بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Prevalence and Risk Factors of Equine Strongylosis in Khartoum State - Sudan

الانتشار وعوامل الخطر لمرض الاسترونجلوسس في الفصيلة الخيلية بولاية الخرطوم – السودان

A Thesis Submitted to the College of Graduate Studies in partial fulfillment of the Requirements for the Degree of Master in Preventive Medicine (M.P.V.M)

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بسم الله الرحمن الرحيم

قال تعال

(والخيل والبغال والحمير لتركبوها وزينة ويخلق مالاتعلمون)

صدق الله العظيم

سورة النحل الاية (٨)

DEDICATION

To the soul of my lovely father

To my mother

To my wife

To my daughter

To my brothers and sisters

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First of all, thanks to Allah to Whom would be ascribed all perfection and majesty.

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Abstract:

Across-sectional study was carried out from November 2016 to January 2017 to determine the prevalence of *Strongylus species* in donkeys and horses in the Khartoum state . Fresh faecal samples were obtained from 384 animals randomly selected horses (n=227) and donkeys (n=107). Coprological examination for the detection of *Strongyle* eggs was performed using the floatation technique. The overall prevalence of *Strongyle* infection in both species of animals was 30.5% (117/384). In the two separate species; the infection rates were 15.5% (43/277) in horses and 69.2% (74/107) in donkeys.The infection rates of *Strongylus* were 64.7% and 28.9% in young and adult animals respectively. The infection rate in male animals was 25.7% and in female it was 57.9%, 29.1% in good condition animals and 43.2% in emaciated one. The infection rate in indoor housed animals was 25.0% and 28.8% in outdoor animals, 16.0% in animals kept in good hygiene and 49.7% in those kept in bad hygiene. According to the pattern of feeding, the infection rate was 24.3% in in-grazing animals and 70.6% in out-grazing animals, while it was 21.5% in animals not previously infected and 68.5% in previously infected animals. In racing horses the rate of infection was 0.00%, 19.5% in loading animals, and 69.2% in working animals. In those animals where deworming is practiced the infection rate was 0.00% while it is 49.1% in those where anuthelmintics are not used. The highest prevalence of infection was in Omdurman(48.1%), Bhari(32.0%), and Khartoum city(10.4%). There was significant association between all the potential risk factor and the infection rate at the univirate analysis($p < 0.25$), while there were no significant difference at the multivirate analysis ($p < 0.05$).

Strongylosis is an important Disease in these areas causing health problem in equine.

ملخص البحث

أجريت دراسة مقطعيه في الفترة ما بين نوفمبر 2016 إلى يناير 2017 لتحديد معدل الانتشار لأنواع سترونجيلوس في الحمير والخيول في ولاية الخرطوم. تم الحصول على عينات البراز الطازجة من 384 حيوان تم اختيارها عشوائيا الخيول(ن = 227) والحمير (ن = 107). تم إجراء فحص البراز للكشف عن بيض سترونجيل باستخدام تقنية التفو. وبلغت النسبة الكلية لعدوى سترونجيل في كلا النوعين من الحيوانات 30.5٪ (384/117). في نوعين منفصلين وكانت معدلات الإصابة 15.5٪ (277/43) في الخيول و 69.2٪ (107/74) في الحمير. وكانت معدلات الإصابة ستونجيلوس 64.7٪ و 28.9٪ في الحيوانات الصغيرة والكبار على التوالي. وبلغت نسبة الإصابة في الحيوانات الذكور 25.7٪ وفي الإناث كانت 57.9٪ و 29.1٪ في حالة الحيوانات الجيدة و 43.2٪ في حالة الحيوانات الهزيلة. وكان معدل الإصابة في الحيوانات الساكنة في الأماكن المغلقة 25.0٪ و 28.8٪ في الحيوانات الساكنة في المراعى المفتوحة، و 16.0٪ في الحيوانات التي حافظت في اماكن جيدة النظافة و 49.7٪ في تلك التي حافظت في اماكن سيئة النظافة . وفقا لنمط التغذية، كان معدل الإصابة 24.3٪ في الحيوانات التغذية الداخلى و 70.6٪ في حيوانات التغذية خارجى، بينما كان 21.5٪ في الحيوانات التي لم يصاب سابقا و 68.5٪ في الحيوانات المصابة سابقا. في حيوانات السباق كان معدل الإصابة 0.00٪ و 19.5٪ في حيوانات الحمل ، و 69.2٪ في الحيوانات العمل . في تلك الحيوانات التى يستخدم فيها مضاد الديدان كان معدل الإصابة 0.00٪ في حين أن 49.1٪ في تلك التي لم يتم استخدام مضاد الديدان. وكان أعلى معدل انتشار للعدوى في أم درمان (48.1٪) ثم بحرى (32.0٪)، ومدينة الخرطوم (10.4٪). كان هناك اختلاف معنوي بين جميع عوامل الخطر المحتملة ومعدل العدوى في تحليل الفردى تحت قيم معنوى(اقل من او تساوى 0.25) في حين لم يوجد اختلاف معنوية في التحليل المتعدد تحت قيم معنوى (اقل من او تساوى 0.05).ان مرض الاسترونجلوسس هو مرض مهم في هذه المناطق مما يسبب مشكلة صحية للفصيلة الخيلية.

Introduction

Equines are the hosts to a great number of gastrointestinal parasitc species, of which nematodes of the family strongylidae, commonly known as strongyle nematodes or strongyles, are the most important ones. These parasites are ubiquitous and with equine being continually exposed throughout their lives and live in the large intestine of equines.

Strongylidae are classified into two subfamilies, Strongylinae and Cyathostominae, sometimes categorized as large and small strongyles respectively. The main characteristic feature of strongyle nematodes is awell-developed buccal capsule, the shape and size of which are important for species identification. Research groups, mainly in Australia (Hung *et al.*, 2000) and the UK (McDonnell *et al.*, 2000), are currently working on establishing the phylogenetic relationships of the two subfamilies. By comparing DNA sequences it has been shown that the genera with small cylindrical buccal capsules are likely to have evolved from those with large buccal capsules (Hung *et al.*, 2000).

The first *Strongyle* nematode to be identified was the *Strongylus equines* which was describe by (Lichtenfels, 1975) and during the following century descriptions and naming of several *Strongyle* species were published. Since then the classification of these parasites has undergone some revision, partly due to the development of modern molecular based techniques. These techniques have opened the door for studies on the molecular relationships between species.

Strongylosis is the more common and economically destructive disease of horses. Clinically, infected horses exhibit signs of

unthriftinesis, anemia, colic and diarrhea (Urquhart *et al*., 1996). Young horses may carry thousands of parasites and experience severe clinical symptoms with certain mortality if not treated (Herd, 1990). The most commonly mixed species of Strongyle infections are found in horses (Boxell *et al*., 2004).

