EQUINE COLIC, KNOWLEDGE AND PRACTICES OF HORSE HANDLERS IN THREE LOCAL GOVERNMENT AREAS IN KADUNA STATE, NIGERIA

BY

EMMANUEL RICHARD EDEH

DEPARTMENT OF VETERINARY MEDICINE,
FACULTY OF VETERINARY MEDICINE,
AHMADU BELLO UNIVERSITY,
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BY

Emmanuel Richard EDEH DVM (ABU) 2011
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DEPARTMENT OF VETERINARY MEDICINE,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA

SEPTEMBER, 2018

DECLARATION

I declare that the work in this Dissertationentitled **"Equine Colic, Knowledge and Practices of Horse Handlers in Three Local Governments in Kaduna State, Nigeria"**has been performed by me in the Department of Veterinary Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University Zaria under the supervision of Professor L.B. Tekdek and Dr. S.N.A. Sa'idu. The information derived from the literature is duly acknowledged in the text and a list of references provided. No part of this dissertation has been presented for another degree or diploma at this or any other institution.

Emmanuel Richard EDEH ---------- ----------
Signature Date

CERTIFICATION

This Dissertationentitled, **"Equine Colic, Knowledge and Practices of HorseHandlers in Three Local Governments in Kaduna State, Nigeria"**by Emmanuel Richard EDEH, meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

Prof. L.B. Tekdek ---------- ----------
Chairman, Supervisory Committee Signature Date

Dr. S.N.A. Sa'idu ---------- ----------
Member, Supervisor Committee Signature Date

Prof. P.A. Abdu ---------- ----------
Head, Department of Veterinary Signature Date
Medicine, Ahmadu Bello University,
Zaria.

Prof. S.Z.Abubakar ---------- ----------
Dean, School of Postgraduate Studies, Signature Date
Ahmadu Bello University, Zaria.

DEDICATION

This dissertation is dedicated to Almighty God for grace and perseverance to complete this study.

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ABSTRACT

Cases of colic in horses experienced by field Veterinarians and Veterinary clinics have not been documented in the study area. A purposeful study was carried out in three Local Government Areas (LGAs) namelyIgabi, Sabon Gari and Zaria LGAs of Kaduna State, Nigeria for the documentation of such cases. Convenience sampling was used to select the stables and a Veterinary Clinic with adequate records for the purpose of the study. A 5-year retrospective study and1-year prospective study were carried out in the study area to determine the occurrence of colic in horses. Structured questionnaires were used to obtain information on the causes and recognition of clinical signs of colic, diagnostic methods employed, management practices and predisposing factors for colic from the horse owners, grooms, trainers, managers and attending veterinary personnel. The knowledgeand practices of these horse handlers were assessed using both open-ended and close-ended structured questionnaires. A 5-year review of equine medical treatment records from a Veterinary clinic and 36 selected stables was done for the retrospective study, while a 1-year prospective study was conducted in the same study area. An overall colic occurrence of 17.2% was recorded in the stables and a Veterinary Clinic. The clinical signs of colic described by horse handlers included frequent attempts to lie down and pawing (37.5%), lateral recumbency, flank watching, rolling with bruises on parts of the body (18.3%), lateral recumbency, flank watching and sweating (13.3%), kicking and biting at the abdomen (11.8%), Flehmen's response, blowing and sweating (10%), standing stretched out as if to urinate (5.8%), and diarrhoea (3.3%).In the retrospective study with 1540 horses involved, there was no association (χ^2 = 8.173; df =4; P = 0.085) between the occurrence of colic and age. There was an association (χ^2 = 7.079; df =2; P = 0.029)

between the occurrence of colic and sex.There was an association (χ^2 = 10.771; df = 3; P = 0.013) between the occurrence of colic and breed.There was an association (χ^2 = 16.115; df = 3; P = 0.001) between the occurrence of colic and use, whereas, in the prospective study with 311 horses involved, there was an association (χ^2 = 10.600; df =4; P = 0.031) between the occurrence of colic and age.There was no association (χ^2 = 1.665; df = 2; P = 0.435) between the occurrence of colic and sex.There was no association (χ^2 = 3.792; df =2; P = 0.150) between the occurrence of colic and breed.There was no association (χ^2 = 2.656; df =4; P = 0.448) between the occurrence of colic and use. Sudden changes in hay (χ^2 = 43.623; df = 1; P = 0.000), concentrates (χ^2 = 39.079; df = 1; P = 0.000) and the use of drugs in herd management (χ^2 = 122.555; df = 1; P = 0.000), were identified as causes of colic. Common diagnostic approaches employed by Veterinary personnel included the use of history and physical examination without rectal palpation (77.3%); history, physical examination with rectal palpation (9.1%);history, physical examinationwith rectal palpation and post-mortem examination (13.6%). Spasmodic/simple colic (91.5%) was the common type of colic encountered. Antispasmodics (40.9%) and non-steroidal anti-inflammatory drugs (27.3%)were commonly used to treat most cases of colic. Predisposing factors observed for the occurrence of colic in horses in the study area included management practices (χ^2 = 32.629; df = 3; P = 0.000) and dental health care (χ^2 = 9.903; df = 1; P = 0.002). The study concluded that the occurrence of colic in horses is common in the study area and various causes were identified which were change in hay and concentrate fed, the use of drugs such as albendazole, ivermectin and imidocarb. It is recommended that sudden changes in feed be avoided and regular feeding schedules be

maintained. Also, horse keepers are advised to consult with more experienced veterinarians before the use of drugs in the treatment of horses.

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LIST OF ABBREVIATIONS

$	Dollars
%	per cent
´	Minute
´´	second
°	Degree
ADRs	Adverse Drug reactions
ATP	Adenosine triphosphate
B.C.	Before Christ
CBC	Complete blood count
cm	Centimetre
CNS	Central nervous system
COX-1/2	Cyclooxygenase 1 or 2
CV	Cardiovascular
DH	Diaphragmatic hernia
DSS	Dioctyl Sodium Sulfosuccinate
EDTA	Ethylene diamine tetraacetic acid
EFE	Epiploic foramen hernia
EGS	Equine Grass Sickness
EGUS	Equine gastric ulcer syndrome
FLASH	Fast localised abdominal sonography of horses
GIT	Gastrointestinal tract
IR	Ischemia-reperfusion
km^2	square kilometre
L	Liter
LC	Large colon
LDDLC	Left dorsal displacement of the large colon
LGAs	Local Government Areas
mm	millilitre
NSAIDs	Non-steroidal anti-inflammatory drugs

oz.	ounce
PCV	Packed Cell Volume
PDJ	Proximal enteritis/anterior enteritis or duodenitis-proximal jejunitis
PM	Post-mortem examination
RDC	Right dorsal colitis/Right dorsal colon
RDDLC	Right dorsal displacement of the large colon
ROS	Reactive oxygen species
SCOD	Simple colonic obstruction and distension
SI	Small intestine
SPSS	Statistical Package for Social Sciences
U.S.A.	United States of America
U.K.	United Kingdom
WBC	White Blood Cells
α-2	alpha-2
<	less than
>	more than
h	hour
γ	gamma

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

The lives of humans and horses have been bound together for thousands of yours (Draper *et al.*, 2014). The population of horses in Nigeria is estimated to be 214,000 (FAOSTAT, 2014). Different breeds of horses have been reported to be kept in Kaduna State and they include exotic horses such as the Argentine Polo ponies, the South African, while the local breeds include the West African Barbs, the Sudanese country breed and the West African Dongola (Garba, 2006). The horse has functioned as man's inseparable and indispensable companion throughout classical antiquity (White, 2012). The partnership between horse and master in antiquity rested on many factors; perhaps the most important being that the horse provided man with his quickest means of overland movement (White, 2012).

Indigenous horses have been used by institutional and private owners in Nigeria for pleasure riding, polo, racing, ceremonies, entertainment and research (Useh *et al.*, 2005; Ehizibolo *et al.*, 2011). Horses are associated with sports, royalty and some special traditional festivals in the Northern part of Nigeria (Bukar *et al.*, 2007). These uses have encouraged horse owners to import exotic breeds to overcome the limitations of the available local breeds (Saror, 1976). Indigenous horses inNigeria have beendescribed as members of a group of horses collectively referred to as the West African Dongola or West African Barb(Hendricks, 2007). Horses of this classification are often called "degenerate Barbs" and are believed to have an admixture of Barb

blood. ‘The Barb’, is horse of the Berbers, the ancient inhabitants of North Africa, who were involved in the conquest of the world in 211 B.C. (Dixon, 2014).

Colic is a term used to describe abdominal pain in the horse. However, there are many causes of colic, some of which may be mild whilst others can be life threatening (Proudman, 1992; Hillyer *et al.*, 2002; Little and Blikslager, 2002).Colichas resulted in the death of horses throughout recorded history (Adeyefa, 1990). In fact, today it is the number one cause of equine death and second only to lameness in terms of economic losses (Cohen and Woods, 1999; Hillyer *et al.*, 2001a). It is one of the most difficult diseases to study since there are several aetiologies to it (White, 2006). Out of every 100 horses in a population, four to ten cases of colic can be expected per year (Kaneene *et al.*, 1997; Tinker *et al.*, 1997). The incidence of colic has been reported to range from 3.5 to 26% in different countries (Uhlinger, 1992; Kaneene *et al.*, 1997; Tinker *et al.*, 1997; Hillyer *et al.*, 2001a; Traub-Dargatz *et al.*, 2001; Akinrinmadeand Olusa, 2009). Predisposing factors for colic include age, breed, diet and feeding practices, weather, exercises and previous history of colic (Traub-Dargatz *et al.*, 1991; Hillyer *et al.*, 2001b; Hudson *et al.*, 2001; Olusa and Akinrinmade, 2014).

Between 10-15% of colic cases happen in horses that have had clinical signs of colic before, with some horses having two to four episodes per year (White, 2006). Fortunately, the majority of colic cases (80-85%) are termed “simple colic” or “ileus” because no specific diagnosis is identified, and the cases mostly resolve spontaneously or respond to medical treatment (Tinker *et al.*, 1997; Mair*et al.*, 1999;White, 2006). Despite advances in the management of acute intestinal lesions in horses, recurrent or chronic types of colic remain a management challenge (Freeman, 2010). The distinction between chronic and recurrent colic is often difficult (Freeman, 2010). Chronic colic is

usually defined as colic signs observed daily over a period of days or longer (Freeman, 2010). Recurrent colic, on the other hand, is colic that has 3 or more episodes of transient colic or of prolonged colic over periods of one month to one year or more (Freeman, 2010).

Since colic has been studied only as a natural disease, determining the aetiologies of different diseases that cause colic is problematic (White, 2006). Determination of risk factors for specific types of colic may identify the causes and help to decrease disease incidence by reducing exposure to an incriminated risk (White, 2006).Colic risk is defined as the odds that colic incidence will increase in a group of horses exposed to a particular factor compared to the colic incidence in a group that is not exposed to that factor (Tinker *et al*., 1997; White, 2006). Horses that have had previous episode of colic are 3 times more likely to have a second colic episode compared to a horse that has never had one (Tinker *et al*., 1997). Colic risk may also be categorized into internal and external risks (Radostits *et al*., 2006). Breed or enlarged inguinal rings are examples of an internal risk, while diet and housing are considered external risks (Boden, 2005; White, 2006).

1.2 Statement of Research Problems

Horses are kept in Nigeria for a variety of purposes (Garba, 2006; Bukar *et al*., 2007). Equine diseases are rarely reported in Nigeria (Mshelia *et al*., 2010; 2012). The incidence of specific intestinal diseases causing colic in the general equine population in Nigeria is not known (Akinrinmade andOlusa, 2009;Olusa and Akinrinmade, 2014). Simple and impaction colic were found to be the most common reasons for abdominal pain in horses presented to Veterinary Teaching Hospitals or practices (White, 2006).

Currently, there is an increasing interest in equestrian activities such as polo, racing, leisure, traditional uses (Ehizibolo *et al.*, 2011) and military events (Umar *et al.*, 2013) in Nigeria. Presently, the field situation of equine colic in Nigeria cannot be said to be completely known either and the clinical manifestations may not be entirely missed but the diagnosis is often missed particularly in mild cases, due to unawareness among owners, handlers, trainers and Veterinary clinicians because of its broad spectrum of clinical presentations, often mimicking other infectious diseases (Olusa and Akinrinmade, 2014). Thus, there is the need to investigate the causes of colic and its predisposing factors, the knowledge and practices of horse handlers. Also, the clinical signs of colic, the diagnostic procedures used for colic cases, and the conventional and traditional treatment methods used by veterinary personnel and horse handlers.

1.3 Justification of the Study

Horses have a tremendous socioeconomic value in Nigeria, particularly in the Northern part where they are used for polo, racing, traditional ceremonies, and even sugar milling functions (Bukar *et al.*, 2007; Mshelia *et al.*, 2012; Umar *et al.*, 2013). Adeyefa (1990) reported a retrospective study of colic over a 10-year period in Ibadan. Similarly, Akinrinmade and Olusa (2009) reported the incidence, diagnosis and management of colic in polo horses in Lagos,while Mayaki (2017) reported that colic was one amongst the prevailing equine clinical conditions handled as per cases in the Veterinary Teaching Hospital in Sokoto.Previously, Zaria was reported to be a national and international centre of attraction for durbar, polo and racing activities (RIM, 1992). Economically, the equine population contributes little to the community except the key role in traditional, pleasure and equitation activities (Bukar *et al.*, 2007; Umar *et al.*,

2013).However,economic benefits are particularly high in polo and racing for which horses are now being imported fromArgentina and South Africa (Mshelia *et al.*, 2012).

Several health problems such as equine piroplasmosis, equine influenza, African horse sickness, tetanus, epizootic lymphangitis, ulcerative lymphangitis and colic, in particular have been reported to cause severe socio-economic losses to horse owners in Nigeria (Mshelia *et al.*, 2010; Mshelia, 2013; Musa, 2013; Mayaki, 2017). Colic is responsible for more deaths in horses than any other disease (Traub-Dargatz *et al.*, 2001; Mshelia *et al.*, 2012). In the normal farm population, horse mortality from all types of colic was 0.7 deaths per 100 horse-years, with a colic case fatality rate of 6.7% (Tinker *et al.*, 1997). With the seeming paucity of information on equine colic in Nigeria (Olusa and Akinrinmade, 2014), there is a need to investigate the causes, predisposing factors, knowledge and practices of horse handlers with respect to colic so as to document the status of the condition in the study area. This is to provide the necessaryinformationon clinical signs, diagnosis and treatment in order to ensure a healthy horse population and to provide the necessary services as expected of them.

1.4 Aim of the Study

The study was aimed at determining the occurrence of colic in horses using retrospective and prospective studies, and associated predisposing factors, diagnostic procedures, treatment, knowledge and practices of horse handlers in selected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria.

