the farms had separate quarantine, while 5% used part of the rearing cages as quarantine.

Dead birds were collected twice daily from houses in 28 (46.7%) farms, while 21(35%) collected once daily, 43 (71.7 %) of farms dispose dead carcasses by thrown away Table (8).

Table (8) Manure and dead birds disposal

Item	Frequency	Percentage (%)
Manure and dead birds disposal		
litter and manure disposal		
Sale	22	36.7
Burial	3	5.0
Use are fertilizer	35	58.3
Presence of quarantine		
Yes	54	90.0
No	3	5.0
In a part of cages	3	5.0
Collection of dead birds		
Once daily	21	35.0
Twice daily	28	46.7
More	11	18.3
Dead birds disposal methods		
Burning	2	3.3
Burial	15	25.0
Left thrown away	43	71.7

3.4.4 Food and water sources

Out of 60 farms, 33(55.0%) had source of treating water. most of farms 38(63.3%) provided rations from well-known companies. Protected feed stores were observed in 51(85%) of investigated farms Table (9).

Table (9) Food and water sources

Item	Frequency	Percentage (%)
Food and water sources		
presence of water treating source		
Yes	33	55.0
No	27	45.0
Source of feeding		
Within farm	14	23.3
From companies	38	63.3
Atbara factory	8	13.3
Protected feed stores		
Yes	51	85.0
No	9	15.0

3.5 Treatments and vaccination of poultry diseases

The majority of poultry farms 37(61.7 %) in study area used vaccines imported by well known companies in Khartoum stat and 23(38.3%) farms imported vaccines from pharmacy in Atbara. 52(86.7%) Follow vaccination programs supplied by the same company and 8(13.3%) by vet. 46(76.7%) of farms are using antibiotic for both treatment and prevention. About 40(66.7%) of the respondent did not able to specify diseases presence during the current production cycle and Seasonality of diseases occurrence . only 20(33.3%) of farms were supervised by a veterinarian. interestingly about 54 (90%) of farms had keeping records Table (10).

Table (10) Disease treatment and vaccination

Item	Frequency	Percentage (%)
Source of vaccine		
pharmacy in Atbara	23	38.3
companies from Khartoum	37	61.7
Program of vaccine		
from companies	52	86.7
by vet	8	13.3
Used of antibiotic		
Prevention	2	3.3
Treatment	12	20.0
Prevention& treatment	46	76.7
Disease affected the farm		
Newcastle	7	16.7
Gumboro	3	5.0
No	10	16.7
Other	40	66.7
Disease appearance time		
Summer	6	10.0
Winter	18	30.0
Autumn	8	13.3
Not determined	19	31.7
No disease	9	15.0
Veterinary supervision		
Vet	20	33.3
Technician	6	10.0
vet on call	10	16.7
owner experience	24	40.0
Presence of keeping records		
Yes	54	90.0
No	4	6.7
Production records	2	3.3

3.6 Knowledge about biosecurity

Regarding Knowledge Half of the respondents have heard about and recognized the meaning of biosecurity as isolation, sanitation and traffic control. About 48(80%) of the respondents were awared about the importance of biosecurity in protecting poultry flocks from diseases. Regarding proper practice of biosecurity Only 18(30%) of farmers had basic biosecurity training while the majority 41(68.3%) did not have .(23.3%)have guidebook of biosecurity while (76.7%) did not have .Almost of the farm 51(85%) owners issue orders to implement biosecurity measures on their farms Table (11).

Table (11) Knowledge level about biosecurity

Item	Frequency	Percentage (%)
Meaning of biosecurity		
Isolation	12	20.0
Traffic control	4	6.7
Sanitation	2	3.3
All	30	50.0
I don't know	11	18.3
2and 3	1	1.7
Importance of biosecurity		
Protect poultry	48	80.0
Increase production	3	5.0
I don't know	9	15.0
Do you have basic biosecurity training		
Yes	18	30.0
No	41	68.3
By experimental	1	1.7
Is there any order to employees for application of biosecurity measures?		
Yes	51	85.0
No	9	15.0
Do you have a guide book of bio security at the farm?		
Yes	14	23.3
No	46	76.7

3.7 Problems facing application of biosecurity

The main obstacle facing application of biosecurity measures were the high cost in 22(36.7%) farms, 19 (31.7%) farms mentioned two reason, no enough knowledge of biosecurity measures and no knowledge of biosecurity importance . While 4(6.7) farms mentioned that there are no problems facing them Table (12).

