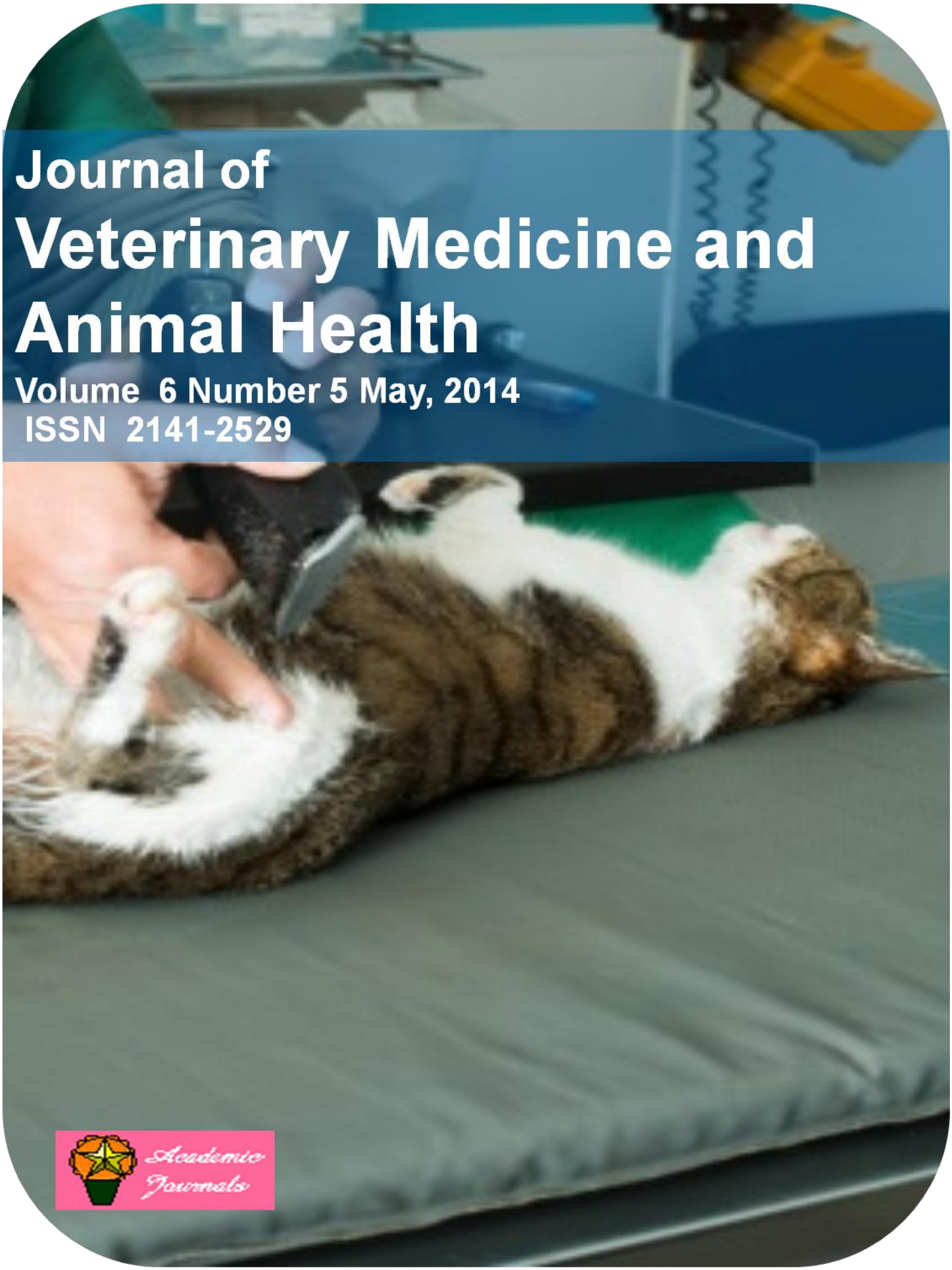

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Review

Pathophysiologic mechanisms of pain in animals – A review

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The sense of pain is of practical significance in human and veterinary medicine. Its management and prevention constitute integral and fundamental parts of quality and compassionate care of patients. In order to recognise, assess, prevent and treat pain, an understanding of its pathway and the pathophysiologic mechanisms is necessary. This review discusses definitions of pain, its classification, description, pathophysiologic mechanisms, neuro-transmission and evaluation of pain as well as physiological responses to pain, with special reference to domestic animals. It is concluded that adequate understanding of pathophysiologic mechanisms of pain and the physiologic responses of animals to pain may aid its efficient management.

Key words: Pain, definitions, pathophysiologic mechanism, animals, review.

INTRODUCTION

According to the International Association for the Study of Pain (IASP), pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage (Merskey, 1979). Molony and Kent (1997) described pain as an aversive sensory and emotional experience, representing awareness by the animal of damage or threat to tissue integrity. Broom and Fraser (2007) described it as an aversive sensation and feeling, associated with actual or potential tissue damage. Pain is derived from the Latin word `Poena` which means 'punishment'. The understanding of pain is very important and it is viewed from four points based on its pathophysiology: nociception, pain, suffering and pain behaviour (Woolf, 2004).

All tissue injuries, including that from elective surgery, may cause pain. Pain-induced stress responses mediated by the endocrine system, are one of the negative consequences of pain. Increased cortisol, catecholamines and inflammatory mediators cause tachycardia, vasoconstriction, decreased gastro-intestinal motility, delayed healing and sleep deprivation. In addition, trauma causes unseen changes in the central nervous system (CNS). Inadequate pain prevention or management leads to magnification of pain perception and a prolongment of pain state (Heller et al., 2007). If pain is left untreated or

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under-treated, animals become depressed, lethargic, withdrawn, and eventually immobile (Gleed and Ludders, 2008).

Pain medicine can be daunting and challenging, the ability to offer a safe and effective therapeutic regimen is very important, especially in the setting of the opioid abuse epidemic (Smith and Pappagallo, 2013). A broad knowledge of the pathophysiologic mechanism of pain, its pharmacology and pharmacokinetics, may aid in the use of medications and injections for clinical pain therapy.

WHY TREAT PAIN?

Pain control for routine management procedures is considered one of the most important welfare priorities in livestock production today. This is particularly true at a time when public scrutiny regarding animal production and care is high (Bayvel, 2004). Although there is a plethora of published scientific studies dedicated to assessing pain as well as strategies aimed at reducing it, the current knowledge of food animal pain, its assessment and alleviation are still very limited (Flecknell, 2000). Current positive attitudes about animal welfare have increased the importance of pain management in livestock. Even minor surgical procedures in livestock are now performed using a combination of regional, local or general anaesthesia combined with uninterrupted post-surgical analgesia. Attitudinal changes based on current knowledge and enlightenment toward animal suffering have necessitated the understanding of pain modulation by large animal veterinarians and the willingness of clients to incur extra cost for the alleviation of pain in their animals (Bayvel, 2004).

Pain is a percept consisting of initial nociception, followed by a slower but integrated emotional phase. The cerebral cortex, thalamus and the limbic system are involved in pain processing, so specific behaviours to painful stimuli depend upon species, breed, temperament and rearing (Kamerling, 1993).

CLASSIFICATION OF PAIN

Although traditionally, pain can be categorized as acute or chronic based on duration. A more contemporary approach considers pain as adaptive or maladaptive (Woolf, 2004). Adaptive pain is a normal response to tissue damage. Adaptive pain includes inflammatory pain which is a major component of many pain states. Woolf (2004) opined that acute pain disappears once the damaged tissue has been healed. In contrast, chronic (or persistent) pain lasts beyond the expected healing time for an injured tissue (Molony and Kent, 1997). Chronic pain can be more difficult to recognise because it is not possible to identify behaviour that would uniquely and reliably indicate its existence (Mogil and Crager, 2004). It is also important to realise that various tissues and organs of the body can have different sensitivities to painful stimulation. For example, mucous membranes, cornea or dental pulp are considered to be extremely sensitive, whereas parenchymatous organs are less painful (Henke and Erhardt, 2001).

Physiologically, pain is divided into two categories/classes: nociceptive and neuropathic (IASP, 2012). Nociceptive pain is the perception of painful sensation and it is generated by an injury that activates nociceptors in peripheral tissues (Loeser and Treede, 2008). Reports suggest that the nociceptive system may be altered in chronic inflammatory pain (Woolf, 2004). Neuropathic pain is the pathology of the somatosensory system, either in its peripheral elements (peripheral neuropathic pain) or in the CNS (central neuropathic pain) (Loeser and Treede, 2008). It is either central or peripheral (outer surface), depending on the origin of the stimulus; for example, direct damage to the spinal cord or the peripheral nerves, respectively (Carroll, 2009).

Nociceptive pain

Nociceptive pain is further divided into two categories: somatic and visceral. Somatic body pain, which in humans has been described as localized, sharp, aching, or throbbing pain, originates from skin and connective tissues, including the muscles, joints and bones (Faries, 2010).

Somatic pain originating in the skin is called superficial pain. If it originates in the connective tissues such as the muscles, bones and joints, it is called deep pain. In other words, somatic pain refers to pain originating from the periphery and can be, in most cases, well localised (Robertson, 2002).

Visceral (organ) pain is usually dull or hard to localize and originates from receptors in the heart, lungs, kidneys, liver, gastro-intestinal tract, uterus or bladder. Painful states are caused particularly by tissue or nerve damage, inflammatory processes, viral infections or demyelination and are characterised by pain hypersensitivity (Vinuela-Fernandez et al., 2007). Visceral pain arises from the viscera (Joshi and Gebhart, 2000). McMahon et al. (1995) suggested that the sensitivity of viscera to mechanical, thermal or chemical stimuli is very different. Information from certain regions of viscera converges on spinal neurones and pathways that also convey information from somatic structures. For example, some cows exhibit an extreme sensitivity in the region of the sternum, when they suffer from traumatic peritonitis caused by a wire or nail perforating the wall of the fore- stomachs (Frandson et al., 2009).

Nociceptive pain can be acute (short-lived, remitting) or persistent (long-lived, chronic) and may primarily involve injury to somatic or visceral tissues. Pain that is inferred to be related to on-going activation of nociceptors that innervate somatic structures, such as bone, joint, muscle and connective tissues, is termed as “somatic pain”. This pain is recognized by identification of a lesion and characteristics that typically include a well-localized site and an experience described as aching, squeezing, stabbing or throbbing (AMA, 2010). Arthritis and metastatic bone pain are the examples of somatic pain (Landa, 2012).

Pain arising from stimulation of afferent receptors in the viscera is referred to as visceral pain. Visceral pain caused by obstruction of hollow viscous is poorly localized and is often described as cramping and gnawing, with a daily pattern of varying intensity; however when organ capsules or other structures such as myocardium are involved, the pain usually is well localized and described as sharp, stabbing or throbbing, descriptors similar to those associated with somatic pain (AMA, 2010). Visceral pain is usually described as more diffuse and unpleasant than somatic pain (Paine et al., 2009) and the diffuse nature of true visceral pain is probably due to the low density of visceral sensory innervations and extensive divergence of the visceral input within the CNS (Giamberardino and Vecchiet, 1997).

Neuropathic pain

Neuropathic pain originates within the nervous system itself and arises as a disorder of processing of nociceptive activity or as a result of abnormal activity in nociceptive pathways (Lamont et al., 2000). Neuropathic pain is typically manifested by disproportionate hypersensitivity to stimuli (hyperalgesia), abnormal pin and needle sensations (hyperpathia) and nociceptive responses to harmless stimuli (allodynia) (Leung and Cahill, 2010).

Idiopathic pain

It is necessary that patients who have acute or persistent pain without a known physical source should not be inappropriately labeled. This may lead to inadequate assessment in the future and therapeutic decisions that are inappropriately skewed; unfortunately, in many quarters, it also leads to stigmatization of the patient and the potential for greater suffering on this basis. When reasonable inferences about the sustaining pathophysiology of a pain syndrome cannot be made, and there is no positive evidence that the aetiology is psychiatric, it is best to label the pain as “idiopathic” (AMA, 2010).

PATHOPHYSIOLOGIC MECHANISMS OF PAIN

Neurones have evolved specialized properties that allow them to receive information, process it and transmit it to other cells. The stimuli translated into nerve impulses include, light, pressure, chemicals, temperature, vibration and sound waves. Sensory reception begins in receptor cells, specialized to respond to particular kinds of stimuli and transmitted through a corresponding nerve fibre (afferent neurones) to the CNS for processing (Stillwell, 2009). Enormous strides have been made in understanding the neurophysiology and neurochemistry of the systems that transmit and modulate information about noxious events (Willis, 2007). Much also is known about acute inflammation which commonly drives these neural processes. In contrast, relatively little is known about the pathophysiology underlying most persistent pain syndromes (AMA, 2010). Nonetheless, it is now widely accepted that persistent pain may be sustained by different types of mechanisms and clinical characteristics can be used to broadly divide pain syndromes into nociceptive, neuropathic, psychogenic, mixed or idiopathic (AMA, 2010).

Two major classes of nociceptors exist (Meyer et al., 2008). The first includes medium diameter myelinated (Aδ) afferents that mediate acute, well-localized “‘first”’ or fast pain while the second class of nociceptor includes small diameter unmyelinated “C” fibers that convey poorly localised “second” or slow pain (Basbaum et al., 2009). Primary afferent nerve fibers project to the dorsal horn of the spinal cord, which is organized into anatomically and electro-physiologically distinct laminae (Basbaum and Jessell, 2000); by contrast C nociceptors project more superficially to laminae I and II. The stratification of afferent subtypes within the superficial dorsal horn is further highlighted by the distinct projection patterns and circuits engaged by C nociceptors (Braz et al., 2005). The most ventral part of lamina II is characterized by the presence of excitatory interneurons that express the gamma isoform of protein kinase C (PKC), which has been observed in injury-induced persistent pain (Malmberg et al., 1997).

