IMMUNOLOGICAL RESPONSE OF CATTLE TO GASTROINTESTINAL HELMINTHS BURDEN AND TREATMENT CHOICE IN SEMI-INTENSIVE MANAGEMENT SYSTEM

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MINNA

SEPTEMBER, 2023

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ANIMAL PRODUCTION

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DECLARATION

I hereby declare that this thesis "**Immunological response of cattle to gastrointestinal helminths burden and treatment choice in semi-intensive management system"** is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

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CERTIFICATION

The thesis titled "**Immunological response of cattle to gastrointestinal helminths burden and treatment choice in semi-intensive management system"** by Mohammed, Abubakar Kwotu (MTech/SAAT/2018/8106) meets the regulations governing the award of degree of Master of Technology of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to my mother Hajiya Rahinatu Shehu Muhammed (late). May Almighty Allah forgive her shortcomings and grant her Aljannah Firduasi (Amin).

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ABSTRACT

The study was conducted to determine the effect of different anthelmintic drugs on the haematological and immunological responses of cattle to gastrointestinal helminth infection over twelve (12) weeks period in a longitudinal study. The cattle were managed in a semi-intensive system and are made up of male and female animals. The anthelmintic drugs were administered at the beginning of the experiment (once) and blood and faecal samples taken at weekly intervals and transported to the laboratory of the Niger state veterinary hospital, Minna, for haematological, immunological and parasitological examinations. The blood sample was collected from the animals for haematology and immunoglobulin test, while faecal samples were collected for identification of helminth eggs from the experimental animals, for a period of twelve (12) weeks. The animals were allowed to graze in a controlled pasture in a fenced enclosure during the day followed by provision of supplementary feeding in the evening. The cattle were divided into four groups A, B, C and D. Group A, was control while group B, C and D were administered albendazole, levamisole, baminth F dewormers respectively. Data collected on the animals' body temperature, live body weight, faecal and blood samples examinations, were analyzed using analyses of variance (ANOVA) at ($p < 0.05$) level of significance and descriptive statistics. The results of this experiment showed that the administration of anthelmintic drugs (such as albendazole, levamisole and baminth F) had effect ($p<0.05$) on parasites and eggs reduction in the gastrointestinal tract of the animals. There was marginal ($p<0.05$) increase in the weight of the treated groups. The temperature of the animals were slightly increased in untreated and treated groups. There was significant difference ($p<0.05$) in the haematological values of haemoglobin (Hb), packed cell volume (PCV) and white blood cell (WBC). There was significant difference ($p<0.05$) in the immunoglobulin E (IgE) and immunoglobulin M (IgM), though there was improvement in immunoglobulin values of IgA, IgG and IgD. There was significant effect of the treatment (with albendazole, levamisole, baminth F dewormers) on the reduction of gastrointestinal parasites irrespective of sex, age, and drug types compared to the control group. The female animals at puberty, had higher susceptibility to gastrointestinal parasites as compared to their male counterparts. Thus, proper deworming schedule should be carried out with anthelmintic drugs at the right time to control gastrointestinal helminths in cattle.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Livestock is an essential agricultural commodity in developing countries of the world. They are reared under a wide variety of production systems ranging from large-scale intensive commercial enterprises to traditional small-holder and village production systems (Jorgen, 1998). Livestock production is, therefore, an invaluable component of pastoral and agro-pastoral farming, with human populations largely depending on it for meat, milk, fat, dung and farm energy (Wilson, 1991).

In Nigeria, ruminants comprising cattle, sheep and goats constitute the livestock farm animals and about 13.9 million cattle, 22.1 million sheep, 34.5 million goats are currently being reared by farm families in the country (Lawal-Adebowale, 2012). These livestock animals are mostly managed on free-range/ extensive system and semi-intensive system, where the animals are allowed to roam the streets and neighbourhood to scavenge with little or no special provision of supplements for the animals (Lawal-Adebowale, 2012). Thus the growth potential of ruminants have not been maximally exploited due to obstacles such as diseases, malnutrition and mismanagement (Adzitey, 2013). Parasitic diseases contribute to low productivity of livestock in many countries, expecially in the tropics like Nigeria (Ibrahim *et al.*, 2014).

Ruminants managed in extensive systems and semi-intensive system of management are very susceptible to various parasitic helminths (Ibrahim *et al*., 2014), because they open graze on pastures very close to faecal materials, where the concentration of helminths infective stages are very high (Mondal *et al.,* 2000). The gastrointestinal tracts (GITs) of this livestock frequently shelter a variety of helminths, which cause clinical and subclinical parasitism (Regassa *et al*., 2006). Gastrointestinal helminth infection is a health problems limiting the productivity of livestock such as cattle (Dimaner *et al*., 2000; Johannes *et al*., 2009), with infected animals having reduced weight gains, reduced food conversion rates, abortion, infertility and reduced meat and milk production, and sometimes leading to high mortality rates (Tisdell *et al*., 1999; Adama *et al*., 2013).

Gastrointestinal helminths are a diverse group of metazoan parasites (worms), comprising of three taxonomic groups, namely nematodes, trematodes and cestodes. Parasites in each of these groups have very different life cycles and are localised in various tissues or inside the luminal organs of their hosts (Neil and Hany, 2012). They may be transmitted orally (*Strongyles*, *Fasciola sp.*), by transcutaneous route (*Ancylostoma sp*., *Strongyloides sp*., *Schistosoma sp*.) and by an arthropod vector (*Onchocerca volvulus*, *Dirofilaria immitis*). Their definitive and intermediate hosts includes mammals, birds, reptiles, fish, molluscs and arthropods and may be localized in organ lumen or tissues such as the gut, liver (parenchyma and bile ducts), lung and lymphatic vessels. The successive developmental stages of parasitic species may infect different tissues and cells of different organs (Gaba *et al*., 2005).

Despite this great complexity, helminths usually cause asymptomatic or subclinical chronic infection, although some hosts can suffer from severe diseases which may be fatal. Furthermore, worms tend to be aggregated in their distribution, with a large number of hosts harbouring few parasites and a few heavily infected hosts (Hall *et al*., 2009). This remarkable equilibrium between most hosts and parasites is the product of long-term coevolution of the two partners and particularly of the immune defence of the host and the immune evasion of the parasite. Helminths have developed several means of escaping these immune responses.

Recently, Maizels *et al*. (2004), called them “masters of immunomodulation”. These immunomodulatory abilities enable the worm to persist in the host and can lead to interactions with inflammatory and immune mechanisms involved in other infections or to vaccines or allergic and autoimmune diseases.

Helminth infections are typically associated with hypereosinophilia, considerable IgE production, mucous mastocytosis, and goblet cells hyperplasia (Anthony *et al*., 2007). These immune parameters are involved in different effector mechanisms highly depending on where the helminth is localized. Several mechanisms against tissue-dwelling parasites have been described. These parasites are mainly larval stages of trematodes (*Schistosoma sp*., *Fasciola sp*.) or nematodes, which migrate through tissue (Capron and Capron, 1992). Antibody-Dependent Cellular Cytotoxicity (ADCC) is dependent on eosinophils, neutrophils, macrophages, or platelets as effector cells and IgE, IgG, or IgA as antibodies. The parasitic structures covered by antibodies are destroyed by cells carrying receptors to the Fc fragment (RFc) (Meeusen *et al*., 2005). When these cells are activated by fixation of the antibodies to the RFc, they release products that are toxic to the worm (major basic protein, eosinophil cationic protein, eosinophil-derived neurotoxin, reactive nitrogen intermediates. ADCCs are also able to immobilize nematode larval stages as they migrate through the gut mucosa (Piedrafita *et al*., 2001).

Some important risk factors that might promote helminth infections are carelessly handled by the farmers keeping these animals. Such risk factors include grazing or feeding habits, pasture management, immunological status, nutritional deficiency, presence of intermediate hosts and vectors, number of infective larvae and eggs released into the environment, and a conducive weather condition for the development of the helminth's eggs to infective stages as reported by Odoi *et al*. (2007).

Olubukola *et al*. (2014) which reported that 41.6 % of the cattle screened from Ibadan abattoir (southwestern Nigeria) had helminth infection, thus providing valuable information of helminthic burden among cattle in Nigeria. Precisely, nematode infections were high, accounting for 71.7 % of the total helminth burden, Trematode (26.5 %) and cestode (2.01 %) infections were lower. Smilarly, Edosomwan and Shoyemi (2012) also reported a helminthic prevalence of 47.4 % in the South-South region of Nigeria but lower than the 50.8 % and 62.1 % earlier reported in South-Eastern and South-Southern Nigeria, respectively (Nwigwe *et al*., 2013 and Elele *et al*., 2013). The variation observed could be due to the periods or seasons in which the studies were conducted as well as the sources of cattle sampled in the various regions as reported by Olubukola *et al*. (2014). However, the treatment of gastrointestinal helminths to improve the productivity of livestock is paramount since animals managed on the extensive and semi-intensive system are exposed always to helminth infections. This study, therefore, investigates the sex and immunological response of cattle to gastrointestinal helminth burden and treatment choice in the semi-intensive management system.