Among the gastro-intestinal nematodes of horses, large *Strongyle* infectionare most devastating and were reported with an infection rate of 58.5% (Saeed *et al*., 2010). Three Strongyle species were identified in the genus Strongylus which were S.vulgaris, S.equinus, S.edentatus.The three Strongylus species that infect horses are common through the world, particularly S.vulgaris, which is also recognized as the most pathogenic species of the large Strongylus. It is estimated that 45 to 90 percent of horses harbor *S. vulgaris* (McCraw and Slocombe, 1976). Their prevalence of infection is high, and a few equines are likely to escape out of this disease by the end of their first year of life (Duncan, 1985).Indifferent parts of the world studies have demonstrated a shift in the prevalence of various species of equines under treatment with different classes of anthelmintic (deworming drugs) (Gawor,1995) especially S.vulgaris where their prevalence had been decreased greatly in recent decades (Herd,1990).However the overall prevalence of Strongylus nematodes remained high in herds where anthelmintic have not been used. Intrinsic factors like age and sex are found to affect the prevalence of Strongyle infection and egg excretion (Bucknell et al., 2002).

Objectives;

The objectives of the study is

1- To estimate the prevalence of strongylosis in equine in Khartoum state.

2- To investigate the risk factors associated with the occurrence of strongylosis in equine.

CHAPTER ONE

Literature review

1.1.1 Etiology : *Strogylus vulgaris*(Urquhart *et al*., 1996).

1.1.2 Scientific classification

Kingdom: Animalia

Phylum: Nematoda

Class: Chromadorea

Order: Strongylida

Family: Strongylidae

Genus: *Strongylus*

Species: *S. vulgaris* , *S. edentatus* , *S. equinus* , *S. westeri* (Urquhart *et al*., 1996).

The population of the equine in the world is 122.4 million (Abayneh, *et al*., 2002). In the distribution pattern, 98% of all donkeys, 97% of all mules and 60% of all horses are found in the developing countries. The number of equines in Africa is in the range of 17.6 million comprising 11.6 million donkeys, 2.3 million mules and 3.7 million horses (Abayneh *et al*., 2002; Belay, 2006). Equines (donkeys, mules and horses) play an important role as working animals in many parts of the world, employed for packing, riding, carting and ploughing. Equine power is vital for both rural and urban transport system where is cheap and provides the best alternatives in places where the road network is insufficiently

developed, the terrain is rugged and mountainous and in the cities where narrow streets prevent easy delivery of merchandise (Yoseph *et al*., 2005; Woodford, 2009).In areas away from roads, many people use mules and donkeys to transport food and other supplies to villages (Pearson and Krecek, 2006; Woodford, 2009). Long working hours and difficult conditions are experienced by donkeys and mules. These animals are often engaged in work for long hours and when get free, they are left to browse and feed on garbage's. These have the potential to affect negatively their welfare and quality of life (Traversa, 2009; Kharchenko and Kuzmina, 2010).

In the developing world, there are estimated 110 million of equine. Parasitic helminthes are one of the most common factors that affected the health of working donkeys and horses worldwide. They cause various degrees of damage depending on the species and number of parasite, nutritional and the immune status of equines (Soulsby, 1992). They decrease the activity, production and productivity in the animals mainly in the reduction of body weight or failure to gain weight or even increase the mortality in acute case (Sawsan *et al.*, 2008). A number of studies conducted to detect association between poverty and animal diseases identified gastrointestinal parasitism as one of the most important problems for equine in developing countries (Gizachew and Ayana, 2010).

The parasite has long been considered as one of the most common and pathogenic parasites of the horse (Claire and Masterson, 1987; Krecek *et al*., 1987; Tolliver *et al*., 1987; Peter and Waller, 1997; Gasser *et al*., 2004; Hubert *et al*., 2004; Martin *et al*., 2007; Toscan *et al*., 2012).

1.1.3 Morphology

Figure 1.1 Close-up of *Strongylus vulgaris* mouthparts, (Soulsby, 1986).

Strongylus worms have a reddish color due to ingested blood. *Strongylus vulgaris* is up to 25 mm long, *Strongylus edentatus* up to 40 mm, and *Strongylus equinus* up to 50 mm. Female worms are longer than male worms. As for other roundworms, the body of these worms is covered with a cuticle, which is flexible but rather tough. The cuticle of these species shows a circular striation. The worms have a tubular digestive system with two openings, the mouth and the anus. All species have a characteristic well formed, rather spherical buccal capsule equipped with basal teeth to cut the host's tissues (Figure1). They feed on blood and tissues of the organs they migrate through. These worms are so-called plug feeders, i.e. they cut out small portion of the tissue in the organs where they stay or are migrating through. They also have a nervous system but no excretory organs and no circulatory system, i.e. neither a heart nor blood vessels. The female ovaries are large and the uteri end in an opening called the vulva. Males have a copulatory bursa with two spicules for

attaching to the female during copulation.The eggs are ovoid (Figure2), rather small (45 x 80 micrometers), thin-shelled and usually contain a 16-cell morula, (Soulsby, 1986).

Figure 1. 2 *Strongylus* Spp eggs(Soulsby, 1986)

1.1.4 Life cycle

All species of *Strongyle* nematode have direct life cycles but are somewhat complicated as they involve somatic migration of larval stages (Bucknell *et al*., 1995; Osterman, 2005; Kuzmina, 2006; Martin *et al*., 2007). There are significant differences in number of eggs in female uteri in various *Strongylus* species where the egg number differs 50–100 times between species (Kuzmina *et al*., 2012). Eggs are laid by adult female *Strongyle* nematode and passed in the faeces into the external environment where they hatch to the first stage larvae (L1s), at 12– 39°C with adequate moisture. The minimum temperature for eggs to hatch is 7–8°C (Ogbourne, 1975). From the egg on the ground per pasture, L1 emerges which grows and molts to L2 and then to the L3 stage. The L3 is the infective stage and under optimal summer conditions it requires about ten days to two weeks to develop from the time the egg is passed. L3s retain an outer protective sheath and are more resistant to chilling and dehydration than the L1s and L2s. Dehydration can prevent L3s from leaving the faeces and gaining

contact to herbage. Most larvae climb no higher than 10 cm from the soil surface and can move 15 cm horizontally and during rain L3s migrate from the faeces to the surrounding herbage most efficiently. (Bucknell *et al*.1995). After ingestion of L3 by the host, they pass to the small intestine, remove their external covering and initiate the internal phase of development. Removal of protective covering depends upon the stimuli from physiological / biochemical conditions in the gut of the host. Larvae of large Strongyle nematode emerge from the sheath through an anterior cap, whereas larvae of small *Strongyle* nematode escape via a longitudinal slit in the region of the oesophagus (Kuzmina *et al*., 2012). Removal of outer covering at 38˚C within 3 hours using an artificial intestinal fluid comprising trypsin, pancreatin, sodium bicarbonate and sodium dithionite has been achieved experimentally (Kuzmina *et al*., 2006). Internal phase of large *Strongyle* nematode larval development encompasses a somatic migration, whereas those of small *Strongyle* nematode burrow into the glands in the caecum and colon, and become encysted with no further migration. (Eysker *et al*., 1986; Gasser *et al*., 2004). In the submucosa next molting occurs ie L4 on about day 4 or 5. Working against the flow of blood, the L4s gradually move up the arterial system of the intestine. By the 8th day larvae have reached the cecal and ventral colic arteries. When these larger arteries are reached, the route of migration is marked by a twisty thread of fibrin on the intima and by day 14 larvae may be found in mural thrombi. The ileo-cecal and cranial mesenteric arteries are reached between 11 and 14 days . The traveling advance attains its climax by the 19th day at which time larvae may be found in almost any part of the arterial system but are always most abundant in arteries close to the origin of the cranial mesenteric artery (McCraw and Slocombe, 1976; Hopfer *et*