Neumann et al. (2008) indicated that this PKCγ layer is targeted predominantly by myelinated non-nociceptive afferents. Projection neurons within laminae I and V constitute the major output from the dorsal horn to the brain (Basbaum and Jessell, 2000). These neurons are at the origin of multiple ascending pathways, including the spinothalamic and spinoreticulothalamic tracts, which carry pain messages to the thalamus and brainstem, respectively. Attention has now been focused on spinal cord projections to the parabrachial region of the dorsolateral pons, because the output of this region provides for a very rapid connection with the amygdala, a region generally considered to process information relevant

to the aversive properties of the pain experience (Basbaum et al., 2009). From these brainstem and thalamic loci, information reaches cortical structures. There is no single brain area essential for pain (Apkarian et al., 2005), rather, pain results from activation of a distributed group of structures, some of which are more associated with the sensory-discriminative properties (such as the somatosensory cortex) and others with the emotional aspects (such as the anterior cingulate gyrus and insular cortex) (Basbaum et al., 2009).

Mechanism of nociceptive pain

According to Landa (2012), clinically, pain can be labelled "nociceptive" if it is inferred that the pain is due to on-going activation of the nociceptive system by tissue injury. Although neuroplastic changes, such as those underlying tissue sensitization, are clearly involved, nociceptive pain is presumed to occur as a result of the normal activation of the sensory system by noxious stimuli, a process that involves transduction, transmission, modulation and perception (Figure 1) (AMA, 2010).

Tissue injury activates primary afferent neurones called nociceptors, which are small diameter afferent neurones (with A-delta and C-fibres) that respond to noxious stimuli and are found in skin, muscles, joints and some visceral tissues (Willis, 2007). The fibres have specific receptors that may be responsible for noxious mechanical, chemical or thermal stimuli. One class, called transient receptor potential (TRP) receptors, has been undergoing intensive investigation in the hope of ultimately yielding new therapies for pain (Bevan and Anderson, 2009). The TRPV1 receptor, for example, has been found to be the specific site for reaction to capsaicin, a compound that activates C-fibre nociceptors. Presumably, nociceptive processes linked to noxious events involving somatic or visceral structures begin with activation of these specific receptors, which leads to transduction, the process by which exposure to a sufficient stimulus produces depolarisation of the peripheral nerve (AMA, 2010). There are varying nociceptive primary afferent neurones. Most are "silent", active only when suprathreshold stimuli impinge. Some are specific to one type of stimulus, such as mechanical or thermal, but most are polymodal. The number and size of the receptive fields served by each fibre may be small or large, respectively (AMA, 2010). Nociceptors can also be distinguished according to their differential expression of channels that confer sensitivity to heat (TRPV1), cold (TRPM8), acidic milieu (ASICs) and a host of chemical irritants (TRPA1) (Julius and Basbaum, 2001).

Depolarisation of the primary afferent involves a complex neurochemistry in which substances produced by tissues, inflammatory cells and the neurone itself influence transduction of pain (Landa, 2012). The role of prostaglandins, bradykinin, protons, nerve growth factor and other compounds provide opportunities for the development of new analgesic drugs (AMA, 2010). Once depolarisation occurs, transmission of information proceeds proximally along the axon to the spinal cord and then on to higher centres (Landa, 2012). Complex systems that modulate this input occur at all levels of the neuraxis and are best characterized in the spinal cord. The neuroanatomy, neurophysiology and neurochemistry of these processes are very complex (Stein et al., 2009). Transmission across the first central synapse may be influenced by activity in the primary afferent itself and modulatory neural pathways that originate segmentally or supraspinally; further modulation results from processes initiated by glial cells (Apkarian et al., 2005).

The neurochemistry of the processes involves an extraordinary array of compounds, including endorphins, neurokinins, prostaglandins, biogenic amines, gamma-amino butyric acid (GABA), neurotensin, cannabinoids, purines and many others (AMA, 2010). The endorphinergic pain modulatory pathways are characterized by multiple endogenous ligands and different types of opioid receptors such as: *mu*, *delta* and *kappa*. Endorphins are present in the periphery, on nerve endings, immune-related cells and other tissues, and are widely distributed in the CNS (Landa, 2012). They are involved in many neuroregulatory processes apart from pain control, including the stress response and motor control systems. Opioid drugs mimic the action of endogenous opioid ligands. Most of the drugs used for pain are full *mu* receptor agonists (AMA, 2010); they belong to the G protein-coupled receptor family and signal via a second messenger (cyclic AMP) or an ion channel (K^+) (Gustein and Akil, 2001).

Other pain modulating systems, such as those that use monoamines (serotonin, adrenaline and dopamine), histamine, acetylcholine, cannabinoids, growth factors and other compounds are targets for non-traditional analgesics, such as specific antidepressants and anticonvulsants. It is likely that entirely novel analgesic compounds will become commercially available in the future as drug development programme target these systems (Woolf, 2004). Nociceptive pain may involve acute or chronic inflammation. The physiology of inflammation is complex. In addition to an immune component, retrograde release of substances from C polymodal nociceptors also may be involved (Landa, 2012). This "neurogenic inflammation" involves the release from nerve endings of compounds such as substance P, serotonin, histamine, acetylcholine and bradykinin. These substances activate and sensitize other nociceptors. Prostaglandins produced by injured tissues also may enhance the nociceptive response to inflammation by lowering the threshold to noxious stimulation (AMA, 2010).

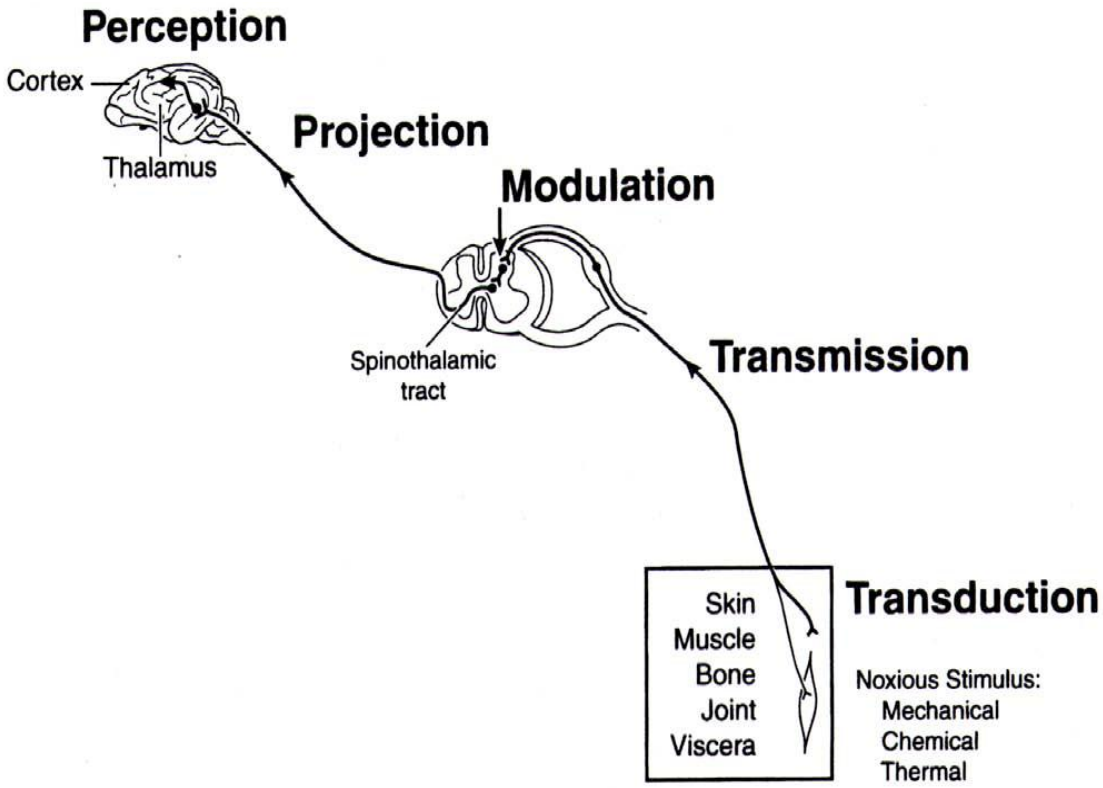

Figure 1. A schematic diagram of pain process. Source: Alvin (2006).

Mechanism of neuropathic pain

Neuropathic pain is the label applied to pain syndromes inferred to result from direct injury or dysfunction of the peripheral nervous system or CNS. These changes may be caused by injury to either neural or non-neural tissues. Although neuropathic pain may be strongly influenced by on-going tissue injury or other stimuli that activate the sensory system, there is an assumption that the fundamental mechanisms sustaining the pain may become independent of any on-going tissue injury (Jarvis and Boyce-Rustay, 2009). Although representing a gross over-simplication of very complex processes, it may be valuable to sub-classify neuropathic pain syndromes, based on additional inferences of the primary location of the sustaining mechanisms (Portenoy, 1999). Some of the neurophysiologic and neuroanatomic changes that may occur in peripherally-generated neuropathic pain have been elucidated (Truini and Cruccu, 2006).

Injury to a peripheral nerve axon can result in abnormal nerve morphology. The damaged axon may grow multiple nerve sprouts, some of which form neuromas. These nerve sprouts, including those forming neuromas, can generate spontaneous activity, which peaks in intensity several weeks after injury. These areas of increased sensitivity are associated with a change in sodium receptor concentration and other molecular processes. They can occur at sites of demyelination or nerve fibre injury not associated with the severing of axons (Landa, 2012). Unlike normal nerve, these injured regions are more sensitive to physical stimuli, which is clinically associated with tenderness and the appearance of Tinel's sign (that is pain or tingling when the area over a nerve is tapped). After a period of time, atypical connections may develop between nerve sprouts or demyelinated axons in the region of the nerve damage, permitting "cross-talk" between somatic or sympathetic efferent nerves and nociceptors (Landa, 2012).

Other changes occur in peripheral nerve that are related to pain and yet poorly characterized. Anterograde and retrograde transport of compounds may shift and messages that are received in cell bodies may turn on specific genes. More proximally, there are identifiable trans-synaptic changes. Some of these alterations in morphology and function result in peripheral sensitisation, which may be related to a lower threshold for signalling or an expansion in receptive fields. Functional neuro-imaging has demonstrated the extraordinary neuroplasticity

of the brain in the setting of a neuropathic pain, such as phantom pain, but the mechanisms responsible are unknown (Bingel and Tracey, 2008).

Mechanism of psychological and "idiopathic" pain

There is an exceedingly complex relationship between the psyche and pain perception (Gamsa, 1994). In some patients, the experience of persistent pain appears to induce disturbances in mood (reactive depression or anxiety), impaired coping (often with catastrophization) and other processes, which in turn appear to worsen pain and pain-related distress. Other patients have pre-morbid or co-morbid psycho-social concerns or psychiatric disorders that are best understood as evolving in parallel to the pain. These disturbances also can contribute to the pain experience and driver pain-related distress. Patients with personality disorders, substance-use disorders or mood disorders often are best served by primary treatment for the psychiatric problem at the same time that pain-related interventions are offered. This array of pre-morbid, co-morbid and reactive psychosocial disturbances is individual and complex, and may occur in a shifting mix of primary and secondary concerns (Landa, 2012). On occasion, the psychological evaluation yields evidence that the pain itself is predominantly sustained by psychological factors. This phenomenon is known generically as "psychogenic" pain, and is subject to the specific diagnoses codified under the Somatoform Disorders in the Diagnostic and Statistical Manual of the American Psychiatric Association (Frances et al., 2000).

PAIN RECOGNITION AND ASSESSMENT

Humans and animals have common anatomical and physiological features which have given rise to why animal pain is so often ignored. The answer to this question may be due to the fact that the ability to assess pain in farm animals is still very limited. However, the inability to fully recognize pain does not mean that it does not exist. This is particularly true for ruminants in which concealment of vulnerability and weakness appears to be adaptive (Broom, 2001; Weary et al., 2006). This conclusion is based on numerous studies providing strong scientific support based on behavioural and physiological indicators of pain measured as part of the assessment (Stafford and Mellor, 2005; Coetzee, 2011).

PHYSIOLOGICAL RESPONSES TO PAIN

The main glucocorticoid hormone that is released in response to stresses, including pain, is cortisol (Hecter and Pincus, 1954; Weary et al., 2006). The corticosteroid level can be measured in plasma or saliva and is a widespread means for the physiological assessment of the activity of the hypothalamus-pituitary-adrenal axis, which is activated in painful conditions (Molony and Kent, 1997). Cortisol measurement has been used in animals to estimate the effects of different painful procedures such as abdominal surgery (Pearson and Mellor, 1975), electro-immobilisation (Jephcott et al., 1986, 1987) and castration (Mellor and Murray, 1989). Samples of blood are usually collected from the jugular vein and for estimation of cortisol levels by radioimmunoassay (RIA) (Shutt et al., 1988; Mellor and Murray, 1989; Graham et al., 1997).

Plasma cortisol levels in groups of animals undergoing painful stimulation are compared with control groups of animals which are without pain and just handled. Weary et al. (2006) noted that measurements of physiological parameters often require the restraint of animals and tissue sampling, which can be stressful and may influence the results. Despite these caveats, the assessment of plasma cortisol levels remains a well-proven and common method for pain evaluation, which include plasma determination of concentration of adrenocorticotropin hormone, glucose and lactate (Prunier et al., 2005; Mormede et al., 2007; Keita et al., 2010). Prunier et al. (2005) used lactate measurements to reveal the metabolic processes taking place during pain. Catecholamines are produced in response to stressful events (including pain), and this result in an increase in glycogenolysis and mobilisation of glycogen, predominantly from muscle tissue, and as a consequence an increase in lactate and glucose production. In addition to cortisol parameters, Shutt et al. (1988) and Mears and Brown (1997) used changes in plasma immunoreactive beta-endorphin as an indicator of pain by means of RIA. Attempts have also been made to connect pain (caused by castration of male pigs) with fluctuations in the levels of tumour necrosis factor alpha, interleukin-1beta, C-reactive protein, serum amyloid A and haptoglobin in blood; however, no changes in the levels of these substances were revealed (Moya et al., 2008).

Conclusion

Pain control and management is an important welfare concern even in routine management procedures of livestock. Adequate knowledge and understanding of its mechanisms and physiologic responses in animals may serve as an aid to its efficient management and consequently, increased livestock production.

Conflict of Interests

The author(s) have not declared any conflict of interest.