1.2 Statement of the Research Problem

Gastrointestinal helminths are parasitic agents of animals especially ruminants such as cattle and they limit cattle production in many developing countries as reported by Keyyuet *et al.* (2015).

The growing challenge of helminths is the resistance of some of the parasites to commercially available drugs whereby some drugs are not effective against prevention and treatments of helminths borne diseases any longer due to changes in biological activities and mechanisms of evading host immune system rendering most synthetic helminthic drugs non-effective (McCarthy *et al*., 2012).

1.3 Justification for the Study

There is an urgent need to look into zoonotic vectors since most gastrointestinal helminths are zoonotic in nature as the health of both the animals and the herder could be affected.

Helminths infection in cattle is also responsible for carcass condemnation at the slaughter houses, especially during the meat inspection resulting in economic loss and low protein yield (Dermauw *et al*., 2018). This is typically seen in the case of liver fluke infection in which the liver is condemned (Innocent *et al*., 2017). Also, related to this is the case of pimply gut in which most part of the gastrointestinal tract is condemned during meat inspection (Nwankwo *et al*., 2019). These apart from the economic loss to the producers, they are also risk factors for public health of the people who consume meat as well as industrial uses of beef production of other food products.

The treatment of helminths in cattle has both economic and public health implications. The economic aspect has to do with the prevention of cattle from devastating effect of the parasites to improve their production performances and increase revenue generation from cattle. This is because, helminths as the major cause of health constraint to ruminants' well-being compromised productive performance, mortality of animals due to parasitic diseases (Greyling, 2017). In the aspect of human public health, helminths infestation in cattle could be a source of human health complications and compromise whereby many diseases emanated resulting in loss of human lives (Rukambile, 2020). In Nigeria, considerable supply of meat for human consumption is from cattle, hence helminths contaminated meat could be source of zoonotic impact on human health are considerably greater loss of human lives (Adedipe *et al*., 2014). Therefore, it is justified to investigate the complexities associated with immune functions with respect to the choice of drugs against helminths. Furthermore, efforts at understanding types of helminths and treatment options that will culminate the effects of helminth infection on cattle and its carcass will minimize meat and carcass condemnation and reduction of economic loss suffer by cattle producers as well as protection of publich health complications.

1.4 Aim and Objectives of the Study

The study aim is to investigate the effect of different anthelmintic drugs on the immunology of different sexes of cattle under semi-intensive production.

The objectives of the study were to:

i. determine the helminth burden of cattle under semi-intensive production;

ii. evaluate the effect of different anthelmintic drugs on helminth load of cattle under semi-intensive production system;

iii. assess the effect of different anthelmintic drugs on haematological parameters of cattle under semi-intensive production system;

iv. determine the effect of different anthelmintic drugs on immunoglobulin parameters of cattle under semi-intensive production system;

v. evaluate the relationship of anthelmintic drugs to helminths load, sex and age of cattle under semi-intensive production system.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 An Overview of Helminthiasis and Animals' Gastrointestinal Parasites

Helminthiasis is an animal disease which is also known as worm infestation. It is a macro parasitic disease of animals whereby a given part of the animal's body becomes infested and damaged by the parasites known as helminths (Fomum, 2018). It is a disease caused by a broad range of organisms which are primarily intestinal parasitic worms including roundworms (*Ascaris lumbricoides*), whipworms (*Trichuris trichiura*), or hookworms (*Necator americanus* and *Ancylostoma duodenale*) among others (Hailu, 2020). However, helminths are numerous species of these parasites, which are broadly classified into tapeworms, flukes, and roundworms; they often live in the gastrointestinal tract of their hosts and may also burrow into other organs, where they induce physiological damage (Cork and Lejeune, 2019).

Helminthiasis is a common disease of livestock in Nigeria, which could be regarded as one of the major impediments against livestock productivity. In an earlier field veterinary study, helminth parasites were regarded as the major cause of the anemic condition of cattle in Nigeria following haematological examination of cattle helminths which revealed a considerable population of helminths parasite irrespective of age and sex of the animals (Obi and Anosa, 2010). The disease has become a long lasting parasitic disease of cattle because; many livestock keeper easily passed the disease for ordinary poor animal performances whereby less or little attention is paid to its management, especially under resources poor production system (Ibeagha-Awemu *et al*., 2019). Losses associated with helminth infections include the reduction in productive potential such as decreased growth rate, weight loss, diarrhoea, abortion, infertility, anorexia, and anaemia and sometimes death (Swai *et al*., 2006; Adama *et al*., 2013).

The livestock production loss reportedly linked with helminthiasis is huge. This is because, the production loss associated with only the trematodes was reported to be more than 3 billion dollars loss of production associated with infection and overt clinical disease in the global livestock farming (Beesley *et al.*, 2018). The gastrointestinal helminths are known to be a major constraint to ruminants' well-being and productive performance. They are parasitic agents of livestock that have capacity to infest different animal species and are known to limit cattle production in many areas and countries including Nigeria (Adedipe *et al*., 2014). The direct implications of helminths could be mortality of animals due to parasitic diseases, although may not be alarming but the indirect effects on livestock productivity and their zoonotic impact on human health could be considerably greater than the direct loss of animals (Ekong *et al*., 2012). This is because, the indirect losses are associated with helminth infections causing a reduction in productive potential such as decreased growth rate, and weight loss of the animals (Swai *et al*., 2006).

The leading factors contributing to the prevalence of helminths and the diseases they caused include important predisposing factors such as the grazing habits, climate, nutritional deficiency, pasture management, immunological status, vector, presence of intermediate host, and the number of infective larvae and eggs in the environment (Radostits *et al*., 1994). The intensity of the parasites infestation is determined by factors including the host species, pathogenicity of the parasite species, the host/ parasite interaction, and response of the parasites to anthelmintic drugs usage (Over *et al*., 1992). Although, helminths and their complications to animal's performance are challenges of livestock production. The most critical challenging factor is the parasites-host interactions which is related to how the helminths invade a host and progresses to cause disease as well as compromised the animal's performances.

The infestation of animal system by helminths usually trigger a chain of recellular defensive response by the immune cells; with the day 0 - 14 of exposure, ther is usually an initiation of antigen-specific cellular proliferation whereby the production of imteluekin 4 (IL-4) overtake the production of IL-13 to dominate the cellular responsive system within a period of 0 – 60 days (Flynn and Mulcahy, 2008). In a situation whereby the infection persist, there is a disappearance of this defensive system which usually ushered in another line of defense, which is a dramatic collapse of the antigen-specific cellular proliferation in order to allowed the host cytokine profile to become dominated by IL-10 (Flynn *et al*., 2010). The relationship between immunoglobulins and helminths can be described to be complicated and tricky; because successful delivery of helminths into the system of livestock by intermediate hosts usually followed by series of immunological compromises.

The first action is the migratory regulations of the macrophages in response to the helminths by the host cell, in a situation whereby an activated macrophages, there is a suppression of the parasites due to dominance activities of IL-10 (Garcia-Campos, 2016). In case the parasites evade this suppressive action, there is a building up of a parallel the adaptive response which becomes detectable within can be measured in the host animal. However, there are now increasing conditions whereby animals are not capable of building these required suppressive and adaptive actions – a situation which has led to increased parasites evading of host cellular immune functions. The immunoglobulins, are key markers of tracking progression and or decline in helminths actions, apart from signaling the cellular resistance to parasitic exploits, the immunoglobulins are also used as marker of diagnosis. It was reported that in a rat model, there was general increase in IgG, IgG and IgE with a decline in IgM throughout a 10 week infection study; which is an indication that changes in these immunglobulins can be used as measure for determining effectiveness of drugs and progression of infection (Poitou *et al*., 1993).

2.2 Immunoresponse and Parasite-Host Interactions Regulation of Helminths Infections

Naturally, animals develop an immune response against invading helminthes. There are different variations in features and type of immune responses in animals of different infectious agents (Ryan *et al.*, 2020). The immune response to a set of parasites usually leads to the production of antibody; infection by protozoan parasites is associated with the production of immunoglobulins IgG and IgM; while the immune response to helminths usually leads to the synthesis of substantial amounts of IgE in addition to IgG and IgM (Hodžić *et al*., 2020). These are specific T-cell response; in addition to these specific T-dependent responses, a non-specific hypergammaglobulinaemia also usually develops as a result of some parasitic infections. These non-specific antibodies are usually a result of polyclonal B cell activation, which is usually a mechanism triggered by the released parasite antigens acting mutagens in the cellular environment (Olayinka-Adefemi, 2019). Sometimes, this response is ineffective at counteracting the parasite and can enhance the pathogenicity by causing the production of autoantibodies, and may actually lead to a diminished specific response due to B cell exhaustion – a mechanism which indirectly could be increasing the severity of the parasite against the host animal due to the generation of autoreactive T cells or activation of suppressor responses (Konstantinovic *et al*., 2019). Furthermore, antibodies are produced to bind with the surface of parasites and cause direct damage, or interact with other molecules to complement capacity of the antibodies then leading to cell lysis. Also, antibody increases uptake by phagocytic cells through complement activation leading to enhanced ingestion due to complement receptors (Gabriel *et al*., 2019).

