**TICKS AND TICK PATHOGENS OF DOGS**

**BY**

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**CERTIFICATION**

This is to certify that this seminar report was carried out by OLADELE, BOLUWATIFE AFOLABI, Matric No: AEB/2019/1121 under my supervision and submitted to the Department of Animal and Environmental Biology, Federal University Oye-Ekiti, Ekiti State, Nigeria.

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**DEDICATION**

This seminar report is dedicated to Almighty God who is my Alpha and Omega, my Beginning and the End, also to my loving and caring parents and also to my family and friends.

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My sincere appreciation goes to my Heavenly Father, the King of kings, lord of lords, and the Lion ofJudea, who grant me the grace and opportunity to be alive and made it possible for me to write this seminar review.

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**CHAPTER ONE**

**1.1 INTRODUCTION**

Parasitic diseases is a global problem and considered as a major obstacle in the health and product performance of animals (Rushton and Bruce, 2017). These may be due to endo-parasites that live inside the body, or ecto-parasites such as ticks, mites, flies, fleas, midges, etc., which attack the body surface. Among ecto-parasites, ticks are very important and harmful blood sucking external parasites of mammals, birds and reptiles throughout the world (Kassari *et al.,* 2020). The medical and economic importance of ticks had long been recognized due to their ability to transmit diseases to humans and animals. Ticks belong to phylum, Arthropoda and make up the largest collection of creatures in order Acarina. Ticks are divided into two groups: soft bodied ticks (Argasidae) and hard bodied species (Ixodidae). Hard ticks feed for extended periods of time on their hosts, varying from several days to weeks, depending on such factors as life stage, host type, and species of tick. The outside surface, or cuticle, of hard ticks actually grows to accommodate the large volume of blood ingested, which, in adult ticks, may be anywhere from 200 to 600 times their unfed body weight. Additionally, many soft ticks have an uncanny resistance to starvation, and can survive for many years without blood meal. The outside surface, or cuticle, of soft ticks expands, but does not grow to accommodate the large volume of blood ingested, which may be anywhere from 5 to 10 times their unfed body weight (Starck *et al.,* 2020).

Ticks cause great economic losses to livestock in the world and have adverse effect on livestock host in several ways and parasitize a wide range of vertebrate hosts, and transmit a wider variety of pathogenic agents than any other group of arthropods. There are 899 tick species those parasitize the vertebrates including Argasidae (185 species), Ixodidae (713 species) and Nuttalliellidae (1 specie) (Shah *et al.,* 2015). Ticks are the most important ecto-parasites of livestock in tropical and sub-tropical areas, and are responsible for severe economic losses in livestock. The major losses, however, caused by ticks are due to their ability to transmit protozoan, rickettsial and viral diseases of livestock, which are of great economic importance world-wide.

Tick-borne protozoan diseases (e.g. *Theileriosis* and *Babesiosis*) and rickettsial diseases (e.g. *Anaplasmosis*) and *cowdriosis* and tick-associated dermatophilosis are major health and management problems of livestock in many developing countries. The economically most important ixodid ticks of livestock in tropical regions belong to the genera of *Hyalomma*, *Boophilus*, *Rhipicephaius* and *Amblyomms* (Nejash, 2015)

* 1. **Ticks and their significance**

Ticks (Acari: Ixodidae) transmit a wide variety of pathogens to vertebrates including viruses, bacteria, protozoa and helminthes. Tick-borne pathogens are believed to be responsible for more than 100,000 cases of illness in humans throughout the world. Ticks are considered to be second worldwide to mosquitoes as vectors of human diseases, but they are the most important vectors of disease-causing pathogens in domestic and wild animals. Infection and development of pathogens in both tick and vertebrate hosts are mediated by molecular mechanisms at the tick-pathogen interface. These mechanisms, involving traits of both ticks and pathogens, include the evolution of common and species-specific characteristics (Jia *et al.,* 2020).

Ticks are haematophagus parasites of man, domestic and street animals, birds of health and economic importance worldwide (Karshima *et al.,* 2022). They transmit many micro-organisms and protozoans infectious diseases and their toxins causes different signs and symptoms that may be fatal according to infesting tick-saliva protein. Ticks are small, blood-sucking arachnids belonging to the order Parasitiformes. They are ectoparasites, meaning they live externally on the skin of animals, including mammals, birds, and sometimes reptiles. Ticks are important vectors of various pathogenic protozoa, bacteria and viruses that cause serious and life-threatening illnesses in humans and animals worldwide. Estimating tick-borne pathogen prevalence in tick populations is necessary to delineate how geographical differences, environmental variability and host factors influence pathogen prevalence and transmission (Nimo-Paintsil *et al.,* 2022).

