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Review

Ectoparasites of clinical importance in North-Western Nigeria: A clinical review

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The purpose of this review is to elucidate the effect ectoparasites on cattle, their mechanism of attack on the host and the control measures that are available to mitigate their parasitic effect on their host. Ectoparasite is a parasite that lives on or in the skin yet not inside the body. Bugs and lice are ectoparasites. Invasion with an ectoparasite is called an ectoparasitosis. There are two major classes of arthropods of veterinary importance, namely, the Insecta and Arachnida. For the purpose of this review, emphasis will be laid on the order Diptera. Diptera are an order of insects that involves the two-winged or genuine flies, which have the hindwings lessened to shape adjusting organs (halteres). It incorporates numerous gnawing structures, for example, mosquitoes and tsetse flies that are vectors of disease.

Keywords: Cattle, control measures,ectoparasite, disease

INTRODUCTION

The name of this phylum, derived from Greek words *arthros,* a joint and *podos,* a foot, refers to the fact that members of this phylum have jointed limbs like those of a lobster or crab. Arthropods are metamerically-segmented. The segments of arthropods show a tendency to become associated in groups, the anterior segments forming the head, the middle ones, the thorax and the posterior ones, the abdomen (Soulsby, 1982). The phylum Arthropoda contains over eighty percent of all known animal species and consists of invertebrates whose major characteristics are a hard chitinous exoskeleton, a segmented body and jointed limbs (Urquhart *et al*., 2003). A dominant feature of the internal anatomy of the arthropoda is the fact that the general cavity is not a coelom. It is a space full of blood which is called the hemocoele. The blood in it baths all the organs of the body (Soulsby, 1982). There are two major classes of arthropods of veterinary importance, namely, the Insecta and Arachnida. The two major classes can be differentiated by the following general characteristics: Insects have three pairs of legs, the head, thorax and abdomen are distinct, and they have a single pair of antennae. While in the class Arachnida, adults have four pairs of legs, the body is divided into a cephalo-thorax and abdomen and there are no antennae (Urquhart *et al*., 2003).

Among the great variety of species of arthropods and lifestyles they display, a relatively small number have developed the ability to live directly at the expense of other animals known as hosts. The relationship is to the detriment of the host but does not usually kill the host immediately. This is described as parasitism. These parasites, with a few exceptions, live on or burrow into the surface of the host's epidermis and are generally described as ectoparasites (Pegram et al., 1989). The association between arthropod ectoparasites and vertebrate hosts may take a variety of forms. In some cases, the parasite may be totally dependent on the host in which case the parasitism is described as obligatory. Alternatively, the parasite may feed or live occasionally

on the host without being completely dependent on it, in which case, the parasitism is described as facultative (Pegram et al., 1989).

INSECTS OF CATTLE

Among all kinds of species of animals, about seventy percent are insects. Only a few types are of veterinary and medical importance (Bhatia *et al*., 2006). The insects are a very large and successful class constituting about ninety percent of all known arthropods. Members of the class Insecta can be distinguished from other arthropods by the presence of only three pairs of legs in adults and the broad division of the tagmata into three sections: head, thorax and abdomen (Pegram et al., 1989). The head is an ovoid or globular capsule which consists of a number of sclerites or plates at the anterior end of the body. Eyes are usually present and are placed laterally above the cheeks or genae. They are compound eyes and may meet one another in the midline (holoptic) or may be wide apart (dichoptic). Simple eyes may be present (ocelli) and are arranged in a triangle on the dorsum or vertex (Soulsby, 1982). Antennae situated between or in front of the compound eyes vary greatly in form, may carry hairs or special bristles. The mouthparts are made up of labrum (upper lip), labium (lower lip), two pairs of biting jaws, mandibles (upper pair) and maxillae (lower pair) which lie between labrum and labium (Soulsby, 1982). There is great variation in the structure of the mouthparts depending on feeding habits, with adaptations for chewing , biting, sponging or piercing-sucking (Urquhart *et al*., 2003). The second segment of the body of an insect is the thorax which is made up of three segments: the prothorax, mesothorax and metathorax, legs consisting of basal coxa, trochanter, femur, tibia and tarsus. The last segment, abdomen is usually clearly segmented, soft and membranous. Various structures present include the copulatory claspers, ovipositor and external genitalia (Soulsby, 1982).

All insects have specialized external such as the wings and internal body structures which are helpful in the identification amongst the large variety of arthropods (Bhatia *et al*., 2006). Wings are a key reason for the success of the class, allowing insects to migrate, locate distant food sources and colonize new habitats (Pegram et al., 1989). Wings are usually two pairs but in the Diptera, the posterior pair is reduced to a pair of balancers or halters. Wings are supported by 'veins' which are breathing tubes or trachea. The arrangement of the veins is a valuable means of identification in many cases (Soulsby, 1982).

For the purpose of this review, emphasis will be laid on the order Diptera. This order of insects contains all the flies of veterinary importance. They are generally characterized by having a single pair of membranous wings, mesothoracic pair with the metathoracic pair being modified to form a pair of halters (Soulsby, 1982), (Urquhart *et al*., 2003). Flies have a wide distribution and are of great economic importance to livestock because in addition to exciting livestock (fly worry) some flies suck blood, transmit diseases or their larvae maybe parasitic (Hassan and Hassan, 2003). The mouthparts are adapted for sucking and usually form a proboscis, the labium having at its distal end a pair of fleshy lobes (labella). The mesothorax bears the wings which are usually large; prothorax and metathorax are small and fused with the mesothorax (Soulsby, 1982). Metamorphosis is complete in dipteric flies. Many members of this group are also important as vectors of disease (Urquhart *et al*., 2003). The order Diptera is one of the largest orders of the class Insecta with nearly 85,000 species. The dipteric flies of cattle can be grouped into blood-feeding flies, nuisance flies and myiasis causing flies (Pegram et al., 1989).