1.5 Objectives of the Study

The objectives of this study were to determine:

1. The retrospective and prospective occurrence, causes and clinical signs of colic in selected stables in three Local Government Areas (LGAs) ofKaduna State, Nigeria.
2. To identify associated predisposing factors for colic in horses inselected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria.
3. To identify the diagnostic methods and management practices used by veterinarians and handlers for such cases inselected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria.
4. To determine the knowledge and practices of horse handlers with respect to colic in horses inselected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria.

1.6 Research Questions

1. What are the retrospective and prospective occurrence, causes and clinical signs of colic in horses inselected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria?
2. What are the possible predisposing factors for colic in horses in selected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria?
3. What are the diagnostic methods and management practices used for colic in horsesinselected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria?
4. What are the knowledge and practices of horse handlers on colic in selected stables in three Local Government Areas (LGAs) of Kaduna State, Nigeria?

CHAPTER TWO
2.0 LITERATURE REVIEW

2.1 Introduction

Acute abdominal pain in the horse, often referred to as colic, is one of the most common medical emergencies horse owners have to deal with, and is one of the most frequent emergency conditions encountered in practice (Traub-Dargatz *etal.*, 2001; Edwards, 2013; Bowden *et al.*, 2014; Valberg, 2015). Colic has been recorded throughout history as a frequent and important cause of death in horses (Irelan*det al.*, 2011; Wormstrand *et al.*, 2014). Colicsimply indicates that the horsehas pain, usually associated with its abdomen and is related to its gastrointestinal tract (Mair *et al.*, 1999; Dukti and White, 2009; Edwards, 2013; Valberg, 2015), and is second only to old age as a killer of horses (White, 2006). It is not a specific disease but a lot of symptomsthat presentchallenges for differential diagnosis (Radostits *et al.*, 2006; Dukti and White, 2009). Losses caused by equine colic are almost entirely due to death of these animals, and is estimated to cost the horse industry in the United States of America (U.S.A.) approximately $144 million annually (White, 2006). However, the cost of treatment and the emotional trauma to the horse owners are important considerations (Baher *et al.*, 2014).

2.2 Aetiology of Colic

Proposed aetiologies of equine colic mostly reflect management factors which include rapid changes in diet (from oats to corns), overfeeding of grain, poor-quality forage and inadequate water supply (White and Lessard, 1986;Traub-Dargatz *etal.*, 1990; Cohen and Peloso, 1996). Others include the presence of irritants and/or foreign objects that

can be ingested, medications that affect intestinal motility, irregular work, fatigue, drinking excessively after work, stormy weather, increased temperatures, idiosyncrasy, and faulty mastication (White, 2007; Olusa and Akinrinmade, 2009; 2014). Dietary factors, including the feeding of concentrates or poor quality roughage, are considered primary causes of colic (Archer and Proudman, 2006; White, 2006). Over 70 causes of colic have been identified in the horse (Ethell *etal.*, 2000).

2.3 Epidemiology of Colic

Colic is one of the most difficult conditions to study using epidemiologic methods due to the large number of diseases that can cause it (White, 2006). Most studies of the epidemiology of colic do not provide details of specific diseases but rather consider colic as one condition (Radostits *et al.*, 2006). Important information about the incidence, mortality, and risk factors for colic, has been provided through epidemiology (White, 2006). This inclusion of many diseases into one category, while maximizing the statistical power of the studies, is unfortunate because it obscures important details regarding the occurrence and risk factors of individual diseases. Furthermore, much of the information related to the incidence, treatment and outcome of horses with colic is derived from studies of horses examined at referral centers (Traub-Dargatz *etal.*, 2001; Radostits *etal.*, 2006).Out of 100 horses in the general population, 4 to 11 cases of colic are expected during 1 year (Kaneene *et al.*, 1997; Tinker *et al.*, 1997; Hillyer *et al.*, 2001a; UC Davis, 2008). The annual number of colic cases, however, may vary greatly between farms, ranging from 0 to 25 or 30 cases per 100 horses (Hillyer *etal.*, 2001a; Traub-Dargatz *etal.*, 2001). Approximately 10 to 15% of colic cases occur in horses that have experienced previous episodes of abdominal pain, with 2 to 4 colic episodes

per year for some horses (Tinker *etal.*, 1997). The true incidence of specific intestinal diseases causing colic in the general equine population is not known (White, 2006). Eighty to eighty-five per cent of colic cases can be designated as simple colic or *ileus* because no specific diagnosis is identified; and most horses respond to medical treatment or resolve spontaneously (Tinker *etal.*, 1997).Studies on horses with colic presented to veterinary practices were reported to have a predominance of simple obstruction or spasmodic colic, with impactions diagnosed in approximately 10% of affected horses (Proudman, 1992). Similarly, in one cohortstudy, approximately 30% of horses with colic were identified by owners but never examined by a veterinarian because the colic was transient or resolved with treatment by the owner (Tinker *etal.*, 1997).

2.4 PathophysiologyofEquineColic

2.4.1 Pathophysiology of intestinal obstruction

Any interference, mechanical or functional, with the progression of intestinal contents constitutes an obstruction (Gelberg, 2012; Edwards, 2013). The obstruction is said to be simple when the obstructive process is not complicated initially by vascular compromise of the bowel (White, 2007; UC Davis, 2008). In strangulating obstruction there is obstruction to both the blood supply and the lumen of the intestine (Freeman, 2011a). Obstructions due to intravascular occlusion of the blood supply, frequently associated with *Strongylus vulgaris* larvae in the cranial mesenteric artery or its branches are described as non-strangulating infarction (Edwards, 2013). The various mechanisms involved in the equine acute abdomen include:

2.4.1.1 Simple obstruction

This is characterized by a physical obstruction of the intestinal lumen, usually due to intraluminal blockage from dehydrated food mass, or from extraluminal pressure from adhesions, stricture formation, or foreign bodies (Roussel *etal.*, 2001; Cohen *etal.*, 2004; Lopes, 2009). The primary pathophysiological abnormality caused by this obstruction is related to the trapping of fluid within the intestine anterior/cranial to the obstruction (Mair *etal.*, 1999), mostly in the upper gastrointestinal tract, where the fluid is sequestered and/or loss by nasogastric reflux (Edwards, 2013). The intestine becomes distended due to the trapped fluid and gas production from bacteria (Mair *etal.*, 1999), and subsequent activation of stretch receptors within the intestinal wall leads to the associated pain (Radostits *etal.*, 2006). This initial problem of fluid loss from circulation results in decreased plasma volume, leading to a reduced cardiac output, and acid-base disturbances (Zimmel, 2003). Impairedblood supply leads to hyperaemia and congestion, and ultimately to ischaemic necrosis and cellular death (Edwards, 2013), which subsequently affects the vascular endothelium, leading to an increased permeability initially leaking plasma and eventually blood into the intestinal lumen (Jones and Blikslager, 2004). Similarly, gram-negative bacteria and endotoxins can enter the bloodstream, leading to further systemic effects (Hanson, 1999).

2.4.1.2 Strangulatingobstruction

Strangulating obstructions have similar pathological features as a simple obstruction, except that the blood supply is immediately affected (Laws and Freeman, 1995; Blikslager *et al.*, 1997; Moore, 1997; Gelberg, 2012). The lesion that develops during strangulation is often severe, leaving little viable bowel for further injury during reperfusion (Blikslager *etal.*, 1997). Common causes of strangulating obstruction are

intussusceptions, torsion or volvulus, and displacement of intestine through an opening such as a hernia, a mesenteric rent, or the epiploic foramen (Gelberg, 2012).

2.4.1.3 Non-strangulating infarction

Non-strangulating infarction results following cranial mesenteric arteritis caused by migration of *Strongylus vulgaris* and has become a rare disorder since the advent of broad spectrum anthelminthics (Rolfe, 2008).Any segment of the intestine supplied by the cranial mesenteric artery or one of its major branches may be affected, but the distal small intestine and large colon are more commonly involved (Blikslager and Jones, 2004).

2.4.1.4 Inflammation or ulceration of the gastrointestinal tract

Gastrointestinal conditions induced by non-steroidal anti-inflammatory drugs (NSAIDs) are manifested by mucosal ulceration, inflammation, bleeding, and protein-losing enteropathy (Meschter *et al.*, 1990; Hough *et al.*, 1999).Breaching of the mucosal barrier by invading pathogens or irritants/toxicants generates soluble and neural signals that initiate inflammatory responses (Kagnoff and Eckmann, 1997). Inflammatory response of the gastrointestinal tract (GIT) is a mechanism aimed at eliminating pathogens, initiating tissue repair, and restoring the gastrointestinal barrier (Jones, 2004). Thus, if the inciting stimulus is not eliminated quickly, the inflammatory response itself causes significant tissue injury (Kagnoff and Eckmann, 1997). Inflammation of the bowel may lead to increased permeability and subsequent endotoxemia due to peritonitis (Lohmann and Barton, 2004). Permeability of the intestinal mucosal barrier frequently increases in cases of acute gastrointestinal disease (Barton and Collatos, 1999).

Erosions or ulcerations of the mucosal surface occurs very commonly in the stomach (gastroduodenal ulceration), due to damage from stomach acid or alteration in protective mechanisms of the stomach, where such erosions and ulcers can occur along any part of the GIT normally exposed to acid (Mertz and Walsh, 1991). Hough *et al.* (1999) reported that horses with large intestinal disease resulting from NSAID toxicity generally received inappropriately large doses of the NSAIDs. The right dorsal colon (RDC) may also develop ulceration, usually secondary to excessive NSAID use, which alters the homeostatic balance of prostaglandins that protect the mucosa (Blikslager and Roberts, 1998). Moreover, signs of NSAID toxicity have been reported in horses treated with appropriate doses of phenylbutazone (Cohen *et al.*, 1995a).

2.4.1.5 Ischemia-reperfusion (IR) injury

Tissue injury and/or tissue death occur as a result of the initial ischemic insult, which is determined primarily by the magnitude and duration of the interruption in the blood supply, and then subsequent damage induced by reperfusion (Parks and Granger, 1986). During prolonged ischemia, adenosine triphosphate (ATP) levels and intracellular pH decrease as a result of anaerobic metabolism and lactate accumulation (Sanada *et al.*, 2011). As a consequence, ATPase-dependent ion transport mechanisms become dysfunctional, contributing to increased intracellular and mitochondrial calcium levels (calcium overload), cell swelling and rupture, and cell death by necrotic, necroptotic, apoptotic, and autophagic mechanisms (Zhao *et al.*, 2000). Although oxygen levels are restored upon reperfusion, a surge in the generation of reactive oxygen species occurs and proinflammatory neutrophils infiltrate ischemic tissues to exacerbate ischemic injury (Yellon and Hausenloy, 2007). The pathologic events induced by IR orchestrate the opening of the mitochondrial permeability transition pore, which appears to

represent a common end-effector of the pathologic events initiated by IR (Yellon and Hausenloy, 2007).Reactive oxygen species (ROS) and reactive nitrogen species have been associated with injurious effects to the intestines during reperfusion (Moore *et al*., 1994; 1995).Studies in horses have documented deleterious effects of IR injury (Henninger *et al*., 1992; Darien *et al*., 1995; Vatistas *et al*., 1998).However, the pathogenesis of IR injury is incompletely understood (O'Donnell and Nabel, 2011; Wong *et al*., 2012).

Wong *etal*. (2012) concluded thus, that the vast majority of mucosal injury associated with ischemia occurs during reperfusion of ischemic intestine and not during the ischemic period. Multiple equine studies have also demonstrated a similar progression of intestinal injury during IR (Horne *etal*., 1994; Vatistas *etal*., 1996; Kooreman *etal*., 1998; Vatistas *etal*., 1998).

2.5 Types of Colic

Colic is a clinical term known to horsemen, for the simple reason that horses are highly susceptible to colic, and the clinical signs of colic can be quite spectacular and even frightening (Ducatelle, 2013). Colic is a broad term, covering all clinical signs associated with any form of pain in the abdominal cavity of horses (Abutarbush *et al*., 2005), and can be caused by many different agents. There are many types of colic along with their causes and predisposing factors (Ethell *et al*., 2000; Keen and Coates-Markle, 2005;DVEP, 2015). Several classification systems of equine colic have been described including a disease-based system classifying the causes of colic as obstructive, obstructive and strangulating, non-strangulating infarctive, and inflammatory (peritonitis, enteritis) (Radostits *et al*., 2006; UC Davis, 2008). Colic cases can also be

classified on the basis of the duration of the condition as being: acute (< 24-36 h), chronic (> 24-36 h) and recurrent (multiple episodes separated by periods of > 2 days of normality). Another classification system is anatomically based, which describes cases involving specific organs (Radostits *etal.*, 2006). Based on severity, colic can be classified on the basis of behavioural manifestation exhibited as mild, moderate or severe (Cohen*et al.*, 1995b; Taylor*et al.*, 2010). Regardless of the classification system used, some estimates are that fewer than 20% of colic cases seen in the field have a definitive diagnosis (Kaneene *etal.*, 1997; Tinker *etal.*, 1997).

Different parts of the gastrointestinal tract can be affected and symptoms vary following the affected organ, the type and the severity of the colic (White and Lessard, 1986). This list of the types of colic is not exhaustive, but details of some of the types which may be encountered are hereby enumerated (Table 2.1).