Table (12) problems facing application of biosecurity

Item	Frequency	Percentage
Problems and obstruction		
high cost	22	36.7
no enough knowledge of bio measures	9	15.0
no knowledge of biosecurity importance	6	10.0
no problems	4	6.7
2and3	19	31.7

3.8 Association between systems of production and application of biosecurity

Chi square analysis revealed that there is about 16 parameters of parts of questionnaire have significant differences *($p \leq 0.5$)* according to implementation of biosecurity in three husbandry system of production (open, semi closed and closed system).

3.8.1 Association according to basic information

Results showed there are positive association between systems and locality sig (.000), open system common in Atbara locality and barber and closed system distributed in Shendi, there is no closed system in Atbara locality Table (13).

Table (13) Distributed farms in locality

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig PV
Distributed farms in locality					
Atbara	30(78.9%)	12(66.7%)	0(.0%)	42(70.0%)	Sig.000
Aldamer	2(5.3%)	3(16.7%)	0(.0%)	5(8.3%)	
Barber	6(15.8%)	1(5.6%)	1(25.0%)	8(13.3%)	V31.59
Shendi	0(.0%)	2(11.1%)	3(75.0%)	5(8.3%)	

There is an association between type of production and system of productions sig.000 p value 35.853 , Majority farms of layer production 36(80.0%) in open system, while Majority farms of broiler production 9 (64.3%) in semi closed system and only one farms of grower production 1(1.7%) in closed system Table (14).

Table (14) Type of production in different husbandry systems

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig PV
Type of production					
Layer	36(80.0%)	9(20.0%)	0(.0%)	45(100.0%)	Sig.000
broiler	2(14.3%)	9(64.3%)	3(21.4%)	14(100.0%)	V35.853
Grower	0(.0%)	0(.0%)	1(1.7%)	1(100.0%)	

Also there is an association between Building material and system of production sig .000 (≤ .05), Bricks, cement and wooden roof are common in material building of open system 17(44.7%) and the rest of them1 4(36.8%) are muds and wooden roof, while all semi closed 18(100.0%) and all closed system 4(100.0%) are bricks and cement and zinc roof table (15).

Table (15) Building materials in three husbandry system

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig PV
Building materials					
Bricks and cement and wooden roof	17(44.7%)	0(.0%)	0(.0%)	17(28.3%)	Sig.000
Muds and wooden roof	14(36.8%)	0(.0%)	0(.0%)	14(23.3%)	
bricks and cement and zinc roof	7(18.4%)	18(100.0%	4(100.0%)	29(48.3%)	V 37.132

Results showed there is appositive association between number of birds and the type of system sig .000 (≤ .05) Ten birds in square meter are common in semi closed system 9(50.0%) and closed system3 (75.0%), but seven birds in squarmeter are common in open system 24(63.2%) table (16).

Table (16) Number of birds in squarmeter

Item	Open N (%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig PV
Number of birds in squarmeter					
10	2(5.3%)	9(50.0%)	3(75.0%)	14(23.3%)	Sg.000
7	24(63.2%)	7(38.9%)	0 (.0%)	31(51.7%)	V30.889
8	12(31.6%)	1(5.6%)	0 (.0%)	13(21.7%)	
Battery	0(.0%)	1(5.6%)	1(25.0%)	2(3.3%)	

3.8.2 Association according to Isolation

Results showed there is an association between distances to nearest farm and type of system sig .016 ($p \leq .05$) , Less than 500 m of distance to nearest farm are common in open system 28 (73.7%) while more than 500 m are common in closed system 3 (75,0%) and semi closed system 8 (44.%) Table (17).