Blood-feeding flies of cattle

Blood-sucking flies particularly stable flies, horn flies and tabanids can cause severe disturbance and annoyance to cattle, leading to reduced weight gain, reduced milk production and hide damage. Fly bites may also cause pruritic papules and wheals. Blood-sucking flies may also be important vectors of viral, bacterial, and protozoan diseases and filaroid nematodes (Pegram et al., 1989).Horn flies, *Lyperosia irritans* (*Hematobium irritans* in North America) are small, 3-4mm, grey-black flies that resemble stable flies but are more slender and about half the size (Soulsby, 1982),(Bhatia *et al*., 2006) . The face and thorax are silvery-grey. The thorax has two-well marked dark stripes. The palps are almost uniform in thickness, yellowish and nearly equal to the proboscis. When feeding, they are usually in a head-downward position (Bhatia *et al*., 2006). Their life cycle is completed in 8 to 45 days depending on temperature and humidity. The horn fly rests on different parts of the host's body – on light or dark-colored patches of hair (dark when cool and light when hot) and underside during rain or heat. Horn flies will only leave their host when they lay eggs, move to other cattle in the herd, or when the cattle enter buildings. Most of the feeding occurs along the underline of the animal and often bloody, scabby sores can be seen. Horn flies are able to exist in warm, moist climate. Horn flies congregate around the back and sides of cattle. The female lays eggs in fresh dung of cattle and buffalo which hatch in about 20-24 hours when sufficient moisture is available. The larva burrows into dung to feed on it. The adult fly emerges from the bright red pupa in 8-9 days. The adult flies live from 10 days to several weeks but do not live longer than a day away from the host. They attack mostly old cattle when they are in poor condition. They are spread chiefly by their hosts

Soulsby, 1982;Bhatia *et al*., 2006).

Tabanids, are commonly known throughout the world as horse flies, although they will attack and feed on a wide variety of large animals and man. The pain caused by their bites leads to interrupted feeding, and as a consequence, the flies may feed on a succession of hosts and are therefore important in the mechanical transmission of pathogens such as Trypanosomes (Urquhart *et al.,* 2003). There are many genera of tabanids but only three are of veterinary significance, namely, *Tabanus, Hematopota* and *Chrysops.* They are closely related in behavior and pathogenic significance so are considered as a group. There are over 3000 species of tabanids (Urquhart *et al.,* 2003). The wing venation of tabanids is very characteristic, especially, the branching of the fourth longitudinal vein. Their mouthparts are prehensile and masticatory; larvae are carnivorous (Soulsby, 1982). They are generally dark coloured, but may have various stripes or patches of colour on the abdomen and thorax. The coloration of the wings is useful in differentiating the three major genera. Thus, the *Tabanus* has clear or brownish wings while there are often dark bands across the wings in *Chrysops.* In contrast, *Hematopota* has mottled or speckled wings. The mouth parts which are adapted for slashing and sponging, are strong, short and always point downwards (Urquhart *et al*., 2003). They attack chiefly large animals like horses and cattle, they abound near their breeding places and are most active on hot, sultry days (Soulsby, 1982).

Stable flies (*Stomoxys spp.*) are grey and approximately 7-8mm in length. The commonest species is *Stomoxyscalcitrans.* They look similar to houseflies (*Muscadomestica*) but have a 'checkerboard' type pattern on the ventral abdomen and have distinct, biting mouthparts. Both males and females are blood feeders and congregate on the lower legs of the cattle. The simplest method of differentiating stable flies from *Musca* and other genera of non-biting muscid flies is by examination of the proboscis, which in *Stomoxys* is conspicuous and forward projecting (Urquhart *et al*., 2003). The proboscis is prominent, directed horizontally forwards and has small labella (Soulsby, 1982). Stable flies have a worldwide distribution as *Muscadomestica*. Larva of *Musca* and*Stomoxys*can are differentiated by examination of the posterior spiracles (Urquhart *et al.,* 2003). When feeding, the proboscis swings downwards and skin penetration is achieved by rasping action of fine teeth on the end of the labium. Approximately, three minutes is required for a blood meal and feeding is often interrupted, thus allowing mechanical transmission of pathogenic microorganisms and protozoa such as trypanosomes. *Stomoxys calcitrans* can also act as an intermediate host of the nematode, *Habronema* (Urquhart *et al.,* 2003). Stable flies are primarily aproblem in feedlot and dairy operations, but can also be a significant pest of range cattle, especially when large round bales are placed in pastures. These flies prefer fairly strong light and live about a month under natural conditions. They are swift fliers but are not inclined to travel long distances. Both male and female are blood suckers (Soulsby, 1982). In large numbers, these flies are a source of great annoyance to grazing cattle and in some areas, there are estimates of milk and meat production losses of up to 20% (Urquhart *et al*., 2003).