The parasitic helminths trigger regulation of innate immune responses that are of two major forms which are cytokine-mediated inflammatory responses. These responses are innate immune functions and they occur as results of cytokines production resulting from coordinating activities of the inflammation pathways (Oyesola *et al*., 2018). The pathway stimulate epithelial cells exposure to helminths and their products leading to the production of cytokines including IL-25, IL-33, and thymic stromal lymphopoietin; in a chain of linking activities, these cytokines promote innate immune cell activation for the polarization of CD4+ T helper type 2 (Th2) cells to produce another set of cytokines including the IL-4, -5, -9, and -13 which are primarily involved in immune activation and increased epithelial cell turnover (Jayalatha *et al*., 2021).

2.3 The Manipulation of Helminths Parasites Response to Anthelmintic Drugs

The hosts usually manipulate helminths parasite response to drug by activation of cytokine pathways that regulate innate immune responses during helminth infection. This pathway is a complex process comprising the activities of epithelial cell-derived cytokines and aluminas, chemokines and chemokine receptors, and growth factors and survival cytokines. In addition, there is also an activation of non-cytokine pathways that regulate innate immune responses during helminth infection. This pathway is complex and comprises a network of communications, including bioactive lipid mediators, direct cellular interactions, antibodies and receptors and other alarmins, as well as neurotrophic factors (Oyesola *et al*., 2018). Furthermore, there is also activation of crosstalk between epithelial cell-derived cytokines and other innate immune cell regulators. These activities usually leads to biochemical synergy and web of regulations involving almost all important bodily biomolecules.

In the intestine, IL-25 is largely produced prominently in response to helminth infection. This is an activity that usually lead to recruitment of epithelial cell and tuft cells which are responsible for the production of the intestinal cytokine IL-25 9 (Wiedemann and Voehringer, 2020). This is because, there was a single cell RNA sequencing analysis of small intestinal epithelial cells which showed that a subset of CD45-expressing tuft cells may also be a major TSLP source. This established the principal roles of these cells as factors determining animal's capability of withstanding heliminth infection due to their roles in the production of cytokine in the inflamed epithelium (Howitt *et al*., 2016). The immune activities in response to helminths are however related with some haematology parameters because, notable cells in the loop of epithelial and tuft cells includes the basophils, and eosinophils which also produce cytokines such as IL-25, IL-33, and TSLP (Wang *et al*., 2017). In anthelmintic treatments, there is usually an alteration of host–parasite interactions with consequences on the dynamics of infection. The overall profile of the infection might appear fundamentally conserved at the host population level. In most cases under drug administration, there are perturbations which are disproportionately affecting the components of parasites population as well as modifying the host responses and ultimately impact parasite fitness and long-term persistence.

In the demonstration of the above hypothesis, a rabbit–helminth system was investigated whereby experimental animals were trickle-dosed with either one or two helminth species, treated halfway through the experiment with an anthelmintic and reinfected one month later following the same initial regime. Parameters including the parasite traits (body length and fecundity) and host immune responses (cytokines, transcription factors, antibodies) were quantified at fixed time points and compared before and after drug treatment, and between single and dual infections (Cattadori *et al*., 2019). The outcome of this study revealed that the resistant host phenotype was observed through an increased, reduced population, growth in body length, and fecundity for the group with the regulated protective immune response. However, there was an accumulated of parasite population and increased growth in host with low resistance. This is the general actions of anthelmintic drugs on parasites whereby there is an induction of external perturbations reducing parasite fecundity, body length and number of eggs in utero with comparable increasing host resistivity via upregulation of immune functions.

2.4 Performance and Economic Implications of Helminths in Livestock Production

There is a moderately high prevalence wide spread challenges of gastrointestinal helminth infection of both economic and zoonotic importance in cattle slaughtered for human consumption in different parts of the developing countries (Pozio, 2020). In Nigeria, it was reported that there is high prevalence of gastrointestinal parasitic infection in slaughtered cattle. Following this observation, it was suggested that appropriate anthelminthic regime and control measures be implemented in cattle while public health awareness should be encouraged among consumers of beef as means of preventing gastrointestinal parasites public health problems (Shitta *et al*., 2019). The gastrointestinal infectious parasites are one of the main health problem of ruminant animals either large or small because of their propensity to get infected during grazing. This infestation usually causing weight loss, stunted growth, and death in extreme situations (Albers *et al*., 1983). Apart from these, intestinal helminths such as *Haemonchus contortus*, cause severe anaemia in lambs, with a daily intake of up to 30 ml of blood per infected sheep (Escribano *et al*., 2019). Considering the economic implication of these parasites, there is a huge cost lost to animal death and treatment of clinically infected animals. The cost of parasites treatment alone across the world has been estimated to be huge worldwide while effectiveness of anthelmintic drugs has been reported to be dwindling in many countries (Walker *et al*., 2021). The effectiveness of drugs has been associated with potentially more expensive formulations which could be a serious cost in research and pharmaceutical investment. It was on this basis, some research concluded that seeking for alternatives means of gastrointestinal parasite control remains an urgent area of ruminant health research (Taylor *et al*., 2009).

The increasing prevalence of high parasitic helminths is a growing burden which may likely cause loss of production. This also justified the call for the application of modern molecular biology and biotechnology tools for unraveling the complex of drug resistance by helminths (Bergwerff *et al*., 2021). On this note, the search for genetic markers associated with host resistance and parasites evading of host immune responses has been one of the strategies in the fore-front of tackling helminths parasites. These markers could be more effective in selection of animals with natural capacity to eliminate the parasites and at the same time provide a better ground for identification of factors contributing to the evading capacities of the parasites. In has been opined that, the use of DNA markers from blood or tissue samples could aid the understanding of parasite action and host responses based on the genotypes, functional and morphological traits (Malakar *et al*., 2019). Economically, gastrointestinal parasitic infections are the main health problem for grazing animals and the parasite resistance to drugs is now widespread, and the growing parasites resistance to gastrointestinal drugs required the need for understanding the genetic basis for host-parasites relationships (Vande Velde *et al*., 2018).

2.5 Reviews of Nematodes, Trematodes, Cestodes and Pasture Contaminations in Cattle

There are many helminths of economic importance with significant negative implications on performances of cattle. These include nematodes, trematodes, cestodes which contaminate pasture as route of causing infection in cattle (Farooq *et al*., 2012). These gastrointestinal nematode epidemiology is determined by climatic factors, environmental conditions, host susceptibility, and management systems that characterize cattle production globally (Charlier *et al*., 2020). Nematodes occur, usually with mixed infections of several species and more than 20 different species are known, but the relative importance differs in different climatic regions and according to hostage because of an acquired immunity (Chávarri *et al*., 2012). The influence of weather and micro environmental factors in the development and survival of free-living stages is increasingly understood and is modelled to study the effects of climate change and adapted control approaches (Sattenspiel, 2000). Human behaviour and social epidemiology are increasingly used to improve the communication of control strategies.

The trematodes are a diverse group of parasites affecting both humans and animals health worldwide. It was reported that trematodes evolved from the free-living flatworms which are progenitors of the present-day *rhabdocoel turbellarians*, and became intimately associated with mollusks and, ultimately, developed into their parasitic forms (De Waal and Mehmood, 2021). Within the vertebrates, the final host of these worms are found in numerous organs, including the gastrointestinal tract, lungs, liver, and vascular system. The parasites causes infections which are responsible for substantial production losses in the livestock industry and decrease in the quality of life in human (Qian and Zhou, 2017). They cause significant economic losses to pastoral agricultural communities and commercial animal farmers, estimated at US$ 2 billion per year, through the death of infected cattle, liver condemnation, and productivity losses associated with reduced feed conversion quality (De Waal and Mehmood, 2021). Fasciolosis is widespread cattle disease common in tropical areas, affecting up to 90 % of cattle, and is considered the most significant helminth parasite (Mehmood *et al*., 2017).

Cestodes are a group of the most prevalent helminths causing dieseases in cattle as well as a great health problem of humans in many countries (Abdalla, 2019). Cestodes cause a disease condition known as cestodiasis by three broad categories of cestodes morphologically recognized as cyctic *Echinococcesis*, *E. granulosus*, and *E. alvelere*. Cestodes parasite infections in cattle are of the major importance in many areas and are a primary factor in the reduction of production and productivity of livestock. The losses caused by parasites can be distinguished into direct and indirect losses. Direct losses include those due to acute illness and death and condemnation of organs and carcasses at meat inspection, while indirect losses include the mitigation of productive potential such as decreased growth rate, weight loss in young growing animals and late maturity of slaughter stock (Eke *et al*., 2019).