Table 2.1: Types and causes of equine colic

S/no.	Type of colic	Description	Reference
1.	Gas (tympanic) colic	(i.) Gas build-up due to excessive fermentation of ingesta in the intestine or a decreased ability to move gas through, secondary to physical obstruction of the large intestine and they can also occur sporadically.	Zimmel (2003); Radostits *et al.* (2006); Rolfe (2008)
		(ii.) Change in diet, feeding rapidly fermentable feeds, low dietary roughage levels, parasites and anthelminthic administration	Cohen (2003a)
2.	Colic caused by Impactions	(a.) Large colon (pelvic flexure) impaction	
		- Ingesta impaction of the large colon occurs at sites of anatomical reductions in luminal diameter - Particularly the pelvic flexure of the left colon and the right dorsal colon	Dabareiner and White (1997); Ethell *et al.* (2000)
		(b.) Ileal impaction	
		- Causes are unknown - Feeding horses hay with high-fiber content has been associated with ileal impaction in the U.S.A.	Hanson *et al.* (1996); Parks and Allen (1998)
		(c.) Sand impaction	
		- As horses naturally graze, sand can be ingested in well-managed individuals	Husted *et al.* (2005)
		- Horses fed off the ground on sandy soil or heavily grazed pastures ingest some sand by extrapolation	Ragle *et al.* (1989); Husted *et al.* (2005); Kendall *et al.* (2008); Rood and Tebeau (2011)

S/no.	Type of colic	Description	Reference
2.	Colic caused by Impactions	(d.) Caecal impaction	
		- Not particularly common.	Smith *etal.* (2010)
		- However, progression of caecal impaction to rupture is a potentially life-threatening complication associated with the condition.	Gerard (2007)
		(e.) Gastric impaction	
		- Not a common problem in the horse.	Merritt (2003)
		- Impaction typically caused by rapidly fermenting feeds, coarse feeds (bedding or poor quality roughage), poor dental care, poor mastication, inadequate drinking, and ingestion of a foreign object.	Kellam*et al.* (2000); Sanchez (2004); Blikslager (2005)
		(f.) Small colon impaction	
		- Occurs infrequently	Gerard (2007)
		- Risk factors include age, poor dental care, poor quality hay, lack of water or exercise, parasite damage, and motility problems	Rolfe (2008)
		(g.) Large colon impaction	
		- Occurs infrequently at the pelvic flexure and right dorsal colon, two areas where the lumen narrows from a relatively large tube to a smaller diameter (left ventral colon to pelvic flexure, right dorsal colon to transverse colon)	White and Dabareiner (1997); Ethell *et al.* (2000); Gerard (2007)
		(h.) Enteroliths and fecaliths impaction	
		- Enteroliths are mineralized masses typically composed of magnesium ammonium phosphate (struvite) and collect around a small central nidus, often a metallic foreign body	Blue and Wittkopp (1981); Freeman (2010); Gelberg (2012)

S/no.	Type of colic	Description	Reference
		- They generally lodgeat the pelvic flexure or transverse colon	Lloyd *et al*. (1987); Gyang *et al*. (1988)
		- Other locations where they can obstruct the intestine are usuallythe right dorsal and transverse colon, but rarely in the small colon	Gerard (2007); Smith *et al*. (2010)
		- Fecaliths, are hard formations of ingesta that obstruct the GIT, and may require surgery to resolve	Mshelia *et al.* (2010)
		- Common problem in young horses because of their less discriminating eating habit	McClure *et al*. (1992); Rose and Hodgson (1993)
		- Common causes include ingestion of rope, bailing twine, straw bedding, wood shavings, plastic and feed bags	Blikslager and Jones (2004)
3.	Colic caused by Displacements	(a.) Large colon displacement	
		- Common cause of colic. Classified as left dorsal, right dorsal displacements, and non-strangulating volvulus of the large colon, with other locations seen as well	Rakestraw and Hardy (2006)
		(b.) Left dorsal displacement (neprosplenic or renosplenic entrapment) (LDDLC)	
		- Occurs when the left dorsal and ventral colons migrate lateral to the spleen in a dorsal direction until they become entrapped in the nephrosplenic space	Gelberg (2012)
		(c.) Right dorsal displacement of the large colon (RDDLC)	
		- Occurs when the pelvic flexure and left colons migrate cranially and to the right abdomen until the right colons are located between the caecum and the body wall	Rakestraw and Hardy (2006)

S/no.	Type of colic	Description	Reference
		(d.) Torsion and Volvulus - A volvulus is a twist along the axis of the mesentery, while torsion is a twist along the longitudinal axis of the intestine	Budras*et al*. (2009)
		- Various parts of the horse's gastrointestinal tract may twist upon themselves	Ethell*et al*. (2000); Robinson and Carmalt (2009)
		- Strangulating large colon volvulus (LCV) is one of the most fatal causes of colic in horses	Robertson (1990)
		(e.) Intussusception - Causes unknown, thought to be associated with intestinal irritability and hypermotility	Ethell *et al*. (2000)
4.	Colic caused by Entrapments	(a.) Epiploic foramen entrapment - Intestine may enter the foramen from the visceral surface of the liver toward the right body wall or in the opposite direction	Vachonand Fischer (1995)
		(b.) Mesenteric rent entrapment - When torn, the mesentery may incarcerate a segment of the intestine (typically the small intestine), the gastrosplenic ligament, the broad ligament, and the caecocolic ligament	Becht and McIlwraith (1980); Yovich *et al.* (1985); Gayle *et al*. (2000, 2001); Shoemaker *et al*. (2004)
5.	Colic caused by tumors	(a.) Strangulating pedunculated lipoma - As lipomas grow, it stretches the connective tissue into a stalk which wraps around a segment of bowel, typically small intestine, cutting off its blood supply and causing strangulation	Mair *et al*. (1999); Zimmel (2003); Radostits *et al.* (2006); White (2009); Gelberg (2012)

S/no.	Type of colic	Description	Reference
		(b.) Mural masses and strictures	
		- Mural masses such as abscesses, tumors adenocarcinoma, lymphosarcoma), granulomata and hematomas can cause luminal obstruction and impaction, typically in older horses	Pearson and Waterman (1986)
		- Trauma, ulceration of the mucosa, and parasitic damage are speculated causes of intramural hematomas	Pearson and Waterman (1986)
6.	Colic caused by Ulcerations	(a.) Gastric ulceration	
		- Equine gastric ulcer syndrome (EGUS) describes a number of multifocal or focal ulceration, gastric emptying disorders, and generalized gastritis	Andrews *et al*. (1999); Bertone (2000); Jones (2002); Rabuffo *et al.* (2009)
		- Risk factors for gastric ulceration include confinement, infrequent feedings, a high proportion of concentrate feeds such as grains, excessive non-steroidal anti-inflammatory drug use, and the stress of shipping and showing	Murray and Eichorn (1996); Mitchell (2001); Cohen (2003b); McClure*et al*. (2005); le Jeune *et al.* (2009); Freeman (2010)
		(b.) Right dorsal colitis (RDC)	
		- RDC is an ulcerative syndrome that is associated with non-steroidal anti-inflammatory drug use, most commonly phenylbutazone	Lester (2004)
		(c.) Proximal duodenitis jejunitis (DPJ)	
		- Proximal enteritis (anterior enteritis or duodenitis-proximal jejunitis [DPJ]) is characterized by transmural inflammation, and sometimes overt necrosis of the duodenum and proximal jejunum	McConnico (2004) Proudman (2013)
		- Aetiology, poorly understood	

S/no.	Type of colic	Description	Reference
7.	Ileus	- Ileus is defined as a functional obstruction of the GIT, and is characterized bya loss of coordinated propulsive motility of the stomach and the intestine	Little *et al.* (2001); Ducatelle (2013)
		- Disruption to normal motility occurs commonly in horses for a variety of reasons	Radostits*et al.* (2006)
8.	Herniations	Hernias may be congenital or acquired	Mair *et al.* (1999)
		(a.) Inguinal-scrotal herniation	
		- Common in horses, with the jejunum and ileum being the incarcerated segments in most cases	Mezerova *et al.* (2003; 2008a, b) Schumacher and Perkins (2010)
		- On rare occasion, the large colon is trapped in the inguinal canal or scrotal bag	Ivens *et al.* (2009); Mendoza *et al.* (2010)
		(b.) Umbilical hernia	
		- Congenital umbilical hernias present atbirth are due to failure of the abdominal wall to close. Acquired umbilical hernias develop at 3 – 4 weeks of age	Moorman and Jann (2009);Edwards (2010)
		- More common in fillies than in colts, and may be hereditary	Mair *et al.* (1999)
		(c.) Excessive straining to defecate or micturate, and infection of the umbilicus, may be causative factors	Mair *et al.* (1999)
		(d.) Diaphragmatic hernias (DH)	
		- DH are rare, and may be congenital or acquired, few records of congenital defects in horses	Everett *et al.* (1992); Kaneps (1992)
		- Accidental rupture of diaphragmatic muscles usually occurs from abdominal crushing, following blunt trauma or penetrating injuries of the abdomen and chest	Sabev and Kanakov (2009).

S/no.	Type of colic		Description	Reference
9.	Foal colic	-	Causes of colic in foals include meconium impaction, severe enteritis, umbilical and inguinal hernias, uroabdomen, congenital problems such as aganglionosis and atresia coli and small intestinal intussusception and gastric outflow obstruction	Bohanon (2005); Hardy (2009)
10.	Cold water colic	-	It has been suggested that a 'hot' horse will develop colic and muscle cramps if it drinks a lot of cold water at once, because too rapid cooling, can lead to muscle cramping	Camargo (2011); Loving (2016)
11.	Chronic colic	-	Chronic colic is usually defined as colic signs observed daily for a period of days	Freeman (2011a)
12.	Recurrent colic	-	Episodes of transient colic or of prolonged colic over long periods	Hart and Southwood (2010); Freeman (2011a)

2.6 Clinical Signs of Colic

Clinical signs of colic usually relate to signs of abdominal pain, and can be classified either due to be true colic in the digestive system or false colic outside the digestive system as in the liver, urinary system and others (Keen and Coates-Markle, 2005; Archer and Proudman, 2006; James, 2010; Edwards, 2013; Curtis *et al.*, 2015). Hewetson (2006) defined the clinical sign syndrome as spasms of the digestive system and the major sign being pain which is manifested as pawing, stamping, kicking or rolling. With the severity and frequency of kicking, pawing, sweating, flank watching, attempts to lie down and demeanour being indicators of pain (Mair, 2002; Ashley*et al.*, 2005; Southwood, 2013).

A horse with gastrointestinal pain can behave in a variety of ways that include: in mild pain, occasionally paw the ground, turn its head to its flanks, stretch out or lie down for longer than normal; in moderate pain, pawing, cramping with attempts to lie down, kicking at the abdomen, lying down and attempting to roll or rolling and turning its head to its flank; in severe pain, sweating, dropping to the ground, violent rolling and continuous movement or pawing are the signs usually displayed (UC Davis, 2008; Taylor *et al.*, 2010; Edwards, 2013).

2.7 Risk factors for Equine Colic

Various risk factors associated with colic were identified after a review of several studies (Goncalves *et al.*, 2002). These factors can be categorized as 1) intrinsic horse factors; 2) medical history, and 3) external factors (Goncalves *et al.*, 2002; Radostits *et al.*, 2006).

2.7.1 Intrinsic horse characteristics associated with colic

A variety of intrinsic factors may predispose an individual to increased or decreased risk of suffering from colic, with some types of colic being gender-specific (inguinal herniation in stallions, and uterine torsions in mares), but there is no clear association between gender and colic (Archer and Proudman, 2006).

2.7.1.1 Sex

Blikslager *et al.* (1992) and Edwards and Proudman (1994), reported gelding to be at an increased risk of suffering from associated with pedunculated lipomas, whereas Kaneene *et al.* (1997), reported geldings to be at reduced risk of developing colic of any cause. Conversely, Cohen*et al.* (1999) and Traub-Dargatz *et al.* (2001), found no significant association between gender and incidence of colic. Associations between gender and risk of colic may be confounded by other factors such as use of horse and associated management practices (Archer and Proudman, 2006).

2.7.1.2 Age

Studies of the association between age of a horse and colic also yielded conflicting results. Foals less than 6 months old were found to be at a decreased risk of suffering from colic Traub-Dargatz *et al.* (2001) but certain types of colic such as surgical lesions of the small colon (Reeves*et al.*, 1989), intussusceptions (Cohen, 1997) and ascarid impactions (Southwood *et al.*, 2002) were reportedly more prevalent in this group. Tinker *et al.* (1997) reported an increased risk for colic in horses between 2 to 10 years old. They also noted that there may have been other confounding factors to explain this, or this age group may have been a marker for use of horse, training, exercise or

nutritional factors. Conversely, horses older than 8 years (Cohen and Peloso, 1996), 10 years (Cohen *et al.*, 1999) or horses of increasing age (Reeves *et al.*, 1989; Kaneene *et al.*, 1997) were found to be at an increased risk of suffering from colic. Older horses and ponies have been reported to be at an increased risk of suffering from colic associated with pedunculated lipomas (Blikslager *et al.*, 1992; Edwards and Proudman, 1994). McCarthy *et al.* (2004), reported young horses to be at an increased risk of equine grass sickness (EGS), with horses aged 3 – 5 years been at maximal risk (Doxey *et al.*, 1991).

2.7.1.3 Breed

There were varied associations between the breed of horse and colic in different studies. Tinker *et al.* (1997) and Traub-Dargatz *et al.* (2001) reported Thoroughbreds to be more likely to develop colic. Tinker *et al.* (1997), identified Arab horses to be at reduced risk of colic, whereas, Cohen *et al.* (1995a, 1999), Cohen and Peloso (1996), and Reeves *et al.* (1996) found Arab horses to at significantly increased risk. Kaneene *et al.* (1997), found no association between breed and colic. These findings may represent true breed difference in colic risk or are a consequence of confounding or perhaps referral bias and certain factors may be considered to explain these findings: breed may be confounded by use and related management practices. Specific types of colic are seen more often in certain types of breed of horses such as dorsal displacement in large Warmblood breeds (White, 1997) or small colon impactions in ponies, Arab and American miniature horses (Dart *et al.*, 1997). Enterolithiasis is particularly prevalent in certain breeds such as Arab horses and Morgans, making genetic predisposition a possibility (Cohen *et al.*, 2000; Hassle, 2004).

2.7.1.4 Other intrinsic factors

Horses that exhibit crib-biting/windsucking behaviour have been identified to be at significantly increased risk of suffering from simple colonic obstruction and distension (SCOD) colic(Hillyer *et al.*, 2002), and epiploic foramen entrapment (EPE) in two hospital populations (Archer *et al.*, 2004). Though, crib-biting/windsucking behaviour may not play a direct role in the aetiology of this type of colic, it may be an indicator of management practices, temperament or other factors that predispose to colic (Archer *et al.*, 2004). The size of a horse might also be an influencing factor. In a study describing the affected organs for the different types of colic, large breeds were seen to be prone to dorsal displacement of the large colon. The intrinsic factors of Hanoverian horses of having large nephrosplenic spaces predispose them to nephrosplenic entrapment (White, 1990). The impaction of the small colon appears to be more frequent in ponies (Cohen, 1997). In a case-control study conducted on 800 equids, temperament, and especially irritability and excitability appeared to be risk factors (Reeves *et al.*, 1996).

2.7.2 Medical history

Horses with a history of colic have been identified to be at an increased risk of suffering from further episodes (Cohen*et al.*, 1995a, 1999; Reeves *et al.*, 1996; Tinker *et al.*, 1997). In a study by Traub-Dargatz*et al.* (2001), 43.5% of horses suffering from colic were reported to have had colic previously, 11% of these within 1 year of the colic event. Horses that had previously suffered from colic have also been significantly associated with SCOD colic (Hillyer *et al.*, 2002). Individuals with a history of recurrent colic and previous identification of enteroliths in the faeces are indicators of that such individual may be at increased risk of suffering an obstruction due to

enterolithiasis and are candidates for implementation of preventative measures (Hassel*et al.*, 1999; 2001). Studies conducted by Cohen*et al.* (1995a, 1999), on cases and controls, showed that the risk is even greater if the horse had an abdominal surgery history: a risk about five times greater than a horse with no history of surgery. Medical treatment or vaccination increases the risk for colic due to stress, especially if they have an effect on intestinal motility (Proudman, 1992; Kaneene *et al.*, 1997). On the contrary, no significant association was shown between recent vaccination and colic (Cohen *et al.*, 1999). In a recent study, relation was found between dental disorders or the lack of dental care and colic (Akinrinmade and Olusa 2009; Olusa and Akinrinmade, 2014). However, the mortality rate is not significantly different between horses suffering from colic for the first time and horses with recurrent colic history (respectively 12% and 17%)(Cohen and Peloso, 1996).