Culicoides spp. are an important group of flies. They are small flies about 1-3mm long which occur in large numbers when water is abundant. They breed along water courses and especially low lying vlei areas. Some also breed in fresh dung pads. There are over 800 species of *Culicoides,* commonly known as midges. Their wings are generally mottled, which are held at rest like a closed pair of scissors over the grey or brownish-black abdomen. The small mouthparts hang vertically. The adult females suck blood. The short proboscis consists of a sharp labrum, two maxillae, two mandibles, a hypopharynx and a fleshy labium (Urqhuart*et al.* 2003). These biting midges mostly attack in warmer months and are active at dusk and early mornings (Otto *et al*., 2003).*Glossina,* the sole genus in the family*, Glossinidae*, is commonly known as tsetse fly. These are a small distinct genus of 22 species which feed exclusively on the blood of vertebrates (Pegram et al., 1989). *Glossinaspp.,* undoubtedly the most important blood-sucking flies since they transmit several species of the protozoan haemoparasite, *Trypanosoma,*leading to fatal diseases of domestic animals, occur only in Africa (Soulsby, 1982). They are narrow-bodied flies measuring between 6mm to 14mm in length and yellowish to dark-brown in colour. At rest, the wings are held scissor-blade like, overlapping the abdomen. The proboscis is long, forward directed and embraced by long palps. The most characteristic diagnostic feature of genus is the discal medial cell of the wings which is described as 'hatchet-shaped' (Pegram et al., 1989). All species of *Glossina* feed on blood of vertebrates. Some species of hosts are more susceptible than others and the prevalence of these flies depend on the number and suitability of hosts (Soulsby, 1982).

Myiasis-causing flies

Myiasis is defined as the infestation of living animals with the larva of dipteran flies. It may be facultative (optional), as in the calliphorids, or obligatory as in the oestrids. It may also be cutenous as in *Lucilia*, nasal example *Oestrus* or somatic as in *Hypoderma* (Urquhart *et al.,* 2003).

Cutenous myiasis of cattle is most commonly caused by the obligate screw worms, *Cochliomyiahominivorax* (Neartic and neotropial regions), *Chrysomya bezziana* (Oriental and Afrotropical regions) and *Wohlfahrtiamagnifica* (Eastern Palaertic). Myiasis occurs largely as a consequence of skin damage due to trauma;

castration or dehorning wounds are common oviposition sites, as in the umbilicus of newly born calves. Eggs may also be deposited in body orifices such as nostrils, eyes, mouth, ears, anus and vagina. Larvae-filled lesions may be ulcerated, cavernous and painful. Secondary bacterial infection, toxemia and dehydration lead to death (Pegram et al., 1989). *Hypoderma bovis* and *H. lineatum* are adult flies of pathogenic larvae (de Castro et al., 1985). Third-stage larva of warble flies *Hypoderma,* produce painful nodular lesions approximately 3cm in diameter with a central hole in the skin of the back (Pegram et al., 1989).*Hypoderma bovis* and *H. lineatum* resemble bees but being dipteran, have only one pair of wings. Abdomen is covered with yellow-orange hairs with a broad band of black hairs around the middle. The mature larvae are thick and somewhat barrel-shaped, tapering anteriorly; when mature, they are 2.5 – 3.0cm long and most segments bear short spines (Urquhart *et al.,* 2003). *Hypoderma* has great capacity for population re-generation, hence, any control measures must have total eradication as their object, with safeguards against their re-introduction (Urqhuart*et al*., 2003). Hypoderma infestation is most common in beef cattle, although it may be seen in dairy cattle raised in feedlot conditions and young cattle are most severely affected (de Castro et al., 1985).

Dermatobia hominis, also known as the torsalo, berne or human bot fly is a serious pest of cattle. The larvae create boil-like swelling where they enter the skin. The cutenous swellings can be pruritic and the exit holes may attract other myiasis flies. Infestation may result in damage to the hide and a reduction in milk and meat production (Pegram et al., 1989). The adult fly resembles *Calliphora* with the abdomen having a bluish metallic sheen but there are only vestigial mouth parts covered by a flap. Mature larva measure up to 2.5cm long and are somewhat oval (Urquhart *et al*., 2003).

Nuisance flies of cattle

The family Muscidae comprises many biting and non-biting genera, the latter commonly referred to as nuisance flies. As a group they may be responsible for 'fly-worry' in livestock and a number of species are vectors of important bacterial, helminth and protozoan diseases of animals (Urquhart *et al.,* 2003). The major genera of importance include *Musca*(houseflies and related flies), *Hydrotaea* (head fly),*Stomoxys* (stable fly) and *Haematobia*(horn-fly). An atypical genus included here is *Glossina* (tse-tse fly) which is given family status in some classifications (Urquhart *et al*., 2003).

Members of the non-biting genus (*Musca*) are not obligatory parasites, but they can feed on a wide variety of animal secretions and are especially attracted to wounds. Species are *Musca domestica* (house-fly) and *M. autumnalis* (face-fly). A number of *Musca spp.* have been incriminated in the spread of diseases including mastitis, conjunctivitis and anthrax. Eggs of various helminths may be carried by flies which feed on faeces and they may also act as intermediate hosts of a number helminthes (Soulsby, 1982).