Ticks are important vectors of various pathogenic protozoa, bacteria and viruses that cause morbidity and mortality in humans and animals worldwide. Domestic animals are parasitized by many tick species thereby causing considerable economic loss. Human transmission of tick-borne diseases can occur through the bite of an infected tick, exposure to an infected animal, or consuming animal products. Evidence suggests that zoonotic tick-borne diseases are increasing in geographical range, and infection rates are likely to become a major public health threat in the future. Worldwide, ticks serve as important vectors of Crimean-Congo haemorrhagic fever virus (CCHFV), with species of the genus Hyalomma considered the principal vectors. Wild and domestic animals such as cattle, sheep and goats play the role of amplifying hosts or reservoirs in the spread of the virus. Although human infections normally occur through tick bites, other possible routes include drinking unpasteurized milk from infected animals and being exposed to blood or tissues from infected individuals or animals infected with the virus. CCHFV is endemic to Africa, the Balkans, the Middle East and Asian countries, with a high case fatality rate (Brites-Neto *et al.,* 2015).

* 1. **Overview of ticks as vectors for various pathogens in dogs**

Ticks are the second most common blood-feeding parasites after mosquitoes. They do not only destroy blood cells thereby causing anaemia but also transmit and carry different kinds of protozoa, viruses and bacteria some of which may cause tick-borne diseases (TBDs). These tick-borne diseases not only include various existing infectious diseases, but also comprise of both emerging and reemerging infectious diseases (Nejash, 2016). An instance of such emerging infectious disease is fever characterized by thrombocytopaenia, this was reported in China and was seen to be endemic and it poses a serious threat to both animal and human health. However, in the last few decades, the number of reported cases of infection with new TBDs in humans and animals has increased. Transmission of tick-borne pathogens occurs from tick to their hosts but both trans-ovarianlly (i.e. the eggs acquire infection from the egg-laying female) and trans-distally (i.e. both larvae and nymphs are able to transmit the pathogen to the next developmental stage). Attaching of ticks firmly to their hosts, facilitates the effective blood feeding, the transmission of pathogens but also the spread of both ticks and microorganisms to different geographical habitats via migrating animals or travelling pets. Owing to the fact that some TBDs in humans are zoonoses and are of grave economic and medical importance, it is necessary to expatiate more on the tickborne pathogens in pets particularly of dogs. The most common tick-borne protozoan pathogens of dogs are Babesia and Hepatozoon . These haemoparasites live in mammalian blood cells and cause severe diseases and sometimes death in infected animals (Ogbu *et al.,* 2018).

Tick‐borne disease occurs when ticks infected with a pathogen bite a dog and transmit the pathogen into the dog’s body. Many of these pathogens are zoonotic, meaning they can also infect humans. Disease is not spread between dogs and humans directly because these pathogens must complete their life-cycle phase within the tick to become infectious. Therefore, while humans and other non‐canine family members can also become infected, a direct tick bite is required to transmit disease. The most common tick‐borne diseases are Ehrlichiosis, Anaplasmosis, Rocky Mountain spotted fever, Hepatozoonosis, Babesiosis, and Lyme disease. The feeding time required to allow disease transmission from a tick to a dog or person varies between ticks and disease agents (Richards *et al.,* 2017).

The brown dog tick (*R. sanguineus*) is the most common ectoparasites of dog in the world. This tick feeds on a wide variety of mammals including human and birds (by attaching to the skin and sucking blood (Buczek and Buczek, 2020). However, dogs are its preferred host and are where it is most commonly found. The brown dog tick can cause skin irritation in dogs where large numbers are present. It can infest houses and kennels. More significantly, the tick can carry and spread a range of blood-borne diseases that can affect both animals and humans. These include Rocky Mountain spotted fever and Mediterranean spotted fever in humans and Ehrlichiosis, Babesiosis and Anaplasmosis in dogs. Moreover, in the era of globalization and climate changes, the brown dog tick has becoming increasingly relevant from a public health perspective. This tick has also been implicated in the transmission of pathogens of zoonotic concern (e.g., *Ricktettisa rickettsii*) and recent studies have shown that *R. sanguineus* ticks exposed to high temperatures are more prone to bite humans. Within the last few decades, newly identified tick-borne diseases or re-emergence of known tick borne diseases with new geographical patterns or prevalence have been described around the world. The important spreading pathogens by a greater mobility of human populations and their companion animals combined with changes in the ecosystems favorable to survival of ectoparasites have led to the recognition of tick borne diseases in areas usually considered as free of this infection (Efstratiou *et al.,* 2021).

*R. sanguineus* is a good example of parasite globalization to its ubiquitous distribution which has clearly been facilitated by dog movements with their owners or trough trade (Faouzi *et al.,* 2018). As more attention is given to the care of the companion animals, especially in developed countries, and better detection tools (based on molecular technique) allowing more sensitive and specific detection of tick-borne pathogens. Tick- borne diseases are recognized as an emerging infectious threat not only to dogs but also to human. This information is still limited in Indonesia, whereas the epidemiological studies which support the emergence or re-emergence of tick-borne pathogen in dogs around the world is necessary.