al., 1984; Osreman, 2005). The molting to the fifth stage (L5) occurs as early as 9 days and by 120 days. At this stage most larvae are pre-adults measuring up to 18 mm long. *S. vulgaris* larvae tend to remain in the arterial site until they molt to the fifth stage, though many fourth stage larvae are apparently swept away before the last molt occurs. Larval size and the thrust from the flow of blood are important factors in the separation of larvae from arterial lesions. The pre-adult larvae reach the small arteries on the serosal surface of the large intestine and terminal small intestine.

1.2 Epidemiology

Strongyle nematode eggs are passed with the faces, and under good conditions they will hatch into first stage larvae (L1) within 2-4 days. The embryonated eggs tolerate low temperatures (even freezing), which will only delay further development (Uhlinger, 1991). The rate of hatching is directly proportional to the temperature of the environment (Ogbourne, 1972). Laboratory studies have shown that at temperatures between 25-33°C hatching is completed within 24 hours, whereas below 5°C the eggs remain viable but do not hatch (Mfitilodze and Hutchinson, 1987). The first stage larvae are susceptible to freezing temperatures as well as to desiccation. When faecal material dries quickly the eggs hatch but the L1s do not develop further (Ogbourne, 1972). The L1s feed on bacteria before they develop to the second stage. The L2s are quite resistant to desiccation, but like the L1s they die following prolonged periods of cold. It is well known that the L3s are capable of surviving severe cold, especially under a protective snow cover which somewhat stabilizes the climatic variations (Urquhart *et al.*, 1996). Thus, the Swedish winter is not an obstacle for the L3s on pasture; a considerable number of infective

larvae deposited in August-September may survive over the winter (Lindberg, 1976). Furthermore, it has been observed that the vegetation on old pasture is more favorable for overwintering larvae than is new pasture (Nilsson and Andersson, 1979). Nevertheless the overwintered larvae do not usually constitute a major problem the following summer. It is difficult to predict pasture infectivity since many factors, for example rainfall, temperature, moisture and degradation of faeces, influence the development and survival of eggs and larvae . The proportion of overwintering larvae differed tenfold both over the season and from one year to the next.

Strongylosis is most frequently a problem in young horses reared on permanent horse pastures, although cases of severe disease may occur in adult animals. kept in suburban paddocks and subjected to overcrowding and poor management.

Although the pre-parasitic larval requirements of the horse *Strongyle nematode* are similar to those of the *Trichostrongyles* of ruminants, adult horses, unlike cattle, may carry substantial worm burdens and therefore have a considerably influence on the epidemiology of infection. Thus there are two sources of infection during the grazing season in temperate areas. First there are infective larvae developed during the previous grazing season and have survived on pasture over winter. The second and probably more important source of inflective larvae is the eggs passed in the current grazing season by horses, including nursing mares sharing the same grazing areas. Pasture larval levels increase markedly during the summer months when conditions are optimal for rapid development of eggs to $L_{3.}$

At present there is little evidence for rising in fecal egg output in breeding mares due to a relaxation of immunity since the egg rises in the spring occurs in both breeding and non-breeding animals and is often unrelated to parturition. There is increasing evidence that many Cyathostome L_3 ingested during the autumn show a degree of hypubiosis and remain in the large intestinal mucosa until the following spring. Mass emergence of these larvae results in the severe clinical signs described previously.

Strongylosis is a common disease of horses. It occurs throughout the world and causes deaths when control measures are neglected. *Strongylus vulgaris* is the most important parasite that causes vermenous arteritis and colic. *Strongylus edentates* and *S. equinus* also occur with lesser consequences (Blood *et al.*, 1983). These parasites migrate in the circulation and vital organs and cause severe damage. That is fatal in some instances (Pandey and Eysker, 1989).

1.3 Pathogenesis

Strongylus vulgaris is the most pathogenic of the large *Strongyle* nematode because of the prolonged (at least 4 months) and extensive migrations through the mesenteric arterial system and its branches before returning to be mature in the cecum and colon. Larval migrations cause damage to the smooth endothelial surfaces of arteries, providing a focus for clot formation. These clots (thrombi) are accompanied by inflammation and a progressive thickening of the arterial walls.

The pathogenesis of *Strongylus* has been studied based on elucidation of experimental mono specific infections (Drudge *et al*., 1966; McCraw and Slocombe, 1974; Malan *et al*., 1982; Alam *et al*, 1999). The

damage caused by large and small *Strongyles* is attributed to larval stages. Small *Strongyles* have small buccal capsules and feed superficially on the mucosa (Duncan, 1985). Large *Strongyle* nematode have large buccal capsules by which they attach to the intestinal mucosa, pull out a plug of tissue, absorb the host cells, crack the blood vessels and suck blood, feed on the mucosa and consume blood (Levine, 1980). Hemorrhage occurs subsequent to feeding at the injured site which eventually is marked by a scar. The larvae cause minimal inflammatory response as long as they remain encysted however their synchronous emergence of large number results in diffuse inflammation of the cecum and ventral colon (Love *et al*., 1999). In all the cases a normocytic, normochromic anaemia is observed in affected equines (Ogbourne, 1975). The L4s and L5s migrate through the arterial system and cause verminous arteritis with marked intima thickening infiltrated with inflammatory cells. They can cause mechanical damage and inflammation in the liver, pancreas and peritoneal cavity. A considerable of lesions in the cranial mesenteric artery was found approximately nine months after infection with *S.vulgaris* larvae (Duncan and Pirie,1985).

1.4 Clinical signs

The prepatent periods (the time from infection until eggs are detectable in faeces) for members of this genus vary from 6 months for *S. vulgaris* to 10-12 months for *S. edentatus* (Urquhart *et al.*, 1996).There is poor hair coat, impaired performance, weight loss, anemia, persistent low grade fever, verminous arteritis and colic related to *S. vulgaris* (Radostits *et al.*, 2006). Ill-thrift to sudden death (Umur and Acici, 2009), diarrhea and anorexia often take place (Waqas *et al*., 2014). high infection rate with *Strongyle* parasites may result in a stumpy performance and reduced life

probability of working equines (Bogale *et al.*, 2012). Changes in hematological values include reduction in total erythrocyte count (TEC) and packed cell volume (PCV) (Saleem *et al.*, 2000), reduced hemoglobin concentration and eosinophilia (Waqas *et al.*, 2014; Dennis *et al.*, 1992). Monocytopaenia, normocytic and normochromic anemia and reduced survival cell may also occur because of blood sucking capability of the *Strongylus* (Sipra *et al.*, 1999).