Diseases of cattle transmitted by dipteran flies

In many areas of the world particularly, the tropics, arthropod-borne diseases are among the major limiting factors to the efficient production of livestock. These diseases result in debilitation, blindness, lameness, wasting, congenital defects, abortions, sterility and death. Flies have a wide distribution and are of great economic importance to livestock because in addition to exciting livestock (fly worry), some flies suck blood, transmit diseases or their larvae may be parasitic (Hassan and Hassan, 2003). The key to the success of arthropod-borne disease transmission lies in the competence of vector efficiency. Whereas one vector species may be extremely efficient in the transmission of a particular pathogen, a closely related species may be totally incompetent as a vector. Responses by host may range from dramatic escape behavior in which self-injury can occur, to less sensational movement into shades or simply stamping and tail switching. However, all these behavioral changes result in reduced time spent in feeding and decreased performance (Pegram et al., 1989). Adult females of *Tabanus spp.* feed in the vicinity of open water and have reciprocating, scissor-like mouthparts, which they use to lacerate tissues and lap up the oozing blood. They consume 0.1-0.3ml at a single feeding. These flies act as mechanical transmitters of anthrax, anaplasmosis, tularaemia and trypanosomosis (Soulsby, 1982; www.pubs.ext.vt/edu/456/456-016/section_2_livestock_2.pdf), (Merck Veterinary Manual, 2010). The bites of the tabanids are painful and irritating and may lead to wheals in soft-skinned animals. Horses and cattle are restless when troubled by these flies and may become unmanageable if they are in a harness (Soulsby, 1982). These flies feed every three to four days causing a great deal of annoyance and because their feeding is often disturbed, are efficient mechanical vectors of the organisms responsible for diseases such as Pasteurellosis amongst many others (Urquhart *et al.,* 2003).

The feeding and breeding habits of *Musca domestica* and other related species make them ready carriers of numerous pathogenic microorganisms (Soulsby, 1982). These flies are not only a source of annoyance but may also mechanically transmit viruses, bacteria, helminths and protozoa due to their habit of visiting faecal and decaying organic matter (Urquhart *et al*., 2003). Although, it may be of minor direct annoyance to animals, its potential for transmission of viral, bacterial and protozoan parasites is of significance. However, its pathological

significance varies considerably, depending on the precise circumstances in which it occurs (Pegram et al., 1989). Larval stages developing in faeces become infected with worm eggs present in faeces. The hairy feet and legs of the fly also act as suitable carriers of bacteria from material on which the fly settles (Soulsby, 1982). Pathogens may be carried on the hairs of the feet or regurgitated in the saliva during feeding. More than a hundred pathogens associated with the housefly may cause disease in humans and animals including typhoid, cholera, tuberculosis, anthrax, mastitis and conjunctivitis (Soulsby, 1982), (Pegram et al., 1989).*Musca domestica* are also thought to be capable of transmitting *Coryneabacterium pseudotuberculosis,* the bacteria responsible for mastitis in dairy herds after feeding on contaminated milk or lesions (Pegram et al., 1989). House flies are suspected to be mechanical vectors of the *Escherichia coli* pathogens, harboring the bacteria in their intestines and excreting it for at least three days after feeding (Pegram et al., 1989).

Musca autumnalis, commonly referred to as the face fly, is an important vector of bovine keratoconjunctivitis caused by *Moraxella bovis*. Face flies are also intermediate hosts of *Paraflaria bovicola*, the causative agent of parafilariasis of cattle. The irritation of the eye arising from their feeding can exacerbate the transmission of pinkeye and other conditions such as eye worm. Adults are developmental hosts for *Thelazia* nematodes which live in the conjunctival sac of cattle and horses causing conjunctivitis, keratitis, photophobia and epiphora (Pegram et al., 1989). Other species of the *Muscidae* including *Muscalarvipara, M. convexifrons, M. vetustissima* (commonly referred to as bush flies)act as intermediate hosts of *Thelazia spp.* worms which infest the conjunctival sacs and lacrimal ducts of domestic animals (Otto *et al*. 2003).

Bovine ephemeral fever, known as the three-day stiff sickness, a viral disease transmitted by *Culicoides* midges and mosquitoes is prevalent when the midges are numerous (Otto *et al.,* 2003). Five days after animals are infected by the virus, the animals develop fever, depression and stiffness. The disease usually clears up in three days as the name indicates. More serious cases have been seen in which the cattle show stiffness, nasal discharge and watering eyes. Muscle tremors may be seen. In very severe cases, the animals may become recumbent and may be unable to rise at all. They develop bloat and salivate due to the loss of swallowing reflex. Later the animals slide into a coma and die. There is a huge drop in milk production and abortions in dairy cattle. Dairies which are located near dams or vleis are at high risks. Affected animals need intensive care. Cattle and sheep are the most common hosts attacked by midges but some species feed on dogs or birds. Cattle also show considerable irritation during attacks by a large number of midges leading to vigorous stamping of feet, switching of tail and continuous movement (Otto *et al*., 2003).

Blue tongue is an infectious, non-contagious, insect-borne disease, primarily of domestic and wild ruminants. Sheep and cattle are most commonly affected. Although *Culicoides* midges prefer feeding in cattle, they do attack sheep and transmit the Blue tongue virus in the process. Cattle and wild ruminants are reservoirs of the blue tongue virus (de Castro et al., 1985). Bites of *Culicoides spp*. cause itching and swellings. Several species are vectors of protozoa and filaroid nematodes and intermediate hosts of filariid nematodes (Soulsby, 1982). *Haematobia spp.* (*Haematobia minuta* in Africa) are blood suckers but are not known to transmit diseases other than *Stephanofilarial spp.* and their chief importance being to worry animals and interfere with grazing. The irritation and blood loss caused by200-500 or more flies will reduce weight gains of beef cattle and milk yield of dairy cattle (Otto *et al*., 2003). Horn flies tend to rest quietly until disturbed whereas other flies always seem to be on the move. Depending on the weather, horn flies will rest on different parts of the host body (underside during intense heat or rain) or on light or dark-colored patches of hair (dark patches when cool, light when hot). Horn flies rarely leave their host except to lay eggs, to move to other cattle in the herd, or when cattle enter buildings. Most feeding occurs along the underline of the animal and results in scabby, often bleeding, sores. Flies will continue to feed around the margins of these sores causing the sores to get larger with each successive year of attack. The hide gradually takes on a calloused, rough appearance. Each fly may feed from 10 to 38 times each day, causing annoyance and irritation to the host. Grazing time is disrupted, resulting in significantly reduced weight gains and daily production.