In endemic areas, outbreaks of helminth disease occur most frequently where there is an increase in the infecting mass which usually occurs seasonally and after at least one parasitic generation (Colombo and Grencis, 2020). The factors which influence such an increase are those affecting contamination of the environment with eggs or larvae and those controlling the development, dissemination, survival and availability of the free-living larval stages, i.e. translation (Augusto *et al*., 2019). Important contamination aspects include the biotic potential of the helminth, management practices such as dates of turning out to grazing of housing animals and the density of stocking, immune status of the host and hypobiosis (Wight, 2018). Translation depends primarily on suitable temperature and humidity levels, but is also influenced by general factors such as soil structure, vegetation type and drainage. Certain rotational grazing practices can also favour translation (Marapara *et al*., 2021). Furthermore, where susceptible stock is introduced into an infected area, the helminth-naive juveniles are particularly susceptible; although the absence of a significant age, immunity to many helminths ensures the continuing susceptibility of helminth-naive adults. Meanwhile, the genetic factors such as breed, sex, haemoglobin type and hereditary susceptibility of certain breeding lines may exacerbate susceptibility. The longevity of helminth infective stages during this stage could also contribute by maintaining infection between successive batches of livestock.

2.6 Prevalence of Gastrointestinal Parasites in Cattle

The presence of gastrointestinal parasites recovered from the faecal samples among ruminant animals globally especially in the tropics includes nematodes, trematodes, cestodes. It could be as a result of important predisposing factors such as grazing habit, climate, nutritional deficiency, pasture management, vector, presence of intermediate host and the number of oocysts and infective larvae in the enviroment (Radostits *et al*., 1994). Though, the intensity of the parasites infestation could be attributed to factors including the host species, pathogenicity of the parasite species, the host/ parasite interaction and response of the parasites to anthelmintic drugs usage (Over *et al*., 1992). Muhammad *et al*. (2022) reported the prevalence of gastrointestinal parastes in cattle such as *Oesophagustotum sp*., *Haemonchus sp*., *Fasciola sp*., *Trichostongylus sp*. when benzimidazole (albendazole) was used to asses it efficacy and impact on the performance of 400 (100 each) of cattle and cattle-heifers, buffaloes and buffalo-heifers at two commercial diary farms in the Province of Punjab, Paskistan. Furthermore, Gross *et al*. (1999) reported that grazing cattle are susceptible to gastrointestinal parasites when a study was carried out on abattoir surveys of culling dairy cows, fecal egg counts of milking cows, and serological tests in association with the worm count of the culled cows on milk production which were collated to assess the level of parasitism in a dairy herd. The gastrointestinal helminthes are known to be major constraint to the well-being ruminants (including cattle) in many areas and country including Nigeria (Adedipe *et al*., 2014). Furthermore, reports from different parts of the world, stated that parasitic infestation in cattle kept under a grazing system of production are growing threat to animal production. According to Telila *et al*. (2014), the prevalence of gastrointestinal parasitism of cattle in the East Showa Zone, Oromia regional, state, Central Ethiopia – a situation which was attributed to cattle grazing in a condition similar to this present study which afford cattle to roam during the day on extensive rangeland and shed in the night. Even in non-bovine species, exposure to range land can be a source of intestinal parasite infestation because a study reported presence of helminth infections in laying hens kept in organic free range systems in Germany (Rivero *et al*., 2021).

2.7 Effect of Administration of Anthelmintic Drugs on the Parasite Load in Ruminant Animals

There are a number of anthelmintic drugs have been in use to effectively control gastrointestinal parasites in ruminants such as cattle, sheep and goat. These anthelmintic drugs includes, ivermectin, organophosphate, benzimidazole, imidazothiazole and macrocyclic lactone groups, fenbedazole, piperazine citrate, levamasole and baminth F. The administration of these drugs irrespective of their types significantly led to a reduced parasitemia loads in the cattle compared to the control group. These confirmed the efficacies of the anthelmintic drugs in fighting the menace of gastrointestinal parasites in ruminant animals under grazing system. These agreed with the findings of Muhammad *et al*. (2018) who reported effective reduction in the control of nematode infections in cattle when levamisole (at 10 mg/kg) and albendasole (at 7.5 mg/kg) were administered on day 7, 14 and 21 in first and second parity animals. Similarly, Muhammad *et al.* (2022) also reported high significance in anthelmintic control impact (egg per gram of faeces $P<0.01$) compared to control group on day 14 post-medication, when benzimidazole (albendazole) was used to asses it efficacy and impact on the performance of 400 (100 each) of cattle and cattle-heifers, buffaloes and buffalo-heifers at two commercial diary farms in the Province of Punjab, Paskistan. Miller *et al*. (1992) also reported that fenbendazole at the dose rate of 5 mg/ kg of body weight has oocyts reduction by 100 % egg count in paratisized calves. Furthermore, Gross *et al*. (1999) also reported that the administration of anthelmintic drugs including organophosphate, benzimidazole, imidazothiazole and macrocyclic lactone groups can effectively eliminate these parasites when a study was carried out on abattoir surveys of culling dairy cows, fecal egg counts of milking cows, and serological tests in association with the worm count of the culled cows on milk production which were collated to assess the level of parasitism in a dairy herd. Similarly, Sultana *et al*. (2015) also reported that administration of fenbedazole at the dose rate of 7.5 mg/kg and piperazine citrate at the dose rate of 220 mg/kg of body weight significantly reduced eggs per gram post administration to calves at 28^{th} day. Anthelmintic drugs are effective in controlling parasitic infections but the efficacy of the anthelmintic drugs was not 100 % in any animal species/ breed which might be the problem of drug resistance. It might be due to the regular or under-dose usage of the same group of drugs. Therefore, it is recommended to apply alternative treatment and in combination of two groups (Sadiq *et al*., 2022).

2.8 Effect of Anthelmintic Drugs Administrations on Body Weight Changes in Ruminants

The live body weight gain among ruminant animals such as cattle, sheep and goat were reported to have significantly increased administration of anthelmintic drugs in the treatment of gastrointestinal parasites. This agreed with the findings of Sultana *et al*. (2015) who reported significant increase ($P<0.01$) in the live body weight gain when fenbedazole 250 mg at the dose rate of 7.5 mg/kg and piperazine citrate 100 mg at the dose rate of 220 mg/ kg of body weight were administered to calves at 28th day. The reason may be due to the removal of parasitic loads, proper absorption and metabolism of nutrient in the parasite free gastrointestinal tract. On the other hand, there was decrease in the the final body weight of the untreated group (control) of the experimental animals. These agreed with the work of Sultana *et al*. (2015) who reported significant decrease in the untreated control group when fenbedazole 250 mg at the dose rate of 7.5 mg/kg and piperazine citrate 100 mg at the dose rate of 220 mg/kg of body weight were administered to calves. The reason could be attributed to overload of parasites in the gastrointestinal tract which hindered digestion and absoption of nutrients to the animals.

2.9 Haematological Parameters of Ruminant Animals Administered Anthelmintic Drugs

Hematological parameters is a good indicator for the physiological status of animals. This shows the positive correlations with the animal's health and nutritional status (Adejumo, 2004). The haematological parameters mostly used for laboratory examinations are haemoglobin concentration (Hb), packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC), neutrophils, lymphocyts, monocytes, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC). Experimental ruminant animals have been reported to have good health stautus after administration of anhelmintic drugs against gastrointentinal parasites. Sultana *et al*. (2015) reported significant increase ($P<0.01$ and $P<0.05$) in Hb and PCV when fenbedazole 250 mg at the dose rate of 7.5 mg/ kg and piperazine citrate 100 mg at the dose rate of 220 mg/ kg of body weight were administered to calves. Furthermore, Hassan *et al*. (2012) reported significant improvement in the PCV, Hb and RBC when ivermectin and triclabendazole and levamisole Hcl was administered at the dose rate of 0.2 mg/kg and 20 mg/ kg of body weight in black Bengal goat. The result findings could be due to the lack of the blood sucking gastrointestinal nematodal parasites. The rise in PCV after treamnet might be associated with the increase of Hb, as these parameters are closely interrelated with each other. Furthermore, Islam (2003) also reported significant improvement in the the blood parameters after treatment of helmintic parasites in buffalo. The improvement of blood PCV, Hb, WBC, neutrophils, lymphocytes and monocytes level in the blood of experimental animals might be due to the elimination of intestinal parasites.