It is generally accepted that mucosal feeding adults of all three *Strongylus* species can have significant effects on infected horses although there appear not to be any clinical signs that can be specifically attributed to them. General clinical signs of pale mucous membranes, poor weight gains and even weight loss combined with dull, staring coats are seen in horses infected with large *Strongylus*. However, these clinical signs are generally seen in most parasitic infections of the digestive tract. The "wormy horse" is generally a poor performance and poor looking, a description that is often described as "unthrifty". Horses like this are now relatively uncommon in the United States because of the wide use (some would say the overuse) of anthelmintics and the acceptance of parasite control programs by veterinarians and the horse-owning public. Anemia, emaciation, poor coat and poor performance are frequently attributed to large *Strongylus* while in the intestine. Diarrhoea is more common sign in small *Strongyle* infection than with large *Strongyle* nematode (McCraw and Slocombe, 1976).

These clinical signs are related to the feeding habits of adult worms which grasp a piece of mucosa with their large mouths and digest it, a process that produces considerable bleeding at the bite site and results in

formation of an ulcer. Necropsies show that there are many more ulcers than the actual number of adult large *Strongyle* nematode in the cecum and colon, a finding that suggests that these worms feed, then move to a fresh site. It also implies that their primary source of food is mucosal tissues and that blood is ingested only as part of the mucosal meal. This means that the large *Strongyle* nematode are more accurately described as mucosal feeders than blood suckers. Fever in *S. vulgaris* infection is attributed to tissue damage or a toxic substance elaborated by larvae. The most steady change in early *S. vulgaris* infection would result a rapid increment in total white cell (WBC) counts. These values rise sharply during the first three weeks to levels of 17,000 to 22,700/mm3. Eosinophils values will increase after the second week and demonstrate little change in acute infection. Increments in serum total protein and globulin fractions occur as early as the first week following infection. Thrombus formation can block arteries, causing infarction of intestinal walls and/or intermittent lameness, and is commonly associated with clinical signs of marked pyrexia, anorexia, severe colic and death (Pilo *et al.,* 2012).

1.5 Diagnosis

Symptoms are not of value for diagnosis. Diagnosis has usually relied on the use of the method of fecal flotation (Duncan and Pirie., 1985; Nautrup *et al*,. 2003; Gasser *et al*., 2004; Kaplan and Nielsen., 2010; Andersen *et al*., 2013). Since it is not possible to distinguish between *Strongyle* eggs of different species morphologically, fecal samples are cultured to allow the development to L3s, which may be collected for study and then the species can be easily identified. A method for detecting mucosal larval stages would be valuable in the diagnosis of larvae. A

copro-antigen ELISA has shown promise with moderate to good diagnostic sensitivity and specificity as well as a positive correlation with worm numbers (Kania and Reinemeyer, 2005; Skotarek *et al*., 2010). Change in the blood picture associated with *S. vulgaris* is not unlike that seen in bacterial infections (Drudge *et al*., 1984). Alterations in blood biochemical and haematological parameters can be detected in a proportion of infected horses. Hypoalbuminaemia is a common finding in naturally infected horses, which is probably due to the increased permeability of the intestines. A rise of β-globulin in serum has also been reported in natural infections. A marked reduction of serum fructose amines (glycated serum proteins) has been reported for horses with experimental cyathostomin nematode infection (Dowdall *et al*., 2004).

It is almost impossible to distinguish between the eggs of the three Strongyle species. This usually requires copro culture to isolate the larvae, which is rather laborious. Research to develop accurate and easy-to-use diagnostic tools have not yet resulted in a commercially available test kit. (Soulsby,1986). Diagnosis is primarily based on clinical history, clinical signs of the disease and detection of *Strongyle* eggs in the faeces of affected animal mainly through direct smear method (Waqas *et al*., 2014). Specific amplification of ribosomal DNA in faeces may be used for the *Strongyle* nematode detection and identification (Radostits *et al*., 2006).

1.6 Prevention and control

Prevention by routine deworming of horses is unnecessary in all regions during the 6 month period after infection that comprises the

unfavorable season for *Strongyle* transmission. During this interval, environmental conditions largely prevent new parasites from developing. Even if horses have high egg counts during that period, relatively few of those eggs can develop into adults. Therefore, the goals of parasite control are being accomplished by the climate, and compound treatment is not required (Reinemeyer, 2009). Since small numbers of infective larvae may have grave effects on foals thus mares in foal or newly foaled should be regularly examined for *Strongyle* eggs and treated with suitable anthelmintics. Climatic influences cannot effectively clean pastures from one grazing season to the next (Martin *et al*., 2007). The use of herbal compounds as anthelmentics against strongylosis is not yet to be explored.

An important measure to reduce the risk of infection is to avoid overstocking, because if too many animals share the same pastures, horses will rather eat grass contaminated by manure, which increases the risk of ingesting infecting larvae. Ideally each animal should be allocated 2 to 3 acres (0.8 to 1.2 hectares) of land. If feasible, too humid pastures should be drained, the dryer the pasture, the lower the survival of infective larvae and the lower the risk of infection for the horses. Frequent manure removal is also recommended and pastures should not be fertilized with fresh manure. Water tanks should regularly be cleaned and grazing close to them must be avoided. Being wet and frequently visited they are likely to be highly contaminated with infective larvae. To prevent infestations indoors, stable hygiene is crucial. They must be regularly cleaned, manure has to be removed daily and the bedding must be changed regularly. Humidity has to be kept as low as possible, e.g. with adequate ventilation. Alternate grazing with livestock (cattle, sheep) that are not susceptible to *Strongylus* infection may be considered as well, but livestock can carry

other parasites that affect horses. Horses coming into a farm must be always checked for pre-existing infections (e.g. through adequate fecal examination) or treated with a broad-spectrum anthelmintic before they are allowed to share pastures and premises with other horses. In case of doubt quarantine measures must be considered (Soulsby, 1986).

1.7 Treatment

Usually, equines are treated with anthelmintic drugs to eliminate adult *Strongyles* from the large intestines to prevent excessive contamination of pastures with eggs and L3s. Thiabendazole has been widely used and several other drugs have been developed or approved for use in adult horses, including benzimidazole, tetrahydropyrimidines and organic phosphorus compounds (Drudge *et al*, 1975; Drudge *et al*., 1984; Tolliver, 1987; Saeed *et al*., 2008). Thiabendazole at the rate of 250 mg/kg body weight given through stomach tube on two consecutive days is useful (Coffman and Carlson, 1971).