Table (17) Distance to nearest farm in three systems

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig value
Distance to nearest farm					
Less than 500 m	28(73.7%)	7(38.9%)	0(.0%)	35(58.3%	Sig.016
More than 500m	8(21.1%)	8(44.4%)	3(75.0%)	19(31.7%)	V12.240
500m	2(5.3%)	3(16.7%)	1(25.0%)	6(10.0%)	

Also Chi square test revealed positive association between type of system and distances between houses sig .002 ($p \leq .05$), less than 100m of distances between houses are common in open system 19 (67.9%). And 100m common in semi closed system and closed system in proportion (70%) % and 20 % respectively, and about 15 farms in open system consist of one house Table (18) .

Table (18) Distance between houses in three husbandry system

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig value
Distance between houses					
less than 100m	19(67.9%)	9 (32.1%)	0 (.0%)	28(100%)	Sig.002
more than 100m	3 (60.0%)	1 (20.0%)	1 (20.0%)	5(8.3%)	
100m	1 (10.0%)	7 (70.0%)	2 (20.0%)	10(16.7%)	
One houses	15(88.2%)	1(5.9%)	1(5.9%)	17(28.3%)	V20.976

Positive association between type of system and presence of fence and gate sig .004 ($p \leq .05$) All closed system farms 4(100%) and majority of semi closed system farms 14(77.8%) have fence and gate , but most of open system farms don't have. Table (19).

Table (19) Presence of fence and gate

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig value
Presence of fence and gate					
Yes	15(39.5%)	14(77.8%)	4(100.0%)	33(55.0%)	Sig.004 V15.205
No	22(57.9%)	2(11.1%)	0(.0%)	24(40.0%)	
Only fence	1(2.6%)	2(11.1%)	0(.0%)	3(5.0%)	

Also Positive association between type of system and locking gate sig .004 ($p \leq .05$) All closed system farms 4(100%) and about 10 (55.6%) farms in semi closed system , only 8(21.1%) farms in open system locked the gate when do not used, in other side 23(60.5%) farms in open system and 4(22.2%) don't have gate table (20).

Table (20) Keeping gate locked in different systems

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	Sig value
Do you keep gate locked when not in used?					
Yes	8(21.1%)	10(55.6%)	4(100.0%)	22(36.7%)	Sig.004 V15.447
No	7 (11.7%)	4(6.7%)	0(.0%)	11(18.3%)	
No gate	23(60.5%)	4(22.2%)	0(.0%)	27(45.0%)	

3.8.3 Association according to traffic control

There is association between type of system and presence of parking area sig .000, All farms 4 (100.0%) in closed system have parking area, while 34 (89.5%) farms in open system and 12 (66.7%) farms in semi closed haven't. Table (21).

Table (21) Presence of parking area in three husbandry system

Item	Open N(%)	Semi closed N(%)	Closed N(%)	total	Sig value
Presence of parking area					
yes	4(10.5%)	6(33.3%)	4(100.0%)	14(23.3%)	.000
No	34(89.5%)	12(66.7%)	0(.0%)	46(76.7%)	17.633

Also positive association between husbandry system and restricted moving of vehicle sig .048 ($p \leq .05$) all closed system farms 4(100.0%) restricted movement of vehicles, 9 (50.0%) farms in semi closed and 24(63.2%) farms in open system don't restrict vehicle movement table (22).

Table (22) Restricted moving of vehicles in three husbandry systems

Item	Open N(%)	Semi closed N(%)	Closed N(%)	total	Sig value
restricted moving of vehicles					
yes	14(36.8%)	9(50.0%)	4(100.0%)	27(45.0%)	.048
No	24(63.2%)	9(50.0%)	0(.0%)	33(55.0%)	6.093

3.8. 4 Association according to sanitation

3.8.4.1 Cleaning and disinfectant

In table (23) Results of Chi square test revealed association between type of husbandry system and using disinfectant in footpath sig .000, Majority of closed system farms 3 (75.0%) have disinfectant footpath, while most farms in open system 33(86.8%) and farms in semi closed system 12 (66.7%) didn't have, In other side there was 5(13.2%) farms in open system used two shoes (for out and enter).