Clinical findings of infestation by the screw worms, *Cochliomyia hominivorax* and *Chrysomyia bezziana* include extensive damage to skin and muscles accompanied by a copious amount of brown discharge and a foul-smelling odor (de Castro et al., 1985). Flies deposit eggs in wounds resulting from castration, accidents, dehorning, branding, scalding by dips, tick bites and so forth as well as around the vulva of cows when there is a bloody discharge or navel of young calves (Soulsby, 1982). Animals are initially irritated by fly strike then become pyrexic, anorexic, depressed and death may ensue (de Castro et al., 1985). Cattle, pigs and equines suffer most frequently but other animals including fowls, dog and man may be affected by the old world screw worm, *Chrysomyia bezziana* (Soulsby, 1982).These screw worms whose principal hosts are cattle, pigs and horses cause severe myiasis that may be fatal. *Callitroga spp*. and *Lucilia spp*. cause myiasis in cattle with the former being able to produce severe and fatal forms of myiasis (Hassan and Hassan, 2003). Most cases occur during rainy weather. Maggots penetrate tissues; liquefy tissues thereby extending lesions considerably (Soulsby, 1982; www.umass.edu/cdl). Stable flies cause severe irritation and lead to significantly

lowered production of meat and milk. They also transmit important diseases such as Lumpy skin disease, a viral disease in cattle and other ruminants. Before the development of the characteristic lumps, the animals develop a fever and are depressed. The skin lesions develop fourteen days after original infection and this can be limited to focal areas or can be widespread. More severe and often fatal cases are seen in young animals, affecting internal organs as the trachea. In the dairies, the disease can be catastrophic as milk production falls drastically and cows develop mastitis due to lesions occurring on udders. Allerton virus infection which is similar to Lumpy skin disease is also transmitted by stable flies. This disease can be confused with Lumpy skin disease but it is a mild disease that clears up eventually. Anaplasmosis, though a tick-borne disease is transmitted and spread by stable flies especially in dairies and feedlots. Besnoitiosis or elephant skin disease is also transmitted by stable flies.

Hypoderma infestation (warbles and grubs), if heavy, may worry the cattle resulting in production losses (de Castro et al., 1985). Hide damage is the main economic damage of warbles. If accidentally ruptured, or larva dies within the skin, anaphylaxis and death may occur. If larva becomes lodged within the spinal cord, acute posterior paralysis without systemic signs may occur (Urquhart *et al,* 2003).Other significant losses are caused by carcass and hide depreciation and the cost of control programs (de Castro et al., 1985). *Hypoderma lineatum* and *Hypoderma bovis* cause annoyance and fright with running (gadding) to avoid the flies resulting in loss of production in cattle herds (Pegram et al., 1989). Clinical findings in *Hypoderma* infestation include small numbers of painful sub-cutenous nodules, each with a breathing pore are seen over the withers of young cattle. Occasionally, nodules can be extremely numerous. Other clinical findings are associated with inflammatory reactions to larvae, interrupted migration or aberrant migration of larvae (de Castro et al., 1985). An inflammatory reaction may occur around larvae in the submucosa of the oesophagus resulting in oesophageal obstruction and subsequently results in the build-up of rumenal gases and bloat ensues (de Castro et al., 1985). Paralysis could also result from an inflammatory reaction surrounding dead larvae in spinal column in cattle and horses (de Castro et al., 1985).

Although, tsetse flies are limited in their distribution to sub-Saharan Africa, the importance of the animal trypanosomoses (nagana of cattle) in Africa ranks tsetse as one of the world's major arthropod-vector groups. The very complex developmental cycle of the trypanosome within the tsetse vector is further complicated by several of other factors related to the biology of the vector, pathogen, and host. Not only are the various species of tsetse flies characterized by differences in their distribution, biology, and host preferences, but even within the same species environmental factors (especially humidity, temperature, and vegetation), densities and composition of mammalian hosts, and vector population densities affect their epidemiological role. In addition, there are wide intra-specific variations in both morphology and pathogenicity of trypanosomes.

Arachnids of cattle

Members of the class Arachnida are a highly diverse group of largely carnivorous, terrestrial, chelicerate arthropods. They are characterized by having the body parts divided into two parts –the cephalothorax and abdomen (Pegram et al., 1989). The class Arachnida includes the ticks and mites which are of considerable veterinary importance and also the spiders and scorpions. The mouthparts are extensively modified and carry two pairs of appendages, the first called chelicerae and the second, the palps (Urquhart *et al.,* 2003). Ticks are obligatory blood-sucking arachnid arthropods infecting mammals as well as birds, reptiles and amphibians. They are vectors of disease agents (such as Babesiosis, cowdriosis, anaplasmosis) causing anaemia, dermatitis, paralysis, otocariasis, as well as loss of production (Schmidt and Roberts, 1989; www.vetk_state.edu/depts/vhc/agpra). They are vectors of pathogens such as *Babesia spp, Theileria spp., Anaplasma spp.* (Soulsby, 1982). Cattle ticks transmit the organisms that cause tick fever, which is a serious blood parasite disease of cattle. This disease can be lethal to susceptible animals and others may suffer a severe loss of condition.