Tick-transmitted infections are an emerging problem in dogs. In addition to causing serious disease in traditional tropical and semi-tropical regions, they are now increasingly recognized as a cause of disease in dogs in temperate climates and urban environments (Singh *et al.,* 2018). Furthermore, sub-clinically infected companion animals could provide a reservoir for human tick-transmitted infectious agents, such as *Ehrlichia chaffeensis, Ehrlichia ewingii,the Ehrlichia phagocytophil*a and *Rickettsia conorii*. Here, we discuss the emergence of new canine tick transmitted diseases, which results from several factors, including the expansion of the tick range into urban and semi-urban areas worldwide, the movement of infected dogs into previously non-endemic areas, and the advent of novel molecular techniques for diagnosis and pathogen identification.

**CHAPTER TWO**

**TICK-BORNE PATHOGENS IN DOGS**

**2.1 *CANINE EHRLICHIOSIS***

Ehrlichiosis is also known as canine rickettsiosis, canine hemorrhagic fever, canine typhus, tracker dog disease, and tropical canine pancytopenia (spelling) is a tick-borne disease of dogs usually caused by the organism, *Ehrlichia canis*. Humans can become infected by *E. canis* and other species after tick exposure (Adenubi *et al.,* 2020).

**2.1.1 Etiology**

Ehrlichia is a Rickettsia of the Anaplasmataceae family, Gram-negative intracytoplasmic bacteria that invade and multiply within leukocytes and platelets in the peripheral blood of various species of domestic and wild mammals (Ogbu *et al.,* 2018). It causes Ehrlichiosis, a world-wide distributed zoonosis, concentrated in tropical and subtropical regions due to the geographical distribution of its vector tick Ixodidae, *R. sanguineus* which can rarely infect humans. In Brazil, this seems to be the main vector for *E*. *canis* in urban areas, although in rural areas human infection seems to be related to the genus Amblyomma. Several species of Ehrlichia infect dogs such as *Anaplasma platys*, *E. equi, E. ewingii, E. risticii, E. chaffeensis, E. sennetsu* and *E. canis*. The latter being the main species that infects dogs producing several clinical symptoms fever, anorexia, vomiting, loss of weight, enlargement of the liver, spleen and lymph nodes, epistaxis, hemorrhage and thrombocytopenia (Ogbu *et al.,* 2018).

**2.1.2 Transmission Cycle**

The brown dog tick (*R. sanguineus*) acts as the primary vector of *E. canis* transferring the pathogen between hosts during blood meal (Juasook *et al.,* 2021). Dogs both domestic and wild serve as reservoir hosts for this pathogen and are the primary hosts of brown dog ticks. Brown dog ticks become carriers of the pathogen when they take a blood meal from a rickessemic dog. Stored in mid-gut and salivary gland of an infected tick (Ogbu *et al.,* 2018), *E canis* is transferred via the saliva of ticks carrying the pathogen to host during blood meal. If infected while in the larval stage, the ticks retain the pathogen through the next two life instar and can inoculate hosts during blood meals in both the nymph and adult stage in transstadial transmission. Because of the vector of *E.* *canis* uses canine species as a primary host, this organism is most commonly associated with dogs, but human cases have been reported.

**2.1.3 Clinical signs**

There are three stages of Erhrlichiosis:

* **Acute stage:** Symptoms present around 1-3 weeks after bite from infected tick. Enlarged lymph nodes, weakness, lethargy, depression, lack of appetite, difficult respiration and limb edema.
* **Sub-clinical stage:** The organism may be present from months or years without clinical symptoms.
* **Chronic stage:** Abnormal bleeding, nose bleeding, severe weight loss, fever, difficulty in breathing due to inflammation of the lungs, joint inflammation and pain, seizures in some animals, lack of coordination, head tilt, anemia, kidney failure and paralysis (Brites-Neto *et al.,* 2015).

Symptoms of *Ehrlichiosis ehrlichia* species infect white blood cells and platelets, causing symptoms associated with inflammation and problems with blood clotting. Common symptoms can include any of the following:

* Depression and/or lack of energy
* Loss of appetite
* Runny eyes and nose/discharge
* Spontaneous nose bleeds
* Bruising on gums and belly
* Lameness/joint pain
* Spontaneous and shifting leg lameness, reluctance to move

**2.1.4 Pathology**

Studies have shown that partial feeding of nymphs infected as (tick) larvae with *E. canis* is one possibility for these ticks to be able to infect dogs (Ogbu *et al.,* 2018). The *E*. *canis* organisms are found in the mid-gut and salivary glands of infected adult ticks. The tick can transfer the organism from its saliva to the dog while feeding. Once inside the dog, they infect monocytes capable of spreading throughout the lymphatic system, including the spleen and liver. This will lead to an abnormal increase in cell size and number, known as hyperplasia. Replication and cell division can lead to further spreading of the bacterium throughout the host and eventually leads to anaemia and an increase in platelet count. Once the dog is infected, several signs of Ehrlichiosis include marked thrombocytopaenia, pyrexia, reduction in the packed cell volume and the presence of *E. canis* in peripheral blood mono-nuclear cells (Nair *et al.,* 2016). If the infection is not treated, the disease can take on a chronic form, where bone marrow will fail to develop along with anaemia, making the dog more susceptible to other infections. The dog will respond poorly to treatment at this stage and soon die of hemorrhage.