Table (23) Using of disinfectant in footpath

Item	Open (%)	Semi closed	Closed (%)	Total	sig value
(A)Cleaning and disinfectant:					
Using of disinfectant in footpath					
Yes	0(.0%)	6(33.3%)	3(75.0%)	9(15.0%)	.000
No	33(86.8%)	12(66.7%)	1(25.0%)	46(76.7%)	
used two shoes (out and inter)	5(13.2%)	0(.0%)	0(.0%)	5(8.3%)	24.369

Majority of farms in closed system 3(75.0%), and farms in semi closed 11(61.1%), while only 9 (23%) in open system decontaminate equipment as routinely table (24).

Table (24) Decontamination of equipment

Item	**Open (%)**	**Semi closed**	**Closed (%)**	**Total**	**sig value**
Decontamination of equipment					
as routine	9(23.7%)	11(61.1%)	3(75.)	23(38.3%)	
after out break	0(.0%)	0(.0%)	1(25.)	1(1.7%)	S.000
water , soap in morning	27(71.%)	2(11.1%)	0(.0%)	29(48.%)	
water after some days	1(2.6%)	0(.0%)	0(.0%)	1(1.7%)	V39.849
beginning of the patch	1(2.6%)	5(27.8%)	0(.0%)	6(10.0%)	

3.8.4.2 Litter and manure disposal

Positive association between type of production and litter and manure disposal sig .000 Majority of farms in closed system 3 (75.0%) , 10 (55.6%) farms in semi closed system disposal litter and manure by sale, whereas majority farms in open system 27(71.1%) used litter and manure as fertilizer table (25) .

Table (25) Litter and manure disposal

Item	Open (%)	Semi closed	Closed (%)	total	sig value
Litter and manure disposal					
Sale	9(23.7%)	10(55.6%)	3(75.0%)	22(36.7%)	S.010
Burning	2(5.3%)	0(.0%)	1(25.0%)	3(5.0%)	
Use as fertilizer	27(71.1%)	8(44.4%)	0(.0%)	35(58.3%)	V13.189

3.8.5 Association according to disease vaccination and treatments

There is association between type of system and using antibiotic sig .025, Majority of all type of husbandry system used antibiotic for prevention and treatment. Closed system 3(75.0%), open system 34(89.5%), semi closed system 9 (50.0%). But small proportion of them used antibiotic for prevention .table (26).

Table (26) Used of antibiotic in three husbandry system

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	sig value
Used of antibiotics					
prevention	1(2.6%)	1(5.6%)	0(.0%)	2(3.3%)	S.025
treatment	3(7.9%)	8(44.4%)	1(25.0%)	12(20.0%)	
Prevention & treatment	34(89.5%)	9(50.0%)	3(75.0%)	46(76.7%)	V11.52

Also there is a positive association between veterinarian supervision and type of production system .000, All the farms 4(100.0%) in closed system and 12 (66.7%) in semi closed system had veterinarian supervision, while 24 (63.2%) in open system depending on personal experience .fig (11).