2.7.3 External factors

2.7.3.1 Feeds and feeding practices

Certain feed types and feeding practices have long been identified as causes of colic (Archer and Proudman, 2006). Horses are fed two main types of feed: forages and concentrates, and both have been incriminated as risk factors for colic (Goncalves *et al.*, 2002;Archer and Proudman, 2006). Change in diet, specifically changes in the batch, type, or amount of hay and in the type or amount of concentrate, is associated with increased risk of colic (Cohen, 2003b). Diets with an imbalance of roughage to concentrate, feeding certain feedstuffs such as coastal Bermuda grass hay, spoiled feed, young protein-rich grass, coarse poor quality roughage, pelleted feeds, overfeeding, underfeeding and feeding on the ground have previously been implicated but these

findings were anecdotal or based on observations of case populations without any comparable control population (Tinker *et al.*, 1997). A high percentage of fibre has been suggested to favour the impaction of the small intestine by stimulating intestinal motility, resulting in water absorption (Holland *et al.*, 1998).Traub-Dargatz *et al.* (2001) reported no association of colic with types of dried forage or frequency of feeding forage. In contrast, horses with a history of being fed coastal Bermuda grass hay were significantly associated with previous colic and recurrent colic as reported by Cohen and Peloso (1996), and Little and Blikslager (2002), whereas Hudson *et al.*(2001) reported that feeding hay from round bales and hay other than alfalfa, coastal or Bermuda types, were significantly associated with colic. Consequently, hay of poorer quality and low digestibility has been shown to predispose horses to colic (Cohen *et al.*, 1999). However, other studies have shown opposite results, where a decrease in colic was observed when horses only received forages (Tinker *et al.*, 1994, 1997; Cohen *et al.*, 1999).

Evidence associating a specific type or amount of concentrate with colic is conflicting (Cohen *et al.*, 1999; Traub-Dargatz*et al.*, 2001), whereas feeding of more than 2.7 kg of oats/day was significantly associated with colic (Hudson *et al.*, 2001). Thus, the risk of colic is increased with the quantity of concentrate ingested (Tinker *et al.*, 1994); feeding more than 2.5 kg of concentrate per day appears to increase the risk of colic by 4.8%, and more than 5 kg increased it by 6.3% (Tinker *et al.*, 1997).

Feeding whole grain (except corn) was reported to increase the risk of colic (Reeves *et al.*, 1996; Tinker *et al.*, 1997). The arrival of concentrate in the colon causes a decrease

in the luminal pH and modifies the intestinal flora, favouring the production of endotoxins, and these imbalances could explain the observed association of the amount of concentrate with colic (Clarke *et al.*, 1990b; Julliand *et al.*, 2001). Concentrate type, quantity and frequency of feeding do appear to be important in the aetiopathogenesis of colic and requires further investigation (Archer and Proudman, 2006).

A change in the quality or quantity of feed, as well as a change in the time of feeding or in the schedule of feeding results in an increased risk of colic (Proudman, 1992; Cohen *et al.*, 1999; Loving, 2011).Among the changes in the feeding, type of hay remains as the most significant factor (Cohen *et al.*, 1999; Hudson *et al.*, 2001). Several studies demonstrate that change in feeding practices is significantly associated with increased risk of colic(Cohen *et al.*, 1999; Hudson *et al.*, 2001; Hillyer *et al.*, 2002; McCarthy *et al.*, 2004).

2.7.3.2 Internal parasitism

Internal parasites, especially tapeworms and strongyles (*Strongylus vulgaris*) are well-documented causes of colic in the horse due to their multiple actions that include obstruction, traumatic, irritating and toxic actions, resulting in motility disturbances, arteritis, thromboembolism and peritonitis caused by migrating parasites (Love, 1997; White, 1997; Proudman *et al.*, 1998). As a result, pain appears in the digestive system, with modified transit time and altered motility (Love, 1997). Strongyles (*Strongylus* spp.) have been described as one of the causes of colic in horses (Duncan and Pirie, 1972). These parasites could cause non-strangulating colic, but spasmodic colic in most of the cases (White, 1990). The larvae are especially incriminated since they alter the

motility of the small intestine as they migrate in the blood vessels resulting in thromboembolic disorders (Love, 1992; Pugh and Thompson, 1992). The availability of modern anthelmintics has resulted in reports of *S. vulgaris*-associated colic now being rare (Archer and Proudman, 2006), though colic cases due to strongyles still occur (Barrett *et al.*, 2004). More recently, certain strongyle species (mainly *Cyathostomum*), have developed resistance to antelhelminthics, and have been implicated as a cause of colic (Little and Blikslager, 2002). Several studies have identified increased risk of colic associated with recent anthelminthic administration, which can be attributed to rapid destruction of the parasites with consequent obstruction of the intestinal lumen (Reid *et al.*, 1995; Kaneene*et al.*, 1997; Cohen*et al.*, 1999; Southwood*et al.*, 2002, White, 2011).

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2.7.3.3 Management factors associated with colic

A number of management factors have been reported to predispose horses to colic and are discussed below (Cohen, 2003a).

2.7.3.3.1 Housing

Housing conditions seem to influence the risk of colic in horses. For example, horses maintained on pasture all year round are less exposed to colic than those that spend 100% of their time living indoors (Cohen *et al.*, 1999; Hudson *et al.*, 2001). Changes in housing management occur particularly when horses are movedfrom their homes to different locations for events, with a consequent change in feeding practices predispose

them to colic (Cohen *et al.*, 1995a, 1999; Reeves, 1997; Kaneene *et al.*, 1997). A change in housing is often associated with inconsistencies in management practices such as change in feed (Cohen *et al.*, 1997) and a change in activity from which the horse was formerly accustomed to (Cohen *et al.*, 1995a, 1999). Cohen *et al.* (1995a) and Tinker *et al.* (1997) found no association between occurrence of colic and the type of bedding. However, the problem of straw as bedding is well-known by horsemen, where impaction colic often appears just after a change in bedding, particularly if there is no other source of fibre (Loving, 2011).

Mild episodes of colic may be more likely detected in stabled horses compared to those turned out to pasture for long periods oftime as stabled horses may have less opportunity for exercise(Kaneene *et al.*, 1997).Moreover, a relative risk factor of 1.6 was measured for horses stalled more than 50% of the time (Cohen *et al.*, 1999). It has been proposed that confinement, which generates stress and boredom, could increase the risk for chronic colic (Clarke *et al.*, 1990a). Cohen *et al.* (1995a, 1999) reported that a change in stabling within the previous two weeks to be associated with increased risk of colic, although these studies did not examine which particular stabling changes predisposed horses to colic.Hillyer *et al.* (2001b) reported that increased hours spent in the stable was also associated with increased risk of SCOD, particularly in the 14 days following change in housing, and large risk was found in horses stabled between 19 and 24 hours per day.

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arteritis, thromboembolism and peritonitis caused by migrating parasites (Love, 1997; White, 1997).

2.7.3.3.2 Activity

A number of studies have demonstrated that both increases (Hillyer *et al.*, 2001a) and decreases (Cohen *et al.*, 1999) in activity levels may be associated with colic. Associations of a particular activity with colic have been inconsistent (Reeves *et al.*, 1996), but individual studies have associated racing, eventing, showing and breeding with an increased risk of colic (Pugh and Thompson, 1992;Cohen *et al.*, 1999). Changes in activity often occur concomitantly with changes in stabling and diet (Cohen *et al.*, 1999). For example, a horse with a lameness problem might simultaneously have its exercise curtailed, be restricted to a stall, and experience a change in diet (Cohen, 2003b; Loving, 2011). Epidemiologically, this occurrence can make it difficult to separate the effects of activity from those of stabling, diet, or both. Mild episodes of colic may be missed on premises where horses spend most of their time on pasture and are not used for any activities (Kaneene *et al.*, 1997). It has been documented that development or worsening of squamous lesions in the glandular portion of the stomach when horses are in intensive training is due to increased intra-abdominal pressure and subsequent gastric compression pushing acidic content into the squamous lined portion of the stomach. This is as a result of the stomach of the horse being divided into two portions: the glandular and non-glandular portions, with the glandular/squamous lined portion been highly sensitive to changes in pH. Thus, the susceptibility to lesions(Archer and Proudman, 2006). In addition, the duration of acid exposure may be directly related to daily duration of exercise (Lorenzo-Figueras and Merritt, 2002).

Clinically, colic is multifocal, and no single risk factor is likely to completely explain any given episode of the problem (Tinker *et al.*, 1997).

2.7.3.3.3 Access to water

Watering of horses, if not regular, increases the risk of colic and a reduction in watering is caused by several factors such as the absence of a bucket in the stall (Cohen *et al.*, 1999), a limited access to water in paddocks (Reeves *et al.*, 1996), a low water temperature or a lack of water in cold weather (White, 1990; Kaneene *et al.*, 1997). Water deprivation may be associated with increased risk of large colon impaction (White, 1997) and could possibly explain the large increase in the risk of horses suffering from SCOD following transportation (Hillyer *et al.*, 2002). Provision of fresh palatable water is critical in prevention of colic in the horse (Cohen, 2003a).

2.7.3.3.4 Dental prophylaxis

Poor dentition is reported to increase the risk of large colon impaction (White, 1997).Hillyer *et al.* (2002) identified horses that had their teeth checked or treated fewer times per year to be associated with increased risk of SCOD. Cohen *et al.* (1995a) did not identify frequency of dental prophylaxis to be associated with decreased risk of colic, although both cases (horses with colic) and their controls received dental care making this comparison difficult. Olusa and Akinrinmade (2014) reported that some forms of dental abnormalities predisposed horses to colic.

2.7.3.3.5 Premise/owner factor and use of horse

Horses whose owners provide their care have been shown to be at decreased risk of colic or recurrence of colic compared to horses cared for by a non-owner (Reeves *et al.*, 1996; Hillyer *et al.*, 2001a). Owners may provide better health care for their horses or this finding may be related to other factors such as density of horses on the premises or

their exercise level (Cohen, 2003b). A study by Reeves *et al.* (1996) did not find any association between colic and the use of horse. Similarly, Traub-Dargatz *et al.* (2001) also reported no association between the gender of the person making health care decisions on the operations or the relationship of the person implementing health care to the owner of the operation. Horses used for eventing, showing, or horses in training, particularly flat-trained race horses, have been shown to be at an increased risk of colic in some studies (Kaneene *et al.*, 1997;Tinker *et al.*, 1997; Hillyer *et al.*, 2001a). However, in these studies, confounding factors such as age, breed and type of horse, nutrition, exercise and transport were not all taken into account when considering the use of horse as a risk-factor for colic (Archer and Proudman, 2006). The use of horse may be significant for specific types of colic such as strangulating obstructions of the large colon in brood mares (Reeves *et al.*, 1996).

2.7.3.3.6 Climatic conditions

Weather-related factors have been considered by some investigators (Goncalves *et al.*, 2002). The incidence of colic may be seasonal in some horse populations and for specific types of colic (Archer and Proudman, 2006). Proudman (1992) and Hillyer *et al.* (2001a) reported an increased incidence of colic of any type during the months of spring and autumn in the United Kingdom (U.K.). In separate studies conducted over a 12-month period in the U.S.A., Traub-Dargatz *et al.* (2001) reported a higher percentage of colic cases in spring compared to summer or autumn, whereasTinker *et al.* (1997) reported the highest incidence in the months of December, March and August of the study year.

Despite many suggestions that weather-related factors may be associated with the development of colic, there is no statistical proof to this and the precise conditions predisposing to colic remain ill defined (Cohen, 1997; McCarthy *et al.*, 2001;Goncalves *et al.*, 2002). It is important to consider that seasonal incidence of colic may not be associated with weather factors alone but other potentially alterable management factors common to that time of the year such as stabling, the quantity of feed or exercise levels(Hillyer *et al.*, 2001a; Archer *et al.*, 2004).

2.8 Pathology Associated With Colic

The potential value of haematology in equine practice is well documented by numerous case reports and experimental studies (Divers, 2011). The maximal use of haematology is to help with diagnosis and/or prognosis of the ill horse. Evaluation of the haemogramme is essential in assessing the conditions of the gastrointestinal tract (Davis and Jones, 2004). Haematologic alterations associated with diseases of the GIT are often nonspecific, reflecting systemic response to inflammation, dehydration, endotoxaemia, or sepsis (Radostits *etal.*, 2006).Changes in some blood indices such as increased packed cell volume (PCV), and total white blood cells (WBC), and alteration of some biochemical parameters like increased total protein, albumin, glucose and decreased levels of potassium can be observed in equine colic (Nappert and Johnson, 2001; Alsaad and Nori, 2009; 2010; Hassel *etal.*, 2009).The alteration in the biochemical parameters can be attributed to the haemoconcentration and inflammatory responses. Leukopenia, with neutropenia and a left shift, toxic changes in the neutrophil cytoplasm, and lymphopenia occur commonly (Feldman, 1988). During the early stages of endotoxaemia, elevations in circulating concentrations of inflammatory mediators, epinephrine, and cortisol produce characteristic changes in the haemogramme

(Feldman, 1988).Haemoconcentration and hyperfibrinogenemia are common during endotoxaemia (Poskitt and Poskitt, 1985). Thrombocytopenia and other coagulopathies are also features of endotoxaemia (Davis and Jones, 2004). Indeed, thrombocytopenia may be the earliest indicator of sepsis (Poskitt and Poskitt, 1985). Neutrophilic leukocytosis occurs during the later stages of endotoxemia (Duncan *et al.*, 1985).