Currently, there are three main classes of commonly-used drugs, categorized by their mode of action: the benzimidazoles (e.g. thiabendazole, cambendazole, fenbendazole and oxibendazole), pyrantel and the macrocyclic lactones e.g. ivermectin and moxidectin (Gasser *et al*., 2004). In the 1990's, treatment intervals practiced for adult horses were 8 weeks for ivermectin and 4–6 weeks for other anthelmintics. Many combinations of macrocyclic lactones (abamectin, ivermectin, moxidectin), including ivermectin combined with pyrantel (tetrahydropyrimidine) and ivermectin combined with praziquantel (pyrazinoisoquinolin derivative), a pharmaceutically formed generic paste containing ivermectin 4% were tested for their effectiveness to control gastrointestinal nematodes of horses (Toscan *et al*., 2012). Alike

formulations of ivermectins had different efficacies calculated by reduction of EPG (Mariana *et al*., 2010). Stages of efficacy of the tested drugs varied against *S. edentatus, S. equinus* and *S. vulgaris.* The generic paste (ivermectin 4%) was less effective than the conservative drugs. The efficacy of oxafex, ivomec and farbenda has been established with 94.7, 98 and 81% respectively on day l4-post medication. On day 28th post medication it was 100%, 96% and 86%, respectively (Saeed *et al*., 2008). Nowaday, it is recommended to reduce the treatment intensity significantly to holdup further development of anthelmintic --resistance (Kaplan and Nielsen, 2010). In severe enteropathy the administration of non steroidal anti-inflammatory agent is also required. Single intravenous dose of 0.6 mg/kg body weight meloxicam once a day recommended for horses (Mahmood and Ashraf, 2010). There is general agreement that the traditional treatment at frequent intervals should be abandoned, and that parasite control be maintained with far fewer anthelmintics (Nielsen, 2012).

CHAPTER TWO

Materials and methods

1.1 Study area

The study was carried out in Khartoum State which has desert and semi-desert climate. The state receives little infrequent rain with an average of less than 300 mm per year, and is characterized by three distinct seasons; cold-dry from November to February, hot-dry from March to June, and hot-wet season from July to October; and wide diurnal and annual temperature variations.

1.2 Study Design

A cross sectional study was conducted in randomly selected horses and donkeys for the detection of the prevalence of *Strongylus vulgaris* infections. Information about sex, age, species, body condition, housing type, hygiene, feeding system, previous history of the disease, usage of the animal, deworming protocol and location of the animal in Khartoum state(Omdurman, Khartoum, Khartoum North and Khartoum city) of the study animals were recorded. The ages were determined using owner's information. Animals were categorized as young (≤ 5years), Old (> 5 years). The body conditions were classified poor and good.

1.3 Sample Size Determination and Sampling Methods

The sample size required for this study was determined according to Thrusfield (2005). Prevalence of 50% was taken as expected prevalence for sample size determination of this study.

The other determinants considered in sample size determination, were 95% confidence interval and 5% desired absolute precision. Hence the sample size is estimated as:

$\mathbf{N} = 1.962 [P_{exp} (1-P_{exp})] / d2$

Where:

N = Required sample size

$\mathbf{P_{exp}}$ = Expected prevalence of nematode parasites

$\mathbf{d_2}$ = Desired absolute precision

1.96 = the value of "z" at 95% level of confidence

d = 5%=0.5

Using the above formula, 384 animal, 277 Horses and 107 Donkeys were examined.

Fecal samples (384 samples) for parasitological examination were collected directly from the rectum of each animal using disposable plastic gloves and placed in new plastic bags. Each selected animal was given an identification number, and then each fecal sample was clearly labeled with a crosponding identification number. The collected samples were soon transported to the parasitology lab of the College of veterinary of Sudan University of Science and Technology. These samples were examined on the day of collection or stored in a refrigerator at 4°C for processing next day. The floatation technique was employed to concentrate parasite eggs in the feces and examined microscopically (10x and 40x) for presence of parasite ova. The 384 fecal samples were examined using

sodium chloride as floatation solution, 2 or 3 gram of feces were ground in a mortar and pestle and placed in a tube. Saturated Sodium chloride was added to the tube which was filled to the top with the same fecal mixture till it made a convex meniscus. A cover slip was inverted over the top of the tube, after 15 minutes the slides was quickly removed and placed on microscopic slide and examined under a microscope for parasite eggs. Identification of the eggs was made on the basis of their morphology (Soulsby, 1986).

1.4 Questionnaire survey:

Owners and/or managers of all farms involved in the study were asked to provide information about potential risk factors suspected to be associated with strongylosis. The questionnaire included information about age, sex, body condition, species as individual risk factors. Also, housing, feeding, use of anthelmentics, hygiene included as management risk Factors. This in addition to previous disease , usage of animal , location as climatic risk factors. These potential risk factors were divided into categories (Thrusfield , 2007).

1.5 Data Analysis

All data of risk factors, was enter to Microsoft excel sheet and was analyzed by using statistical package of social science (SPSS). version (16.0). Descriptive statistics was use to determine the prevalence of the *Strongylus vulgaris* and Pearson Chi-square (x^2) test was used to look at the association between variables and parasitic infection. In all the analysis confidence interval at 95% and P-values less than or at level 0.05 is significance.

CHAPTER THREE

Result

3.1.1 Overall prevalence of equine Strongylosis in Khartoum state, Sudan.

A total Fecal samples of 384 (horses 277 samples and donkeys 107samples) were examined for *Strongylus vulgaris* infestation by flotation test technique. About 117 animals were found positive (30.5%) and 267 animals were found negative (69.5%) for Equine Strongylosis (diagnosed by flotation) (Table: 1). Therefore the overall prevalence of Equine Strongylosis in Khartoum state was 30.5%.

Table 1 : Frequency table for the prevalence of *Strongylus vulgaris* in 384 equine (horses and Donkeys) diagnosed by flotation test in Khartoum state .

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**+ve**	117	30.5	30.5	30.5
	-ve	267	69.5	69.5	100
	Total	384	100	100	

3.1.2 Prevalence of equine Strongylosis based on location :

The results showed that the overall prevalence of strongylosis out of 384 examined animals in Khartoum state was 30.5% by flotation test. The number of the animals in Omdurman was 131 animals. Among these, 63

animals were found to be infected. The rate of infection was 48.1%.But in Khartoum north the number was 128 animals. Among these, 41 animals were found to be infected. The rate of infection was 32.0%. While in Khartoum the number 125 animals. Among these, 13 animals were found to be infected. The rate of infection was 10.4% (Tables 2, 3).

The Chi square test, showed that there was significant association (Table 4) between *S.vulgaris* infection and location (p-value=0.000).

3.1.3 Prevalence of equine Strongylosis based on sex of animals :

The results of study showed the distribution of 384 animals examined for strongylosis by sex. Total number of female examined was 57 animals. Among these, 33 animals were found to be infected. The rate of infection was 57.9%. Total number of males examined was 327 animals, About 84 animals were infected. The rate of infection was 25.7% (Tables 2, 3).

The Chi-square test, showed that there was significant association (Table 4) between *S.vulgaris* infection and sex of animal (p-value =0.00).

3.1.4 Prevalence of equine Strongylosis based on age of animals

The results of study showed the distribution of 384 animals examined for *strongylosis* by age. Total number less than or equal 5 year of age was 17 animals. Among these, 11 animals were infected. The rate of infection was 64.7 %. Total number of animals more than 5 years was 367 animals. Among these, 106 animals were infected, and the infection rate was 28.9% (Tables 2, 3).