2.10 Immunoglobulin Profile of Ruminant Animals Administered Anthelmintic Drugs

The immune defense toward infections is essential for the maintainance of animals' health. The immunological profile of the experimental animals revealed improvement in their values. Henderson (2002) reported that treated animals with anthelmintic drugs had higher activities of IgE and IgM which showed that the drugs administered were effective drugs since all the treated animals irrespective of their ages and sexes had higher activities (The IgE and IgM could then be regarded as the enhancers of the immunoresponsive manipulation of the cattle against the intestinal parasites. In agreement with these points, immunoglobulins expression, seasonal variations, packed cell volume, breed, age, and sex, and states of production were listed among the factors that could determine effectiveness of drugs against intestinal parasites in cattle (Khalifa, 2005). The administered anthelmintic drugs could also have influences on the innate immune response of the ruminant animals (such as cattle, sheep and goat), because of the effect they exert on the immunoglobulins and blood parameters expression. This could also be attributed to the fact that anthelmintic drugs and other sources of chemical compounds capable of exerting immunostimulation in animals and described to be compounds capable of promoting the animals' health and welfare (Bahi *et al*., 2017). The immunoresponsiveness and the overall performance of the cattle via the up regulation of the immunoglobulins also agreed with reports of anthelmintic usage in a study which reported that significant increase in the immunoglobulins when drugs are administered could be associated with resistance to re-infection (Paul, 2016). It was also confirmed in a study on immune response to *Amblyomma variegatum* in cattle and the effects of *haemoparasitism* on the acquisition of tick resistance which opined that administration of anti-parasites can lead to better immune regulations (Dossa, 1995). The roles of immunoglobulin against parasites of intestine in cattle has been demonstrated through better health as revealed in the blood markers therefore, better understanding of antibodies produced by these immunoglobulins, their origin, activation mechanisms, as well as their implications in health and disease are required and could lead to novel health management strategies for both human and veterinary species (Reyneveld *et al*., 2020).

2.11 Effect of Sex on Susceptibility of Cattle to Helminths Infection

The prevalence and intensity of helminth infections has been found to be higher among male than female host as noted in birds, rodents and human (Oliver-Guimera *et al*., 2017). The reason could be that male are often larger-bodied than the female hence, they may ingest greater amount of feed along with the infected pray and provide a large area for parasite contact or more expose (Brown and Symondson, 2014). The higher resistance among female led to the formulation of the female host supremecy paradigm. In other hand, in some circumstances, the behavior of the male host may favour parasitic loads, as seen in *Asworthius sidemi* infection in European bison bulls. This can be explained by the fact that European bison males live solitarily or in small groups, while sub-adults and feamles with calves tends to aggregate, which increase the likelihood of infection (Krasinska and Krasinski, 2000). Increased parasite risk is a cost of high dominance, which attributed to the priority of access to resources such as feed and consequently greater exposure to parasites, as well as greater mating efforts associated with increase testosterone levels, hence increased susceptibility (Agnieszka, 2019). It has been proposed that intrinsic host related factors predispose one sex to be more susceptible to infection than the other. These host-related factors include physiological influences, such as sex hormone and immunity-related factors and behavioural influences, which have been associated with differences in susceptibility and exposure, respectively. Generally, age-related differences in infection prevalence may rise from different behaviours in immune statuses, associated with age, both of which are affected by the host sex. Helminth infection intnnsity follows a hump-shaped profile over time, with low parasite load noted at a very young age, reaching maximum values at intermediate age, and the decreases in older individuals. However, Olubukola *et al*. (2014) reported slightly higher susceptibility of helmminth in female cattle (41 %) over the male cattle (40 %) slaughtered in Ibadan, South-Western Nigeria. However, Raza *et al*. (2013) reported that male cattle were more likely to be infected with helminth than the female cattle. The reason given could likely be that male cattle were more aggressive when feeding than female and thus likely to pick up more ova of helminthes on the pasture. Furthermore, male domestic ungulates are said to be more susceptible to infections in gastrointestinal tract parasites than the females due to hormone dehilitating immune functions, which favour the growth and spread of parasites in male gut (Apio *et al*., 2006). Despite these, the phenomenon of parasitism during pregnancy due to stress decreased immune competence in female animals (Urquhart *et al*., 1996). This may have neutralized the possibility of more male infection though, there were no exert number of pregnant female animals during this study. Some were found pregnant at slaughter. This factor, we believe would have contributed to the increased of prevalence of helminthics infection in female than male.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Site

This experiment was carried out at Waji Farm Nigeria Limited. The farm is located at Kante village along the Tagwai Dam road, Tungangoro, Chanchaga, Minna in Niger State, Nigeria. Minna lies within the geographic coordinates of Latitude 9^0 30^1 North, and Longitude 6^0 33^1 East. It has a savannah vegetation and an annual rainfall ranges between 110mm - 1600mm, the mean daily temperature is 21 ^{0}C and 36.5 ^{0}C minimum and maximum, respectively (Usman, 2011).

3.2 Experimental Design and Administration of Anthelmintic Drugs

Forty (40) cattle of mixed ages, breeds (local and crossbreeds), sexes, tagged and managed under a semi-intensive system were used in a longitudinal study for this research. The animals were classified as young (1 to 3 years) and Adult (> 3 years) and randomly assigned into four (4) treatment groups comprising of Ten (10) animals per group. The animals were distributed as Treatment T1 (control), T2 (albendazole), T3 (levamisole), and T4 (baminth F). The drugs administration was carried out at the beginning of the experiment (once) and blood was collected from animals at weekly intervals (for haematology and immunoglobulin tests), while faecal sample were collected at the beginning of the experiment for identification of helminth eggs and larvae; and at weekly interval from the experimental groups. The experimental groups were administered with the anti-parasitic drugs orally using their body weight according to the recommended dosages by the manufacturers. The study lasted for a period of 12-weeks.

3.3 Management of Experimental Animals

The animals were examined (physical and laboratory examinations) for any signs of disease prior to commencement of the study to ensure that healthy animals were used for the study. The animals were allowed to graze in a controlled pasture in a fenced enclosure during the day followed by provision of supplementary feeding in the evening. The supplementary feeds were hay and concentrate provided for promotion of optimum nutrient supply for the animals. The shelter was well-drained and provided for protection against environmental harsh weather, drinking water was provided as fresh clean water *ad-libitum* daily. Routine activities such as cleaning of watering and feeding troughs, cleaning of the floor, and animals observation for feed intake, respiration rate, physical appearance for presence of ectoparasites, dehydration, abnormal coat colour and texture, excessive soiling with faeces or dirt, and measurement of body temperature were performed twice (at the beginning and at the end of the faecal sample collection).

3.4 Measurement of Rectal Temperature of the Experimental Animals

The rectal temperature of all experimental animals was measured using clinical thermometer at the begining and end of the experiment. The animals were individually restrained, and a digital thermometer (Domotherm THI) with small amount of lubricant at the end of it inserted gently, at an angle to touch the wall of the rectum of the animals. The thermometer was held in position until it beeps and thereafter removed from the rectum. Readings of the rectal temperature were recorded. The thermometer was cleaned from lubricant and any faeces with cool water and soap and disinfectant, and stored until futher use (Burfeind *et al*., 2010).

3.5 Measurement of Live Body Weight of the Experimental Animals

The live body weight of the experimental animals were taken prior to the experiment and at end of the experiment. The animals were weighed using mobile weighing bridge placed on a stable and firm surface. The animals were weighed individually after making them to stand on the mobile weigh bridge and Readings on the scale were recorded.

3.6 Susceptibility of Experimental Animals to Helminths Infection

The experimental animals for this study were grouped according to their ages and sexes. The animals are grouped into 1 – 3 years, 4 – 6 years and 7 – 9 years respectively, for both male and female animals. Similarly, the administration of antihelmentic drugs to experimental animals was carried out according to the ages and sexes of the animals.

3.7 Sample Collection

There was collection of both faecal and blood samples of the animals based on their ages and body weights.

3.7.1 Faecal sample collection

There was a weekly collection of faecal samples directly from the rectum of the studied animals, using disposable hand gloves and transferred into properly well-labelled sterile bottles. 10 mls of sodium-acetate-acetic-acid formalaldehyde (SAF) solution added to each sterile bottle to preserve the faecal samples, according to the procedure described by Endriss *et al*. (2005). The faecal samples were kept in an icebox and transported to the laboratory for examination, in Niger state veterinary hospital, Minna within 30 minutes of collection. The faecal samples collection was carried out on a weekly basis for twelve (12) weeks.

3.7.2 Faecal sample processing

Faecal samples collected were processed and examined for the presence of helminth eggs and larvae using the simple faecal centrifugation floatation technique as described by Foryet (2001). The procedure involved sampling of two (2) g of each collected faecal sample emulsified in already 10 ml of sodium acetate acetic acid formalin (SAF) solution, and was further mixed with 50 ml of sugar solution and strained through a tea stainer into test tubes then subjected to a single-step centrifugation for 10 minutes at 300 rpm. This followed sampling few drops of the centrifuged solution for a wet mount smear on a microscope slide using X10 and X40 objectives lenses and observed under a microscope for eggs and larvae.