Ticks classified under the family Ixodidae are true ticks because all developmental stages (larva, nymph and adult) have a hard chitinous shield known as scutum which extends over the whole dorsal surface of the male and covers only a small portion behind the head in the larva, nymph and adult female tick. Some ticks are coloured and have enamel-like areas on the body and are also known as ornate ticks while inornate ticks do not have these characteristics (Bhatia *et al*., 2006). Ixodid ticks are grouped in three categories according to the number of hosts utilized in their life cycle: one-host, two-host and three-host ticks.

In one-host ticks, all the three stages (larva, nymph, and adult) engorge on the same host animals, and the ecdyses also take place on the body of the same host. Examples include, *Boophilus annulatus, B. microplus and B. decoloratus.* In two-host ticks, the larva engorges and moults to become nymph on the body of the host. It engorges and subsequently drops off on the ground. It then moults to become imago which seeks a new host animal. Examples include, *Rhipicephalus evertsi* and *R. bursa*. Each developmental stage of the three-host ticks requires a different host animal. After having engorged on a host, the stage drops off on the ground and moults. Examples include, *Rhipicephalus appendiculatus,*

Amblyomma hebraeum, Ixodes ricinus, Haemaphysalis spp. (Bhatia *et al*., 2006). All ticks feed on blood and lymph of the hosts. In general, Ixodid ticks are not very host specific. During feeding on the host, the tick buries its mouthparts deeply into the tissues of the host and remains firmly attached until it is fully engorged (Bhatia *et al.,* 2006).

One-host ticks of cattle

Rhipicephalus (Boophilus) annulatus is a famous tick due to early work on biology and control of Babesiosis in cattle. It is a typical one-host tick with monotropic type of behavior of the *Boophilus* sub-genus within the genus *Rhipicephalus*. Sheep, goats and wild ungulates can support successful completion of lifecycle. Cattle are probably the only maintenance host for this tick and infestation of other hosts will only occur when a population of this tick is maintained by cattle. This species of ticks transmit the protozoan *Babesia bigemina* and *Babesia bovis* to cattle. They also transmit *Anaplasma marginale* causing bovine anaplasmosis (gall sickness). Heavy infestations cause damage to hides and probably result in reduced growth in cattle. The period of infestation of cattle is approximately three weeks. The lifecycle can be completed in two months, and six generations per year are possible under conditions of continuous high temperature and humidity (Walker *et al*., 2003). *Rhipicephalus (Boophilus) microplus* is mainly a tick of West and North Africa though it can be found elsewhere such as South-East Sudan and Democratic Republic of Congo. It is often found together with *Rhipicephalus (Bo.) decoloratus*(Walker *et al*.,2003). It is a very important species present in every continent except Europe and a very important vector of *Babesia spp*. and *Anaplasma marginale* in cattle in subtropical and tropical countries (Urquhart *et al*., 2003). *Rhipicephalus (Bo.) decoloratus* is also known as blue tick because of the color of the engorged females. It is the commonest, most widespread and frequent of the one-host cattle ticks in Africa. Cattle are probably the only maintenance host for this tick. Preferred feeding sites of all stages on cattle are, in order of preference, back, upper legs, neck, shoulder, dewlap and belly. The nymph and adult transmit *Babesia*after it has passed transovarially from previous generation of ticks. It is also incriminated in the transmission of *Borellia theileri* and *Anaplasma marginale,* the bacteria causing anaplasmosis in cattle (Walker *et al*., 2003).

Two-host ticks of cattle

Rhipicephalus evertsi evertsi, a two-host tick is the largest and most distinctive *Rhipicephalus spp.* Horses, donkeys, cattle and sheep are the preferred domestic hosts of adult *Rhipicephalus evertsi evertsi*. Larva and nymph infest same hosts as adults and also infest scrub hares and various smaller antelope species (Walker *et al*., 2003). It is commonly referred to as the 'red-legged tick' and can transmit theilerial infections and *Babesia bigemina*and *Babesia equi*(Urqhuart*et al*., 2003). *Hyalomma spp.* are usually two-host ticks with the larvae and nymphs feeding on birds and small mammals while the adults feed on ruminants and equines. The ticks are usually inornate but with banded legs (the 'bont-legged tick), eyes are present and festoons sometimes present. The palps and hypostome are long and the males have adanal shields. *Hyalomma spp*. occur throughout Africa, Asia Minor and Southern Europe (Urquhart *et al.,* 2003). They have been incriminated as vectors of several babesial, theilerial and rickettsial infections. *H. marginatum* and *H. detritum* are important species in Southern Europe and North Africa while *H. truncatum* is found throughout Africa. This genus is mainly responsible for tick toxicosis. The 'toxin' produced by the adult tick causes a sweating sickness in ruminants and pigs characterized by widespread hyperaemia of mucous membranes and profuse moist eczema (Urquhart *et al*., 2003).

Three-host ticks of cattle

The three-host tick, *Amblyomma* are large, usually ornate ticks whose legs have bands of colour, eyes and festoons are present. The palps and festoons are long and ventral plates are absent in males. Important species are *Amblyomma variegatum* and *A. habraeum*, the so-called 'bont ticks' with patterns of colour on back and legs. They are distributed mainly in Africa and transmit the important disease, heartwater in cattle caused by *Cowdria ruminatium* (Urqhuart*et al*., 2003; Taylor et al., 1981). *Haemaphysalis* are inornate ticks with festoons present and eyes absent. Sensory palps are short and broad with second segment extending beyond the basis capituli. *Haemaphysalis punctata* has been reported as causing tick paralysis and has also been incriminated in the transmission of *Babesia bigemina. Dermacentor (*ornate ticks with eyes and festoons) maybe a three-host or one-host tick and are parasitic in many domestic and wild mammals. *Dermacentor andersoni* and *D. variabilis* are responsible for the transmission of *Anaplasma marginale* in cattle and Rocky Mountain spotted fever in man (caused by *Rickettsia rickettsii*) is of importance in North America. Both also cause tick paralysis (Urquhart *et al*., 2003).