The result showed that there was significant association (Table 4) between *S.vulgaris* infection and age of animal using Chi-square (p-value =0.002).

3.1.5 Prevalence of equine Strongylosis based on Species of animals:

The number of donkey examined was 107 animals according to species of the animals and 74 animals were infected. The rate of infection was 69.2%. The number of horses examined was 277 animals. Among these 43 animals were infected and the rate of infection was 15.5%. (Tables 2,3).

The Chi square test showed there was significant association (Table 4) between *S.vulgaris* infection and species (p-value=0.00) .

3.1.6 Prevalence of equine Strongylosis based on Body condition of animals:

According to body condition of the animals. About 347 animals were in good condition. Among these 101 animals were found to be infected. The rate of infection was 29.1 %. Thirty seven animals were emaciate and 16 animal was found to be infected and the rate of infection was 43.2% (Tables 2,3) .

The Chi square test showed that there was significant association (Table 4) between *S.vulgaris* infection and body condition (p-value=0.076).

3.1.7 Prevalence of equine Strongylosis based on Housing of animals

The examined equine (384 animals) of various housing types were examined in this study, and the presence of *S.vulgaris* was investigated. Anumber of 336 animals raised indoor were examined. Among these, 84 animal were infected and the rate of infection was 25.5%. While 48 animals raised outdoor were examined. Among these, 33 animals were infected and the rate of infection was 28.8% (Tables 2,3) .

The Chi square test showed that there was significant association (Table 4) between *S.vulgaris* infection and housing (p-value =0.000) .

3.1.8 Prevalence of equine Strongylosis based on Hygiene of animals

About 219 animals found in good condition were examined for *S.vulgaris*. Among these, 35 animals were found to be infected. The rate of infection was 16.0%. While 165 animals found in bad condition were examined. Among these, 82 animals were found infected. The rate of infection was 49.7% (Tables 2,3) .

The Chi square test showed that there was significant association (Table 4) between *S.vulgaris* infection and hygiene (p-value =0.000).

3.1.9 Prevalence of equine Strongylosis based on Feeding of animals

The number of animals examined which feeding inside was 333 animals. Among these, 81 animals were found infected. The rate of infection was 24.3%. Whereas the number of animals which feeding outside was 51 animals. Among these, 36 animals was found infected. The rate of infection was 70.6% . (Tables 2,3) .

The Chi square test showed that there was significant association (Table 4) between the *S.vulgaris* infection and feeding system (p-value =0.000) .

3.1.10 Prevalence of equine Strongylosis based on Previous history disease of animals

The number of animals examined for previous history of the disease was 73, among these, 50 animal were found infected. The rate of infection was 68.5%. While the number of animals in absent of previous disease 311, among these, 67 animal were found infected. The rate of infection was 21.5% (Tables 2,3).

The Chi square test showed that there was significant association (Table 4) between *S.vulgaris* infection and previous history of disease (p-value = 0.000).

3.1.11 Prevalence of equine Strongylosis based on Usage of the animals

The examined equine (384 animals) categorized according to using and the presence of *Strogylus vulgaris* infection was investigated. Total animals number in the category of racing was 56 animals. Among these, no animals were found infected. The rate of infection was .0%. Whereas 107 animals in the category of working animal there was 74 animals were found infected. The rate of infection was 69.2% and the number of loaded animals was 221 animals .Among these, 43 animals were found infected. The rate of infection was 19.5% (Tables 2,3).

The Chi square test showed that there was significant association (Table 4) between *S.vulgaris* infection and using of animal (p-value= 0.000).

3.1.12 Prevalence of equine Strongylosis based on deworming of animals :

According to using of anthelmintic, and the presence of *S.vulgaris* infection was investigated. Total animals number in the category of anthelmintic used was 130 animals. Among these, no animals were found infected. The rate of infection was 0% . While 254 animals in the category of anthelmintic not used there were 117 animals were infected. The rate of infection was 49.1% (Tables 2,3).

The Chi square test showed that there was significant association (Table 4) between S.vulgaris infection and using of anthelmintics (p-value= 0.000).

Table 2: Summary frequency for the distribution of 384 animals examined for Strongylosis by flotation test according to potential risk factors investigated in Khartoum state:

Risk factor	Frequency	Relative frequency (%)	Cumulative frequency (%)
Sex :			
Male	327	85.2	85.2
Female	57	14.8	100
Age:			
≤ year	17	4.4	4.4
> year	367	95.6	100
Body condition:			
Good	347	90.4	90.4
Emaciation	37	9.6	100
Species:			
Donkeys	107	27.9	27.9
Horses	277	72.1	100
Housing:			
Indoor	336	87.5	87.5
Outdoor	48	12.5	100
Hygiene:			
Good	219	57.0	57.0

Bad	165	43.0	100
Feeding:			
In grazing	333	86.7	86.7
Out grazing	51	13.3	100
Previousdiseas			
No	311	81.0	81.0
Yes	73	19.0	100
Use of animal:			
Racing	56	14.6	14.6
Working	107	27.9	42.4
Loading	221	57.6	100
Location:			
Omdurman	131	34.1	34.1
Khartoum north	128	33.3	67.4
Khartoum	125	32.6	100
Deworming protocol:			
Use	130	33.9	33.9
Not use	254	66.1	100

Table 3: Summary cross-tabulation of Strongylosis in 384 animals examined by flotation test according to potential risk factors investigated in Khartoum state:

Risk factor	Animals tested	Animals affected	Affected%
Sex :			
Male	327	84	25.7
Female	57	33	57.9
Age:			
≤ 5years	17	11	64.7
> 5year	367	106	28.9
Body condition:			
Good	347	101	29.1
Emaciation	37	16	43.2
Species:			
Donkeys	107	74	69.2
Horses	277	43	15.5
Housing:			
Indoor	336	84	25.0
Outdoor	48	33	28.8
Hygiene:			
Good	219	35	16.0
Bad	165	82	49.7
Feeding:			
In grazing	333	81	24.3
Out grazing	51	36	70.6

Previous disease:			
No	311	67	21.5
Yes	73	50	68.5
Use of animal:			
Racing	56	0	.0
Working	107	74	69.2
Loading	221	43	19.5
Location:			
Omdurman	131	63	48.1
Khartoum north	128	41	32.0
Khartoum	125	13	10.4
Deworming protocol:			
Use	130	0	.0
Not use	254	117	49.1

Table 4: Summary of univariate analysis for risk factors associated with equine strongylosis(384 animals) using the Chi-square test in Khartoum State.