The most common serum biochemical abnormalities with diseases of the large or small intestine are electrolyte imbalances (Dart *et al.*, 1992). Serum calcium concentrations are often low with strangulating obstructions and acute inflammatory diseases (Dart *et al.*, 1992). Inflammation of the mucosa can disrupt electrolyte fluxes severely (Arden and Stick, 1988). Ischemia and cellular hypoxia in any segment of the intestine cause a shift in energy metabolism to anaerobic glycolysis, resulting in increased production of lactate and elevated serum lactate concentration (Gossett *et al.*, 1987a). Reduced perfusion of peripheral tissues from hypotensive shock and intestinal ischemia can cause elevations in serum lactate. However, obstruction of the intestine during ischemia may result in absorption of lactate from the lumen (Gossett *et al.*, 1987a). Metabolic acidosis may accompany lactic acidemia, but an inconsistent association exists between the two, especially when mixed acid-base imbalances are present (Gossett *et al.*, 1987a; Gossett *etal.*, 1987b). Elevations of hepatic enzymes, specifically γ-glutamyltransferase, may occur with large colon displacements, duodenal strictures, or anterior enteritis.

Relative polycythemia from haemoconcentration or splenic contraction and changes in red blood cell deformability from hypoxia or hypocalcemia may increase blood

viscosity (Andrews *et al.*, 1990). Blood viscosity also increases in patients with acute obstructive disease. Hyperviscosity reduces perfusion of capillary beds, thereby exacerbating ischemia and tissue hypoxia (Andrews *et al.*, 1990). Hyperviscosity is one manifestation (along with lactic acidemia, coagulopathies, and clinical signs of shock) of the pathophysiologic events that take place during acute inflammatory or vascular injury to the large intestine (Davis and Jones, 2004). Gross pathological findings in cases of colic are mostly dependent on the inciting cause and location of the lesion (Radostits *et al.*, 2006; Gelberg, 2012).

2.9 Diagnosis of Colic

The primary evaluation of horses with abdominal pain is usually an emergency consultation on the field, often with limited facilities and financial restrictions (Curtis *etal.*, 2015). Factors such as temperament of the horse and availability and cost of diagnostic equipment may have a significant impact on the diagnostic tests employed and decisions made (Mair *et al.*, 1999; Curtis *et al.*, 2015). The primary aim of the initial examination is to distinguish horses with a mild or uncomplicated disease process from those with a potentially life-threatening disorder requiring further monitoring, surgery or intensive care (Edwards, 2013). In general, a correct diagnosis is necessary to predict a reliable prognosis (Ihler *et al.*, 2004). In colic cases, however, a correct clinical diagnosis of the site and type of the intestinal lesion is often difficult (Blikslager and Roberts, 1995). Thus, a quick and accurate assessment of horses with acute abdominal pain is important for a rapid diagnosis (Fischer, 1997; Beccati *et al.*, 2011). There are several stages to the assessment of any colic patient. Whilst not all stages are completed in every case, each can provide valuable information in the overall

assessment of the horse (James, 2010). Diagnostic approach relating to the first clinical evaluation of cases has limited evidence (Archer, 2004; Southwood and Fehr, 2012). Many diagnostic tests can be used to evaluate horses with abdominal pain, and these vary in their cost, and the facilities and level of expertise required for performing the techniques and interpreting outcomes (Curtis *et al.*, 2015). Though, the current research evaluating diagnostic tests for horses with clinical signs of abdominal pain is focused on referral hospital populations (Curtis *et al.*, 2015).Several diagnostic tests besides clinical examination are available to guide the practitioners' diagnostic approach, but sixdifferent tests are discussed here. These include response to analgesia/treatment on the primary assessment of horses with clinical signs of abdominal pain,rectal examination, nasogastric intubation, abdominocentesis, haematology and biochemistry, and ultrasound examination, with variable reasons and scenarios in which each diagnostic test is used (Taylor *et al.*, 2010; Edwards, 2013; Curtis *et al.*, 2015).

2.9.1 Response to analgesia/treatment on the primary assessment of the patient

For a horse that is actively showing signs of colic, an abbreviated physical examination (heart rate, mucous membrane colour, and capillary refill time) is performed before administering an analgesic, which gives the veterinarian an opportunity to determine whether or not the colic is going to recur within the time it takes to complete the remainder of the examination (Blikslager, 2013). However, if the horse remains comfortable on the first dose of analgesic, and the remainder of the examination is normal or the veterinarian feels comfortable with the abnormal findings (such as a mild impaction), control of further mild or moderate pain to provide greater relief may be all that is necessary. That is if there is some reasonable chance of medical resolution (Blikslager, 2013). Response to analgesics and other base line treatment is important in

evaluating the success of therapy and gauging what alterations need to be made to meet the patient's on-going needs (White, 2006; James, 2010; Freeman, 2011a).

2.9.2 Rectal palpation

Rectal palpation is an integral part of the approach to a horse with colic, and a routine is usually adopted by the clinician for a thorough and systematic examination (Ethell *et al.*, 2000). It is useful in horses with a history of persistent or recurrent colic, chronic weight loss, fever of unknown origin, or chronic diarrhoea (Ethell *et al.*, 2000; White, 2007; Freeman, 2010). A thorough knowledge of the gross anatomical landmarks and familiarity with normal character of the viscera are important for determining the cause of the colic at hand (Slovis, 2015). Thus, rectal examination should be performed in all colic cases, whenever possible, but it must be approached with a respect for its value and the risks involved (Taylor *et al.*, 2010). Only about 25-30% of the abdominal cavity can be assessed with a rectal exam (Mair *et al.*, 1999; Slovis, 2015).

2.9.3 Nasogastric intubation

Rectal palpation gives an indication of anatomical abnormalities of the caudal abdomen while nasogastric intubation gives an indication of the status of the stomach and small intestine (Slovis, 2015). The presence of gastric reflux (fluid from the stomach after introduction of a nasogastric tube) indicates an obstruction of the small intestine, either mechanical or functional, but can accompany a large colon problem (such as, colonic entrapment or displacement) because of a delay in the gastric-colic reflex (Slovis, 2015). The presence of 1 or 2 litres of reflux is considered normal with large amounts indicating a pathological condition (Radostits *et al.*, 2006).

2.9.4 Abdominocentesis

Abdominocentesis ('belly tap') is a procedure that is usually used along other diagnostic tests (physical exam, rectal exam, ultrasonographic evaluation) in horses with chronic pain, normal cardiovascular (CV) status, lack of nasogastric reflux and normal rectal examination. It is not used in all colic cases (Slovis, 2015). It involves collection of peritoneal fluid using a sterile needle or, alternatively, using a sterile bovine teat cannula (Marr, 2008; Taylor *et al.*, 2010). An abdominocentesis can have complications such as an enterocentesis (Slovis, 2015). Changes in the composition of the peritoneal fluid reflect changes occurring at the peritoneal surfaces of organs within the abdominal cavity (Edwards, 2010). The analysis of peritoneal fluid is most useful in monitoring the progression of persistent, intractable colics and identifying peritonitis. It is also indicative of much rarer conditions such as pancreatitis, rupture of the bladder and chyloabdomen (Edwards, 2010).

2.9.5 Haematology

Useful aspects of haematology in the evaluation of alimentary disease are the PCV, indicators of anaemia and the white cell count (Taylor *et al.*, 2010). In chronic conditions the plasma fibrinogen concentration is also of value, although strictly a biochemical parameter, fibrinogen is often estimated (Taylor *et al.*, 2010; Divers, 2011).

2.9.6 Ultrasonography

This diagnostic technique is a valid and useful supplement to other diagnostic procedures when examining a horse with colic (Taintor*et al.*, 2004; Abutarbush, 2006;

Buchanan*et al.*, 2006; Klohnen, 2008).It is a direct, easy to perform, non-invasive method that gives immediate information on the amount of peritoneal fluid, gastric distension and the appearance and motility of the intestine (Scharner *et al.*, 2002; Freeman, 2002a; Jones *etal.*, 2003).Ultrasonography has been demonstrated to be a useful and reliable method for the assessment of normal equine intestinal wall thickness (Freeman, 2002b; Jones *etal.*, 2003; Dechant*etal.*, 2008; Epstein *et al.*, 2008; Bithell *et al.*, 2010), as well as of strangulating obstructions of both the small intestine (SI) (Klohnen *et al.*, 1996; Freeman, 2002a; Klohnen, 2008; Busoni *et al.*, 2011) and large colon (LC) (Pease *et al.*, 2004; Abutarbush 2006), when compared with histological measurements (Freeman, 2011a). Recently, a protocol for fast localised abdominal sonography of horses (FLASH) for the investigation of colic has been suggested as a technique that can be used in an emergency scenario by veterinarians without extensive ultrasound experience (Busoni *et al.*, 2011; Southwood, 2013).

2.10 Management of Colic

Despite the variety and complexities of equine colic, majority of horses, probably in excess of 90%, presenting with colic resolve with simple medical treatment (Tinker *et al.*, 1997a), but a significant proportion may be critical, requiring intensive medical or surgical treatment for a successful outcome (Curtis *et al.*, 2015). In order to facilitate early treatment, diagnosis is usually restricted to simple discrimination between horses that require medical treatment and those that require surgical treatment (Beccati *et al.*, 2011). This involves assessment of presenting clinical signs and response to analgesic drugs. The main goals for treating horses with colic include relieving pain, correcting physiologic imbalance, and stimulating or maintaining intestinal transit (Zimmel, 2003;

Freeman, 2011b). When necessary, surgery is used to relieve strangulation or simple obstruction (Wormstrand *et al.*, 2014),primary treatments are aimed at decompressing the gastrointestinal tract, treating dehydration or shock, correcting electrolyte imbalance, stimulating intestinal motility, and decreasing intestinal inflammation (White, 2009).

2.10.1 Relief of pain

Relief of visceral pain in horses with severe colic is essential on humane grounds and to minimize injury to the horse and attending personnel during evaluation and therapy (Mair *et al.*, 1999). The most satisfactory method of pain relief is the correction of the cause of increased intramural tension resulting from distension or spasm (White, 2009). However, this may take time, and it is frequently necessary to achieve temporary relief of severe pain chemotherapeutically to allow a thorough clinical examination without risk of injury to the horse and attending personnel (Edwards, 2013). A wide variety of therapeutic agents are used to treat equine colic. They include analgesics to control visceral pain, agents to normalize intestinal contractions during adynamic ileus, anti-inflammatory drugs to reduce the adverse effects of endotoxin, agents to soften and facilitate the passage of ingesta, and drugs to improve cardiovascular function during endotoxic and hypovolaemic shock (Mair *et al.*, 1999; White, 2006). Initial methods used to control pain include decompression, analgesics, and sedatives (Zimmel, 2003).

2.10.1.1 Non-steroidal anti-inflammatory drugs

Nonsteroidal anti-inflammatory drugs (NSAIDs) are some of the most useful drugs for relief of pain associated with either surgical or non-surgical disease in horses (Robertson *et al.*, 2005; White, 2007; Leslie *et al.*, 2011). The therapeutic and adverse

effects of these drugs result from inhibition of cyclooxygenase enzyme-mediated biosynthesis of prostaglandins (Aliu, 2007; Ritter *et al.*, 2008). The NSAIDs commonly employed include dipyrone, phenylbutazone, ketoprofen, meloxicam, firocoxib and flunixin meglumine, which differ greatly in efficacy in the treatment of visceral pain in horses (Dowling, 2003; Edwards, 2013). These different drugs produce varying level of analgesia possibly due to the different concentrations of the two types of cyclooxygenase, COX1 and COX2, in tissues (Morrow and Roberts, 2001). Disadvantages of the NSAIDs, particularly phenylbutazone, include the potential for adverse side effects such as mucosal ulceration of the gastrointestinal tract or renal damage (Collins and Tyler, 1984; Meschter *et al.*, 1986). This is particularly true if these drugs are administered orally, for long periods, during periods of dehydration and/or in combination with aminoglycoside antibiotics (Dowling, 2003).

2.10.1.2 Sedatives

Several α-2 agonists are potent analgesics and cause muscle relaxation and sedation (Hall *et al.*, 2001; Aliu, 2007). This drug group includes xylazine, romifidine and detomidine which have been used for control of abdominal pain in horses (Kohn and Muir, 1988; Merritt *et al.*, 1998). They appear to act by stimulation of the central α-2 adrenoreceptors which modulate the release of norepinephrine and directly inhibit neuronal firing. This causes sedation, analgesia, bradycardia, and in the horse with colic, pain relief (Muir and Robertson, 1985; Kohn and Muir, 1988; Merritt *et al.*, 1998). Phenothiazine tranquilizers like acepromazine, have a peripheral vasodilatory effect which is contraindicated in horses with reduced circulatory volume because they

block the life-saving vasoconstriction which maintains arterial blood pressure and assures, within limits, perfusion of vital organs (Mair *etal.*, 1999).

2.10.1.3 Narcotic analgesics

The analgesic and sedative effects of these drugs result from interaction with central and/or peripheral opioid receptors (Edwards, 2013).Pure opioid agonists such as morphine and oxymorphone are potent analgesics, but they may cause excitation in the horse unless used in combination with drugs such as xylazine (Hall and Clarke, 1991). Morphine reduces progressive motility of the small intestine and colon while potentially increasing mixing movements and increasing sphincter tone with a consequent delay in transit of ingesta (Senior *et al.*, 2004). Pentazocine is a partial agonist which is more effective than dipyrone but less effective than xylazine and flunixin in relieving visceral pain (Mair *et al.*, 1999). Butorphanol is a partial agonist and antagonist whichgives the best pain relief with the least adverse effects of the opioids (Sellon *et al.*, 2002;Dowling, 2003;Smith, 2003).

2.10.1.4 Spasmolytic drugs

Spasmolytic drugs indirectly provide analgesia by reducing spasms of the intestine (Hall and Clarke, 1991). Spasmolytic drugs include cholinergic blockers such as atropine and hyoscine N-butylbromide (Aliu, 2007). Atropine is not recommended for use in horses with colic because its effect in relaxing the intestinal wall and preventing contraction can last for several hours or even days creating tympany and complicating the initial problem with ileus (Edwards, 2013). The combination of hyoscine N-butylbromide and a paraaminophenol derivative (dipyrone) is popular in Europe for

treatment of horses with colic, specifically spasmodic colic and impactions (Roelvink *et al.*, 1991; Malone *et al.*, 2006).

2.10.1.5 Laxatives

Laxatives are commonly used in horses with colic to increase the water content and softness of ingesta thereby facilitating intestinal transit (Taylor *et al.*, 2010). The most common indication for their use is in the treatment of large colon impactions (Radostits *etal.*, 2006). Mineral oil is one of the most common formulation used for horses with colic and is administered through a nasogastric tube (Morresey, 2011). Mineral oil lubricates ingesta but does not reverse dehydration. Other laxatives available for treatment of colic include psyllium, magnesium sulfate (Epsom salts), and dioctyl sodium sulfosuccinate (DSS 4%solution) (Morresey, 2011). Psyllium (16 oz in 8 L water) is a bulk laxative used to treat sand impactions (Gerard, 2007). Magnesium sulfate (0.5 - 1 g/kg in 8 L water) is a cathartic laxative used to treat large colon impactions. Dioctyl Sodium Sulfosuccinate (DSS) (4 to 8 oz in 8 L water) is an irritant laxative used to treat impactions (Lopes *et al.*, 2002). Dehydration must be corrected before laxatives are used because they could worsen the state of the animal (White, 2009).