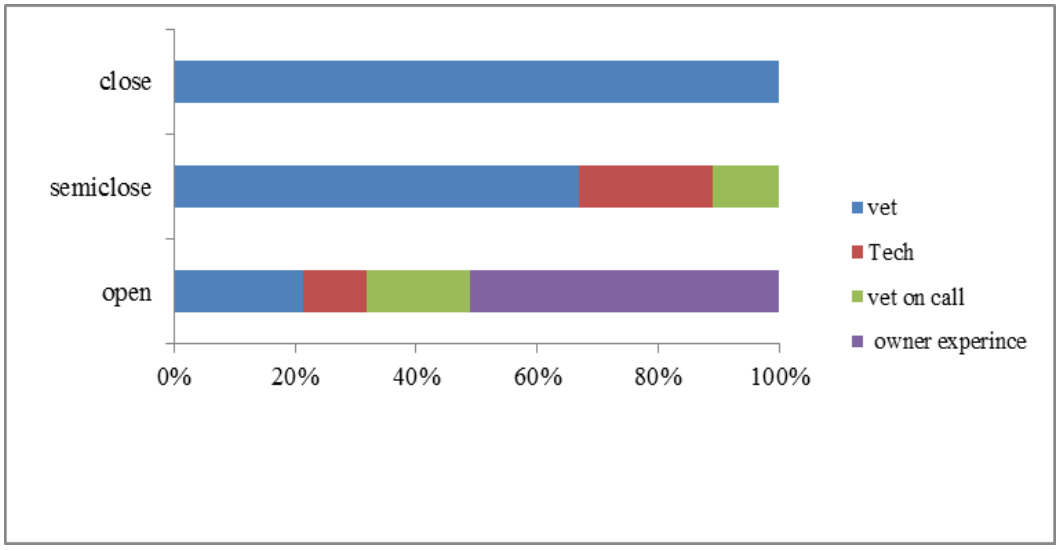

Fig (10) Veterinary supervision in farms

3.8.6 Association according to problems facing application of Biosecurity

Chi square test showed the positive association between type of production and problems facing application of biosecurity sig .000, Majority of farms in closed system 3(75.0%) didn't have problems to application of biosecurity measures, but most farms 11(61.1%) in semi closed system the problems facing them was the high cost and 17 (44.7%) farms in open system the problems facing them were no enough knowledge of biosecurity measures and importance table (26).

Table (27) problems facing application of biosecurity

Item	Open N(%)	Semi closed N(%)	Closed N(%)	Total N(%)	sig value
Problems and obstruction					
high cost	10(26.3%)	11(61.1%)	1(25.0%)	22(25.0%)	S.000 V42.278
lake knowledge of bio measures	6(15.8%)	3(16.7%)	0(.0%)	9(15.0%)	
Lake knowledge about bio.S importance	5(13.2%)	1(5.6%)	0(.0%)	6(10.0%)	
no problems	0(.0%)	1(5.6%)	3(75.0%)	4(6.7%)	
2and3	17(44.7%)	2(11.1%)	0(.0%)	19(31.7%)	

Chapter Four

Discussion

The present study has been conducted in River Nile State, it was intended to evaluate biosecurity measures in a total of 60 commercial poultry farms, to make comparison between three systems of production (open, semi closed and closed system) and also to assess the knowledge of biosecurity measures among poultry farmers in River Nile State localities (Aldamer, Atbara, Barber and Shendi) .These localities were selected according to distribution of poultry farms. Only 60 farms were examined from total 129 registered farms in the state, where 69 farms were found not working at time of this study, for different reasons, such as high cost of poultry nutrition, decrease demand of poultry products due to its high prices, instability of water and electricity supply and other personal problems.

Data were collected during the period from January to April 2019 by using structured questionnaire (interviews and field observations). The poultry industry in River Nile state generally characterized by backyard, small scale, medium scale commercial production system.

The results showed that poultry farms are concentrated in Atbara locality (70.0%), This may be due to habit and culture of population that tended to rear poultry and the fact that Atbara locality is the first locality entering this sector by small private producer and it has a well established infrastructure suitable for poultry industry such as paved roads, electricity and feed factories.

Most of poultry farms (63.3%) in river Nile State are open system because the majority of farmers are small producers that cannot developed their system due to high cost of establishing.

The presence of layer farms is found to be greater than other types of production (75.0) , the layer industry is dominated by open systems , This trend might be attributed to low demand of broiler meat for high prices due to high cost of production .