Control of parasitic flies and ticks of cattle

Acaricidal and insecticidal chemicals or drugs used in fly and tick control are: Organophosphates such as

chlorfenvinfos, dichlorvos, malathione, diazinon, coumaphos and chlorfenvinphos; Chlorinated hydrocarbons such as lindane and methoxychlor; Pyrethrins and pyrethroids such as permethrins, fenvalerate and cypermethrin; others such as Carbamates, Rotenone, Formamidines and numerous repellants; the Avermectins which include Ivermectin injections and pour-on (Hassan and Hassan, 2003; Radostits et al., 1997; www.infonetbiodivision.org).

Fly-control measures

One should not wait until a problem exists to begin a fly control program. Flies are among the most difficult pests to control. A good program needs to be in place before fly numbers increase. Often flies are hidden during a portion of their lifecycle making them undetectable. Knowing when and where they may be found increases the ability to limit potential losses in an animal's performance. Proper identification of the fly and knowledge of the life cycles is important to help to target control measures. Sanitation is the most important factor in any fly control plan. Manure and other organic fly breeding material should be regularly removed from barn and stable areas. Composting manure can also aid in fly control. The heat generated by proper composting will kill fly eggs, therefore reducing fly populations. Clean up spilled feed and other organic materials to prevent additional fly breeding grounds. There is no insecticide on the market that will make up for poor sanitation.

Integrated pest management is the best approach to controlling flies. This involves monitoring, environmental control and treatment of animals as a multiple attack on flies. Resistance to pesticides has occurred over the years, so incorporating multiple management strategies has been the most successful control program. Monitoring can be as sophisticated as counting fly specks on paper placed throughout a barn or as simple as observing animal housing areas and the environment for the presence of adult flies. Either way, knowing the challenge level helps when planning to target them for removal. Areas to monitor include calf housing, accumulated wet bedding in pens, manure around feeders, lagoons, feed storage areas (bins, troughs, bunkers, silos), wet areas in the environment and carcasses. It is best to monitor these areas before fly season begins and every two weeks throughout fly season. The environment must be managed to decrease the areas where flies can lay their eggs. Manure must be disturbed once a week to prevent fly eggs from hatching. This can be done by dragging dry lots, pastures, scraping and hauling manure to storage or spreading it in thin layers on pastures. Stored manure can be an egg laying area for flies if it does not have a hard crust on top. Agitating regularly or adding water will drown the fly larvae. Organic debris such as spilled feed, bedding, rotten vegetation and leaf litter should also be disturbed once a week to prevent fly eggs from hatching. Cleaning up spilled feed, scraping around bunks and preventing accumulations of moist bedding will decrease the adult fly population.

Fly parasites have been used with success on some farms. Predatory mites and beetles eat fly larvae that live in manure, bedding and vegetation. Small wasps lay one of their eggs on the pupal stage of a fly in manure; the wasp egg then develops into a larva which kills the fly pupa by feeding on it. However, the manure cannotbe excessively wet as this prevents parasite movement and larva/pupa destruction. Some wasps feed by piercing through the outer protective layer of fly pupae and consume them, resulting in fly death. Certain fly parasites can only be used in specific geographic areas because they may feed on other beneficial insects.

Area sprays (knockdown) are fine mists of insecticide that rely on contact with the adult fly to kill it. They should be used the same day they are mixed and applied in areas of high fly concentration because they do not last long in the environment (1-2 hours).Residual sprays are insecticides that can be applied to shaded surfaces where flies rest to kill them through contact. Places such as barn walls, ceiling, rafters and calf hutches are commonly treated. To avoid insecticide resistance, it is a good idea to alternate between area and residual sprays.

Control of *Muscidae* has proved difficult. A number of protective or repellent creams are available for application at the base of horns, many of these only prevent skin contact, not annoyance (Urquhart *et al*., 2003; Schmidtmann, et al., 1985). Good sanitation practices are the basis for all fly control programs and can account for as much as 75% toward the prevention of fly breeding. Sanitation should be the first line of defence against house flies and other filth-breeding fly species**.** Under optimum conditions, house flies can complete their life cycle (egg to adult) in as few as 9 days. By adhering to a strict manure management program throughout the period of greatest fly activity it is possible to disrupt the life cycles of these pests. Better control has been achieved using synthetic pyrethroids as spot-on preparations, or the application of one or two insecticide-impregnated ear tags or tail bands usually containing synthetic pyrethroids have proved beneficial in easing fly-worry. Control measures for muscids also apply to *Stomoxys spp.* (Urquhart *et al.,* 2003).