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Species composition, prevalence and seasonal variations of ixodid cattle ticks in and around Haramaya town, Ethiopia

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A cross-sectional study was conducted from September 2009 to March 2010 in and around Haramaya town to determine the species composition, prevalence and seasonal variation of ixodid cattle ticks. During the study period, a total of 3117 adult ixodid cattle ticks were collected from the half body regions of 346 local breeds of cattle which were under extensive management system during early dry and early wet periods and then identified to genera and species level. Six tick species of four genera were identified in which two species each belongs to the genus *Amblyomma* and *Rhipicephalus* and one species each belong to the genus *Hyalomma* and *Boophilus*. Of the total tick collected, *Amblyomma*, *Boophilus, Rhipicephalus* and *Hyalomma* constitutes (65, 26.3, 10.9 and 7.8%), respectively. The prevalence of tick species were *Amblyomma varigatum* (41%) *Boophilus decoloratus* (26.3%), *Amblyomma coherence* (14.9%), *Hyalomma rufipes* (7.8%) and *Rhipicephalus evertsi* (5.5%) and *Rhipicephalus pulchellus* (5.4%). The present study reveals that *A. varigatum* was the most abundant cattle tick species in and around Haramaya town and while the *R. pulchelus*is the least abundant. There was no statistical significance difference (P> 0.05) in tick infestation between sex of cattle's but tick infestation was significantly (P< 0.05) higher in adult age groups of cattle compared to caves. The favorable predilection sites of *Amblyomma* species were ano-vulva, udder/scrotum, but *B. decoloratus* preferred dewlap, perineum and udder/scrotum. The sex ratio of all tick species identified during this study period was skewed towards male except for *B. decoloratus*. The present study on tick species composition and seasonal variability contributes its part on how to design control strategies for ticks and tick borne diseases in the study area.

Key words: Ixodid cattle tick, seasonal variation, tick species composition, prevalence, Haramaya.

INTRODUCTION

In Ethiopia, agriculture is the dominant sector of the economy and accounts for over 50% of the gross domestic product (GDP), 35% of the export revenue, and provides livelihood for over 80% of its inhabitants. At present, four-fifths of the Ethiopian population is engaged in agriculture as small holder farmers who are responsible for 95% of the total agricultural output livestock provides about 35% of agricultural products (Mengistu, 1997).

Ethiopia is one of the countries with the largest number

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of livestock in Africa and livestock production plays a major role in the overall development of Ethiopian's agriculture. Nevertheless, cattle productivity is low (Alekaw, 2000). Factors contributing for this may include the improper management, diseases, nutritional deficiencies, harsh environment and genetic factors.

In Ethiopia, approximately 44.3 million cattle, 46.9 million small ruminants and more than one million camels contributes to the economic welfare of the people by providing hide, power, and traction for agricultural purpose and fertilizer for increasing the productivity of smallholding (Minjauw and Mcleod, 2003).

Ixodid ticks are one of the most common and harmful blood sucking ectoparasite of cattle worldwide. They are responsible for a wide range of livestock health problems in several countries of the world. They reduce cattle productivity, milk yield and skin and hide quality and increase susceptibility to other disease (Tsegaye et al., 2013). Approximately, 80% of cattle populations of the world are at risk of tick infestation and tick born diseases. In addition to sucking large volume of blood, ticks inject pathogens such as viruses, bacteria, protozoa and toxins into their hosts (FAO, 2004).

In Ethiopia, among the major parasitic disease, ticks and tick-born disease rank third after trypanosomiasis and endoparasitism in causing economic losses. Bekele (2002) estimated an overall loss of US$ 500,000 from hide and skin down grading as a result of ticks, and approximately 65.5% of major defects of hides in Eastern Ethiopia are caused by ticks. De Castro (1997) estimated that the annual global cost associated with tick and tick-born diseases in cattle range between US$ 13.9 and US$18.7 billion.

In Ethiopia, ticks are common in all agro ecological zones of the country (Morel, 1980; Pegram et al., 1981). Therefore, relevant data on the population dynamics of ticks is essential for the development of effective tick and tick born disease control program.

Therefore, the current study was undertaken to assess the species composition, distribution and seasonal variation of ixodid ticks in and around Haramaya town.

MATERIALS AND METHODS

Study area description

Haramaya district is situated in Eastern Harerge zone, located in Oromia regional state of Ethiopia. The district has 521.64 km^2 or 52164 ha, and it is situated at longitude of 41°E to 50°E and latitude 9°N to 32°N. The altitude ranges from 1600 up to 2100 m.a.s.l. The mean annual temperature and relative humidity are 18°C and 65%, respectively.

The area receives an annual rain fall of 800 mm with a bimodal distribution pattern. There are four seasons: a short rainy season (from mid-March to mid-May), a long wet season from beginning of July to end of October), a long dry season (from late October to beginning of March), and a short dry season (from end of May to end of June).

Haramaya district is grouped into arid and semi-arid climatic zone where 66.66% is Weina Dega and 33.33% is Kola. The vegetation type that constitutes the available pasture lands in this areas predominantly native grasses and legumes interspersed with open acacia a shrub land (HDARDO, 2002).

Study population

According to the Haramaya Wereda Rural Development and Agricultural Bureau, Wereda has 63,723 cattle, 13,612 sheep, 20,350 goats, 15,978 donkeys, 536 camels and 42,035 poultry. During the study period (September 2009 to March 2010) adult ixodid ticks were collected from 346 cattle consisting of 156 male and 190 female animals. All the animals were local breeds which are owned by different producers. The animals were managed under extensive production system.

Study design

Cross-sectional study

Cross-sectional study was conducted for species composition, seasonal variation and infestation of ticks. Using random sampling, 173 cattle were selected for each season and subjected to standard tick collection and identification techniques. During the study period ticks were collected from different body parts of cattle such as head, brisket, belly, dewlap, back, udder or scrotum leg, ano-genital and tail.

Sampling and sample size determination method

The sample size was calculated according to Thrusfield (1995) by taking 87.1% of expected prevalence and 5% accepted error at 95% confidence interval.

The general formula is:

$$n = \frac{1.96^2\, p_{exp}(1-p_{exp})}{d^2}$$

where n = required sample size, p_{exp} = expected prevalence, d = desired absolute precision.

Accordingly, the estimated sample size was 173 for early dry season and 173 for early wet season. A total of 346 cattle were sampled during the study period (from September 2009 up to March 2010).

Study methodology

Tick collection technique

Removal of feeding ticks from the animals was carried out for about seven months (November 2009 to March 2010). During sampling, each animal was either restricted in a crash, casted or laid down, and then tick collection was done. All visible attached adults' ticks were collected from different predilection sites (anal ano-vulval scrotum, udder, dewlap, chest, belly, flanks tail, back) of each animal. Adult ticks are collected from half body region of cattle at clinic; field of grazing, vaccine place, and watering place during early dry period and early wet period into the universal bottle that containing 70% of ethanol. Ticks were collected from the left body of cattle for collection using good quality forceps and using two fingers.

Table 1. Tick species identified and their percentage of distribution during early dry and early wet periods.

Tick species	Season		Sex		Total	Distribution (%)
	Dry	Wet	Male	Female		
Amblyomma varigatum	235	1017	785	467	1252	40.1
Boophilus decoloratus	163	657	212	445	820	26.3
Amblyomma coherence	148	315	301	162	463	14.9
Hyalomma rufipes	79	163	157	85	242	7.8
Rhipicephalus evertsi	60	112	115	57	172	5.5
Rhipicephalus pulchulles	74	94	98	70	168	5.4
Total	759	2,358	1,831	1,286	3,117	100

Table 2. Sex ratio of adult tick species of each period and the overall ratio of the early dry and wet periods (male:female).

Tick species	Season		Overall
	Dry	Wet	
Amblyomma varigatum	1:1.94	1.6:1	1:0.8
Boophilus decoloratus	0.4:1	0.5:1	0.45:1
Amblyomma coherence	1.9:1	1.8:1	1.8:1
Hyalomma rufipes	2.6:1	1.6:1	2.1:1
Rhipicephalus evertsi	1.8:1	2:1	1.9:1
Rhipicephalus pulchulles	1.5:1	1.3:1	1.4:1

Tick identification

Ticks were counted, identified and recorded by species, sex and instars. All ticks counted were kept in pre-labeled universal bottles containing 70% of ethanol until identification was done according to Walker et al. (2003) and Keiser (1987). Then identification of cattle tick species was made using petri-dishes, stereomicroscope by their morphological characteristics.

Data management and analysis

Samples were labeled on the basis of species, age, sex, breed and origin of the sampled animals and then transported to Veterinary Parasitology Laboratory (Haramaya University College of Veterinary Medicine). SPSS 16.0 computer software programme was used to analyze the data.

RESULTS

Tick species identified

During the study period, a total of 3117 adult ixodid ticks were collected from a half body regions of 346 cattle that were sampled from in and around Haramaya town during the early dry and early wet season. From the collected ticks were 1831males and 1286 females (Table 1). As a whole in the study areas four adult ixodid tick genera and six species were identified in early dry period, and similar number of genera and species of adult ixodid ticks were identified during early wet season except variation in number. During the two seasons, the genera of ticks identified were *Amblyomma* (65%), *Boophilus* (26.3%), *Rhipicephalus* (10.9%) and *Hyalomma* (7.8%), whereas the percentage of species identified was *Amblyomma varigatum* (41.1%), *Boophilus decoloratus* (26.3%), *Amblyomma coherence* (14.9%), *Hyalomma rufipes* (7.8%), *Rhipicephalus evertsi* (5.5%) and *Rhipicephalus pulchulles* (5.4%) (Table 1).

Sex ratio of ticks

During the study period in the study area, the numbers of male ticks were higher than the number of females in *Amblyoma, Hyalomma* and *Rhipicephalus* genera of ticks, but in case of *Boophilus* the numbers of females were higher than the number of males (Table 2).

Attachment sites of ticks on cattle

During the study, each species of ticks were collected from various body regions of cattle. But attachment site preference was stronger in some species than the others. The observed proportion of attachment sites for each species of the ticks during this study was summarized as depicted in Table 3.

Table 3. Favorable attachment sites of tick species.

Species of tick	Site of attachment
Amblyomma species	Brisket, udder and scrotum, dewlap
Boophilus decoloratus	Dewlap, belly/back
Hyalomma rufipes	Scrotum/Udder, brisket
Rhipicephalus species	Tail, anogenital and head/ear

Table 4. Infestation status of ticks on sex of cattle.

Sex	Animals examined	No. positive	OR	P-value	Lower 95% CI	Prevalence (%)	Upper 95% CI
Male	156	135	2.5	0.001	1.42	86.5	4.35
Female	190	158	Ref*			83.2	
Total	346	293		0.000	0.804	84.7	0.883

OR: Odds ratio; Ref*: reference; CI: confidence interval.

Infestation status of ticks on sex of cattle

Using univariate logistic regression to determine the infestation of ticks on the sex of cattle, the result revealed that there is no statistical significance difference between the sex of animals involved in the study and the infestation status is summarized as depicted in Table 4.

Infestation status of ticks on age

Using age as a predictor variable on infestation status of ticks in cattle, the present study revealed that animals with an age group of greater than four (>4years) has high tick infestation status (Odds ratio of 0.96) compared with animals with 2 to 4 years of age. In other words as the age of cattle increased, tick infestation is also increased (Table 5).

Infestation status of ticks on season

Different peaks of prevalence were recorded during the early dry period (78.0%) and 91.3% during the early wet period. Result of the study indicated that high infestation rate was recorded during wet period than dry period in the study area. Results of the present study indicated that cattle are highly infested with ticks in wet period than dry period as depicted in Table 6.

DISCUSSION

In and around Haramaya town all collected ticks were identified and categorized into four genera, namely, *Amblyomma, Boophilus, Hyalomma,* and *Rhipicephalus*, and also six species of these genera were recorded. During both periods (early dry and early wet) similar genera and species were recorded in the study area. The reason of finding similar tick species during both periods was due to short period of study. The species of ticks identified were *A. varigatum, B. decoloratus*, *A. coherence*, *H. rufipes, R. evertsi* and *R. pulchellus* by decreasing order, respectively.

In this study, a total of 3117 adult ticks were collected from half-body regions of cattle in and around Haramaya town. The study indicated that the proportion and frequency of occurrence varied significantly over the season. In the study period, *H. rufipes, R. eversti* and *R. pulchellus* are recorded only in very small numbers, respectively.

Among the total collection, *A. varigatum* were found to be the most abundant species of all ticks in the area (40.1%). This finding is in agreement with the previous work of Solomon et al. (1998) at Sebeta and Abernosa, respectively who recorded the highest counts of *A. varigatum* in July and April during the rainy month of the area. The adults of *A. varigatum* are usually found on their host during the rainy season (Keiser, 1988; Husen, 2009). The reason why this tick species found in a very high number was probably due to the geographic location of the area and also due to its being relatively active throughout the year. Likewise, several researches, which had been conducted in different parts of Ethiopia, indicated that *A. varigatum* is the most abundant tick species with the highest prevalence. Similar to the present study, Mesele (1989) found higher prevalence of 59 and 75.91% in and around Bahirdar, respectively.

A. variegatum is the most widely distributed cattle tick in Ethiopia (Morel, 1980; Pegram et al., 1981) and has a great economic importance, because it is an efficient vector of C*owderia ruminantum.* This parasite also causes the greatest damage to the hide and skin, because of its long mouth parts which render the commodity value less

Table 5. Infestation status of ticks based on age group of cattle.

Age	Animal examined	Number positive	Odds ratio	95% CI	P-value	Prevalence (%)
<2 years	79	57	0.48	0.23 - 1.01	0.056	72.2
2-4 years	94	79	Ref*			84.2
>4 years	173	143	0.96	0.48 - 1.91	0.91	90.8

Table 6. Prevalence of infested animals with different species of ticks in two seasons.

Season	Animals examined	Number positive	Prevalence (%)	P-value
Dry	173	135	78	0.000
Wet	173	158	91.3	0.001
Total	346	293	84.7	0.001

on world market if the ticks are large in number (Solomon et al., 2001). Furthermore, more ulcers caused by this tick species become favorable sites for secondary bacterial infection like *Dermatophilus congolensis* (Kaufnann, 1989).