Risk factors	No. inspected	No. affected (%)	Df	X^2	p- value
Sex:			1	23.766	.000*
Male	327	84 (25.7)			
Female	57	33 (57.9)			
Age:			1	9.842	.002*
≤ 5 years	17	11 (64.7)			
> 5 years	367	106 (28.9)			
Species:			1	1.048	.000*
Donkeys	107	74 (69.2)			
Horses	277	43 (15.5)			
Body condition:			1	3.154	.076*
Good					
Emaciation	347	101 (29.1)			
	37	16 (43.2)			
Housing:			1	37.946	.000*
In dour	336	84 (25.0)			
Out dour	48	33 (28.8)			
Hygiene:			1	50.491	.000*
Good	219	35 (16.0)			
Bad	165	82 (49.7)			
Feeding:			1	44.682	.000*
In grazing	333	81 (24.3)			

Out grazing	51	36 (70.6)			
Previous disease:			1	61.515	.000*
No	311	67 (21.5)			
Yes	73	50 (68.5)			
Usage:			2	1.128	.000*
Racing	56	0 (.0)			
Working	107	74 (69.2)			
Loading	221	43 (19.5)			
Deworming:			1	86.122	.000*
Use	130	0 (.0)			
Not use	254	117 (49.1)			
Location:			2	43.115	.000*
Omdurman	131	63 (48.1)			
Khartoum north	128	41 (32.0)			
Khartoum	125	13 (10.4)			

*means significant value .p- value ≤0.25

Multivariate analysis using Logistic Regression models:

Risk factors that were significant (p-value ≤ 0.25) in the univariate model were re-entered in logistic regression in the final multivariate models. A variables with (p- value ≤ 0.05) was considered statistically significant. In these study there no significant difference in multivariate analysis.

CHAPTER FOURE

Discussion

In this study, fecal examination was done using floatation technique to determine *S.vulgaris* ova in equine. The prevalence rate in this results was 15.5% in horses which higher compared with results of Höglund *et al.* (1997) who recorded 3.6% of the infection rate in these animals. The result obtained in this study were lower than previous reports (Epe, 1993; Abdul-Majeed, 2004; Veli *et al.,* 2005; Tavassoli 2010 and Wannas., *et al*., 2012) who recorded 72.9% 55.5%, 68.4%, 68% and 50% respectively. Also compared to previous studies, our data was low than Getachew *et al.* (2008) Getachew *et al*. (2010) from east Shewa, who reported 100% and 99% respectively. In other countries of Africa, Upjohn *et al.* (2010) who reported

indicated prevalence rates varying between 100% in Ethiopia and 89% in Chad. On the other hand, among the 107 donkeys examined in this study there were 74 (69.2%) donkeys who gave positive result to *Strongylus vulgaris* ova. This result is higher than the result of Gebreab (1998), who reported that the prevalence rate of the parasite was (24.7 %). Also, our result were higher than those obtained from India which the was 8% (Pal, 2002). But Uslu and Guclu (2007) recorded 100% infection in donkeys, compared to previous study, our data was similar to those obtained from Mosul in Iraq Esmaeel (2009) who recorded 70% infection rate.

Strongylus vulgaris eggs are highly prevalent in bothspecies, donkeys and horses, in study reported by Wannas *et al.* (2012) and predomination of *Strongyle*-type eggs with a prevalence of 50% in horse

and 57.14% in donkey. About 58.5% *Strongyle* type egg was predominant ones was also reported by Saeed *et al.* (2010) and 66.67% reported by Mezgebu *et at.* (2013). Chaudhry *et al.* (1991) reported that prevalence rate of 40% *Strongyle* infection in donkeys which is disagreement with results of Ayele and Dinka *(*2010), with 87% in donkeys in Boset, Central Shoa, Ethiopia. Also, Zerihun *et al*. (2011) in Ethiopia and Hassan *et al.* (2004) in Sudan reported a higher prevalence of 99.15% in donkeys . The difference in the prevalence of these parasites in the different places may be due to climatic condition, grazing pattern of the horse and animal number examined. Other studies also reported very high prevalence of *Strongylus vulgaris* between 90 and 100 % (Fikru *et al*., 2005; Ayele and Dinka, 2010; Getachew *et al.*, 2010; Abeba *et al*., 2011; Asefa *et al.*, 2011; Ibrahim *et al*., 2011). The significant difference in the rates of the parasite was statistically significant ($P<0.05$). Higher infections of *Strongylus vulgaris* in the current study correspond with the biology and epidemiology of these parasites as they require longer period to complete the life cycle and slow or partial development of immunity. Many intrinsic (sex, age, breed) and extrinsic factors (management, climate and parasite control program) influence the prevalence of parasites of domestic animals. Use of broad spectrum anthelmintics like benzimidazoles and macrocyclic lactones has resulted in drastic reduction in worm populations of large *Strongyles* infection.

CONCLUSION

The results of the current study indicated that strongylosis is a prevalent parasitic in the surveyed area and is an important health problem of the equines which is speculated to cause heavy economic losses through low performance and short life expectancy of working equines. The parasite will continue to be the most damaging parasite helminthes in the study area. Equines have crucial importance in the life system of developing countries especially in Sudan, particularly for transportation. In spite of the invaluable and unlimited services equines provide man, it is the subject of routine and frequent neglect and maltreatment. Now and for the future, it is within the context of this attitude that the problems associated with equines have to be examined.

Recommendations:

- Public awareness creation to equine owners on proper regular deworming, sufficient feed supply and minimizing extensive open grazing are also important.
- Balancing of the work load and duration should be managed.
- Regular and strategic deworming programmes with efficacious anthelminthics should be carried out regularly.
- All newly introduced animals into the herd must be quarantined and properly screened and treated to prevent environmental contamination with harmful helminthes parasites.
- Improvement of housing and feeding management system for equines are important.
- To conduct more studies on the prevalence of other Strongyle species other than *Strongylus vulgaris* , *Strongylus edentates* and *Strongylus equines* that may be present in horses and in other equines such as donkey.

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Appendice

Appendix I

Questionnaire:

Investigation of equine Strongylosis in Khartoum state, Sudan.

Date _____ Location: _____Address _____

1- Individual risk factors;-

I- **Age :-** ≤ 5 year ( ) , > 5 year ( )

II- **Sex:-** male ( ), female ( ).

III- **Species:-** Donkey ( ) , Horses ( ).

IV- **Body condition:-** Good ( ) , Emaciation ( ).

2-**Management risk Factors;**

I- **Housing :-** indoor ( ), outdoor ( ).

II- **Feeding:** - In grazing ( ), Out grazing( ) .

III- **Use of drug:**- Use ( ), No ( ) .

IV- **Previous history of disease:-** Yes ( ), No ( ) .

V- **Usage of animal:-** Racing ( ), Working ( ), loading( ) .

VI- **Hygiene:-**Good ( ), Bad ( ).

3-**Climatic risk factors;-**

I – **Location:**- Omdurman ( ), Khartoum north ( ) , Khartoum ( ) .

Appendix II

Frequency table for the distribution of infection among 384 equine animals examined at Khartoum state according to potential risk factors.