3.7.3 Microscopic examination and identification of helminth parasites

The identification of parasitic eggs and larvae was carried out based on morphology and size as reported by Kassai (1999). The procedure involves examination of the smeared faecal samples by direct smear and concentration method using Formol-ether concentration technique and saturated salt floatation for adult parasites as described by Urquhart *et al*. (1996).

3.8 Blood Collection and Analysis

The blood samples were collected via the jugular vein of each animal at weekly intervals. There was a collection of 5 ml of blood from each animal between 7:00 am and 10:00 am at weekly intervals for haematology and immunoglobulin test. Part of the blood collected from each animal (2 ml) was emptied into a labelled ethylene diamine tetraacetate (EDTA) tubes for haematological determination and the remaining blood samples (3 mls) were emptied into plain tubes for immunoglobulin test according to the modified procedures of Bakre *et al*. (2020). The haematological parameters including haemoglobin concentration (Hb), packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC) and immunoglobulin (IgA, IgG, IgE, IgD and IgM) were determined according to the method described by Ekwueme (2017).

3.9 Statistical Analysis

The data recorded were subjected to descriptive statistics and analysis of variance (ANOVA) using the statistical sofware SPSS version 20. Differences in means were separated using Duncan multiple range test at ($p<0.05$).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Prevalence of gastrointestinal parasites in experimental animals before the administration of different anthelmintic drugs

The parasitic loads of the collected faecal samples before the administration of different anthelmintic drugs to the experimental animals are shown in Table 4.1. The intestinal parasites recovered from the faecal samples of the experimental animals were *Ascaris sp.*, *Fasciola sp.*, *Trichostrongyles sp.*, *Haemonchus sp.*, *Coopera sp.* and *Oesphagustomum sp.* respectively. There was no significant difference (P>0.05) in the population of helminths between the control and treatment groups. Howerever, there were high level of some parasites such as *Ascaris sp*., *Fasiola sp*., and *Trichostrongyles sp*. while *Haemonchus sp*., *Coopera sp*. and *Oesophagustomum sp*. had lesser loads of eggs recovered from the faecal samples of the experimental animals.

4.1.2 Effect of administration of the different anthelmintic drugs on the parasite load in cattle

The effect of anthelmintic drugs on the parasitic loads in the experimental animals are presented in Table 4.2. The results showed that the administration of anthelmintic drugs caused reduction in the number of parasites in the gastrointestinal tract of the animals. There were significant reduction (P<0.05) observed in the number of *Ascaris sp*., *Fasiola sp*., *Trichostrongyles sp*. and *Oesophagustomum sp*. However, there was no difference in *coopera sp*. and *Oesophagustomum sp*. load between T2 (albedazole), T3 (levamisole) and T3 (baminth F) compared to T1 (control).

Table 4.1: Prevalence of gastrointestinal parasites in the animals before the administration of the different anthelmintic drugs

Parasites (seeded eggs count per g faecal sample)	**T1**	**T2**	**T3**	**T4**	**SEM**	**P-value**
Ascaris sp.	40.00	20.00	40.00	20.00	7.61	0.67
Fasciola sp.	30.00	30.00	10.00	10.00	7.61	0.67
Trichostrongyles sp.	20.00	20.00	10.00	20.00	7.50	0.96
Haemonchus sp.	10.00	10.00	0.00	10.00	4.10	0.80
Coopera sp.	10.00	10.00	10.00	10.00	4.59	1.00
Oesophagustomum sp.	30.00	10.00	0.00	10.00	4.97	0.18

SEM: Standard error of mean, T: Treatment, T1: Control, T2: Albendazole, T3: Levamisole, T4: Baminth F, P-value: Probality value

Table 4.2: Effect of administration of the different anthelmintic drugs on the parasite load in cattle

Parasites (seeded eggs count per g faecal sample)	T1	T2	T3	T4	SEM	P-value
Ascaris sp.	50.00^{b}	10.00^{a}	10.00^{a}	0.00^{a}	6.38	0.04
Fasciola sp.	60.00^{b}	0.00^{a}	0.00^{a}	0.00^{a}	5.75	0.03
Trichostrongyles sp.	30.00^{b}	0.00^{a}	0.00^{a}	0.00^{a}	3.44	0.02
Haemonchus sp.	15.00	0.00	0.00	0.00	2.50	0.41
Coopera sp.	15.00	0.00	0.00	0.00	2.50	0.41
Oesophagustomum sp.	40.00^{b}	0.00^{a}	0.00^{a}	0.00^{a}	4.10	0.03

^{ab} = Means with different superscript in the same row are significantly different ($P<0.05$) SEM: Standard error of mean, T: Treatment, T1: Control, T2: Albendazole, T3: Levamisole, T4: Baminth F, P-value: Probality value

4.1.3 Effect of anthelmintic drugs administration on body weight changes in cattle

The effect of anthelmintic drugs administrations on body weight changes in the experimental animals are presented in Table 4.3. While there were no significant differences (P>0.05) in the initial and final body weight changes in each treatment group, there was a marginal increase in the weight of the treatment groups whereby the final weight recorded were higher compared with the initial body weight in T2 (albendazole), T3 (levamisole) and T3 (baminth F). On the contrary, there was marginal reduction in the the final body weight in T1 (control).

4.1.4 Effect of anthelmintic drugs administration on body temperature of experimental cattle

The effect of drugs administration on body temperature of experimental cattle are presented in Table 4.4. The results showed that there was significant difference (P<0.05) at the initial stage, in the temperature of cattle between T1 and T3 but the temperature of cattle in T2 are similar to the temperature in both T1, T3 and T4. There was no significant difference (P<0.05) in the temperature of cattle in T1 and T4. In the final temperature, there was no significant difference (P>0.05) in the temperature of cattle in T1, T2 and T4 but the temperature of animals in T3 were significantly higher (P<0.05) than the remaining group.

Table 4.3: Effect of anthelmintic drugs administration on body weight changes in cattle

Parameters	T1	T2	T3	T4	SEM	P-value
Initial body weight (kg)	316.00	333.00	291.00	283.00	15.36	0.67
Final body weight (kg)	298.20	358.20	306.20	313.00	15.00	0.52

SEM: Standard error of mean, T: Treatment, T1: Control, T2: Albendazole, T3: Levamisole, T4: Baminth F, P-value: Probality value

Table 4.4: Effect of antihelmitic drugs administration on body temperature in experimental cattle

Parameters	T1	T2	T3	T4	P - value
Initial temperature	39.09±1.03^{a}	39.7±1.28^{ab}	40.61±0.80^{b}	39.01±1.17^{a}	0.004
Final temperature	38.71±1.12^{a}	39.66±1.12^{a}	40.71±1.19^{b}	38.61±1.17^{a}	0.001

^{ab}=Means with different superscript in the same row are significantly different (P<0.05), T: Treatment, T1: Control, T2: Albendazole, T3: Levamisole, T4: Baminth F, P-value: Probality value

4.1.5 Haematological parameters of experimental animals administered different anthelmintic drugs

The haematological parameters of the experimental animals administered with different anthelmintic drugs are shown in Table 4.5. The results showed that there was significant difference ($P<0.05$) in the haemoglobin values PCV and WBC of the treated cattle compared with the control group, whereas RBC values were not different.

4.1.6 Immunoglobulin profile of experimental animals administered different anthelmintic drugs

The administration of different anthelmintic drugs on the immunoglobulin profile of experimental animals are shown in Table 4.6. The results showed significantly ($P<0.05$) increased circulating immunoglobulins (E and M), while other immunoglobulins including IgA, IgG and IgD were not significantly differenct ($P>0.05$) between the control and the treatment groups.

4.1.7 Effect of sex on susceptibility of the cattle to helminths infection

There were differences in the pattern of the cattle susceptibility to helminths based on their ages and sex; at lower age (1 – 3 years), male cattle were more susceptible while at subsequent ages (4 – 9 years), female cattle were more susceptible (Figure 4.1). There was significant effect of the treatment on reduction of gastrointestinal parasites per g of faecal sample irrespective of sex, age, and drug types (as observed in Table 4.2).

Table 4.5: Haematological parameters of experimental animals administered different anthelmintic drugs

Parameters	T1	T2	T3	T4	*Normal range	P-V
Hb (g/dl)	11.52±0.16[b]	13.06±0.10[a]	13.37±0.11[a]	13.26±0.12[a]	11.6-16.6	0.001
PCV (%)	34.52±0.50[b]	39.41±0.31[a]	39.53±0.82[a]	39.95±0.35[a]	35-50	0.001
RBC (x 10^6)	10.49±3.30	6.50±0.05	9.20±1.79	7.75±1.15	4-6	0.349
WBC (x 10^3)	3.70±0.08[b]	4.52±0.05[a]	4.65±0.05[a]	4.56±0.05[a]	4-10	0.001

*Source: Niger State Veterinary Hospital

[ab]=Means with different superscript in the same row are significantly different ($P<0.05$).