B. decolloratus is the second abundant tick species (26.3%). It has been reported also as prevalent in many other parts of the country such as Riftivally (Pegram et al., 1981; Solomon and Kaaya, 1996) and in highland areas of Harer and Dire dawa district (Mannueri and Tilahun, 1991). This present finding is in agreement with tick species surveys (Gebremichael, 1993; Naser, 1985; Dessie and Getachew, 2006) in Wolaita. Similar result was also reported by Solomon et al. (2001) with similar altitude in-dicating the abundance of *B. decoloratus* in Sebeta town.

According to Bekele (2002), relative abundance of *B. decoloratus* increases from lowland towards highland. The present study disagrees with the finding of Alekaw (1998) at Metekel Ranch, Ethiopia showing a prevalence of 5.7% which may be due to the difference in geographical location and altitude factor. This tick species is abundant in wet highlands and sub highlands receiving more than 800 mm rainfall annually (Pegram et al., 1981). The regional distribution of *B. decoloratus* is similar to *A. varigatum* (Feseha, 1983). In this study, female *Boophilus* species were higher in number than males. This may be due to the fact that substantial proportion of females may be engorged in few days and fall on the ground in short period of time as compared to males. Therefore, this study was in agreement with the finding of Mekonnen et al. (2001) who also suggested that engorged females may be removed by self-grooming of the host, because of the large size. Other researchers like, Bellete (1987) and Mohammed (1977) also suggested lower number of *Boophilus* species in their study compared to that of female. This condition is due to the small sized of males of *B. decoloratus* makes difficult to see and get missed during collection.

A. Coherence is the third abundant tick species (14.9%) in this present study. The prevalence of this finding was similar to other reports from South Western Ethiopia, MizanTeferi (Seid, 2004) and from Jimma (Yitbarek, 2004).

H. marginatum rufipes was identified as the fourth abundant tick species collected in and around Haramaya town. This tick species was collected from restricted area of the warm, moderately dry midlands with an altitude of 1800 to 1950 m.a.s.l. (Morel, 1980). Hogestral (1956) indicated that *H. Marginatum rufipes* is widely distributed in the most arid part of the tropical part of Africa which receives 250 to 650 mm annual rain fall and in Ethiopia it was most often collected between 1000 and 2000 m.a.s.l and rare in western high land areas. Therefore, the finding of Hogstral (1956) was in agreement with the present study. The studies of Mohammed (1985) in Wolayita Awraja and Seyoum (2001) in North Wollo zone kobo Girana valley and Solomon (1996) at Abernosa ranch are in agreement with the present finding.

R. evertsi being one of the least recorded tick species in the study area constituting 5.5% of the total adult tick collection. In contrast to this study, the geographical distribution survey of ticks conducted in Gonder Awraja by Eshetu (1988) found that *R. eversti* was the most common abundant tick species of the area. This may be due to geographical location, seasonal variation of the area or may be due to variation in macroclimatic factors (Singh et al., 2000) including higher rain fall associated with high soil moisture content which are favorable for the survival of tick vectors.

R. pulchulles was the least abundant tick species in the study area which is 5.4% in the distribution rate. This finding is in line with Solomon et al. (1998) who recorded small count. *R. pulchellus* (the zebra tick) prefers to feed on cattle, but it also infests other domestic animals (Walker et al., 2003). It was mainly collected in Eastern Tigray, Southern SNNP, Afar, Harar, Somalia and Dire Dawa, but few collections were reported from Gambella.

The result of the present study agrees with the previous study of Surafel (1996) who reported *R. pulchulles* is as the least abundant tick species.

The present study indicates that ticks select favorable site for their attachments on the body of cattle, which is in line with the study of Fanos et al. (2012) in South Western Ethiopia and Howell et al. (1978) in South Africa who reported similar favorable site of ticks to attach themselves onto the cattle's body. The present result also revealed that the infestation of the ticks were not variable in terms of sex of the cattle, that is, male and female cattle were equally infested with ticks. There is no statistical significant difference ($p>0.05$) between the two sexes which implies sex has no impact on the infestation rate. Both male and female animals are equally susceptible and ticks did not prefer sexes since their target is feeding of blood for their survival.

The present study also revealed that tick count was higher in the wet season than the dry season which agrees with Solomon et al. (2001) who reported that ticks were found on cattle throughout the study period, although higher loads of ticks were observed during rainy than dry period. Bekele (2002) also reported the highest total tick count during wet period than the dry period.

There is statistically significant difference ($p<0.05$) in infestation rate among different age groups of cattle. The adults are more susceptible than calves due to the fact that the calves are not often driven with adult age groups into grazing and watering points. This practice naturally reduces the chance of exposure of calves to ticks.

The result of the present study revealed that the prevalence is getting decreased as compared to the previous studies probably due to an increase in the level of awareness of the farmers on how to reduce the tick infestation of their cattle, improvement in the management of their animals and increment of veterinarians per district. In addition to this, the climatic variation is also another factor which may contributes to decrease the prevalence of the tick infestation in the study area.

CONCLUSION AND RECOMENDATIONS

Of all ectoparasites, ticks cause the greatest economic loss in livestock production either by transmitting a wide variety of tick born diseases or by direct coursing to hides and skins. Therefore, this study on species composition and seasonal variation of tick infestation is considered primary as an aid in improving tick control in the study areas. Additionally, the study indicated that the most important and abundant species of tick infestation identified were *A. varigatum* and *B. decolloratus.* This may be due to conducive environmental factors prevailing in the areas. Therefore, the following recommendations are forwarded so as to benefit the livestock owners by overcoming the problems arising from tick infestation.

1. Strategic application of acaricides especially at the beginning of the wet months might minimize the infestation of ticks.
2. The effect of dominant tick species on the productivity of cattle and determination of the minimum load that affect productivity are warranted.
3. Encourage commonly to practice safe and economical traditional control methods as part of integrated tick management.
4. Tick should be managed at an economical acceptable level by a combination of techniques and this requires familiarity with the tick species present and an understanding of their epidemiology.

Conflict of Interests

The author(s) have not declared any conflict of interest.

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Full Length Research Paper

Evaluation of biosecurity measures on broiler farms in Khartoum, Sudan

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This study was designed to evaluate the present biosecurity measures in broiler farms in Khartoum and to compare between the biosecurity practices followed in closed system and open system farms. The primary information that included numbers of broiler poultry in each farms, locations in the state and type of farms were obtained from Ministry of Agriculture and Animal Resources, Khartoum. Multi-stage cluster sampling method was used; collection of information was done at different levels (sites, farms and persons). A total of 45 broiler farms (13 closed and 32 open systems) were chosen from Khartoum, Khartoum North and Omdurman. Data were collected by using structured questionnaire. The respondents were farm owners, farm managers, veterinarians and workers. The results showed that the closed system had a higher level of biosecurity than the open system. 100% of the closed system practiced all in all out system when compared with 81.3% of the open system farms. The open system farms had less secure boundaries; 28.1% of the farms did not have fence when compared with 100% of the closed system farms. Only 2.2% of the farms had washing by disinfectants at the gates. The distance among the pens in each farm which was more than 100 m was 33.3%. Among the 45 farms, 87.5% disinfected the equipment before each production cycle. It was found that 88.9% of the farms collected dead chickens once daily. The results, also, showed that 57% of the farms did not use disinfectants in their foot dips of each pen and 84.4% had no warning signs for entrance of unauthorized people. Among these farms, 17.8% had control plan for vermin, 68.9% of the farms isolated the sick birds, and 26.7% were found to keep different species of birds other than poultry and 15.5% used to treat drinking water for poultry. It is concluded that the majority of the farms in were far from application of biosecurity measures.

Key words: Biosecurity, measures, broiler farms, Khartoum, Sudan.

INTRODUCTION

Biosecurity is the implementation of measures that reduce the risk of introduction and spread of disease agents. Biosecurity requires the adoption of a set of attitudes and behaviors by people to reduce risk in all activities involving domestic, captive exotic and wild birds and their products. Farm's performance is directly linked to good biosecurity measures. Poultry farms can be categorized into four farms according to classification

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system stated by the FAO (2004). Sectors 3 and 4 have lower levels of biosecurity than farms belonging to sectors 1 and 2. Therefore, poultry farms in sectors 3 and 4 have a higher potential risk for acquiring and transmitting diseases, including Highly Pathogenic Avian Influenza (HPAI). Biosecurity practices were designed to minimize the transmission of infectious diseases between and within farms.

The principal elements of biosecurity are segregation, cleaning and disinfection. Biosecurity practices cover a broad range of measures. These have been divided into three categories (Shane, 1997): conceptual, including the choice of location of farms; structural, covering the physical facilities to protect against entry of wild birds; operational, covering the work procedures that farm staff and visitors adopt.

Poultry health management is the emerging issue along with bio-security measure. Livestock and birds are within the major causes of zoonotic diseases transmission chain. Food from livestock sources need to be free from disease causing agents to safe guard public health (Sharma, 2010). In spite of the importance of biosecurity and contact structures in disease transmission, there is little information available in the literature on the biosecurity status of poultry farms (Nespeca et al., 1997).

Due to the expanding poultry production in the Sudan and scarcity of information about the biosecurity practice on poultry farms, it is considered necessary to carry out the proposed research work. Therefore, the aim of the study was to evaluate the present measures of biosecurity on broiler farms in Khartoum and make comparison between closed system and open system biosecurity practices.

MATERIALS AND METHODS

Study area

The study was conducted in Khartoum because it has the largest poultry population in the country. Khartoum is the capital of Sudan, composed of seven localities and estimated population of approximately 7,152,102. It extended between latitudes 15.08 and 16.45 North and longitudes 31.36 and 34,25 East. The state has an area of 22,122 km^2 and shares borders with Northern, River Nile, White Nile, Gazira, North Kordofan, Gedaref and Kassala. The study area covered the following locality of Khartoum: Khartoum, Khartoum North and Omdurman.

Data collection

The primary information and numbers of broiler poultry farms were obtained from Ministry of Agriculture and Animal Resources, Khartoum.

Data were collected from commercial broiler farms from the different localities in Khartoum by using the Global Positioning System (GPS). For each location, the numbers of farms were determined. A total of 45 broiler farms were selected. 13 farms were visited, in Khartoum including 10 open system and 3 close system; 17 farms were visited in Khartoum North including 12 open system and 5 close system; and 15 farms in Omdurman including 10 open system and 5 farms close system.

Methodology

A cross sectional survey was carried out from May 27th until June14th, 2012. Data were collected by means of a questionnaire; respondents were farm owners, farm managers and veterinarians. The questionnaire was administered during face-to-face interview and contained the required data about biosecurity measures, farm design, farm management, poultry health as well as staff knowledge of biosecurity. Questions for biosecurity were grouped into the three components of biosecurity as defined by FAO (2004) which were traffic control, sanitation and isolation. A total of the bioseurity measures were calculated and expressed as frequencies and percentage.

Data analysis

Data were analyzed by Descriptive Statistical Analysis

RESULTS

Results showed that only 20% farms were far from the main road and 24.5% have distances less than 500 m to the nearest farms (Table 1). Results from the survey showed that open system tends to have less secure boundary than that of the close system. Only 2.2% farms had water washing in their gate, 22.2% farms did not have a fence and 93.3% farms did not have warning signs in front of the farms and sheds. Only 3 (6.7%) farms had warning signs for visitors and provide them with protective clothing and boots (Table 2). The results showed that the distance between houses more than 100 m in 15 (33.3%) farms and in 3 3(73.3%) farms the pest control was done as a routine (Table 3). The results showed that closed system has a high level of biosecurity than the open system, 84.6% was using disinfectants in the foot bath in the front shed entrance and both systems do not share equipment between farms, 84.6% of the production personnel did wear protective clothing in the close system when compared with 9.4% in the open system and only 5 (11.1%) collected the dead birds twice daily, also open system does not have a barking area (Table 4).

Traffic onto the farm is an important factor that may enhance the disease risk. Traffic refers to the number of visitors and workers that move into and out of the farm. The result showed that closed system has a high level of biosecurity than open system 92.3% as compared to 56.3%. Only 5 (11.1%) farms provide visitors with clean clothing and boots if they entered the farm. The least number of biosecurity measures which present on the farms were related to traffic control. A total of 31 (68.9%) of the farms separated sick birds from healthy birds. The highest number of biosecurity measures which present on the farms was related to isolation (Table 5). A total of

Table 1. Location selected bird's farms and distance of farm to the nearest farms.

Item	Frequency	Percentage	Closed (%)	Open (%)
location of farm				
Near main road	36	80	61.5	87.5
Far from main road	9	20	38.5	12.5
Distance to nearest farm				
Less than 500 m	11	24.5	15.4	28.1
More than 500 m	34	75.5	84.6	71.9

Table 2. Level of biosecurity at farm gate.

Item	Frequency	Percentage	Closed (%)	Open (%)
Presence of fence				
Yes	35	77.8	100	71.9
No	10	22.2	0	28.1
Presence of parking area				
Yes	6	13.3	46.2	0
No	39	86.7	3.8	100
Water washing in gate				
Yes	1	2.2	7.7	0
No	44	97.8	92.3	100
Warning signs				
Yes	7	15.6	53.8	0
No	38	84.4	46.2	100
Provide visitors with protective clothing and boots				
Yes	3	6.7	23.1	0
No	42	93.35	76.9	100

39 (86.7%) farms practiced all in all out system and 33 (73.3%) of the farms controlled access of wild birds, rodents or insects into poultry sheds or had strict measures to keep other poultry and domestic animals away from their flock. The result showed that 15.5% from surveyed farms implemented water sanitation system (Table 6).

The results showed different sources of origin of chicken. Most obtained commercial farms 80% (Table 7). All of the farms in close system had appropriate vaccination program when compared with 4 (8.9) farms that had no vaccination program in the open system. In 16 (35.6%) of the respondent farms, the feed was manufactured within the farm itself. A total of 24 (53.3%) of the surveyed farms had veterinarian supervision and only 17.8% of respondent farms had training program to the farm staff on biosecurity practice (Table 8).

Among the target population in the study, 73.3% had no slaughter house in their farms. In 29 (64.4%) from surveyed farms, the workers had no certificate declaration (Table 9). None of the farms had hatchery in the open system in target population, in contrast the closed system (38.5%) had hatcheries.