The practices and infrastructure observed in the farms were inconsistent with the three principle elements of biosecurity. The results revealed that the level of knowledge about importance of biosecurity is overall insufficient, only half of the respondent understand the full meaning of biosecurity as isolation, traffic control and sanitation while 18.3 % don't have any information about biosecurity and partial knowledge about the component of biosecurity was noticed (20% of respondent recognize isolation, while traffic control and Sanitation were identified by 7% and 3% of the respondent respectively). Regarding proper practice and awareness of biosecurity the study showed that more than half of farm owners were not trained about biosecurity practice , nearly similar results were obtained in Khartoum state (Maisa and Hyafa .,2017). The majority of the farm owners (85%) were believed on the importance of biosecurity in poultry farms and give order for its application. Guidebook of biosecurity was available with 23% of respondent.

Segregation is considered to be the most effective element of biosecurity (FAO., 2008) but was not observed in the farms studied. The proximity of poultry sheds to humans, roads or water bodies, and the movement of objects, people and other animals in and out of the sheds, allowing vehicles inside the gate, has been identified as a risk factors for H5N1 outbreaks (Alhaji and Odetokun 2011; Ahmed *et a*l.

2012; Gilbert and Pfeiffer 2012; Osmani *et al*. 2014). Results of this study revealed that 58.3% of poultry farms are at high density areas as its proximity to nearest commercial poultry farm were less than 500 meters .

The study revealed that most of farms in open system are at high density area (distances to nearest farm are less than 500 meter) and there are no farms in closed system less than 500 meter. also About (46.7%) of the farms, the distances between houses in the farms less than 100 meter , among three system (67.9%)of farms is less than 100 m is open system , this could be reason of high spread of disease outbreak . About 28.3% of the farms located near the main roads.

Current results showed that about (45%) farms lack a secure boundary fence and gate, open system farms tended to have a less secure boundary than that of the close and semi closed system farms, similar results were reported by Ali *et al* (2014) but disagree with Maisa and Hyafa (2017) who stated that farm fence was available for all farms studied in both close and open systems in Khartoum state. None of the investigated farms posted biosecurity signs .Parking area was recognized in 23% while traffic flow inside the farm is clearly identified in 45% of the farms. Parking areas outside the farms is Clearly identified in closed system farms. The majority of open system farms did not have parking area similar results were reported by (Maisa and Hyafa.,2017) .

Vehicles movement between farms and households without biosecurity measures could be a potential risk of disease transmission as indicated by Eltholth *et al* (2016).

Most of the farm restricted the movement of visitors ,this disagree with Tabidi *et al* (2014) who analysis data of biosecurity

measures for poultry farms registration in Khartoum state , Sudan that showed none of the three production systems succeeded in preventing human access .

Sanitation is poor, majority of poultry farmers do not have footbath this result in line with Ali *et al* (2014). These have serious implication on the spread of contagious poultry diseases by people as well as being of public health importance regarding zoonosis such as highly pathogenic avian influenza, Salmonellosis and dissemination of antibiotic resistant bacteria.

Only (38.3) farms Decontaminate equipmentas as a routine measure, higher results 91.1% were reported by Ali *et a*l (2014), among closed system and semi closed system.

Rodents may also be important vectors, as they can act as both reservoirs and carriers of pathogens (Meerburg *et al*., 2006) from chicken feces or carcasses. Most of the farms (90%) did not have routine control program of rodents but 77% of respondent look usually for evidence of rodents in the farm, this practice does not agree with Waston *et al.* (2008) who found the use of disinfectant and insecticides to control pathogens and insects may harbour avian pathogens .They stated that pests control should be used as a routine for farm biosecurity programs.

Lack of cleaning and hygiene observed during this study could predispose birds to external parasites, which cause harm, discomfort, stress and act as intermediate hosts for various diseases

On the other hand, accumulation of litter and manure in premises could result in ammonium toxicity during the humid wet seasons causing impairment of the respiratory system and predisposing birds to infectious respiratory diseases like ND, infectious laryngotracheitis, infectious bronchitis, infectious coryza

and *Mycoplasma* infections. Furthermore, *E. coli* could gain entry through the damaged respiratory mucosa (Ritz *et al*. 2004).