**2.1.5 Diagnosis**

Diagnosis is achieved most commonly by serologic testing of the blood for the presence of antibodies against the Ehrlichia organism. Many veterinarians routinely test for the disease, especially in enzootic area. During the acute phase of infection, the test can be falsely negative because the body will not have had time to make antibodies to the infection. As such, the test should be repeated. PCR test can be performed during this stage to detect genetic material of the bacteria. The PCR test is more likely to yield a negative result during the sub-clinical and chronic disease phases. In addition, blood test may show abnormalities in the numbers of red blood cells, white blood cells, and most commonly platelets, if the disease is present. Uncommonly, a diagnosis can be made by microscopical examination of blood smear for the presence of the *Ehrlichia morulae*, which sometimes can be seen as intracytoplasmic inclusion bodies within a white blood cell (Little, 2017).

**2.1.6 Treatment**

*E. canis* is commonly treated via chemoprophylaxis with antibiotic, doxycycline. If diagnosed before the clinical stage, *E. canis* is almost completely curable but prolonged presence of the pathogen leads to hemorrhage which usually results in the death of the patient (Aziz *et al.,* 2022).

**2.2 ANAPLASMOSIS**

*Granulocytic* *anaplasmosis* is a tick-borne disease caused by *Anaplasma phagocytophilum* a rickettsial pathogen, causing granulocytic blood infections in humans and animals (Atif, 2015). The clinical appearance of *A. phagocytophilum* infection in dogs is defined in different ways: granulocytic ehrlichiosis most commonly as anaplasmosis or *granulocytic* *anaplasmosis*.

**2.2.1 Etiology**

*A. phagocytophilum* is a Gram negative, obligate intracellular pleiomorphic agent. Up to 2001, *A*. *phagocytophilum* belonged to the genus *Еhrlichia phagocytophila*. This genus included *E. phagocytophila* (causative agent of the tick-borne fever in cattle, goats and sheep), *Ehrlichia equi* (causing granulocytic ehrlichiosis in horses) and an unnamed agent of human granulocytic ehrlichiosis (HGE) (Ogbu *et al.,* 2018). On the basis of sequential analysis of 16S rRNA and groESl operons, these three aetiological agents were united in one species and renamed to *A*. *phagocytophilum*. Target cells for *A*. *phagocytophilum* are neutrophil leukocytes and sometimes eosinophils. The earliest time when anaplasmae could be seen is 4 to 18 days after the infection as elementary bodies of 0 to 6 μm or morules of 4 to 6 μm size in the cytoplasm of blood neutrophils. Microscopically, morules could be registered for a short period of time, usually for 4 to 8 days.

**2.2.2 Clinical signs**

The symptoms of granulocytic ehrlichiosis are not specific fever (up to 41°C), anorexia, lethargy, depression, vomiting, diarrhea, polyarthritis, splenomegaly, lymphoadenopathy and anemia. There are cases of coinfections with *Borrelia burgdorferi*) *Babesia spp*. and the tick-borne encephalitis virus. In experimental infection, the clinical manifestation is not significant. The described haematological deviations in this disease are: leukopenia, rarely leukocytosis, normocytic normochromic anaemia, eosinopenia and mild thrombocytopenia. At the onset of disease, thrombocytopenia may be more prominent (Ogbu *et al.,* 2018).

**Symptoms of *Anaplasma* *phagocytophilum***

*Anaplasma* *phagocytophilum* infect white blood cells, causing symptoms associated with inflammation. Symptoms are often vague and nonspecific.

* Loss of appetite
* Lethargy
* Lameness, reluctance to move
* Neck pain or neurologic signs in some cases

**Symptoms of *Anaplasma* *platys***

*Anaplasma* *platys* infects platelets, causing symptoms associated with failure of blood clotting:

* Bruising on the gums and belly
* Spontaneous nosebleeds

**2.2.3 Diagnosis**

The detection of *A. phagocytophilum morules* in granulocytes is a sufficient prerequisite to identify the disease. This is evidenced in 5% to 37% infected granulocytes in dogs with clinical signs of *A. phagocytophilum* infection. For a more reliable diagnosis however, the performance of additional analyses is advised, such as indirect immunofluorescence, PCR and isolation. Until now, all isolated strains have been cultivated on the human cell line HL-60. Since 2006, the ELISA SNAP 4Dx test kit appeared on the market (IDEXX Laboratories, Westbrook, Maine, USA), that has a high sensitivity (99.4%) and specificity (100%). It detects IgM and IgG antibodies against *A. phagocytophilum* (Ogbu *et al..,* 2018).

**2.2.4 Treatment**

The most efficient anti-Anaplasmatic preparation is doxicyline at a daily dose of 10 mg/kg for 3 to 4 weeks. The clinical effect is manifested within a week after the application. The premature discontinuation of the therapy could however result in A. phagocytophilum carrier stage (Ogbu *et al..,* 2018).