DISCUSSION

The present study has been conducted in Khartoum state targeting the following area Khartoum, Khartoum North, and Omdurman in the Sudan and was intended to examine biosecurity practice on broiler farms in close and open system. Global Positioning System (GPS) technology was used to determine location of farms and the distance between farms. The results showed that majority of the farms 35 (77.8) had a secure boundary fence that is able to stop people and animals entering the farm, most of the farms 39 (86%) practiced all in all out system and 19 (42.2%) farms used disinfectants in foot

Table 3. Level of biosecurity between the farm gate and the shed.

Item	Frequency	Percentage	Closed	Open
Distance between houses				
Less than 100 m	30	66.7	53.8	71.9
More than 100 m	15	33.3	46.2	28.1
Pest control				
As routine	33	73.3	92.3	56.6
After out break	12	26.7	7.7	43.4
Litter and manure disposal				
Burning	9	20	23.1	18.8
Use as fertilizer	5	11.1	7.7	12.5
Accumulate at back yard	7	15.6	7.7	9.3
Sale	24	53.3	61.5	59.4
Structure of farm design				
Well	29	64.4	100	50
Not well	16	35.6	0	50

Table 4. Level of biosecurity at the shed.

Item	Frequency	Percentage	Closed	Open
Using of disinfectants in foot path				
Have no foot path	26	57.8	15.4	75
Yes	19	42.2	84.6	25
Use water	0	0	0	0
Decontamination of equipments				
As routine	41	91.1	100	87.5
After out break	4	8.9	0	12.5
Equipments share				
Yes	0	0	0	0
No	45	100	100	100
Collection of dead birds				
Once daily	40	88.9	76.9	93.8
Twice daily	5	11.1	23.1	6.2
Dead bird disposal method				
Burning	43	95.5	100	93.8
Left thrown away	2	4.5	0	6.2
Production personnel wearing protective clothing				
Yes	14	31.1	84.6	9.4
No	31	68.9	15.4	90.6

path; this results were in agreement with Etih et al. (2010) who reported similar observation. According to Stephen (2012), there was no set distance that will uniformly eliminate the risk of disease transfer. During this study, it

Table 5. Biosecurity measures related to isolation.

Item	Frequency	Percentage	Closed (%)	Open (%)
Isolation of diseased birds				
Yes	31	68.9	92.33	59.4
No	14	31.1	7.7	40.6
Have different species				
Yes	12	26.7	7.7	71.9
No	32	73.3	92.3	28.1
Presence of quarantine area				
Yes	7	15.6	46.2	3.1
No	38	84.4	53.8	96.9

Table 6. Water sanitation and water system cleaning.

Item	Frequency	Percentage	Closed (%)	Open (%)
Cleaning of water system after				
Two weeks	33	73.3	76.9	71.9
Three weeks	12	26.7	23.1	28.1
Source of water treating				
Yes	7	15.5	53.8	0
No	38	84.5	46.2	100

Table 7. Chicken origin.

Item	Frequency	Percentage	Closed (%)	Open (%)
The origin of chicks				
Commercial farms	36	80	61.5	100
Hatcheries within farms	5	11.1	38.5	0
Imported	4	8.9	8.9	0
Disease affected your farm				
IB	0	100	100	100
ND	0	100	100	100
Both	0	100	100	100
None	0	100	100	100

was found that the distance to the nearest farm was more than 500 m and found to be about 75.5% of the respondents of the surveyed farms.

Among the survey in two types of production systems, the results showed that the close system was more secure than the open system, this indicated that management regarding biosecurity is more than open system, also larger facilities are often assumed to implement more advanced biosecurity measures (FAO, 2003). The survey results indicated that majority of the open system lacked the appropriate biosecurity practices such as boundary barriers, water sanitation, restrict visitors, the use of disinfectants in the footbaths, health record keeping and dead bird's disposal in a hygienic way; our results was in agreement with the findings reported by FAO (2003). FAO (2003) categorize that the open system farms have no appropriate biosecurity practices. This study when investigation proved the aforementioned parameters in the surveyed farms which followed an open system.

Table 8. Veterinarian supervision and training of staff on biosecurity and record keeping.

Item	Frequency	Percentage	Closed (%)	Open (%)
Veterinarian Supervision				
Yes	24	53.3	92.3	37.5
No	21	46.7	7.7	62.5
Record keeping				
Yes	30	66.7	100	53.1
No	15	33.3	0	46.9
Training of staff on biosecurity				
Yes	8	17.8	38.5	0
No	37	82.2	61.5	100

Table 9. Presence of slaughter house and drainage.

Item	Frequency	Percentage	Closed (%)	Open (%)
Have slaughter house				
Yes	12	26.7	61.5	0
No	33	73.3	38.5	100
Slaughter house well drained				
yes	10	22.2	61.5	0
No	45	77.8	38.5	100
Worker assigned certificate declaration				
Yes	16	35.6	76.9	18.8
No	29	64.4	23.1	81.2
Workers haves shower before handling poultry meat				
Yes	3	6.7	23.1	0
NO	42	93.3	76.9	100

It was found that about 22.2% from the respondent's water sanitizing system is implemented. Peter and Tim (2009) stated that all water derived from dams, streams, drains and open storage units used for internal shed fogging or drinking water for birds must be sanitized. Sanitation of water helps in minimizing transmitting diseases. Most of the farms (82.2%) did not have control plan of vermin; this practice does not agree with Waston et al. (2008) who found the use of disinfectant and insecticides to control pathogens and insects may harbour avian pathogens. They stated that vermin should be used as a routine for farm biosecurity programs. Only 17.8% of the respondent farms had staff training of about the bio-security practice. It is important for all people with poultry farms to receive training/briefing before starting to work with poultry so that they have general understanding about all aspects of the process and as it is their own task.

Workers who understand the purpose of a bio-security measure are more likely to adopt the practice as part of their daily routine. They are more likely to ensure that any visitors and service contractors act in accordance with the farm biosecurity practice. About 88.9% of the farms collected the mortality once daily. This was in agreement with Arzey and Littleton (2007) who reported that dead birds must be removed from the free range enterprise daily or twice daily if mortality is high. Dead birds must be in appropriate site either on or preferably off farm. In reference to isolation of sick birds, 68.9% of farmers separated sick birds from health birds and 95.5% of respondents used burring for disposable of dead birds and just two farms (4.4%) left dead birds thrown. Sudarnika et al. (2010) found that 24 farmers (96%) separated sick birds from healthy birds and burned or

buried them for disposable and just two farms (4.4%) left dead birds thrown away.

It was noticed that about 11.1% of the farmers reared different species in their farms; this practice is not in agreement with Cardona and Kuney (2002). They reported isolation of premises and species of poultry from sources of infection. This would include bioescurity practices by keeping different bird species separately, preventing exposure of birds to potential sources of disease, preventing introduction of new birds from live bird markets or neighbors into an old flock. A total of 91.1% of the respondents had a vaccination program according to FAO (2007) regulation. In an ideal situation, a vaccination regime is available for the layer and broiler flocks in each country and ever for the respective farms which plan a program depending upon the disease challenge in the country.

Conclusion

In general, the biosecurity measures level among broiler farms in Khartoum can be classified into low in the open system when compared with medium in close system and were far away from international standards especially in the open system. Majority of the farms in this survey were the open system; this could partly interprete their low biosecurity status which gently reflected the general biosecurity of the surveyed farms whether closed or open.

RECOMMENDATIONS

1. Comprehensive and well-designed study of the broiler farms should be carried out including the cost of biosecurity in broiler farms.
2. Overall, government policy needs to facilitate the improvement of biosecurity adoption among poultry farmers.
3. It is advised or recommended provision of an updated biosecurity training workshop for poultry growers and staff who work in poultry farms in order to cover and implement the program and to introduce new updated tools in the program.
4. To preserve records for as long as they are required, providing access to records is also recommended to locate farm composting areas, dead bird management facilities and litter storage areas away from boundaries and neighbors.
5. Hygiene must be improved, first by educating workers to adhere to personal hygiene and slaughter facilities, equipment and personnel garments should be cleaned and disinfected.
6. Standard protocols of bioseurity practice should be enhanced to reduced disease outbreaks.

Conflict of Interests

The author(s) have not declared any conflict of interest.

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Full Length Research Paper

Major causes and risk factors associated with calf mortality in dairy farms in Khartoum State, Sudan

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This study was conducted in dairy farms in Khartoum state in order to determine the major causes and risk factors associated with calves' mortality. The main results revealed that out of 2,310 animals a highest mortality rate was in Hilat kuku 2.16% (n = 50), followed by Alrudwan and Alseleit 1.73% (n = 24) and 1.04% (n = 40), respectively. Application of analytical statistic using one way analysis of variance (ANOVA) showed a significant difference between the mean of the three sites. The most dominant clinical signs in calves was pneumonia, with prevalence rate of 1.08% (n = 25), 1.08% (n = 25) and 0.079% (n = 18) in Alseleit, Hilat kuku and Alrudwan, respectively. In contrast, diarrhea was not observed in two sites. The difference was statistically significant (X^2 = 95.265, P-value = 0.00). Most of the respondents (owner) of the questionnaire survey had a primary level regarding education; Hilat kuku 29.3% (n = 22) and Alseleit 26.7% (n = 20). Further more, most of them had experience of more than 3 years in dairy farms; Hilat kuku 33.3% (n = 25) and 29.3% (n = 22) for the rest of the sites. Education level and experience were found to be statistically significant (X^2 = 8.067 and 3.261, P-value = 0.089 and 0.089, respectively). Some risk factors associated with calves' mortality rate with regard to management were observed in dairy farms in Khartoum state. For instance, a high significant level (X^2 = 17.910, P-value = 0.00) was obtained for feeding of the calves which mainly depended on milk; 33.3% (n = 25) for Alseleit and Hilat kuku and 22.7% (n = 17) for Alrudwan. Moreover, dealing with dead calves was also found to be highly significant (X^2 = 11.949, P-value = 0.003) and most of the respondents did nothing regarding this point; Alseleit 25.3% (n = 19) and Hilat kuku 14.7% (n = 11). In contrast, there no significant level (P > 0.05) was recorded for hygiene, quarantine and presence of veterinary services.

Key words: Risk factors, calves mortality, dairy farms, Sudan.

INTRODUCTION

Calf diseases that cause morbidity and mortality are the results of complex interaction of the management practices

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and environment, infectious agents and the calf itself (Wudu et al., 2008). Different managemental and environmental factors were reported to affect significantly, calf morbidity and mortality, these include: colostral feeding, housing, calving assistance, production system, herd size, season and hygiene of micro-environment (Shiferaw et al., 2002). The mode of passive transfer in neonates varies with the type of placentation and in the case of neonatal calves; it is based on an immediate postpartum ingestion of antibody rich colostrum (Tizard, 1995). The age of the calf is the most important factor affecting morbidity and mortality, approximately 75% of the mortality in dairy animals under one year of age occurs in the first month of their life (Heinrichs and Radostits, 2001).

Common causes of calf diseases and deaths were diarrhoea, pneumonia, joint problems, umbilical diseases, trauma, congenital abnormalities, nutritional deficiencies, dystocia and other infections (Svensson et al., 2003; Singla et al., 2013). Calf losses were significantly reduced by introducing new techniques of management including on-time colostrum feeding, housing, feeding and nutrition (Razzaque et al., 2009). In the present study, the situation of calf mortality in dairy farms at Khartoum State was investigated, with the objectives of describing the prevalence and cause of calf mortality, along with identifying the management risk factors associated with calf mortality.

MATERIALS AND METHODS

Study area

This study was carried out during May to December, 2012 in Khartoum State dairy farms from Alrudwan, Alseleit and Hilat Kuku camps.

Alrudwan dairy camp

Alrudwan dairy camp, located in Western Omdurman, was established in 1993. The camp total area is 75 Fadden, with estimated total dairy units (Heyazat) of 430 Heyaza, including over 12,000 heads of dairy cows (average 27 cow/heyaza raised in an area of 700 to 1000 sq m). The housing system adopted at Alrudwan camp is variable, most of the dairy units (Heyazat) have shades above ground level of about 3 to 3.5 m, roofed by bamboo, with an extended yard in front of the shade. Each heyaza is provided by a feed manger either built of concrete or portable manger made of steel. Clean water is available all day in water troughs. Fifty percent of Alrudwan dairy farms house the young calves of different ages together, while only 5% keep calves separately (young suckling, weaned calves and heifers). Natural mating is the only way to access reproductive activity in Alrudwan farms. Vaccination against hemorrhagic septicemia (HS), black quarter (BQ), contagious bovine pleuropneumonia (CBPP) and anthrax is carried on annually by the governmental veterinary services. The area of study is characterized by high temperature (40 to 45°C) in summer during May to August and lacks shades and trees.

Alseleit dairy camp

The project was established in 2001. The majority of Alseleit dairy farms keep the young calves of different ages together in the same house. The camp is surrounded by trees, with a tree-planting, in the areas of internal roads, among the barns and veterinary service sites.

Hilat Kuku dairy camp

The Kuku project was started in 1960, which was considered to be the largest milk producing and marketing area in Khartoum State and also regarded as a semi-intensive system (small holders) of milk production. The farms previously belonged to Hillat Kuku dairy project, which consist of 3 barns distributed in vast space; each barn composed of small units containing a few number of cows to large, which may reach hundreds.

Questionnaire survey

Questionnaire survey and field observations were used in order to obtain information on major causes and risk factors associated with calf mortality in dairy farms in Khartoum state. Collected information was related to education and experience of the owner, herd structure and size, management and husbandry and veterinary services and bio-security in dairy farms.

Target population and respondents

The target population under investigation was calves with different age group and sex, while the target respondents were the owners of the dairy farms in different sites of Khartoum state.

Production system and sample size

The study was conducted either in intensive production system with large herd size or in semi-intensive production system. It was difficult to use epidemiological formula for calculation of sample size because there was no previous study in respect of calves' mortality. A total of 2,310 calves from 75 dairy farms in different sites of Khartoum state were investigated.

Sampling methods

It is difficult to give all dairy farms under production system in Khartoum state the same chance for being selected. Hence, selection was done according to willingness and support of the owners as described by Thrusfield (2007).