2.10.2 Decompression

A primary method to alleviate abdominal pain is decompression of the distended stomach or intestine (White, 2009). Nasogastric intubation can help relieve gastric tympany or remove gastrointestinal reflux due to a small intestinal obstruction or ileus (Blikslager*et al.*, 1994; Taylor *et al.*, 2010; Mair *et al.*, 2013). The other site at which

distention from gas can be relieved is the caecum (White, 2007; UC Davis, 2008; Taylor *et al.*, 2010). Decompression (enterocentesis) can resolve a primary caecal tympany or help relieve gas build up from a large colon or small colon obstruction but carries the risk of peritonitis (White, 2007; Taylor *et al.*, 2010; Edward, 2013). Decompression of the caecum is done in the right paralumbar fossa midway between the last rib and the ventral prominence of the tuber coxae at the level of the point of the hip (White, 2009). Horses with severe gas colic have been observed to improve with a "therapeutic trailer ride". The mechanism for this response is not understood (Zimmel, 2003).

2.10.3 Management of dehydration in horses with colic

Fluid and electrolyte therapy is integral to successful management of colic patients and includes intravenous fluid administration, enteral fluids administered via a nasogastric tube, and oral administration of hypertonic electrolyte slurries (James, 2010; Schott, 2013). Assessment of dehydration in a field setting is based primarily on skin turgor, heart rate, and capillary refill time (Collatos, 1999). The goal of fluid therapy is to restore circulating volume, provide maintenance needs and correct electrolyte and acid-base imbalances (Zimmel, 2003). Administration of intravenous fluids has been used to help “overhydrate” the circulatory system, thereby stimulating secretion into the dehydrated ingesta in the colon (White and Lopes, 2003). Beyond systemic hydration afforded by fluid administration, dilution of plasma protein in the vascular system reduces plasma osmotic pressure, allowing water diffusion into tissues and specifically in regions of distended bowel (Lopes *etal.*, 2004). Administration of oral fluids through a nasogastric tube is quick, convenient, and inexpensive (Ethell *etal.*, 2000). However,

oral fluid therapy is not adequate for severely dehydrated horses (Zimmel, 2003). Isotonic fluids such as Ringer's solution, lactated Ringer's solution, Plasmalyte A, or Normosol-R are suitable for replacement of volume deficits (Aliu, 2007; James, 2010). Hypertonic (7.2%) saline solution is very useful in the treatment of shock because it increases cardiac output by shifting intracellular fluid to the extracellular space (Collatos, 1999). Colloids are indicated when the total protein or albumin concentrations are decreased to less than 5 g/dl or 2 g/dl respectively. Plasma or Hetastarch (5-10 L) can be used to increase plasma oncotic pressure (Lopes *et al.*, 2004).

2.10.4 Stimulating intestinal motility, and decreasing intestinal inflammation

Motility of the gastrointestinal tract is a complex interplay between central stimuli, the autonomic nervous system, the enteric nervous system, amount and physical characteristics of intestinal content, and integrity of the resident microbial flora (Morresey, 2011). Prokinetic drugs are commonly used for the management and/or attenuation of postoperative ileus (POI) in horses and are commonly administered after small intestinal strangulating obstructions and less commonly for large intestinal lesions (Van Hoogmoed*et al.*, 2004). Lidocaine is the commonly used prokinetic drug (Malone and Turner, 1994; Cohen *et al.*, 2004; Robertson *et al.*, 2005; Malone *et al.*, 2006). Other prokinetic drugs of value are erythromycin lactobionate, metoclopramide and cisapride (Van Hoogmoed*et al.*, 2004; Dowling, 2016).

2.11 Prevention of Colic

Given that the equine gastrointestinal tract evolved to cope with trickle-feeding, it is perhaps not surprising to discover the role that current management practices play (Loving, 2011). Thus, it is pertinent that horse owners be made aware of the significance of these practices, particularly in horses affected by colic, and advised on measures that may be implemented to prevent recurrence (Archer and Proudman, 2006).Identifying horses at high risk may help determine if there is a generalized colic risk on the farm or if specific individuals are responsible for a majority of colic episodes (Mehdi and Mohammed, 2006). Often the problem may be a basic diet or management issue such as lack of fresh water, feeding large amounts of concentrates with insufficient forage intake in the diet or excessive use of medications such as NSAIDs (Cohen, 2003a; Archer and Proudman, 2006). Careful independent observations and record-keeping are often prerequisites to understanding the colic risk factors on a farm (White, 2006).Modern feeding practices such as feeding pellets and large quantity of feed in two servings, are commonly associated with problems of the gastrointestinal tract (Archer and Proudman, 2006). For example, sudden changes in diet have been identified as the most important risk factor in the development of abdominal pain (colic) in horses and the risk appears to be increased for up to 14 days after a diet change (Cohen *etal.*, 1999). Two factors require consideration when trying to prevent colic: farm factors and horse factors (White, 1990; Tinker *etal.*, 1997b). Farm factors include management, use, feeding, and environment (Cohen, 2003b). The associated risks on farms with high rates of colic include poor parasite control, high concentrate levels in the diet, multiple sources of concentrates (including supplements which contain high amounts of soluble carbohydrates), chronic water deficiency, excessive use of NSAIDs, acute changes in hay or grain diet, and horses in training that

are confined and fed large amounts of carbohydrate and lesser amounts of roughage (Cohen *et al.*, 1999; Hudson *et al.*, 2001; Hillyer *etal.*, 2001a, 2002; Buchanan and Andrews, 2003).

Based on these known factors, colic prevention starts by ensuring that horses have constant source of fresh water, that forage makes up at least 60% or more of the diet, and concentrates (soluble carbohydrates) are fed at the minimal level required to maintain weight and performance (Geor and Harris, 2007; Pagan*etal.*, 2007). The turn-out and exercise routines should be regular and consistent. Changes in feed should be completed over a seven-to ten-day period (Cohen *etal.*, 1999).Parasite control must be optimal since anthelminthic resistance is now a concern, making monitoring of parasite-control programmes essential (Lyons *et al.*, 2000; Proudman and Holdstock, 2000; Proudman, 2013).

Careful monitoring of the daily management and measurement of the energy, protein, and fiber in the diet are the first steps in assessing the farm for colic risk (White, 2007). Control of feeding on pasture may also be necessary during periods of rapid growth of forage (Goncalves *etal.*, 2002). Prevention of "sand colic" requires keeping horses from ingesting sand, which in some environments is impossible if horses are turned out on pasture or sand lots (Landes *etal.*, 2007). Repeated dosing with psyllium has been recommended, but the use of psyllium has been questioned due to its inefficiency in removing sand from the intestines in horses (Hammock *et al.*, 1998; Ruohoniemi *etal.*, 2001). A combination of probiotics, prebiotics, and psyllium supplement enhanced faecal sand clearance during a feeding trial, thus suggesting a potential to be used as a

prophylactic treatment for sand enteropathy and sand colic in which management alone is not sufficient to prevent intestinal sand accumulation (Landes *etal.*, 2007).Probiotics are substances and organisms that contribute to intestinal microbial balance, which is involved in protecting the host against diseases. In relation to colic, a healthy gut is unlike to suffer from disturbances if there is a balance in the intestinal microflora.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was carried out in Kaduna State which has an estimated land area of 46,053 km^2 and estimated human and horse populations of 6,066,562 and 2,500 respectively (NBS, 2010; Aliyu, 2014). The State lies between longitude 7°26′19″ East of the Greenwich Meridian and latitude 10°31′35″ North of the Equator (Figure 1) and is 1,995 feet above sea level (KDSG, 2008). It shares boundaries with Zamfara and Katsina States to the Northwest, Kano State to the Northeast, Bauchi and Plateau States to the East, Niger State to the West and Nassarawa and the Federal Capital Territory, Abuja to the South (Figure 1). The State is made up of 23 Local Government Areas (LGAs) (KDSG, 2008).

Kaduna State has distinct wet and dry seasons and it is within the Guinea Savannah vegetation and Sudan Savannah zone of Nigeria. It has an annual rainfall varying between 1000 mm and 1,500 mm and a rainy season, which is between May and September (KDSG, 2008). It is essentially an agrarian State with about 75% of the population engaging in farming. It also has potentials for the livestock industry (RIM, 1992).

Horses are a part of many households in some parts of Kaduna State, and have very high prestige in traditional circles, where local chiefs lose face if they cannot participate in Sallah processions and Durbars with liveried horses (Bukar *et al*., 2007; Mshelia*et al*., 2012). Kaduna State is also a hub of equestrian activities namely polo, racing,

durbar related ceremonial rides, pleasure rides and defence-related equitation activities in Northern Nigeria (RIM, 1992;Mshelia*et al*., 2012; Bukar*et al*., 2013).

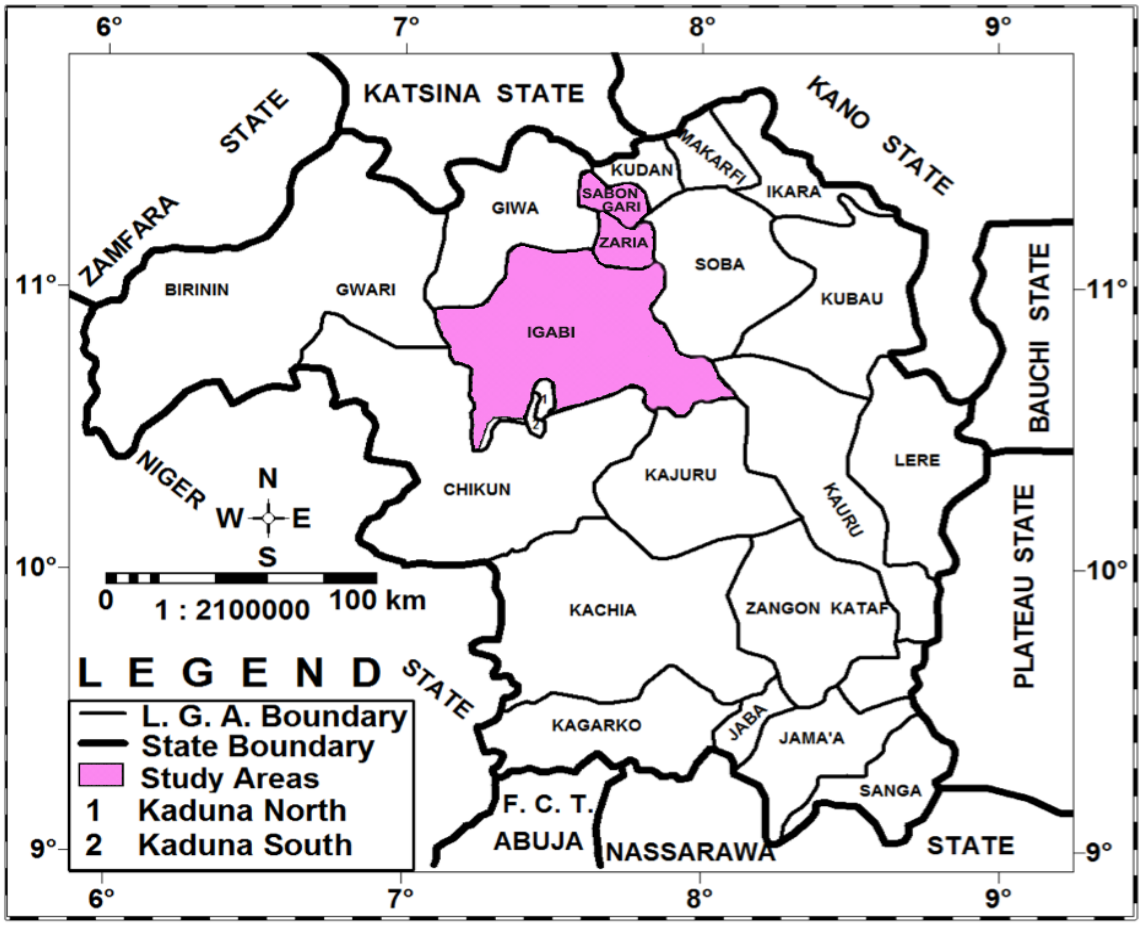

Figure 1: Map of Kaduna State Showing the Study Area (Coloured)

Source: Department of Geography, Federal College of Education Zaria (2015)

3.2 Study Design

A purposeful sampling was carried out in the selected LGAs of Kaduna State based on reports by Mshelia *et al*. (2012) who reported these LGAs (Igabi, Sabon Gari and Zaria), to have the highest horse population in Kaduna State.Convenience sampling was used to select the stables and Veterinary Clinic with adequate records for the study. A 5-year retrospective and 1-year prospective study were carried out in the selected stables and veterinary clinic in the study area.

Structured questionnaires were used to capture information on the recognition, diagnostic methods employed, management protocol and risk factors for colic from the owners, grooms, trainers, managers, and attending veterinary personnel in the study area.

3.3 Study Population

Ceremonial, polo and equitation horses kept in stables in three LGAs (Igabi, Sabon Gari and Zaria) in Kaduna State were selected and sampled for the study. Particular interest was in the clinical cases presented during the study period and those cases with history of colic. Records kept at thirty-six stables and one veterinary clinic in the three LGAs were collected based on the willingness of the owners, grooms, trainers, managers, attending veterinarians and the Veterinary Clinicauthority.

3.4 Retrospective Study

3.4.1 Stable records

At the stables, documented case records,after diagnosis by the resident/consultant veterinarians, along with anecdotal (oral) reports by horse owners, grooms, managers and trainers served as data for the determination of the variables for the study. The retrospective study was tailored to the occurrence, aetiologies, clinical signs and

predisposing factors for equine colic over a five-year period. The diagnoses were done by veterinarians. Clinical case records of horses retrieved from the stables included age, sex, breed, use and clinical cases of colic handled in relation to other diseases(equine influenza, wounds, fever, ulcerative lymphangitis, and lameness).Records of change in batch of concentrates fed, type of forage fed during rainy and dry season,along with records of activities andtheir frequency, rest, records of deworming and administration of vaccines or drugs that had effect on the gastrointestinal tract (GIT) were noted. Diagnostic approach and type of colic handled were obtained by the questionnaires.

3.4.2 Veterinary clinic records

Clinical case recordswere obtained from the Zaria City Veterinary Clinic. Theyincluded those on colic cases/colic reports presented and handled by the clinic per month in relation to other horse diseases spanning the 5-year period under review.