**2.3 HEPATOZOONOSIS**

Hepatozoonosis is a tick-borne disease of wild and domestic carnivores (meat eating animals) caused by protozoan parasite, *Hepatozoon canis* that is transmitted by ticks, usually the brown dog tick, *R. sanguineus* (Vincent, *et al.,* 2021). It mode of transmission is unusual; the tick picks up the organism from an infected host while biting the animal. An uninfected host gets the disease by eating the tick, not from being bitten by the tick. Because of the long prepatent period of the parasite, this disease is not developed soon after tickbites of particular tick season, but there is all possibilities of occurrence of the disease all year round. The life cycle of the apicomplexan protozoon, *Hepatozoon* *canis* in its natural hosts *Rhipicephalus* *sanguineus* (tick) and *Canis* *familiaris* (domestic dog) was studied in an experimental infection. Tick nymphs were fed on a naturally infected dog, or they were infected by percutaneous injection of blood (Ogbu *et al..,* 2018).

Dogs were inoculated by ingestion of adult ticks containing mature oocysts. Gamonts were in syzygy 24 hr after percutaneous injection of ticks. Early oocysts were detected 96 hr after nymph repletion, and mature oocysts in adult ticks were infective to dogs 40 days postmolt. Merogony was detected in dog bone marrow from 13 days postinoculation (PI) and included meronts containing 20-30 micromerozoites, and a second type with 2-4 macromerozoites (Ogbu *et al..,* 2018). Monozoic cysts were observed in the spleen in conjunction with merogony. Gamontogony with infection of leukocytes by micromerozoites occurred from 26 days PI, and gamont parasitemia, which completed the life cycle, was detected 28 days PI. The length of the life cycle from nymphal attachment to parasitemia in dogs was 81 days. Increased body temperatures were evident from 16 to 27 days PI and paralleled the time of intensive bone marrow merogony. Skeletal pain and recumbency were manifested in 2 dogs (Vincent *et al.,* 2021).

**2.3.1 Pathology**

The principal gross pathology in dogs infected with *H. canis* is cachexia. Muscle atrophy is most frequently and most visible in the temporal region (Ogbu *et al.,* 2018). Also, anaemia, midly icteric mucous coats and slightly enlarged spleen and liver were observed. Congestive changes in the lungs and the gastric mucous coat, and pale kidneys are also communicated. Histologically, schizonts are observed in the skeletal and cardiac muscles, lymph nodes, the spleen, liver, kidneys etc. Two types of schizonts are detected: microschizonts containing micromerozoites that are larger and macroschizonts filled with macromerozoites. Microschizonts in the various organs are observed more frequently and at higher extent at the time of schizont formation reaction. However, at the time of merozoites release, an intensive cell response is detected, consisting of equal amounts of macrophages and neutrophils and a varying number of eosinophils.

**2.3.2 Transmission**

Transmission of *H. canis* takes place when dogs ingest ticks containing mature oocyst in the haemocoel. *R. sanguineus* nymphs acquire the infection after feeding on an infected dog. After trans stadial transmission, the tick’s adult stage is infective to dogs through oral inoculation (Schäfer *et al.,* 2022).

**2.3.3 Clinical signs**

The infection with *H. canis* in dogs could occur in three forms:

* Sub-clinical which is probably the commonest one
* Aute developing about one week before the death,
* Chronic with phases of clinical expression and remission.

The clinical signs are very various, but non-specific. In several studies in dogs experimentally and spontaneously infected with *H. canis*, the most frequently observed clinical signs were anaemia, emaciation and intermittent fever (Ogbu *et al.,* 2018). On many occasions, cachexia, depression, muscle hyperaesthesia, purulent conjunctivitis and rhinitis were reported. Less frequently, diarrhea (often bloody), anorexia, para-paresis and para-paralysis were observed. The low parasitaemia with gamont in less than 5% of neutrophils is the most commonly encountered extent of infection. It is generally related to asymptomatic or mild illness. The severe clinical signs are characteristics for high parasitaemia reaching 100% and often are associated with marked leukocytosis.

**2.3.4 Diagnosis**

**Clinical**

Anaemia is the commonest, primary haematological sign observed in most cases. Usually, it is normocytic, normochromic and regenerative in particular. The leukocyte counts are often within the normal range, when the parasitaemia is low and increase in highly parasitaemic animals (up to 150,000/μl). One third of dogs, infected with *H*. *canis* exhibited thrombocytopaenia, but in some instances, it is connected to co-infections such as ehrlichiosis. The changes in some serum biochemical parameters are clearly manifested and include hyperglobulinaemia and hypoalbuminaemia, increased creatine kinase and alkaline phospatase activities (Ogbu *et al.,* 2018).

**Parasitological**

The microscopic detection of *H. canis* gamonts in blood smears stained according to Romanovski-Giemsa, Pappenheim or with Hemacolor is the commonest diagnostic approach to this infection. The protozoa concentration is directly related to the severity of the illness. Gamonts are oval shape with dimensions of 8- 12/3-6 μm and are detected in the cytoplasm of neutrophils and rarely in that of monocytes. Schizonts of *H. canis* could be observed in histological or touch impression preparations from lymph nodes, spleen, and bone marrow. Schizonts are round or oval, with a diameter of about 30 μm and contain 2 or 4 macromerozoites or over 20 micromerozoites. Histologically, micro-schizonts with the so-called “wheel spoke” shape could be observed.