Data management and analysis

Data related to the major causes and risk factors regarding calves mortality were analyzed using International business machine Statistical package for social sciences (IBM SPSS) version 20. Descriptive statistic such as count and percentage was used for

Table 1. Description of the target population in dairy farms in Khartoum state.

Unit	Frequency (%)			X^2	df	P-value
	Alseleit	Kuku	Alrudwan			
Presence of other livestock						
Yes	11 (14.7)	7 (9.3)	6 (8.0)	81.711	6	0.000*
No	14 (18.7)	18 (24.0)	19 (25.3)			
Herd size						
Small (10-70)	13 (17.3)	0 (0.0)	0 (0.0)			
Medium(70-120)	9 (12.0)	1 (1.3)	4 (5.3)	130.745	9	0.000*
Large(>120)	3 (4.0)	24 (32.0)	21 (28.0)			
Bull exist						
Yes	3 (4.0)	0 (0.0)	0 (0.0)	94.149	15	0.000*
No	22 (29.3)	25 (33.3)	21 (28.0)			
Breed						
Local	2 (2.7)	0 (0.0)	5 (6.7)	5.987	2	0.05
Exotic	23 (30.7)	25 (33.3)	20 (26.7)			
Sex						
Male	15 (20.0)	12 (16.0)	15 (20.0)	80.026	6	0.000*
Female	10 (13.3)	13 (17.3)	10 (13.3)			

* = Highly significant (P > 0.001)

different variables and presented as tables and figures, while analytical statistical using one way ANOVA was used for comparison of means of calves' mortality rate between three sites. Chi- square was also used for getting significant level between variable for the same purpose. However, it was difficult to estimate or quantify the risk because the odds ratio can be calculated only for 2 × 2 tables.

RESULTS

This study was conducted in dairy farms in Khartoum state in order to determine the major causes and risk factors associated with calves' mortality. The main results out of 2,310 calves investigated revealed that a high mortality rate in Hilat kuku 2.16% (n=50) was recorded, followed by Alrudwan and Alseleit 1.73% (n=24) and 1.04% (n = 40), respectively. Application of analytical statistic using one way ANOVA showed a significant difference between the mean of the three sites (F=29.214, P-value= 0.000). The results are presented in Figure 1.

Sex was found to be statistically significant (X^2 = 27.245, P-value = 0.00) with regard to mortality rate. The rest of the results are shown in Figure 2. The most dominant clinical signs in calves was pneumonia, with a prevalence rate of 1.08% (n = 25), 1.08% (n = 25) and 0.079% (n = 18) in Alseleit, Hilat kuku and Alrudwan, respectively. In contrast, diarrhea was not observed in two sites. The difference was statistically significant (X^2 = 95.265, P-value = 0.00) (Figure 3). Description of the target population is summarized in Table 1. For instance, the exotic breed is dominant in three sites, giving a percentage of 33.3% (n = 25), 30.7% (n = 23) and 26.7% (n = 20) in Hilat kuku, Alseleit and Alrudwan, respectively. The large herd size (>120) was found in Hilat kuku and Alrudwan 32.0% (n = 24) and 28.0% (n = 21), respectively. Moreover, the existence of bulls was only found in Alseleit 4.0% (n = 3).

Herd size and existence of bulls were statistically significant (X^2 = 130.745, 94.149, P-value = 0.00). Most of the respondents (owner) of the questionnaire survey had a primary level regarding education: Hilat kuku 29.3% (n = 22) and Alseleit 26.7% (n = 20). Furthermore, most of them had experience of more than 3 years in dairy farms: Hilat kuku 33.3% (n = 25) and 29.3% (n = 22) for the rest of the sites. Education level and experience were found to be statistically significant (X^2 = 8.067 and 3.261, P-value = 0.089 and 0.089, respectively). Both education level and experience are presented in Figures 4 and 5, respectively.

Table 2. Questionnaire survey respondents by the owners of the dairy farms in Khartoum state with regard to the effect of management on calves' mortality.

Unit	Frequency (%)			X^2	df	P-value
	Alseleit	Kuku	Alrudwan			
Quarantine new cows						
Yes	2 (2.7)	0 (0.0)	1 (1.3)	2.083	2	0.353
No	23 (30.7)	25 (33.3)	24 (32.0)			
Mineral salt blocks						
Yes	11 (14.7)	11 (14.7)	12 (16.0)	0.108	2	0.948
No	14 (18.7)	14 (18.7)	13 (17.3)			
Disinfection of umbilical cord						
Yes	11 (14.7)	11 (14.7)	12 (16.0)	0.108	2	0.948
No	14 (18.7)	14 (18.7)	13 (17.3)			
Mark new calves						
Yes	15 (20.0)	12 (16.0)	15 (20.0)	0.974	2	0.614
No	10 (13.3)	13 (17.3)	10 (13.3)			
Calves feeding						
Milk	25 (33.3)	25 (33.3)	17 (22.7)	17.910	2	0.000*
Milk replacer	0 (25.0)	0 (25.0)	10.7 (25.0)			
Weaning age						
Before 6 months	0 (0.0)	0 (0.0)	0 (0.0)	0.125	2	0.939
After 6 months	25 (33.3)	25 (33.3)	25 (33.3)			
Hygiene						
Yes	2 (2.7)	1 (1.3)	4 (5.3)	2.206	2	0.332
No	23 (30.7)	24 (32.0)	21 (28.0)			
Vet. Sup. In the farm						
Yes	13 (17.3)	7 (9.3)	9 (12.0)	3.148	2	0.207
No	12 (16.0)	18 (24.0)	16 (21.3)			
After calf dead						
Do nothing	19 (25.3)	11 (14.7)	7 (9.3)	11.949	2	0.003*
Burry	6 (8.0)	14 (18.7)	18 (24.0)			
Burn	0 (0.0)	0 (0.0)	0 (0.0)			

* = Highly significant (P>0.001).

Some risk factors associated with calves' mortality rate with regard to management were observed in dairy farms in Khartoum state. For instance, a high significant level (X^2= 17.910, P-value = 0.00) was obtained for feeding of the calves which mainly depended on milk: 33.3% (n = 25) for Alseleit and Hilat kuku and 22.7% (n = 17) for Alrudwan. Moreover, dealing with dead calves was also found to be highly significant (X^2 = 11.949, P-value = 0.003) and most of the respondants did nothing regarding this point: Alseleit 25.3% (n = 19) and Hilat kuku 14.7% (n = 11). In contrast, there was no significant level (P > 0.05) recorded for hygiene, quarantine and presence of veterinary services. All results regarding management in dairy farms are summarized in Table 2.

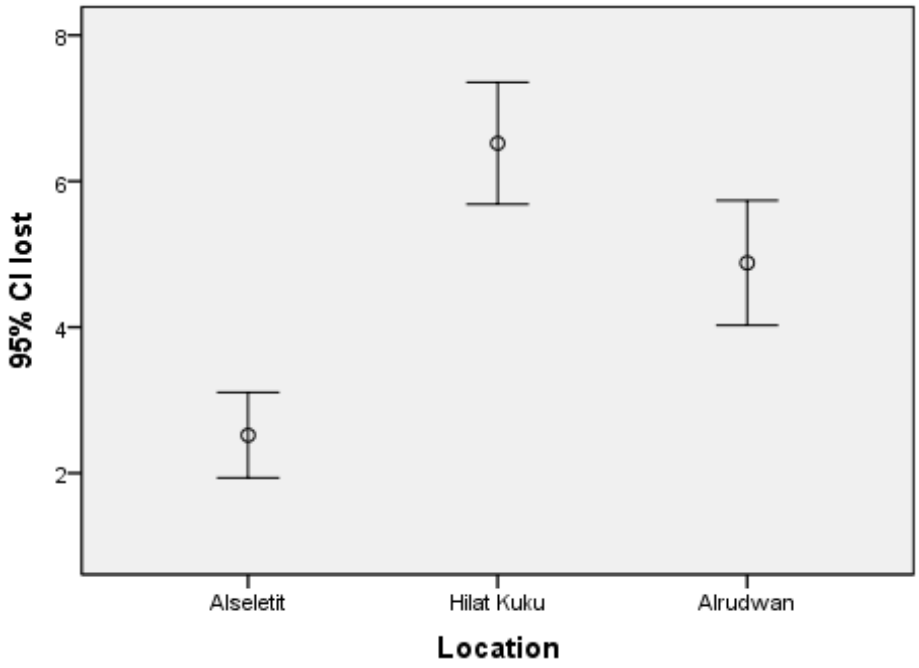

Figure 1. Comparison of means calf mortality rate in dairy farms of Khartoum state (F = 29.214, P- value = 0.000).

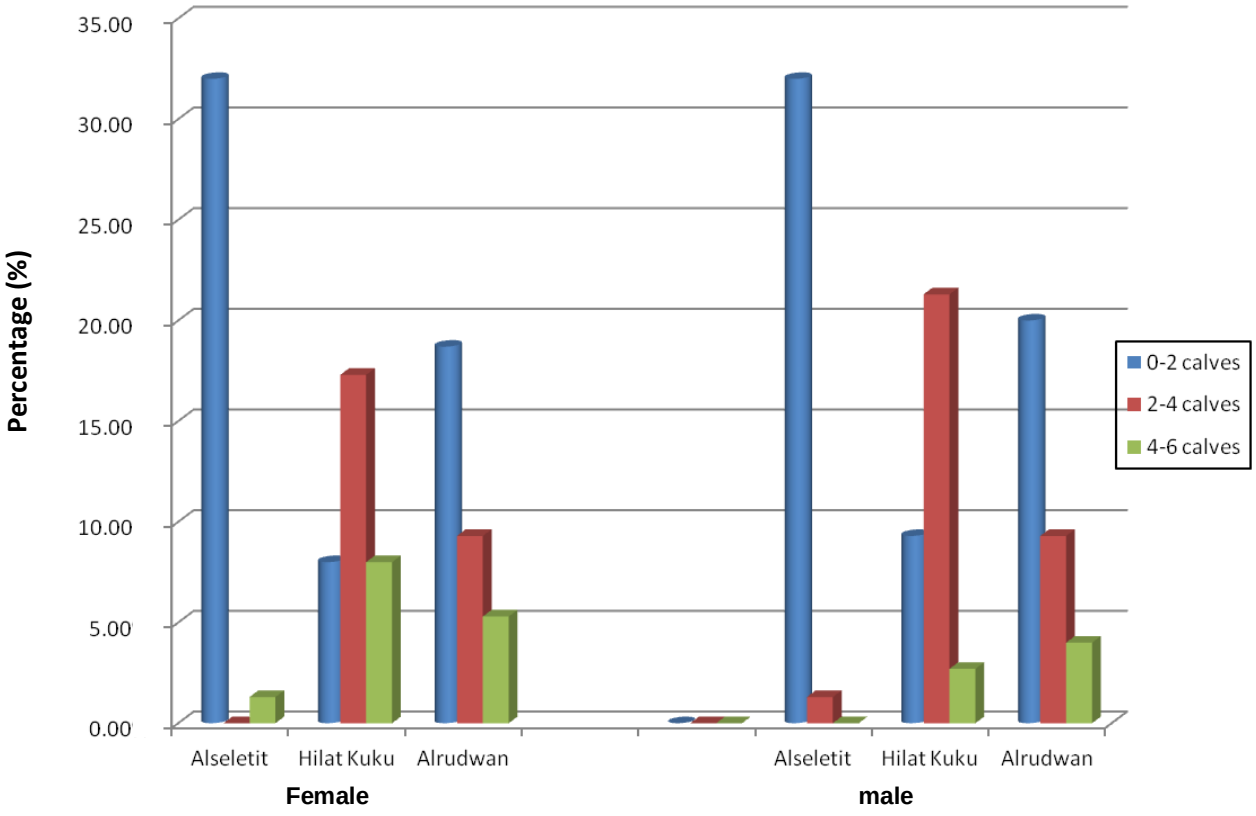

Figure 2. Calf mortality rate by sex in dairy farms in Khartoum state (X^2 =27.245, df = 4, P-value = 0.000).

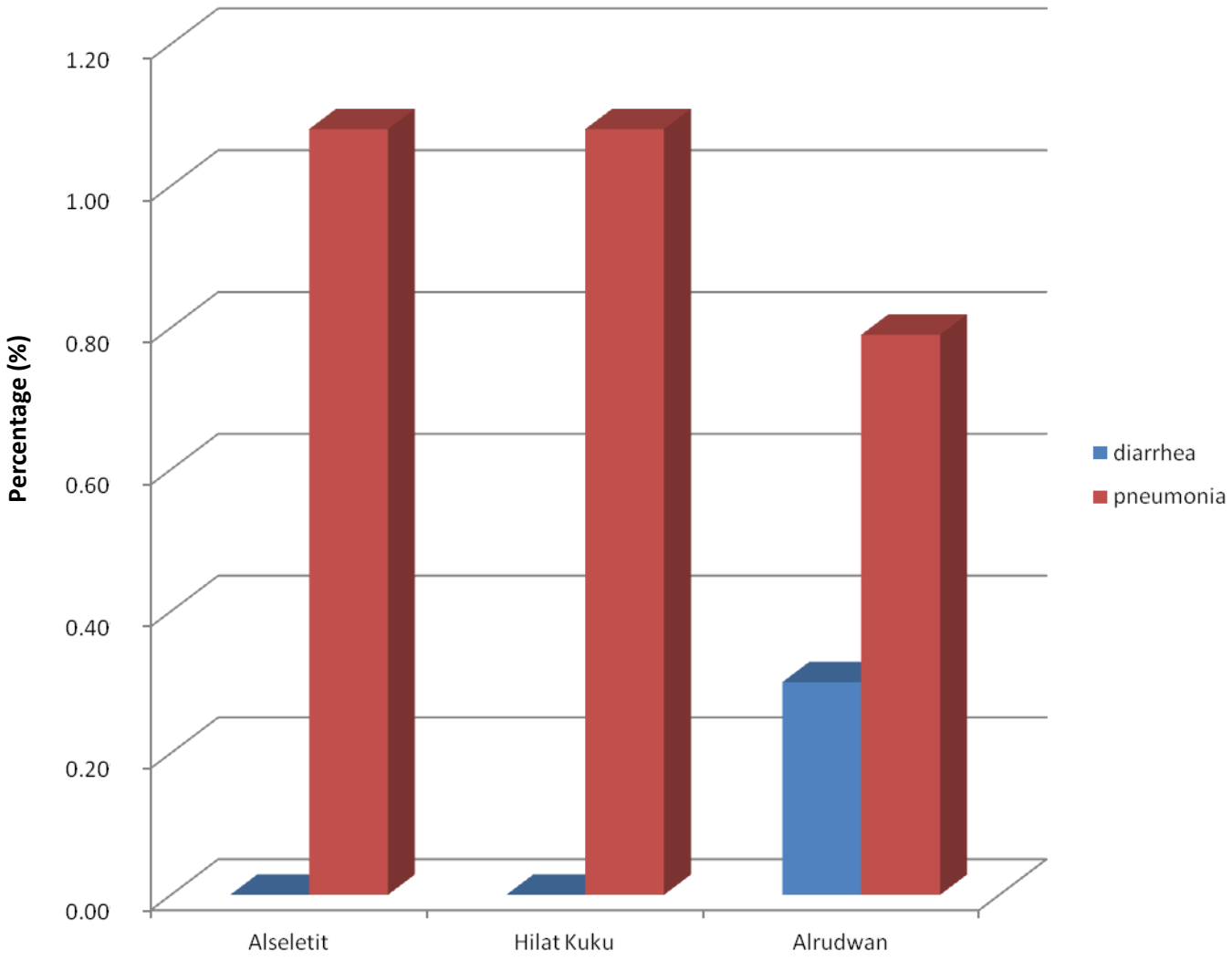

Figure 3. The most dominant clinical signs that associated with calves mortality in dairy farms in Khartoum state (X^2 = 95.265, df = 6, P-value = 0.000).