Improper management of litter, as observed in this study farms, can be particularly risky, influenza viruses are excreted in high concentrations in the feces. Avian influenza viruses have been isolated from freshly deposited fecal material (Robert G. Webster., 1998). Farmers sold feces as fish feed, which served as a means of disposal and increase their income. However, using untreated feces as fish feed is discouraged (WHO 2006); it may contribute to the spread of avian influenza among ducks, other wild birds and humans sharing the same water bodies. The State lies within the tropical area. It occupies the desert and semi desert zones during the dry season, dust can be a problem due to accumulation of dry faeces and fine dust aerosols which could easily transmit airborne respiratory diseases or cause stress to the respiratory mucosa of birds housed in the area.

In reference to isolation of sick birds 90% of farmers separated sick birds from health birds this result similar to Adam (2015) who observed majority of farms (62%) has quarantine area, while 5% uses part of already occupied cages as quarantine.

About 65% of the farmers collected dead birds more than twice daily. This disagree with Ali *et al (*2014) that reported About 88.9% of the farms collected the mortality once daily.

Dead birds must be disposed in appropriate site either on or preferably off farm. Most of the poultry farmers dispose dead birds in any open area near the farm (thrown away near the farm), this results disagree with Sudarnika *et al* (2010), this may lead to the spread of infection to wild birds, domestic free roaming birds, cats and dogs by feeding on these dead birds, and may spread of infections to both humans and animals.

Drinkers and watering system should be protected from wild birds and vermin access.It was found that about 55% of the respondent's water sanitizing system is implemented, on the other hands about 45% of farms watering system are not protected from wild bird and vermin access subjecting the flocks to extremely high risk of disease introduction (USDA APHIS VS. 2015). Peter and Tim (2009) stated that all water derived from dams, streams, drains and open storage units used for internal shed fogging or drinking water for birds must be sanitized. Sanitation of water helps in minimizing transmitting diseases.

New birds are the most common way to introduced disease into the flock. To reduce disease coming in with new birds , must obtain new birds from a reliable supplier of healthy stock and request vaccination certificate (http// www.business.gold .gov.2016) , Results showed that About 70.0% of farmers obtained chicks from uncertified breeder and hatchery companies . Interestingly the majority of farmers obtained vaccines and vaccination program from certified sources.

The most common poultry disease as indicated by the respondents was Newcastle disease, the results are in agreement with Abdurrahman *et al*., (2016) environmental condition is one of the most important issue in ND epidemiology**.** Alexander (1997) reported that the clinical signs of Newcastle disease and the speed at which the signs appear vary widely and depend upon infectivity and dose of virus, the species, age and immune status of the host, environmental conditions and the route of exposure. Such lack of proper management could contribute to the fact that ND is endemic and persistent in poultry flocks.

The principal cause of chicken loss has been attributed to diseases the results of this study revealed, the majority of farms

supervision depending mainly on owners experience this disagree with Zeinab (2019) who mentioned that most of the farms had veterinary supervisor.

The majority (77%) of farmers used medicines mainly antibiotics for prevention and treatment of birds , this practice is not enough to ensure good health of the birds due to the poor knowledge and understanding of the aetiology and pathology of poultry diseases by poultry farmers (Nwanta, 2003). They may therefore succeed in treating the observable symptoms of the disease without dealing with the actual cause.

Lack of assistance from extension services and the ease acquiring of veterinary medicines and misuse of these drugs might leads to the emerging of the resistant bacteria.

Record keeping is very important to assist early detection of poultry health issues and the response to any biosecurity breach (Maisa and Hyafa., 2017) The same observation was obtained from this study.

High cost and inconvenience are major constraints to practicing recommended biosecurity measures as well as no enough knowledge of biosecurity measures and importance.

Conclusion

The majority of open system were far from the implementation of biosecurity measures. Many respondent do not have enough knowledge about biosecurity measures and its importance to protect their poultry as well as themselves from risk of diseases. Biosecurity current situation needs a combined effort from stakeholders, to improve biosecurity levels for those sectors.