A. Frequency distribution of sex:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	327	85.2	85.2	85.2
	female	57	14.8	14.8	100.0
	Total	384	100.0	100.0	

B. Frequency distribution of age:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less or equal 5 year	17	4.4	4.4	4.4
	more than 5 years	367	95.6	95.6	100.0
	Total	384	100.0	100.0	

C. Frequency table of body condition:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	good	347	90.4	90.4	90.4
	emaciation	37	9.6	9.6	100.0
	Total	384	100.0	100.0	

D. Frequency table of species:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	donkey	107	27.9	27.9	27.9
	horse	277	72.1	72.1	100.0
	Total	384	100.0	100.0	

E. Frequency table of housing:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1ndour	336	87.5	87.5	87.5
	outdour	48	12.5	12.5	100.0
	Total	384	100.0	100.0	

F. Frequency table of hygiene:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	good	219	57.0	57.0	57.0
	bad	165	43.0	43.0	100.0
	Total	384	100.0	100.0	

G. Frequency table of feeding:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ingrazing	333	86.7	86.7	86.7
	outgrazing	51	13.3	13.3	100.0
	Total	384	100.0	100.0	

H. Frequency table of previous history of disease:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	311	81.0	81.0	81.0
	yes	73	19.0	19.0	100.0
	Total	384	100.0	100.0	

I. Frequency table of usage of animal:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	racing	56	14.6	14.6	14.6
	working	107	27.9	27.9	42.4
	loading	221	57.6	57.6	100.0
	Total	384	100.0	100.0	

J. Frequency table of deworming:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	use	130	33.9	33.9	33.9
	not use	254	66.1	66.1	100.0
	Total	384	100.0	100.0	

K. Frequency table of location:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Omdurman	131	34.1	34.1	34.1
	Khartoum north	128	33.3	33.3	67.4
	Khartoum	125	32.6	32.6	100.0
	Total	384	100.0	100.0	

Appendix III

Cross-tabulation for the distribution of infection among 384 equine animals examined at Khartoum state according to potential risk factors investigated.

A. Equine Strongylosis and sex cross-tabulation:

		sex of animal		
	count	male	female	Total
result	+ve	84	33	117
	%	25.7%	57.9%	30.5%
	-ve	243	24	267
	%	74.3%	42.1%	69.5%
Total		327	57	384

B. Equine Strongylosis and age cross-tabulation:

		ages of animal		
	count	less or equal 5 year	more than 5 years	Total
result	+ve	11	106	117
	%	64.7%	28.9%	30.5%
	-ve	6	261	267
	%	35.3%	71.1%	69.5%
Total		17	367	384

C. Equine Strongylosis and species cross-tabulation

		species of animal		
	count	donkey	Horse	Total
Result	+ve	74	43	117
	%	69.2%	15.5%	30.5%
	-ve	33	234	267
	%	30.8%	84.5%	69.5%
Total		107	277	384

D. Equine Strongylosis and body condition cross-tabulation:

		body condition		
	count	good	emaciation	Total
result	+ve	101	16	117
	%	29.1%	43.2%	30.5%
	-ve	246	21	267
	%	70.9%	56.8%	69.5%
Total		347	37	384

E. Equine Strongylosis and housing cross-tabulation

		housing type		
	count	1ndour	outdoor	Total
result	+ve	84	33	117
	%	25.0%	68.8%	30.5%
	-ve	252	15	267
	%	75.0%	31.2%	69.5%
Total		336	48	384

F. Equine Strongylosis and hygiene cross-tabulation

		hyegine of animal		
	count	good	bad	Total
Result	+ve	35	82	117
	%	16.0%	49.7%	30.5%
	-ve	184	83	267
	%	84.0%	50.3%	69.5%
Total		219	165	384

G. Equine Strongylosis and feeding cross-tabulation

		feeding system		
	count	ingrazing	outgrazing	Total
Result	+ve	81	36	117
	%	24.3%	70.6%	30.5%
	-ve	252	15	267
	%	75.7%	29.4%	69.5%
Total		333	51	384

H. Equine Strongylosis and previous disease cross-tabulation:

		provious history of disease		
	count	no	yes	Total
Result	+ve	67	50	117
	%	21.5%	68.5%	30.5%
	-ve	244	23	267
	%	78.5%	31.5%	69.5%
Total		311	73	384

I. Equine Strongylosis and usage of animal cross-tabulation

		usage of animal			
	count	racing	working	loading	Total
Result	+ve	0	74	43	117
	%	.0%	69.2%	19.5%	30.5%
	-ve	56	33	178	267
	%	100.0%	30.8%	80.5%	69.5%
Total		56	107	221	384

J. Equine Strongylosis and deworming cross-tabulation

Crosstab

		deworming protocol		
	count	use	not use	Total
result	+ve	0	117	117
	%	.0%	46.1%	30.5%
	-ve	130	137	267
	%	100.0%	53.9%	69.5%
Total		130	254	384

K. Equine Strongylosis and location cross-tabulation:

		location of animal in Khartoum state			
	count	Omdurman	Khartoum north	Khartoum	Total
result	+ve	63	41	13	117
	%	48.1%	32.0%	10.4%	30.5%
	-ve	68	87	112	267
	%	51.9%	68.0%	89.6%	69.5%
Total		131	128	125	384

Appendix IV

Univariate analysis for the association of equine Strongylosis in 384 animals with potential risk factors using Chi square ($\chi 2$) test.

A. Sex:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.766[a]	1	.000
Likelihood Ratio	21.933	1	.000
Linear-by-Linear Association	23.704	1	.000
N of Valid Cases	384		

B. Age:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.842[a]	1	.002
Likelihood Ratio	8.873	1	.003
Linear-by-Linear Association	9.816	1	.002
N of Valid Cases	384		

C. Species:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.048E2[a]	1	.000
Likelihood Ratio	100.788	1	.000
Linear-by-Linear Association	104.537	1	.000
N of Valid Cases	384		

D. Body condition:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.154[a]	1	.076
Likelihood Ratio	2.985	1	.084
Linear-by-Linear Association	3.146	1	.076
N of Valid Cases	384		

E. Housing

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	37.946[a]	1	.000
Likelihood Ratio	34.640	1	.000
Linear-by-Linear Association	37.848	1	.000
N of Valid Cases	384		

F. Hygiene:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	50.491[a]	1	.000
Likelihood Ratio	50.979	1	.000
Fisher's Exact Test			
Linear-by-Linear Association	50.360	1	.000
N of Valid Cases	384		

G. Feeding:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	44.682[a]	1	.000
Likelihood Ratio	40.873	1	.000
Linear-by-Linear Association	44.566	1	.000
N of Valid Cases	384		

H. Previous history of the disease:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	61.515[a]	1	.000
Likelihood Ratio	57.078	1	.000
Linear-by-Linear Association	61.355	1	.000
N of Valid Cases[b]	384		

I. Usage animal:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.128E2[a]	2	.000
Likelihood Ratio	122.130	2	.000
Linear-by-Linear Association	1.208	1	.272
N of Valid Cases	384		

J. Deworming:

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	86.122[a]	1	.000
Likelihood Ratio	121.612	1	.000
Linear-by-Linear Association	85.898	1	.000
N of Valid Cases	384		

K. Location

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	43.115[a]	2	.000
Likelihood Ratio	46.755	2	.000
Linear-by-Linear Association	42.691	1	.000
N of Valid Cases	384		