DISCUSSION

Education level and experience were found to be statistically significant. Similarly, low calf mortality was seen in herds owned by older and more experienced managers which were in accordance with Heinrichs and Radostits (2001). Sex was found to be statistically significant, which agreed with Debnath et al. (1995) who found lower mortality rate for females compared to males. The most dominant clinical signs in calves were pneumonia and diarrhea. These findings are in agreement with many studies which reported diarrhea and pneumonia as the first and second important diseases complexes affecting calf health (Olsson et al., 1993; Debanth et al., 1995; Bhat et al., 2012). Herd size was one of the risk factors significantly affecting the rate of mortality. This finding agreed with Nielsen et al. (2008) who found that mortality risk increased with herd size in Danish herds. The breed of calf showed no significant varriations in calf mortality rate. This could be because the majority of the farms studied included exotic breed (cross breed). In addition, the tropical environment for which temperate breeds are not well adapted might have been an additional stress to increase the risks of health problems.

The majority of farms investigated (69.3%) had no record, which supported El Zubeir and Mahala (2011) who reported that lack of records was among management factors that need correction. Mohamed (2011) found that only 36.33% of farms had poorly designed

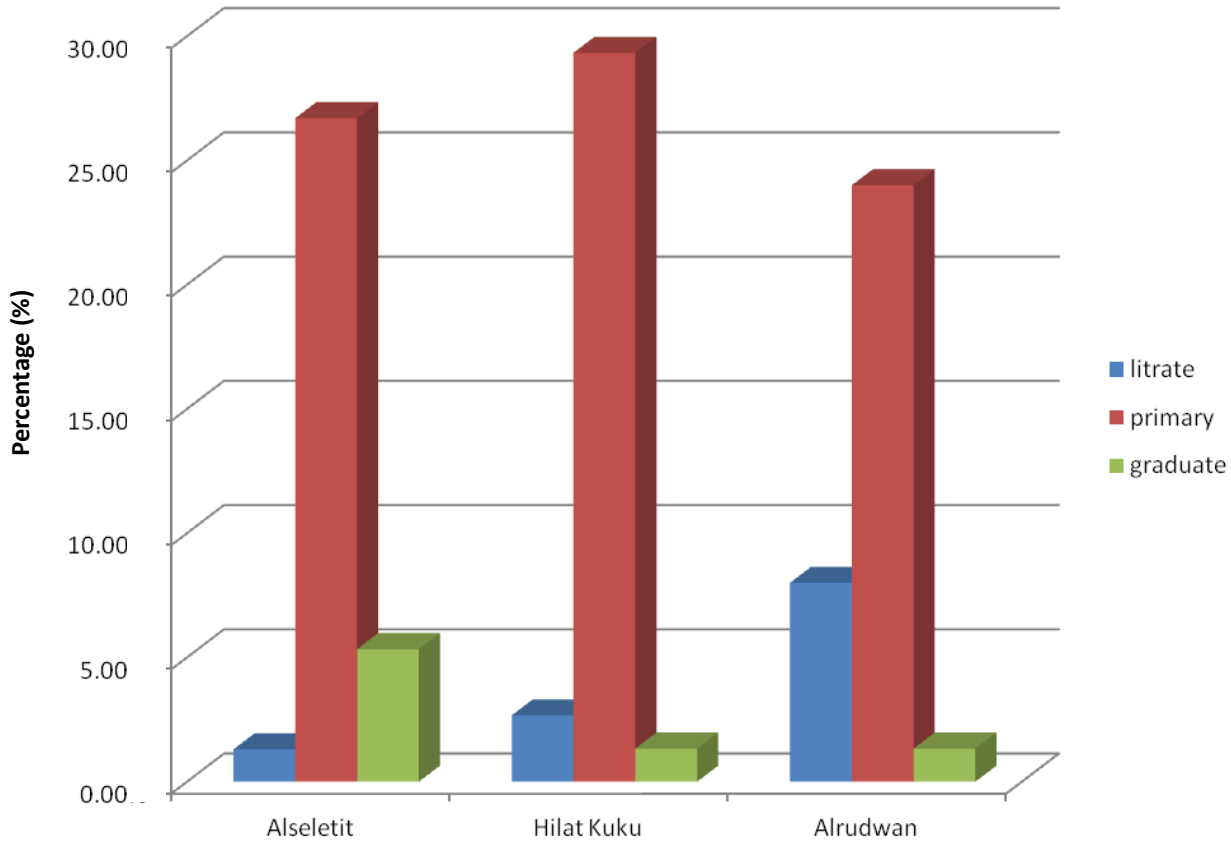

Figure 4. Education level of the respondents of the questionnaire in dairy farms in Khartoum state (X^2= 8.067, df = 4, P-value = 0.089)**.**

records.Bayemi et al. (2005) reported that one area needing much attention in dairy farms is record keeping and farmers need intensive training and follow up. Yousif and Fadl El Mula (2006) reported that farmers do not pay much attention to the importance of keeping records, thus the recording system is poor. The veterinary services did not contribute significantly to calf mortality rate. According to Karib (1962), dairy farms must be under supervision of veterinarians; however in this study 29% of the farms were under veterinary supervision, which agreed with El-Nazeir (2005) and El Zubeier and Mahala (2011) reported that most of the workers give the treatment without consultation of the veterinarians.

Most of the farms under investigation did not quarantine the newly introduced cows and 75% of the farms did not apply correct disposal of dead calves which might be risky for dairy farms and public health. The higher risk of mortality associated with dirtiness of calf house seen in this study agreed with Shiferaw et al. (2002) who reported the effect of hygiene of the micro-environment of calves in the occurrence of calf mortality. However, 61.4% of farms were found unclean. This agreed with El Zubeir and Ahmed (2007) who reported that the health services, preventive measures and disease control were not satisfactory. El Zubeir (2007) reported that general hygiene and sanitation measures such as dung removal, disinfection, cleaning program and maintaining minimal contamination during milking process could not be observed in the majority of dairy farms in Khartoum State.

The survey done in this study showed that calf mortality was high and a lot of malpractices in the investigated dairy farms in the three camps in Khartoum State influenced calf mortality. They include low level of veterinary supervision, lack of attention to the cleanliness of the calves houses and ignorance to provide farm with salt blocks as source of minerals and trace elements.

RECOMMENDATIONS

1. Efforts should be made to increase calving supervision, improve management of newborn calves, and prevent respiratory diseases and diarrhea.

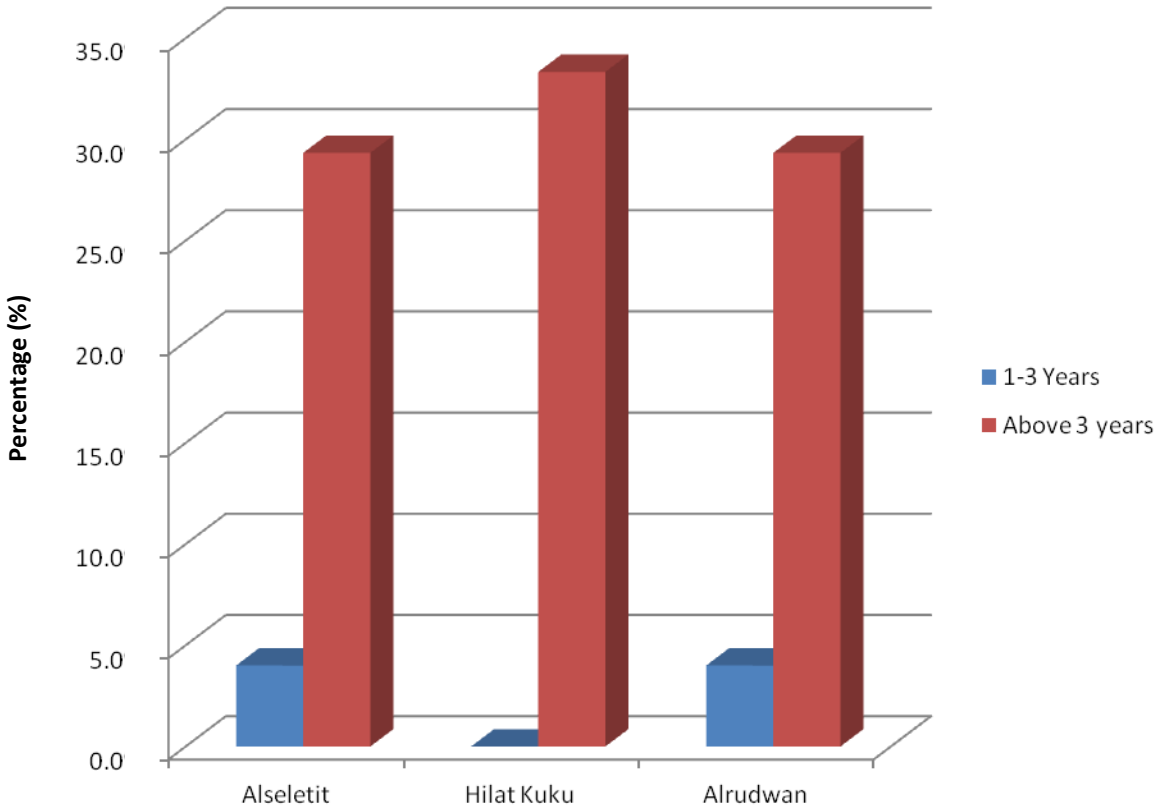

Figure 5. Experience of the respondents of the questionnaire survey in dairy farms in Khartoum state (F = 3.261, df = 2, P-value = 0.089).

2. Implementation of calves' vaccination programs is required to protect calf diarrhea caused by viruses.
3. Activating health laws aimed at reducing the spread of diseases through proper disposal of dead calves and employing of veterinarians at dairy farms.
4. Extension services among dairy farms owners and labors are urgently needed on proper dairy farm practices such as record keeping, sanitary practices and cleaning programs.
5. Research must focus on the causative agents of calf diarrhea and calf pneumonia in order to control and prevent losses due to these diseases.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Full Length Research Paper

Seroprevalence of foot and mouth disease (FMD) and associated economic impact on Central Ethiopian cattle feedlots

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The study was conducted in central part of Ethiopia in 2011 with the objectives to determine seroprevalence and associated economic impact on cattle feedlots. From the total of 38,187 bulls examined for foot and mouth disease (FMD) antibody, 5,536 (14.5%) was found positive and subsequently rejected from international market. The seropositivity of FMD varied from site to site and the variations were statistically significant (χ^2 = 3.28, df = 9, p < 0.001). Similarly, there was statistically significant (χ^2 = 4.55, df = 9, p < 0.001) difference between months of the year. The total annual (2011) economic loss due to bulls rejection from international market was estimated to be 3,322,269 USD which is equivalent to 56,345,682.24 ETB (1 USD = 16.96 ETB). This study indicates that FMD resulted in bulls' rejection from international market which affect livelihood of actors in the value chain and have a major threat to national economies as they tend to affect the international trade. Therefore, directing surveillance and controlling activities at pastoral production system where FMD risk arise and appropriate intervention measures along the market chain are critical factors necessary to prevent the introduction and spread into feedlots.

Key words: Cattle, Central Ethiopia, feedlots, foot and mouth disease, sero prevalence.

INTRODUCTION

Foot and mouth disease (FMD) is one of the most important transboundary animal diseases that cause severe economic losses due to high morbidity and export trade restrictions imposed on affected countries. The etiology, foot and mouth disease virus (FMDv), has seven recognized serotypes (O, A, C, Asia 1, SAT 1, SAT 2 and SAT 3), with distinct immunologic properties. They also differ in distribution across the globe (FAO, 2002; 2007). Five of the seven serotypes of FMDv (O, A, C, SAT 2, SAT 1) are endemic in Ethiopia (Rufael et al., 2008; FAO, 2007; Ayelet et al., 2009; Negusssie et al., 2010). Studies undertaken on FMD so far revealed the existence of the disease in different parts of the country, with prevalence that vary from 8.18% in south Omo (Molla et al., 2010) to 44.2% in different parts of the country(Negusssie et al., 2010) and posing a major threat to cattle in many parts

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of the country, thereby causing considerable economic losses through morbidity, mortality and trade restriction.

Majority of bulls used for fattening are originated from Borena pastoral system where FMD epidemics have been reported (Rufael et al., 2008; Bayissa et al., 2011; Mekonen et al., 2011). Borena cattle population has 55.2 to 58.6% herds which have at least one FMD infected cattle (Rufael et al., 2008; Bayissa et al., 2011).