**2.3.5 Treatment**

The primary drug used nowadays in the treatment of canine *H*. *canis*, is combination therapy of imidocarb dipropionate and tetracycline hydrochloride has been shown to achieve clinical cure. It is administered at 5-6 mg/kg, subcutaneously or intramuscularly at 14-day interval until disappearance of gamonts in blood. However, because of very slow elimination of gamonts in the peripheral blood, in certain cases, imidocarb dipropionate have to be administered over eight week. Apart from this, anti-protozoal regimen, supportive care with non-steroidal anti-inflammatory drugs is very important. Some dogs with un-diagnosed hepatozoonosis may recover as a result of good care by owners (Ogbu *et al.,* 2018).

**2.4 BABESIOSIS**

Babesiosis, a tick-borne protozoan disease of animals caused by the parasite of the genus Babesia is of worldwide importance infection in dogs (Dantas *et al.,* 2017). It may occur by tick transmission, direct transmission via blood transfer from dog bites, blood transfusion, or transplacental transmission. The most common mode of transmission is by tick bite, the *Babesia canis* uses the tick as a vector to reach host mammals. Once infected, the Babesia organisms multiply within the erythrocytes of the host. *Canine babesiosis* ranges in severity from relatively mild to fatal and haemolytic anemia is the main clinical sign. Many species of Babesia belonging to the two forms of Babesia (lager form B. canis measuring 3-5 μm and smaller form, *B. gibsoni* measuring 1-3 μm) are pathogenic to the dog. The major *B. canis* are both host and vector specific; thus *B. canis* (subtype vogeli) is found exclusively in the dog with the tick *R. sanguineus* as its major vector. *B. gibsoni* occurs mainly in Asia, North America and North and East Africa. The common brown dog tick, *R. sanguineus* is the most predominant dog ticks in Nigeria. It does not readily attack humans but usually prefers non-human hosts for completion of its development. *Canine babesiosis* is endemic in Nigeria, tick vectors of *B. canis* occur in large numbers in most parts of Nigeria (Obeta *et al.,* 2020).

**2.4.1 Etiology**

Babesia (Apicomplexa: Piroplasmida) species are ticktransmitted parasites infecting a wide range of wild and domestic vertebrate hosts (Chisu*et al.,* 2019). Traditionally, identification of species has been based on host specificity and morphology of the intraerythrocytic piroplasms. Based on these, *Canine* *babesiae* have been originally recognised to belong to two distinct species, the large pyriform (4-5 μm) *Babesia* *canis* and the small usually pleomorph (1-2.5 μm) *Babesia* *gibsoni*. On the basis of differences in geographical distribution, vector specificity and antigenic properties, *B. canis* has been subdivided into three subspecies, namely *B. canis canis* transmitted by *D. reticulatus* and *R. sanguineus* in Europe, *B. canis vogeli* transmitted by *R. sanguineus* in tropical and subtropical regions and *B. canis rossi* transmitted by *Haemaphysalis leachi* in South Africa. These subspecies also differ from each other in pathogenicity. *B. canis rossi* causes a frequently fatal infection in domestic dogs, even after treatment; *B. canis vogeli* causes a moderate often clinically unapparent infection; and *B. canis canis* infections result in a more variable pathogenicity intermediate between *B. canis rossi* and *B. canis vogeli* (Ogbu *et al.*, 2018).

**2.4.2 Clinical pathological findings**

The clinical and pathological presentation of canine babesiosis varies and is dependent on the species/subspecies responsible for the infection; however, the classical presentations often include: Thrombocytopenia, febrile syndrome (Fever, anorexia, depression, dehydration) and haemolytic syndrome (anaemia, bilirubinuria, haemolysis) in acute cases while the chronic form corresponds to prolonged convalescence characterized by depression. In terms of severity of infections associated with the subspecies of *B. canis*, evidence shows that *B. canis rossi* is the most virulent with haemolytic and inflammatory responses, *B. canis canis* shows a transient parasitaemia (<1%) associated with congestion of internal organs, whereas *B. canis vogeli* lead to a relatively mild infection, often without clinical signs or where present may not be homogenous. Infections due to *B. gibsoni* are usually associated with splenomegally, hepatomegally, haemolytic anaemia and severe thrombocytopenia. Clinical signs of *B. conradae* are similar to those of *B. gibsoni*, but *B. conradae* infection is more pathogenic with pronounced anaemia, higher parasitaemia and lymphadenopathy. *B. (Theileria) annae* infection is characterized by severe regenerative anaemia and thrombocytopenia, azotemia is seen in many cases, while the presence of hyaline and granular casts in the urine of infected dogs is suggestive of renal involvement in the disease (Ogbu *et al.*, 2018).