Recommendations

Based on the present study the following recommendations needed to be taken into consideration to improve productivity and increase profitability of poultry production in river Nile state:

1- Closed and semi-closed poultry housing system with advanced high-tech should be encouraged and established instead of opened poultry housing system in the state to avoid effect of the climatic condition of the state.

2- Establishing rules to implement biosecurity measures in poultry farms.

3- Extension programs should be developed for individual poultry farm according to their particular need and situations with the cooperation of the decision makers and farm veterinarian to ensure the success of the program.

4- More scientific researches on biosecurity and quality control in poultry production under Sudan conditions is needed

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Appendix

Sudan University of Science and Technology

Questionnaires to Evaluate Biosecurity measures in commercial Poultry Farms

In River Nile State

Q .NO (…….).

Basic information of poultry farms				
Locality	Aldamer	Atbara	Shendi	Barber
system of production	Open	semi closed		closed
type of production	Broiler	Layer		Grower
Number of birds in squarmeter	10	7		8
Building materials	Bricks and cement zinc Roof	Muds wooden Roof		others
Distribution of feeder and water	Ideal	Not ideal		
Source of chicks	Omat	enma	Coral	other
Presence of keeping records	Yes	No		Product record

Biosecurity measures related to isolation				
location of farm	Near main road	Far from main road		Very Far from main road
Distance to nearest farm	Less than 500 m	More than 500 m		500m
Distance between houses	Less than 100 m	More than 100 m		100m
Presence of fence and gate	Yes	No		Only fence
keeping gate locked when not in used.	Yes	No		No gate
Biosecurity related to traffic control				
Presence of parking area	Yes	No		
presence of Warning signs put upon gate	Yes	No		
Restriction of vehicles movement	Yes	No		
vehicles subjected to washing and disinfection before entering	Yes	No		
restricted moving of visitors	Yes	No		
Who are allowed to entering the farm	Vet and employees	Owner and employees	Vet and owner and employees	All and others
Equipment share	Yes	No		sometimes

Biosecurity measures related to sanitation:					
(A)Cleaning and disinfectant:					
Does visitors and employees wash hands by water and soap before entering and leaving the farm?	Yes		No		After visiting other farm only
employees having clean work clothes and disposed before leaves premises?	Yes		No		
disinfecting hands before entering poultry house	Yes		No		
Using of disinfectant in footpath	Yes		No		Used two shoes out and inter
Decontamination of equipment	As routine	After out break	Washing by soap and water in morning	Washing by water only after some days	Beginning of the patch
(B) pest control					
Looking for evidence of rodents	Yes		No		
Blocking for holes and trap rodents or wild birds?	Yes		No		
Keeping out rodents by using control program	Sometimes		As routine		No
(C) Manure and dead birds disposal					
Litter and manure disposal	sale	Burning	Use as fertilizer		
presence of quarantine	Yes		No		In a part of cags
Collection of dead birds.	Once daily		Twice daily		more
Dead birds disposal methods.	burning		burial		Left thrown away
(D) Food and water sources					
Source of water treating	Yes		No		
Source of feeding	Within farm		From companies		Atbara factory
Protection of feed stores	Yes		No		

Disease treatment and vaccination				
The source of vaccine	pharmacy in Atbara		companies from Khartoum	
The program of vaccination	Applied by company		By vet	
Use of antibiotic	prevention		Treatment	both
Diseases affected the farm	Newcastle disease		Gumboro (infectious Bursal disease)	other
The disease appearance time	Winter	summer	Autumn	Not determined
Veterinarian supervision	vet	technician	vet on call	owner experience

Knowledge level of biosecurity:						
Meaning of biosecurity	isolation	Traffic control	sanitation	all	Idonot know	2&3
Importance of biosecurity	Protect poultry	Increase production	I don't know			
Biosecurity training	yes	No				
Order to employees to applicate bio security measures	yes	No				
Have a guide book	Yes	No				
Problems facing application of biosecurity						
Problems and obstruction	High cost	Lake of knowledge of biosecurity measures	Lake of knowledge of importance of b.s	No problems	2&3	