Hb: Haemoglobin concentration, PCV: Packed cell volume, RBC: Red blood cell, WBC: White blood cell, T: Treatment, T1: Control, T2: Albendazole, T3: Levamisole, T4: Baminth F, P-V: Probability value

Table 4.6: Immunoglobulin profile of experimental animals administered different anthelmintic drugs

Parameters	T1	T2	T3	T4	*Normal range	P-V
IgA (mg/mL)	11.85±0.45	12.48±0.16	12.28±0.17	12.59±0.19	12-15	0.189
IgG (mg/mL)	71.76±2.28	72.67±0.87	71.73±0.95	73.04±0.92	78-80	0.779
IgE (mg/mL)	$0.05±0.02^{b}$	$0.14±0.01^{a}$	$0.14±0.04^{a}$	$0.14±0.07^{a}$	0.0-0.2	0.001
IgD (mg/mL)	0.12±0.01	0.11±0.04	0.12±0.06	0.12±0.01	0.0-0.2	0.921
IgM (mg/mL)	$2.09±0.06^{b}$	$3.65±0.16^{a}$	$3.77±0.13^{a}$	$3.75±0.15^{a}$	1-5	0.001

*Source: Niger state veterinary hospital

ab=Means with different superscript in the same row are significantly different ($P < 0.05$).

IgA: Immunoglobulin A, IgG: Immunoglobulin G, IgE: Immunoglobulin E, IgD: Immunoglobulin D, IgD: Immunoglobulin M, T: Treatment, T1: Control, T2: Albendazole, T3: Levamisole, T4: Baminth F, P-V: Probability value

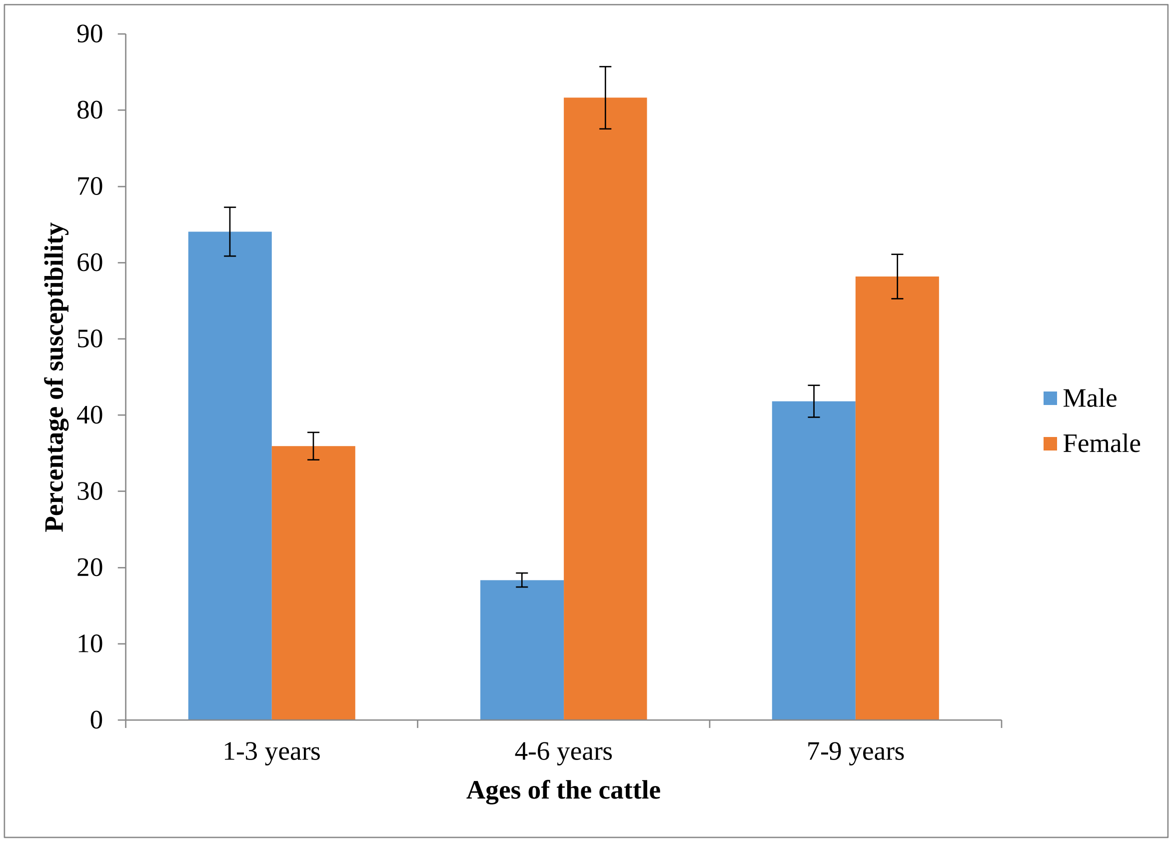

Figure 4.1: The rate of susceptibility of male and female cattle to intestinal helminths in the study cattle population throughout the experimental period.

4.2 Discussion

4.2.1 Prevalence of gastrointestinal parasites in experimental animals before the administration of different anthelmintic drugs

The presence of intestinal parasites recovered from the faecal samples of the experimental animals such as *Ascaris sp., Fasciola sp., Trichostrongyles sp., Haemonchus sp., Coopera sp.* and *Oesphagustomum sp.* could be as a result of important predisposing factors such as grazing habit, climate, nutritional deficiency, pasture management, vector, presence of intermediate host and the number of oocysts and infective larvae in the enviroment (Radostits *et al*., 1994). Though, the intensity of the parasites infestation could be attributed to factors including the host species, pathogenicity of the parasite species, the host/ parasite interaction and response of the parasites to anthelmintic drugs usage (Over *et al*., 1992). The results agreed with the findings of Muhammad *et al*. (2022) who reported similar gastrointestinal parastes in cattle such as *oesophagustomum sp*., *Haemonchus sp*., *Fasciola sp*.,*Trichostongylus sp*. when benzimidazole (albendazole) was used to asses it efficacy and impact on the performance of 400 (100 each) of cattle and cattle-heifers, buffaloes and buffalo-heifers at two commercial diary farms in the Province of Punjab, Paskistan. Gross *et al*. (1999) who reported that grazing cattle are susceptible to gastrointestinal parasites when a study was carried out on abattoir surveys of culling dairy cows, fecal egg counts of milking cows, and serological tests in association with the worm count of the culled cows on milk production which were collated to assess the level of parasitism in a dairy herd. The gastrointestinal helminthes are known to be major constraint to the well-being of ruminants (including cattle) in many areas and countries including Nigeria (Adedipe *et al*., 2014). Furthermore, the present study also agreed with reports from different parts of the world, stating that parasitic infestation in cattle kept under grazing system of production is a growing threat to animal production. According to Telila *et al*. (2014), the prevalence of gastrointestinal parasitism of cattle in the East Showa Zone, Oromia regional, state, Central Ethiopia – a situation which was attributed to cattle grazing in a condition similar to this present study which afford cattle to roam during the day on extensive rangeland and shed in the night. Even in non-bovine species, exposure to range land can be a source of intestinal parasite infestation because a study reported presence of helminth infections in laying hens kept in organic free range systems in Germany (Rivero *et al*., 2021).

4.2.2 Effect of administration of the different anthelmintic drugs on the parasite load in cattle

The study demonstrated the effectiveness of anthelmintic drugs including albendazole, levamisole and baminth F for control of gastrointestinal parasites in cattle. The administration of these drugs irrespective of their types significantly led to reduced helminths loads in the cattle compared to the control group. These confirmed the efficacies of the anthelmintic drugs used in this present study as an effective means of fighting the menace of gastrointestinal parasites in cattle under grazing system. These results are in agreement with the findings of Muhammad *et al*. (2018) who reported effective reduction in the control of nematode infections in cattle when levamisole (at 10 mg/kg) and albendasole (at 7.5 mg/kg) were administered on day 7, 14 and 21 in first and second parity animals. Similarly, Muhammad *et al.* (2022) also reported high significance ($P<0.05$) in anthelmintic control impact (egg per gram of faeces $P<0.01$) compared to control group on day 14 post-medication, when benzimidazole (albendazole) was used to asses it efficacy and impact on the performance of 400 (100 each) of cattle and cattle-heifers, buffaloes and buffalo-heifers at two commercial diary farms in the Province of Punjab, Paskistan. Sultana *et al*. (2015) also reported that administration of fenbedazole at the dose rate of 7.5 mg/kg and piperazine citrate at the dose rate of 220 mg/kg of body weight significantly reduced eggs per gram post administration to calves at 28^{th} day. Furthermore, Miller *et al*. (1992) also reported that fenbendazole at the dose rate of 5 mg/kg of body weight has oocyts reduction by 100 % egg count in parasitized calves. Furthermore, Gross *et al*. (1999) also reported that the administration of anthelmintic drugs including organophosphate, benzimidazole, imidazothiazole and macrocyclic lactone groups can effectively eliminate these parasites when a study was carried out on abattoir surveys of culling dairy cows, fecal egg counts of milking cows, and serological tests in association with the worm count of the culled cows on milk production which were collated to assess the level of parasitism in a dairy herd. Anthelmintic drugs are effective in controlling parasitic infections but the efficacy of the anthelmintic drugs was not 100 % in any animal species/ breed which might be the problem of drug resistance. It might be due to the regular or under-dose usage of the same group of drugs. Therefore, it is recommended to apply alternative treatment and in combination of two groups (Sadiq *et al*., 2022).