**2.4.3 Diagnosis**

Babesia infections are traditionally diagnosed based on the detection of the parasites in thin blood smears stained with Giemsa, Romanowsky and field stains under a microscope (Parija *et al.,* 2015). The blood smears prepared from capillary blood and buffy coat readily reveals the parasites since the parasitized erythrocytes tend to sludge in the capillaries and also preferentially parasitize the reticulocytes over the mature red blood cell. Identification of the parasites relies on the morphology of the intra-erythrocytic forms using their size; however, this method is affected by its limited sensitivity and the subjectivity of the observer especially during asymptomatic and chronic infections when the parasitaemia is low and usually undetected by microscopy.

Other serological tests that have been used for the diagnosis of canine babesiosis are indirect fluorescent antibody technique (IFAT) and enzyme linked immunosorbent assay (ELISA) technique (Weiland and Reiter, 2018). However, these serological tests are known to show cross-reaction between different species of Babesia and do not differentiate acute from chronic infection thus making them non-specific. Cross antigenicity seen in the *B. canis* subspecies is thought to be responsible for vaccine failures in the field as observed. The possibility of developing potent vaccines against canine babesiosis will be dependent on the proper differentiation of the different subspecies. Polymerase chain reaction (PCR) with its several variations as a diagnostic tool for Babesia parasites has been evaluated and found suitable because of its sensitivity and specificity which is estimated to approach 100%, and its ability to detect past, asymptomatic is and current infections (Annoscia *et al.,* 2017). This method lays emphasis on the amplification of the babesia DNA instead of the anti-babesial antibodies, thus making it a very reliable diagnostic tool in acute, per acute and chronic infections most especially in immuno-compromised and young. It has also been found quite useful in epidemiological studies for the identification of new subspecies and for the differentiation of close and genetically distant Babesia species. Recent advances in molecular techniques have seen an avalanche of methods used to diagnose these parasites.

**2.4.4 Transmission**

Transmission of Babesia parasite to the canine host is by the bite of specific ixodid tick vectors of the genus Rhipicephalus (*Rhipicephalus* *sanguineus*), Haemaphysalis (*Haemaphysalis leachi*, *H*. *bispinosa* and *H*. *longicornis*) and Dermacentor (*Dermacentor reticulatus*). Thus the specie of Babesia prevalent in a particular area is influenced by the presence of the specific tick vector in that geographical area. It was suggested a direct dog to dog transmission of *B*. *gibsoni*. They suspect that the parasite is transmitted through blood and saliva when an infected dog with oral abrasions bites a native dog during fights. This bite blood-saliva transmitted *B*. *gibsoni* infection has been associated with breeds of dogs renowned for aggression, such as the American Staffordshire/Pit Bull terriers in the USA and the Tosa breed in Japan. Trans-placental transmission has been reported in puppies as young as 3 days old while experimental infection has led to stillbirths or death of puppies 6 weeks post-partum (Ogbu *et al.,* 2018).

**2.4.5 Treatment**

Drugs that have been used for the treatment of canine babesiosis (*Atavaquone, azithromycin, diminazene, aceturate, phenamidine isethionate, pentamidine, parvaquone, niridazone* and trypan blue) are known to be unable to completely eliminate the parasites and the disease, but can only reduce the severity of the clinical signs and the mortality (Ogbu *et al.,* 2018). These drugs show varying degrees of success rates either alone or in combination in terms of eliminating the parasites or reducing the parasite load as was adduced. Although no known drug(s) has/have the capacity to treat infection due to *Babesia canis*, shows that a combination of azithromycin and atovaquone therapy is able to treat *Babesia gibsoni* infections in dogs successfully without infected erythrocytes being seen in capillary blood smear. Also, blood from dogs with this combination therapy was shown to be negative on PCR assay for about 4 months. Although research has shown that treatment of canine babesiosis due to *B. gibsoni* with diminazene and or imidocarb is ineffective, it is imperative to state that Imidocarb has the capacity to stop the multiplication of the intraerythocytic parasites and also allow the persistence of several parasites in order to induce immunity and as such are desirable for the treatment of infection due to *B. canis.* Most if not all the babesiacidal drugs are toxic to the host and are used with the utmost caution. Toxicity with these drugs is expressed in form of CNS disorders (diminazene); vomiting, colic and diarrhea alongside hepatic, renal or vascular complications (imidocarb). Irrespective of the drug(s) used for the treatment of canine babesiosis, it is recommended that supportive therapy using intravenous fluids, corticosteroids and blood transfusion be used alongside.

**CHAPTER THREE**

**CONTROL AND PREVENTION MEASURES**

**3.1 Acaricide Use**

The first tier of tick control is routine acaricide use.To be effective, acaricides must be applied to the pets well before exposure to ticks (Solano *et al.,* 2016). At present, all persistent acaricides available in the U.S. are topical formulations consisting of either solutions or collars formulated to allow slow release after application; efficacy may last for 30 days (topical liquids) or several months (collars). A number of approved acaricide or acaricide/repellent products for pets exist with proven efficacy against a range of tick species. Pyrethroid-based tick control products (eg, cyphenothrin, deltamethrin, permethrin, etc) have the added benefit of repelling ticks as well as killing them.33

### 3.2 Protocols for Tick Habitats

**Repellents**  
People are advised to use repellents when in areas with questing ticks; recommended products include those containing DEET (N,N-Diethyl-meta-toluamide) and permethrin (Diaz, 2015).