Currently, in Ethiopia there is no government strategy in FMD control through vaccination and movement control (Bayissa and Bereda, 2009). Lack of vaccination strategies (quality, coverage and timing) and free animal movement without certification are thus the main factors that could increase the spread of FMD along the cattle market chain. Furthermore, lack of awareness of the intermediary cattle dealers regarding the risk and the relatively short distance between production and feedlot locations makes the feedlots particularly vulnerable to the introduction of the disease without diagnosis.

Direct effects of FMD on livestock productivity include reduced feed intake, changes in digestion and metabolism, increased morbidity and mortality and decreased rates of weight gain. Indirect losses are those related to the significant costs of FMD control and management and poor access to international markets. Indirect losses are often less visible than the obvious effects of clinical disease but may be equal or more important in their overall economic impact (FAO, 2002). Hence, the introduction of FMD into feedlots can lead to failure of the business and significant disruption of live cattle trade in international markets.

Therefore, if Ethiopia wishes to access the lucrative markets of the developed world for her livestock and livestock products, control of FMD will need to be addressed more aggressively and effectively. For this reason, strategies to reduce the constraints that FMD pose to commercialization and export need to be found urgently. Information and research works regarding its prevalence and associated economic impact in cattle feedlots are a prerequisite for the development of differential policies for prevention and eventual control of epidemics. Therefore, the objectives of this study were to determine seroprevalence and associated economic impact on Central Ethiopian cattle feedlots.

MATERIALS AND METHODS

Study area

The study was conducted in East Shewa Zone located in the central parts of Ethiopia. Absolute location of the Zone extends from 7° 33' 50"N to 9° 08' 56"N and 38° 24' 10"E to 40° 05' 34"E which indicate that this zone is located in tropical climatic zone; though the climate is influenced by altitudinal variation. The total area of East Shewa Zone is approximately 9,633.52 km^2. The altitude ranges from 500 to 4307 meter above mean sea level. The zone can be categorized under rift system of Ethiopia since about 93% of the total area of the zone is completely located in rift system. The zone comprises 32 districts of which 67% are mid altitudes and 33% are lowlands. The mean annual temperature varies between 18 and 30°C and its mean annual rainfall is 410 to 820 mm. Natural vegetations grown in area are grouped under the Acacia wood land and savannah vegetation.

Study animals, source of information and sampling technique

As part of sanitary and phytosanitary (SPS) requirements and rules and regulations of animal quarantine, it is a requirement that all animals being exported to Arabian countries are tested for FMD; hence, all bulls being exported were considered for sam-pling. Therefore, serum samples collected for one year (2011) from apparently healthy 38,187 bulls for certification purpose were used. All animals used for study were male with 3 to 5 years age category and vaccinated for FMD. Survey was performed in 31 feedlots found in central Ethiopia.

Questionnaire survey

A survey was performed on 31 feedlots found in central Ethiopia. Identified feedlots owner/manager were interviewed with semi-structured questionnaire and responses regarding facility design, source of cattle, buying system, diseases preparedness, veteri-nary service, handling of sick cattle, treatment and vaccination system, sanitation, disposal of carcasses were collected in database questionnaire.

Serum samples collection and processing

Serum samples (n = 38,187) collected over one year (2011) period for certification purpose from bulls were used for seroprevalence determination. Blood samples were aseptically collected using 10 ml plain vacutainer tubes from apparently healthy bulls through jugular venipuncure. The tubes were then labeled with tag number of animals and kept protected from direct sunlight in slant position until the blood clotted and sera were separated. The clotted blood or separated sera were transported to National Veterinary Institute laboratory (Debre Zeit) and National Animal Health Diagnostic and Investigation Centre (Sebeta) for investigation. Serum samples were examined for antibodies to 3ABC non structural proteins of FMD virus using a commercially-available enzyme-linked immunosorbent assay (ELISA) test for identifying infected animals from non infected ones.

Economical loss estimation

Economic loss caused by FMD was calculated based on rejection rate of bulls from international markets. Parameters used for economic estimation were the annual (2011) serum tested for FMD, average weight of the bulls, average market prices in terminal market for export and the rejection rates of bulls due to FMD. The annual economical losses due to FMD were calculated thus:

$$C = N \times M \times Rr$$

Where: C = annual economical losses estimated due to rejection of bulls from international market, N = total number of bulls at risk of FMD in East Showa Zone in 2011, M = average terminal market price, Rr = rejection rate.

Data management and analysis

Data were classified, filtered and coded using MS Excel, and

Table 1. Seroprevalence of FMD in relation to site of feedlot operations.

Site	No of tested	No of positive	Seropositive (%)	95% CI
Dera	2090	745	35.6	33.6-37.7
Modjo	484	16	3.3	1.7-4.9
Migra	12180	1468	12.1	11.5-12.6
Wanji	2136	77	3.6	2.8-4.4
Koshe	6399	888	13.9	13.0-14.7
Meki	3544	1327	37.4	35.8-39.0
Awash Melkasa	2417	518	21.4	19.8-23.1
Awash Sebat	4338	335	7.7	6.9-8.5
Nahmaled	3469	106	3.1	2.5-3.6
Adami Tulu	1130	56	5.0	3.7-6.2
Total	38187	5536	14.5	14.1-14.9

χ^2=3.28, df= 9, p=0.000.

were transferred to statistical package for social sciences software version 16. Descriptive statistics was performed to summarize seroprevalence and χ^2 test was used to assess risk factors. In all the analyses, confidence level was held at 95% and P ≤ 0.05 was set for statistical significance.

RESULTS

Questionnaire survey

The study revealed that 25 (80.6%) of feedlots operators (n = 31) use Borena markets as the main source bulls and 6 (19.4%) feedlots operators used Dera and Adama markets for purchasing bulls for their feedlots. However, none of these operators have any idea about previous health status of purchased bulls. All feedlots operators do not use veterinarian to perform pre-purchase inspection and selection of bulls in the market; however, pre-purchase inspections and selection have been conducted by feedlots operators or purchaser groups which involves a visual and physical evaluation of animal while moving freely in the market. In all studied feedlot, the purchased animals were not subjected to any tests before they were moved into feedlots. Only small proportion of feedlots operators [4 (12.9 %)] have trend of buying animals as single whereas majority [27 (87%)] of them have a tendency of buying stocks in a batch. The average time spent on transportation from Borena production areas to feedlots in Central Ethiopia was 1.65 days. In 93.5% assessed feedlots, carcasses are not disposed properly and the scavengers and insects have easy accesses. In all surveyed feedlots, staffs do not use any protective clothing while handling bulls and also do not take any sanitary and disinfection precautions to avoid contamination.

Seroprevalence of FMD

From the total of 38,187 bulls examined for the presence of antibodies to the 3ABC non-structural protein of FMD virus, 5,536 (14.5%) were found positive. The seropositivity of FMD varied from site to site and the variations were statistically significant (χ^2 = 3.28, df = 9, p < 0.001). The highest seropositivity was recorded in Meki (37.4%) and the lowest was recorded in Nahmaled site (3.1%) (Table 1). Similarly, there was statistically significant (χ^2 = 4.55, df = 9, p < 0.001) difference of seroprevalence between months of the year, with highest seropositivity on July (36.3%) and lowest was recorded on April (3.8%) (Figure 1).

Economic loss estimation from FMD

Economic loss caused by FMD was calculated based on FMD rejection rate from international market. According to FMD serology result, 14.5% of bulls in the feedlots were found positive for FMD and subsequently rejected from international markets. During study period, an average of 375 kg bull was sold with 600 USD (1.60 USD/kg) average price at terminal markets for export. Therefore, the total economic loss due to FMD rejection from international market was estimated to be 3,322,269 USD which is equivalent to 56,345,682.24 ETB (1 USD = 16.96 ETB).

DISCUSSION

Using Borena markets as main source of cattle for fattening was the same as reported by Farmer (Farmer, 2010). This might be due to the fact that feedlot owners show a strong preference for Borena cattle due to its large size, efficient feed conversion and superior meat quality (Legese et al., 2008). However, Borena pastoral area is one of the areas in which FMD epidemics have

been reported (Rufael et al., 2008; Bayissa et al., 2011; Mekonen et al., 2011). Moreover, these animals move

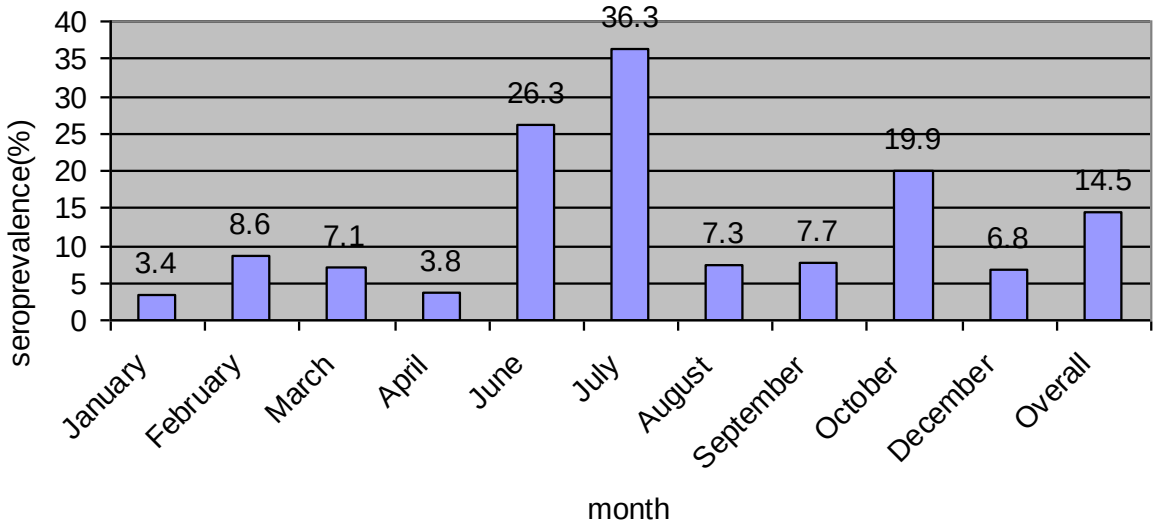

Figure 1. Monthly seroprevalence of FMD in cattle feedlots in Central Ethiopia in 2011.

from production areas to the feedlots without certifications and any test. In this study, we found almost nonexistence of common biosecurity practice in cattle feedlots found in Central Ethiopia, since export of live cattle and meat from Ethiopia are largely feedlot based. Maintaining high standards of biosecurity is one way of making sure that Ethiopian produce remains sought-after in an increasingly competitive market place. How-ever, an accidental animal disease outbreak in feedlots could cause large economic damages with significant international market and trade disruptions. This highlights the need for better understanding of factors reinforcing feedlots operators' decisions regarding implementation of biosecurity practices.

The overall seroprevalence of 14.5% reported for FMD in this study is indicative of its importance in feedlots business. The individual animal seroprevalence result obtained in this study was in close agreement with the previous findings from Andassa dairy farm (Mazengia et al., 2010) and Jijiga zone (Mohamoud et al., 2011) in which seropositivity of 14.6 and 14.05% were reported, respectively. On the other hand, the prevalence reported in this study is a higher value than previous reports of 8.18% (Molla et al., 2010) and 9.5% (Megersa et al., 2009) in South Ethiopia. The seropositivity finding of this study is lower than a record of 21% in the Borana pastoral area (Rufael et al., 2008) and 26.5% in the country (Sahle, 2004). The lower prevalence of FMD in the feedlots than in Borena pastoral system might be due to the fact that bulls were purchased based on their good body condition and health. Thus, the probability of chronically ill animals with poor body condition entering the feedlots is therefore low.

There was significant difference found between sites of feedlots operations with FMD prevalence of 37.4 and 3.1% at Meki and Nahmaled sites, respectively. This variation might be due to the difference of biosecurity measures of the feedlots used. Similarly, there was statistically significant (χ^2 = 4.55, df = 9, $p < 0.001$) difference between months of the year with highest seropositivity on July (36.3%) and lowest was recorded on April (3.8%). The relative low seroprevalence in April might be due to the fact that FMDV transmission over considerable distance by aerosol is less effective in hot and dry condition of the tropics (Hutber and Kitching, 2000). Therefore, the reported higher prevalence of FMD during cold and rainy month of July could be attributed to virus stability under such conditions (Klein et al., 2008).

The total economic loss due to FMD rejection from international market was estimated to be 3.3 million USD. The total estimated economic losses caused by FMD in this study were 14.5% of the total income of the business owners from finished bulls. This loss estimated for individual business owner might be more than estimated since each feedlot operator incurred additional costs associated with treatment of sick bulls and maintenance of the rejected animals. Hence, the introduction of FMD into feedlots has measurable livelihood impact on downstream actors in the market chain and significant disruption of live cattle and their product trade in international markets. Movement restrictions and local quarantines mean the closure of livestock markets and reduced or no opportunities for sale of live animals (Rossiter and Hammadi, 2009). Therefore, smallholders and poor pastoral producers may be severely affected if markets are closed due to this disease (Rich and Perry, 2011).

The present study indicates that FMD was prevalent in the cattle feedlots and resulted in bulls mortality and morbidity which affected livelihood of actors in the value

chain and have major threat to national economies as they tend to affect the international trade. Therefore,

directing surveillance and controlling activities at pastoral production area where FMDV risk arise and appropriate intervention measures along the market chain are critical factors necessary to prevent the introduction of FMDV and spread into feedlots. Further, as a novel diagnostic technique to monitor the spread of infection in large areas, there is a need of point of control diagnostics for developing nations (Liu et al., 2011; Cui et al., 2013; Li et al., 2014). Wadhwa et al. (2012a) described a bead based microfluidic assay for mycobacterial infections. Similar techniques should be developed for FMD. Active surveillance should be carried out based on samples which are less invasive and labor intensive (Wadhwa et al., 2012b; Wadhwa et al., 2012c). Molecular epidemiological, phylogenetic analysis and mathematical modeling should be carried out at the time of new outbreaks to understand the origin, efficacy of current vaccines and design control strategies (Kumar et al., 2013; Massaro et al., 2013).

Conflict of Interests

The author(s) have not declared any conflict of interests.

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