Haematobia spp. is easier to control since they spend much time on their hosts unlike other stock-visiting muscids. Insecticide-impregnated ear tags are thus beneficial, repeated treatment with pour-on or spot-on insecticide preparations are also of benefit in the control of flies (Urquhart *et al*., 2003).Control of horn flies should be implemented when 100-200 horn flies per head of cattle are present. Control measures include the use of pyrethroid or organophosphate impregnated ear-tags. Due to resistance problems, a 3-year rotation schedule

consisting of organophosphate tags for years 1 and 2 and a pyrethroid tag for year 3 should be used. Ear tags should not be used until horn flies are present and should be removed in the fall to help avoid resistance problems. In addition, supplemental control methods such as sprays, pour-ons, and self-treatment devices (dust bags, back rubbers) should be used in late summer to help control horn flies. Sprays and pour-on insecticides afford some control of horn flies, but require frequent application. Topical Ivermectin will provide control for up to 28 days. Back rubbers and dust bags are highly effective ways to treat cattle with insecticides effective against horn flies and do not require handling of cattle. Dust bags and back rubbers should be placed near, but not over, mineral blocks or dust bags or near loafing areas. Several dust bags or back rubbers should be available for use so that less dominant cattle can have access. Oral larvicides mixed with feed or in mineral mixes or blocks kill developing larvae in manure, but do not protect cattle from adult flies. The effectiveness of oral larvicides is also limited by the immigration of horn flies from pastures with untreated cattle. Horse flies (*Tabanus spp*.) and deer flies (*Chrysops spp*.) are the most difficult to control of all blood-sucking flies. Many of the adulticide compounds used for other biting flies will kill them. However, because these flies are intermittent feeders that alight on the host for only a short time, they may not be exposed long enough to be affected. Thus, larger doses of the compounds may be required (Merck Veterinary Manual, 2010; www.afrivet.co.za/veldtalkprinting%5cveldtalk_print_5.htm).Although control of horse flies is difficult; individual animal treatment using repellents or insecticidal sprays may reduce fly bites. Many of the control measures enlisted for horn flies will provide some relief from horse flies and deer flies. Back rubbers and dust bags with permethrin insecticides are effective because horse flies and deer flies tend to attack the upper body and back of cattle. Permethrin sprays and pour-on formulations have some efficacy against horse flies and deer flies, but require frequent re-application. Insecticides may not kill horse flies quickly and in some cases, no control will be apparent.

Control of *Glossina spp*. includes, use of residual formulations of insecticides applied from ground or by aircraft. Use of traps in localized areas is a control method that is cheap, uses local labor and is harmless to the environment. They depend on the presentation of material such as dark cloth which attracts the flies and leads into a trap which often incorporates an insecticide. Odoriferous extracts from cattle placed in or near traps to attract the flies have given promising results (Urquhart *et al.,* 2003).

Administration of Ivermectin injection and expression of the maggots (larvae of myiasis-causing flies) can be done to treat and control myiasis while using insecticide and repellents to get rid of the adult myiasis-causing flies (Hassan and Hassan, 2003).

Tick-control measures

Specific tick control strategies vary according to the breed and type of cattle and to the management system (www.fao.org/ag/aga/agap/frg/feedback/war/u9550b/u9550b04.htm). Control of ticks in cattle is largely based on the use of chemical acaricides applied by total immersion in a dipping tank or in the form of spray, shower or spot-on. Where severely parasitized animals require individual treatment, special formulations of acaricides suspended in a greasy base may be applied to affected areas (Urquhart *et al*., 2003). Control can also be achieved by the use of systemic drugs; by burning tick infested pastures and cultivation of lands to kill all developmental stages of ticks hiding for either egg laying or moulting; through biological control; and by immunization of animals against tick infestation (Bhatia *et al*, 2006). Burning of infested pastures may kill a large number of larvae and other stages of ticks. Rotational grazing of animals leave the ticks devoid of blood meal with resultant death in due course. Biological control can be achieved by using certain flies, ants and birds that parasitize and destroy ticks. Examples of such birds include, *Bubulcus ibis, Buphagus erythrorhyndius, B. africanus.*

A further consideration which influences the regimen of control in ticks is whether the tick is a one-host tick in which all the instars feed and develop on the same host, or a two-host or three-host tick using two or three different hosts respectively. Clearly, the one-host tick is easier to control than the others (Urquhart *et al*., 2003).
Tatchell (1992), further developed the concept of integrated tick management (ITM), emphasizing the importance of animal management, ecology, epizootiology, economics and marketing in the formulation of integrated policies for tick and tick-borne diseases (TBD) control. Essential elements of an integrated tick and TBD control programmes include: appropriate legislation, correct extension messages for both disease and vector control, enzootic stability to TBD through immunization, appropriate strategies such as minimal control in periods of low challenge and strategic control for seasonal challenges, amongst other elements.Major advances have been made in the development of novel methods and strategies for the control of ticks in recent years. Newer and easier methods of applying acaricides are available- ear tags, neck bands, tail bands and pour-on, for example, particularly for the pyrethroids with long residual activities, a mechanical applicator has also been developed (Duncan, 1991). In Kenya, an intraruminalivermectin slow-release device providing a 90-day protection against tick damage was demonstrated (Tatchell, 1992). Tick repellents to use on livestock are

limited (Mwase et al.,1990; www.cfsph.iastate.edu/BRMForproduce) however, several studies have indicated the potential benefits of the using tick-repellent grasses and plants such as *Melinis minutiflora, Stylosanthes* species and *Cassia absus*. The application of tick attractants, such as pheromones, in combination with toxicants has also been considered. Pasture management, including spelling, has been used in Australia, and seasonal changes in cattle grazing areas in Zambia are believed to be responsible for a decrease in tick numbers (www.fao.org/ag/aga/agap/frg/feedback/war/u9550b/u9550b04.htm;http://nz.merial.com/disease-information/dairy/overview.asp).

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