**Tick Habitat Avoidance**  
Recognizing areas to avoid, whenever possible, will decrease the overall number of ticks that have the opportunity to attach and feed (Stafford *et al.,* 2017). As discussed previously, some tick species prefer wooded areas, while others are found in more open surroundings. Tick numbers are often greater along deer trails and other areas frequented by wildlife hosts, and in areas where deer bed down.

### 3.3 Prompt Removal

Even when repellents and protective clothing are used, people should check themselves and their pets for ticks frequently, especially after venturing into prime tick habitat, to insure attached ticks are promptly removed The longer a tick is attached, the greater the chance for transmission of an infectious agent to the host.

## Tick Removal Advice

To remove a tick safely and with the least risk of injury or infection to yourself or the animal, use forceps or a tick tool to grasp the tick mouth parts as close to the skin as possible and apply steady, rearward traction. Once removed, save the intact tick for identification in a vial with ethanol or well-trapped in a piece of tape that is then placed in the freezer. If the person or animal develops signs of a tick-borne disease in the next few weeks, having this tick record may assist with prompt diagnosis and appropriate treatment (Stafford *et al.,* 2017).

When a dog presents with a large number of attached ticks, chemical removal using acaricides is likely the best option; complete manual removal in these cases is difficult to achieve, time consuming, and can be traumatic for the patient.

**Do Not**

* To avoid breaking the mouthparts, do not quickly jerk or twist the tick out of the skin.
* Do not apply a lit match or harsh chemical to the tick in an attempt to encourage it to release as this can induce regurgitation in the tick, hastening transmission of pathogens.
* Do not crush the tick as this may result in exposure of people and pets to infectious material.

### 3.4 Tick Control at Home

Control of ticks in the environment involves restricting habitat, limiting wildlife, and, in some cases, judicious application of environmental acaricides. Due to the intense management required, often these strategies are only employed in the area immediately surrounding the home and not on large acreages.

**Tick-Scaping**  
Limiting the amount of ideal tick habitat involves tick-scaping, or altering the habitat to make it less conducive to tick survival.36

* Most ticks are very susceptible to desiccation; removing ground vegetation and leaf litter where ticks gather to maintain water balance will reduce the numbers that survive.17
* Edging the yard with rocks or gravel can also decrease the number of ticks that cross into the yard from adjacent wooded areas.36
* Exclusion of wildlife from the area immediately surrounding the home, where feasible, may limit the numbers of ticks that are seeded into the environment by natural hosts.
* Treatment of wildlife hosts can also be pursued: permethrin-treated cotton can be distributed to reduce tick numbers on rodent populations and 4-poster bait stations that apply acaricides to deer have been shown to reduce, albeit not eliminate, tick populations in limited areas.36

**Environmental Sprays**

Environmental sprays are also available and are best applied in a targeted fashion to an infested premise, focusing on the perimeter for ticks entering from the surrounding area or, in the case of R sanguineus, on specific locations where dogs spend most of their time. Due to potential toxicity associated with premise sprays, application by a licensed pest control operator is recommended when the interior of a home requires treatment (Ogbu *et al.,* 2018).

**CHAPTER FOUR**

**CONCLUSION**

Tick-borne diseases (TBDs), including emerging and reemerging infectious diseases, are important threats to human and animal health worldwide (Springer *et al.,* 2021). Indeed, the number of reported human and animal infectious cases of novel TBD agents has increased in recent decades. However, TBDs tend to be neglected, especially in resource limited countries that often have limited diagnostic capacity.

The tick-transmitted infectious diseases of dogs that are described in this seminar have recently become a major focus of interest in areas of the world in which they have traditionally been considered non-endemic.

This relates to both their significance to canine health, and to the possible reservoir status of the dog for potentially zoonotic disease. The concern that these diseases might become established in new geographical locations arises from the increased international mobility of pet dogs and increased contact of these animals with non-urban environments and wildlife disease reservoirs. These factors, coupled with the trend for global climatic change, create real risks for animal and human health. These changes come at a time when PCR now enables rapid screening of blood samples for multiple tick-transmitted pathogens, and large-scale epidemiological surveys of disease prevalence. There is an urgent need for the provision of baseline data on the prevalence of these diseases in dogs (and ticks) in traditionally non-endemic areas (e.g. northern Europe), so future trends can be monitored. Further research is required to understand fully the immunopathogenesis of these diseases in dogs, to develop more effective chemotherapy and prophylactic vaccines.

Dogs are very susceptible to tick bites and tick-borne diseases. Vaccines are not made available for all the tick-borne diseases that dogs can get, and they don’t keep the dogs from tick infestation. It is important to use tick preventive product on dogs. Tick bites on dogs are hard to detect. Symptoms of tick-borne disease may not appear for 7-21days or longer after a tick bite.

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