3.5 Prospective Study

3.5.1 Stable records

A stable based prospective study aimed at evaluating the occurrence, aetiologies, clinical signs and associated risk factors for colic as they occurred andwere handled over a one-year period of study was conducted. The study considered age, sex, breed, use, helminth control programme and nutritional status of horses in the different stables that partook in the study. Clinical cases of colic presented during the study were handledby resident veterinarians and records kept. Diagnosis of suspected cases of colic included the use of history, physical examination, clinical signs and other ancillary diagnostic techniques such as abdominocentesis and nasogastric intubation. Clinical diagnoses were established based mostly on historical findings, clinical examination,

and when available, necropsy findings. Weekly visits were paid to the selected stables for one year to check for records of cases of colic during the course of the study. Emergency visits were made where possible, to attend to suspected cases.

3.5.2 Veterinary Clinic Records

Visits were paid once a week, four times a month,to the Zaria City Veterinary Clinic for one year to check for records of cases of colic during the course of the study. Emergency visits were made where possible, to observe cases.

3.6 Questionnaire Preparation and Administration

Two sets of structured open and close ended questionnaires were prepared, one for the veterinary personnel and the other forthegrooms,managers, owners, and trainers. The questionnaires were piloted in group interviews and later in the field and adjustments made as required. One hundred and twenty (120) structured questionnaires were administered to practising veterinarians, veterinary assistants, horse owners, stable managers, grooms and trainers, in the selected study area. Thequestionnaires administeredtoowners, stable managers, grooms and trainers, was aimed at ascertaining the respondents' understanding of the possible predisposing factors and their ability to recognize and manage colic cases in the absence of a veterinarian. Data on demographic variables like horse breed, sex, age, stable size, and use under their holdings were collected. Information on husbandry and management practices (feeds and feeding, water and watering, helminth control programme and other diseases) associated with colic wasalso collected. The questionnaire administered to practising veterinarians and veterinary assistants was aimed at assessing their various selections of diagnostic methods and management of colic in horse, and the predisposing factors.

3.7 Data Analyses

The data obtained from records and questionnaires were presented in tables and plates. They were alsoanalyzed using SPSS version 20.0 statistical package. Descriptive statistics, Chi square and Odds ratio were used to test for association between categorical variables. P values < 0.05 were considered significant.

CHAPTER FOUR

4.0 RESULTS

4.1 Occurrence, Causes and Clinical Signs of Colic in the Retrospective and Prospective Studies in selected Stables and a Veterinary Clinic

4.1.1 Occurrence of colic in the retrospective study

4.1.1.1 Yearly occurrence of colic cases

A total of 1540 clinical case reports were obtained from records for 2010 to 2014 from the selected stables and a Veterinary Clinic of which 264(17.1%) were cases of colic.There was no statistically significant difference (χ^2 = 4.236; P = 0.516) in occurrence of colic in relation to other cases (equine influenza, wounds, fever, ulcerative lymphangitis, and lameness)during the period of the study, though the year 2014 had the highest occurrence of colic cases (26.1%) (Table 4.1).

4.1.1.2 Occurrence of colic by age

From the study, a total of 264 (17.1%) out of 1540 horses were reported to have had colic and 6 (18.2%) of these horses were within the age range of 1 to 5 years, 34 (23.3%), 200 (15.7%), 21 (32.3%) and 3 (11.5%) in the age ranges of 6 to 10, 11 to 15, 16 to 20, and 21 to 25 years old respectively (Table 4.2). There was no statistically significant association (χ^2 = 8.173; P = 0.085) between age and occurrence of colic. Though, the 16 – 20 years old range had the highest occurrence (32.3%) (Table 4.2).

Table 4.1: Retrospective study of occurrence of colic between 2010 and 2014 in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Year	Total no. of cases recorded	No. of colic cases (%)
2010	294	49 (18.6)
2011	284	43 (16.3)
2012	303	50 (18.9)
2013	327	53 (20.1)
2014	332	69 (26.1)
Total	**1540**	**264 (17.1)**

$\chi^2 = 4.236$; df = 4; P = 0.516

Table 4.2: Retrospective study by age of proportional morbidity of colic in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Age group (years)	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
1-5	33	21	63.6	12	36.4	6	18.2	0	0	6
6-10	146	113	77.4	33	22.6	32	21.9	2	1.4	34
11-15	1270	1188	93.5	82	6.5	187	14.7	13	1.0	200
16-20	65	47	72.3	18	27.7	18	27.7	3	4.6	21
21-25	26	11	42.3	15	57.7	3	11.5	0	0	3
Total	**1540**	**1380**	**89.6**	**160**	**10.4**	**246**	**16.0**	**18**	**1.2**	**264**

$\chi^2 = 8.173$; df = 4; P = 0.085

4.1.1.3 Occurrence of colic by sex

A total of 1159 stallions, 277 mares and 104 geldings were presented. Of the 1159 stallions presented, 184 (15.9%) were cases of colic, while 56 (20.2%) out of the 277 mares were cases of colic, and 24 (23.1%) of the 104 geldings had colic (Table 4.3). There was a statistically significant association (χ^2 = 4.093; P = 0.029) between the occurrence of colic and sex with the geldings having the highest occurrence (23.1%).

4.1.1.4 Occurrence of colic by breed

A total of 1140 West African Barb breed of horses presented with 177 (15.5%)colic cases. 337 Argentine polo ponies presented 77 (22.8%) colic cases, while 40 Sudanese Country breed of horses presented 5 (12.5%) colic cases. Similarly, 23 West African Dongola breed of horses presented5(21.7%) colic cases (Table 4.4). There was a statistically significant association (χ^2 = 10.771; P = 0.013) between the occurrence of colic and the breed of horses recorded, with the highest occurrence in the Argentine polo ponies (22.8%).

Table 4.3: Retrospective study showing occurrence of colic by sex in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Sex	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
Stallions	1159	999	86.2	160	13.8	166	14.5	18	1.6	184
Mares	277	277	100	0	0	56	20.2	0	0	56
Geldings	104	104	100	0	0	24	23.1	0	0	24
Total	**1540**	**1380**	**89.6**	**160**	**10.4**	**246**	**16.0**	**18**	**1.2**	**264**

$\chi^2 = 7.079$; df = 2; P = 0.029

Table 4.4: Retrospective study on breed disposition to occurrence of colic in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Breed	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
West African Barb	1140	980	86	160	14.0	159	13.9	18	1.6	177
Argentine polo ponies	377	377	100	0	0	77	22.8	0	0	77
Sudanese country breed	40	40	100	0	0	5	12.5	0	0	5
West African Dongola	23	23	100	0	0	5	21.7	0	0	5
Total	**1540**	**1380**	**89.6**	**160**	**10.4**	**246**	**16.0**	**18**	**1.2**	**264**

$\chi^2 = 10.771$; df = 3; P = 0.013

4.1.1.5 Occurrence of colic by use

A total of 160 pleasure horses, 247 equitation horses, 329 polo horses and 804 horses with multiple (pleasure and polo) were presented. 18 (11.3%) of the 160 pleasurehorses presented were colic cases. 34 (13.8%) of the 247 equitation horses presented were colic cases. Similarly, 78 (23.7%) of the 329 polohorses presented were colic cases, and 134 (16.7%) of the 804 horses with multiple uses presented were colic cases (Table 4.5). There was a statistically significant association ($\chi^2 = 16.115$; $P = 0.001$) between horse useand the occurrence of colic, with polo horses showing the highest (23.7%).

Table 4.5: Occurrence of colic by use in the selected stables and a Veterinary Clinic in the Retrospective study in Kaduna State, Nigeria

Use	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
Pleasure	160	0	0	160	100	0	0	18	11.3	18
Equitation	247	247	100	0	0	34	13.8	0	0	34
Polo	329	329	100	0	0	78	23.7	0	0	78
Multiple use	804	804	100	0	0	134	16.7	0	0	134
Total	**1540**	**1380**	**89.6**	**160**	**10.4**	**246**	**16.0**	**18**	**1.2**	**264**

χ^2=16.115; df=3; P = 0.001

4.1.2 Occurrence of colic in prospective study

4.1.2.1 Occurrence of colic cases

A total of 311 cases reports were obtained from the selected stables and the Zaria City Veterinary Clinic of which 54 (17.4%) were cases of colic. There was no statistically significant difference (χ^2 = 4.136; P = 0.416) in the occurrence of colic in relation to other cases (equine influenza, wounds, fever, ulcerative lymphangitis and lameness) during the period of the study (Table 4.6).

4.1.2.2 Occurrence of colic by age

A total of 54 (17.4%) out of the 311 horses handled had colic (Table 4.7), of which 16 (20.0%) within the age range of 6 to 10 years were reported to have had colic and 30 (15.1%), 4 (22.2%) and 4 (57.1%) in the age ranges of 11 to 15, 16 to 20, and 21 to 25 years respectively, had colic (Table 4.7) with the horses of 21 – 25 years old range having the highest occurrence (57.1%). There was a statistically significant difference (χ^2 = 10.600; P = 0.031) between age and occurrence of colic.

4.1.2.3 Occurrence of colic by sex

A total of 202 stallions, 82 mares and 27 geldings were presented in the prospective study. Out of which 31 (15.3%),17 (20.7%) and 6 (22.2%) respectively were colic cases. Nostatistically significant association (χ^2 = 1.665; P = 0.435) existed between the occurrence of colic and sex(Table 4.8).

Table 4.6: Occurrence of colic cases in selected stables and a Veterinary Clinic in the Prospective Study in Kaduna State, Nigeria,

Study location	No. of equine cases reported	Total no. of colic cases reported (%)
Stables	288	53 (18.4)
Veterinary Clinic	23	1 (4.3)
Total	**1540**	**54 (17.4)**

$\chi^2 = 4.136$; df = 1; P = 0.416

Table 4.7: Occurrence of colic in prospective study by age in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Age group (years)	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
1-5	7	4	57.1	3	42.9	0	0	0	0	0
6-10	80	74	92.5	6	7.5	15	18.7	1	1.3	16
11-15	199	193	97.0	6	3.0	30	15.1	0	0	30
16-20	18	13	72.2	5	27.8	4	22.2	0	0	4
21-25	7	4	57.1	3	42.9	4	57.1	0	0	4
Total	**311**	**288**	**92.6**	**23**	**7.4**	**53**	**17.0**	**1**	**0.3**	**54**

$\chi^2 = 10.600$; df = 4; P = 0.031

Table 4.8: Occurrence of colic in prospective study by sex in selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Sex	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
Stallions	202	179	88.6	23	11.4	30	14.9	1	0.5	31
Mares	82	82	100	0	0	17	20.7	0	0	17
Geldings	27	27	100	0	0	6	22.2	0	0	6
Total	**311**	**288**	**92.6**	**23**	**7.4**	**53**	**17.0**	**1**	**0.3**	**54**

$\chi^2 = 1.665$; df = 2; P = 0.435

4.1.2.4 Occurrence of colic by breed

A total of 203 West African Barb breed of horses were presented of which 31 (15.3%) were cases of colic,102 Argentine polo ponies werepresented with 23 (22.5%) colic cases recorded. 3 Sudanese Country breed and 3 West African Dongola breed were presentedand no colic cases were recorded(Table 4.9). There was no statistically significant association (χ^2 = 3.792; P = 0.150) between the occurrence of colic and the breed of horses.

4.1.2.5 Occurrence of colic by use

A total of 24pleasure horses, 46 equitation horses, 98 polo horses and 143 horses with multiple (pleasure and polo) were presented. With 2 (8.3%), 8 (17.4%), 21 (21.4%) and 23 (16.1%) colic cases respectively presented (Table 4.10). Therewasno statistically significant association (χ^2 = 2.656; P = 0.448) between the occurrence of colic and use.

Table 4.9: Prospective study on breed disposition to occurrence of colic in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Breed	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
West African Barb	203	180	88.7	23	11.3	30	14.7	1	0.5	31
Argentine polo ponies	102	102	100	0	0	23	22.5	0	0	23
Sudanese country breed	3	3	100	0	0	0	0	0	0	3
West African Dongola	3	3	100	0	0	0	0	0	0	3
Total	**311**	**288**	**92.6**	**23**	**10.4**	**53**	**17.0**	**1**	**0.3**	**54**

$\chi^2 = 3.792$; df =3; P = 0.150

Table 4.10: Occurrence of colic in the prospective study by use in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Use	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
Pleasure	24	1	4.2	23	95.8	1	4.2	1	4.2	2
Equitation	46	46	100	0	0	8	17.4	0	0	8
Polo	98	98	100	0	0	21	21.4	0	0	21
Multiple use	143	143	100	0	0	23	16.1	0	0	23
Total	**311**	**288**	**92.6**	**23**	**7.4**	**53**	**17.0**	**1**	**0.3**	**54**

$\chi^2 = 2.656$; df = 3; P = 0.448

4.1.3 Causes of colic identified by thestudy

4.1.3.1 Occurrence of colic due tochange in feed

Out of 120 respondents to questionnaires on the role of change of feed with respect to the occurrence of colic, 73 (60.8%) of the respondents incriminated a recentchange in the quality of hay fed as an inciting factor for colic, while 47 (39.2%) respondents did not (Table 4.11). The change in quality of hay refers to the change in the texture from fine slender stems to coarser, rougher and thicker stems. There was a statistically significant association (χ^2 = 43.623; P = 0.000) between change in quality of hay fed and colic, with the odds of having colic after a change in the quality of hay being 0.168 times more likely to occur compared to no change in hay quality(Table 4.11).

Similarly, 75 (62.5%) out of the 120 respondents on the role of change of feed with respect to the occurrence of colic, incriminated a recent change in the batch of concentrate fed as an inciting cause of colic (Table 4.12).The change inbatch of concentrate refers to the introduction of an entirely different sample of concentrate as against the sample currently being fed, as a replacement, which most times is done abruptly. There was also a statistically significant association (χ^2 = 97.776; P = 0.000) between changes in batch of concentrate fed and colic, with the odds of having colic after a change in the batch of concentrate being 0.162 times more likely to occur compared to no change in batch of concentrate.

On the role of grain feeding with respect to the occurrence of colic during the study period, 64 (53.3%) respondents reported feeding grains routinely, while 56 (46.7%) fed grains at

variable periods (Table 4.13). There was no statistically significant association ($\chi^2 = 5.632$; $P = 0.060$) between grain feeding and colic.