4.2.3 Effect of anthelmintic drugs administration on body weight changes in cattle

The marginal increase in the live body weight gain among experimental animals administered albendazole, levamisole and baminth F may be due to the removal of parasitic loads, proper absorption and metabolism of nutrient in the parasite free gastrointestinal tract. These results agreed with the findings of Sultana *et al*. (2015) who reported significant increase ($P<0.01$) in the live body weight gain when fenbedazole 250 mg at the dose rate of 7.5 mg/kg and piperazine citrate 100 mg at the dose rate of 220 mg/kg of body weight were administered to calves at 28^{th} day. On the other hand, the present results showed decrease in the the final body weight of the untreated group (control) on administration of the drugs to the experimental animals. These results also agreed with the work of Sultana *et al*. (2015) who reported significant decrease in the untreated control group when fenbedazole 250 mg at the dose rate of 7.5 mg/kg and piperazine citrate 100 mg at the dose rate of 220 mg/kg of body weight were administered to calves. The reason could be attributed to overload of parasites in the gastrointestinal tract which hindered digestion and absoption of nutrients to the animals.

4.2.4 Effect of anthelmintic drugs administration on body temperature of experimental cattle

The effect of anthelmintics showed that there was significant difference ($P<0.05$) among the experimental animals after the experiment. However there was slight increase in the body temperature of treated animals over the control group. This could be attributed to factors such as the environmental temperature and periods which the experiment was carried out, and the effect of the anthelmintic drugs in relation to the breed or age of the animals**.**

4.2.5 Haematological parameters of experimental animals administered different anthelmintic drugs

The haematological improvement observed in Hb, PCV, WBC, after administration of different anthelmintic drugs showed significant effect ($P<0.05$) on the experimental aniamls. These results agreed with the findings of Sultana *et al*. (2015) who reported significant increase ($P<0.01$ and $P<0.05$) in Hb and PCV when fenbedazole 250 mg at the dose rate of 7.5 mg/kg and piperazine citrate 100 mg at the dose rate of 220 mg/kg of body weight were administered to calves. Furthermore, Hassan *et al*. (2012) reported significant improvement in the PCV, Hb and RBC when ivermectin and triclabendazole and levamisole Hcl was administered at the dose rate of 0.2 mg/kg and 20 mg/kg of body weight in black Bengal goat. The result findings could be due to the lack of the blood sucking gastrointestinal nematodal parasites. The rise in PCV after treamnet might be associated with the increase of Hb, as these parameters are closely interrelated with each other. Similarly, these results also agreed with the findings of Islam (2003) who also reported significant improvement in the the blood parameters after treatment of helmintic parasites in buffalo. The improvement of blood PCV, Hb and WBC level in the blood of experimental animals might be due to the elimination of intestinal parasites. However, the haematological parameters are within the normal range of values as reported by Niger state veterinary hospital.

4.2.6 Immunoglobulin profile of experimental animals administered different anthelmintic drugs

The immunological profile of the experimental animals revealed improvement in their values. The findings of this present study which indicated that the treated animals had higher activities of IgE and IgM showed that the drugs administered were effective drugs since all the treated animals had higher activities (Henderson, 2002). The IgE and IgM could then be regarded as the enhancers of the immunoresponsive manipulation of the cattle against the intestinal parasites. This could be attributed to factors such as immunoglobulins expression, packed cell volume, (Khalifa, 2005). The administered drugs could also have influences on the innate immune response of the cattle because of the effect they exert on the immunoglobulins and blood parameters expression. This is because drugs and other sources of chemical compounds capable of exerting immunostimulation in animals were described to be compounds capable of promoting the animals' health and welfare (Bahi *et al*., 2017). The immunoresponsiveness and the overall performance of the cattle via the up regulation of the immunoglobulins also agreed with reports of anthelmintic usage in a study which reported that significant increase in the immunoglobulins when drugs are administered could be associated with resistance to re-infection (Paul, 2016). It was also confirmed in a study on immune response to *Amblyomma variegatum* in cattle and the effects of *haemoparasitism* on the acquisition of tick resistance which opined that administration of anti-parasites can lead to better immune regulations (Dossa, 1995). In this present study, roles of immunoglobulin against parasites of intestine in cattle has been demonstrated through better health as revealed in the blood markers therefore, better understanding of antibodies produced by these immunoglobulins, their origin, activation mechanisms, as well as their implications in health and diseases are required. This could lead to novel health management strategies for both human and veterinary species (Reyneveld *et al*., 2020). However, other immunoglobulins including IgA, IgG and IgD had improved values and falls within the normal range of values.

4.2.7 Effect of sex on susceptibility of the cattle to helminths infection

The rate of susceptibility of male and female cattle to intestinal helminthes in the experimental annimals (Figure 4.1) revealed the prevalence and intensity of helminth infections. This report findings generally revealed higher rate of susceptibility of female cattle to intestinal parasites than the males except for animals on 1 – 3 years of age. However, Oliver-Guimera *et al*. (2017) reported higher prevalence and intensity of helminth infections among male than female host as noted in birds, rodents and human. The reason could be that as the male are often larger-bodied than the female, they tend to be more aggressive when feeding than female and thus likely to pick up more ova of helminthes on the pasture. Furthermore, male domestic ungulates are said to be more susceptible to infections in gastrointestinal tract parasites than the females due to hormone dehilitating immune functions, which favour the growth and spread of parasites in male gut (Apio *et al*., 2006). However, the present results agreed with the work of Olubukola *et al*. (2014) who reported slightly higher susceptibility of helmminth in female cattle (41 %) than the male cattle (40

%) slaughtered in Ibadan, South-Western Nigeria. The reason could be the phenomenon of parasitism during pregnancy due to stress which decreased immune competence in female animals (Urquhart *et al*., 1996). This may have neutralized the possibility of more male infection. Though, there were no exert number of pregnant female animals during this study. Some were found pregnant at slaughter. Also at puberty, due to hormonal interactions in female animals, they tend to be more prone to helmintic infection than the male. These factors, we believed would have contributed to the increased prevalence of helminthics infection in female than male. Age-related differences in helmintic infection prevalence may rise from different behaviours in immune statuses, associated with age, both of which are affected by the host sex. Helminth infection intensity follows a hump-shaped profile over time, with low parasite load noted at a very young age, reaching maximum values at intermediate age, and the decreases in older individuals. This agreed with this work with female animals (1 - 3 years) which had low load, animals (4 - 6 years) had higher load and annimals (7 - 9 years) had lower loads of intestinal parasites. This could be attributed to the exposure of the animals to gastrointestinal helminthes when feeding on pasture.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The pre-treatment assessment of intestinal parasites in the cattle showed that some gastrointestinal parasites could be a threat to performances of the cattle as a result of the high prevalence rate obtained across the treatment groups.

All the anthelmintic drugs used showed efficacy in the elimination of the gastrointestinal parasites in the animals and improved the well-being of the cattle because the parasites recovered from the faeces of the treated animals were significantly ($P<0.05$) lowered compared with the control group.

Animals administered baminth F had significantly higher efficacy in eliminating gastrointestinal parasites compared with other treatment groups.

The untreated animals showed significantly ($P<0.05$) high levels of gastrointestinal parasites including *Ascaris sp*., *Fasciola sp*., and *Trichostrongylus sp*. presence in their faecal samples.

The improved well-being of the cattle was demonstrated through elevated immunoglobulins IgE and IgM as well as haematological parameters including packed cells volume (PCV), haemoglobin (Hb), and white blood cell (WBC).

At ages 4 – 9 years, the female animals showed to be more susceptible to helminthic infections when compared with their male counterparts.

5.2 Recommendations

This study recommended the use of anthelmintic drugs, including albendazole, levamisole, and baminth F, because in addition to the anthelmintic effect they also improve the immonological status of the cattle as showen in elevating of IgE and IgM as drugs against gastrointestinal parasites of cattle in the study area while further studies on identifying the types of antibodies produced by different breeds of cattle in response to the anthelmintic drugs is recommended.

5.3 Contribution to Knowledge

The thesis revealed that administration of different anthelmintic drugs on helminth load of experimental cattle under semi-intensive production system had positive effect in the elimination of parasites load and increase final body weight rate by 100.00 % and 16.75 %, respectively, when compared to the control.

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