Table 4.11: Occurrence of colic due to change in hay fed in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Change in hay fed	Designation of Respondent						Total (%)	OR (95% CI)
	Vet.	Vet. assist.	Grooms	Trainers	Managers	Owners		
No change in quality of hay fed	2 (4.3)	3 (6.3)	34 (72.3)	2 (4.3)	2 (4.3)	4 (8.5)	47 (39.2)	0.168 (0.151 – 0.186)
Recent change in quality of hay fed	11 (15.1)	6 (8.2)	47 (64.4)	3 (4.1)	2 (2.7)	4 (5.5)	73 (60.8)	1 (Ref)
Total	**13 (10.8)**	**9 (7.5)**	**81 (67.5)**	**5 (4.2)**	**4 (3.3)**	**8 (6.7)**	**120 (100)**	

$\chi^2 = 43.623$; df = 1; P = 0.000

Key:
Vet. = Veterinarian
Vet. assist. = Veterinary assistants
OR = Odds Ratio

Table 4.12: Occurrence of colic due to change in concentrate fed in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Change in batch of concentrate fed	Designation of Respondent						Total (%)	OR (95% CI)
	Vet.	Vet. assist.	Grooms	Trainers	Managers	Owners		
No change in batch of concentrate fed	4 (8.9)	3 (6.7)	30 (66.7)	2 (4.4)	2 (4.4)	4 (8.9)	45 (37.5)	0.162 (0.146 – 0.180)
Recent change in batch of concentrate fed	9 (12.0)	6 (8.0)	51 (68.0)	3 (4.0)	2 (2.7)	4 (5.3)	75 (62.5)	1 (Ref)
Total	**13 (10.8)**	**9 (7.5)**	**81 (67.5)**	**5 (4.2)**	**4 (3.3)**	**8 (6.7)**	**120 (100)**	

$\chi^2 = 39.079$; df = 1; P = 0.000

Key:
Vet. = Veterinarian
Vet. assist. = Veterinary assistants
OR = Odds Ratio

Table 4.13: Occurrence of colic due to grain feeding in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Grain feeding	Designation of respondents						Total (%)
	Vet.	Vet. assist.	Grooms	Trainers	Managers	Owners	
Whole grain fed routinely	4 (6.2)	5 (7.8)	45(70.3)	3 (4.7)	1 (1.6)	6 (9.4)	64 (53.3)
Variable (grains at particular periods)	9 (16.1)	4 (7.1)	36(64.2)	2 (3.6)	3 (5.4)	2(3.6)	56 (46.7)
Total	**13(10.8)**	**9(7.5)**	**81(67.5)**	**5 (4.2)**	**4 (3.3)**	**8 (6.7)**	**120(100)**

$\chi^2 = 1.527$; df = 1; P = 0.217

Key:
Vet. = Veterinarian
Vet. assist. = Veterinary assistants

4.1.3.2 Occurrence of colic due to drugs used in treatment of horses

From the study, 33 (27.5%) out of the 120 respondents reported the occurrence of colic shortly after drug administration while 87 (72.5%) of them reported the occurrence of colic spontaneously even without drug administration (Table 4.14) andthere was a statistically significant association between using drugs and colic (χ^2 = 122.555; P = 0.000), and the odds was 6.250 times more likely for colic to occur after the use of drugs such as albendazole, imidocarb dipropionate and ivermectin.

Table 4.14: Occurrence of colic due to drugs used for treatment of horses in selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Grain feeding	Designation of respondents						Total (%)	OR (95% CI)
	Vet.	Vet. assist.	Grooms	Trainers	Managers	Owners		
Spontaneous occurrence	8 (61.5)	6 (66.7)	60 (74.1)	4 (80.0)	3 (75.0)	6 (75.0)	87 (72.5)	6.250 (5.626–6.943)
After drugs* administration	5 (38.5)	3 (33.3)	21 (25.9)	1 (20.0)	1 (25.0)	2(25.0)	33 (27.5)	1 (Ref)
Total	**13(10.8)**	**9(7.5)**	**81 (67.5)**	**5 (4.2)**	**4 (3.3)**	**8 (6.7)**	**120(100)**	

$\chi^2 = 122.555$; df = 1; P = 0.000

Key:

Vet. = Veterinarian
Vet. assist. = Veterinary assistants
OR = Odds Ratio
drugs* = albendazole, imidocarb dipropionate and ivermectin drench (given separately)

4.1.4 Observed clinical signs and lesions due tocolic

The clinical signs of colic described by the horse handlers were frequent attempts to lie down and pawing (37.5%), lateral recumbency, rolling with bruises(18.3%), lateral recumbency, flank watching and sweating (13.3%) kicking and biting at the abdomen (11.8%), Flehmen's response, blowing and sweating (10.0%), standing stretched out as if to urinate (5.8%), and diarrhoea (3.3%). (Table 4.15) (Plates 1 – VI).

The gross lesions observed at post-mortem examinations after fatal episodes of colic during the study included gastric rupture (Plate VII), the presence of *Gasterophilus* larva in the stomach (Plate VIII), ruptured colon (Plate IX), adhesions between the caecum and colon(Plate X), distended caecum with multiple ruptures (Plate XI), oedematous viscera (Plate XII), perforated caecum due to poor quality hay (Plate XIII), histopathologic examination of the perforated caecum due to poor quality hay (Plate XIII), showed the presence of an awn within the mucosa of the affected caecum (Plate XIV),perforation on the serosal surface of the colon (Plate XV), ruptured ileocaecal junction (Plate XVI), melanoma of the right kidney (Plate XVII), ruptured diaphragm (Plate XVIII), oedematous and cyanotic colon, with strangulation of the colon by the mesentery (Plate XIX) and volvulus of the intestine (Plate XX).Certain local management practice known as *'chusa'*, which involves force feeding of horses with boli of concentrate can predispose to impaction colic (Plate XXI).

Table 4.15: Respondents description of clinical signs of colic in horses in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Desig. of respondents	No. of respondents	Frequency of Clinical signs observed (%)							Total No. (%)
		Freq. attempts to lie down, pawingNo. (%)	Lat. recumbency, rolling with bruises No. (%)	Lat. recumbency, flank watching, sweatingNo. (%)	Kicking and biting at the abdomenNo. (%)	Flehmen's response, blowing, sweatingNo. (%)	Standing stretched out, straining as if to urinateNo. (%)	DiarrhoeaNo. (%)	
Vet.	13	3 (23.1)	2 (15.4)	3 (23.1)	2 (15.4)	2 (15.4)	0 (0.0)	1 (7.6)	13 (10.8)
Vet. assist.	9	3 (33.3)	2 (22.2)	2 (22.2)	1 (11.1)	0 (0.0)	1 (11.1)	0 (0.0)	9 (7.5)
Groom	81	35 (43.2)	14 (17.3)	8 (9.9)	9 (11.1)	7 (8.6)	5 (6.2)	3 (3.7)	81 (67.5)
Trainer	5	1 (20.0)	1 (20.0)	1 (20.0)	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)	5 (4.2)
Manager	4	1 (25.0)	1 (25.0)	1 (25.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	4 (3.3)
Owner	8	2 (25.0)	2 (25.0)	1 (12.5)	1 (12.5)	1 (12.5)	1 (12.5)	0 (0.0)	8 (6.7)
Total	**120**	**45 (37.5)**	**22 (18.3)**	**16 (13.3)**	**14 (11.8)**	**12 (10.0)**	**7 (5.8)**	**4 (3.3)**	**120(100)**

Key:
Desig. = Designation
Vet. = Veterinarian

Vet. assist. = Veterinary assistant
Lat. = Lateral

Plate I: Colicky mare in a 'dog sitting' posture in a box

Plate II: Colicky gelding in a ‘dog sitting’ posture in a paddock

Plate III: Skin abrasion (arrowed) above the eye due to rolling on the ground after episode of acute colic in a mare

Plate IV: Skin abrasion (arrowed) below the point of hip due to rolling on the ground after episode of acute colic in amare

Plate V: Colicky mare pawing (arrowed) the ground

Plate VI: Flank watching (arrowed) by a colicky mare

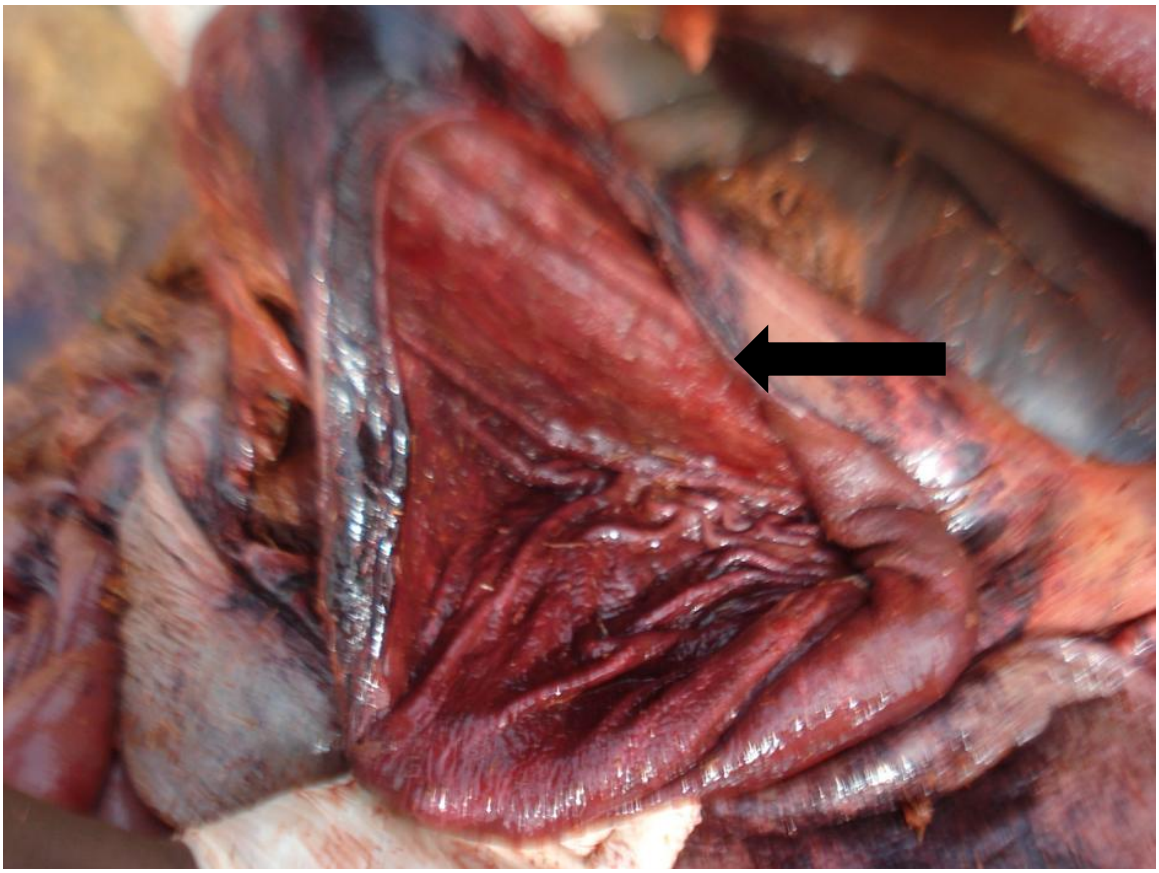

Plate VII: Gastric rupture (arrowed) due to impaction colic: rupture occurred on the greater curvature of the stomach.

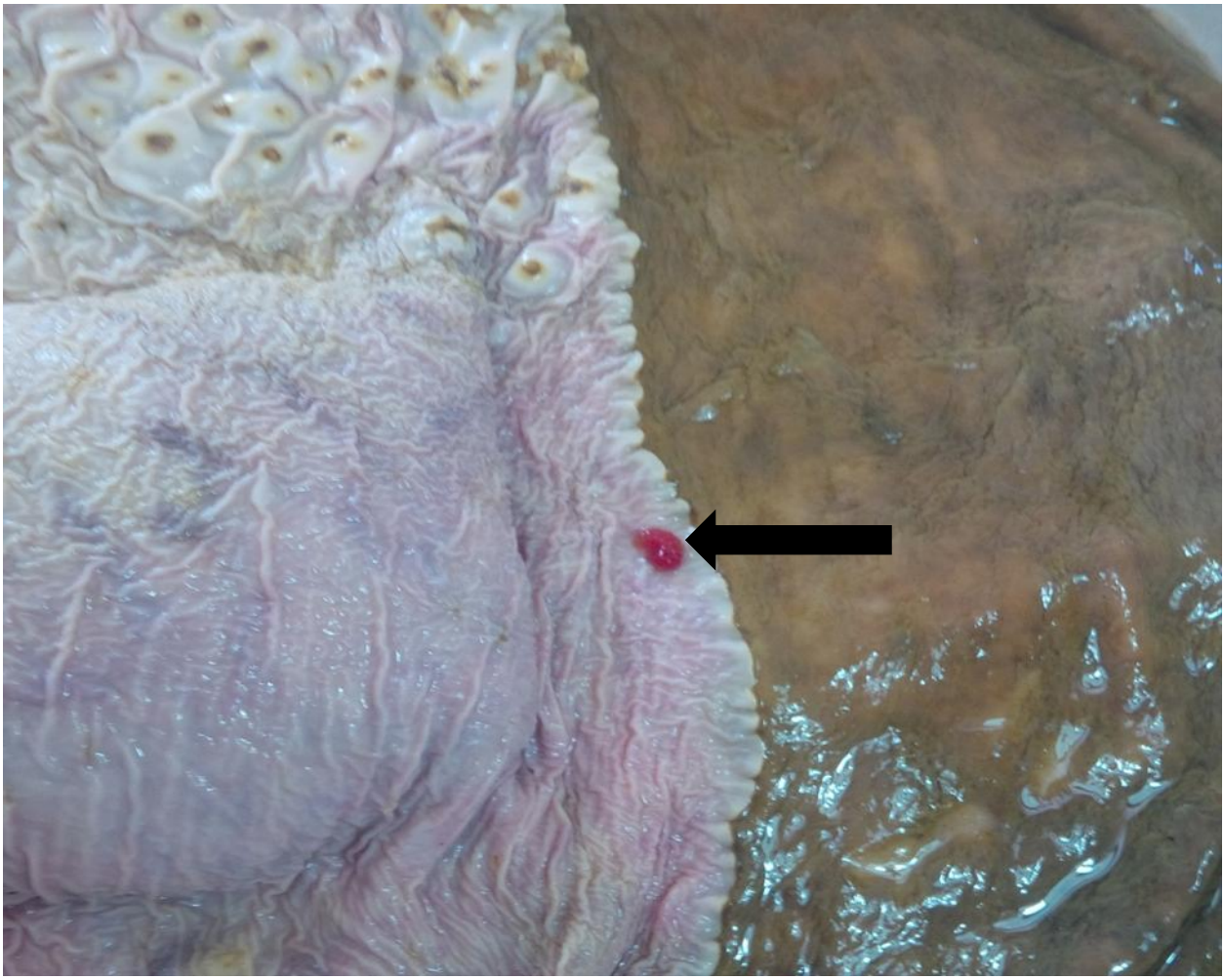

Plate VIII: Presence of *Gasterophilus* larva (arrowed) on the glandular mucosa of the stomach close to the *Margo plicatus*observed in a mareat post-mortem after an episode of severe colic.

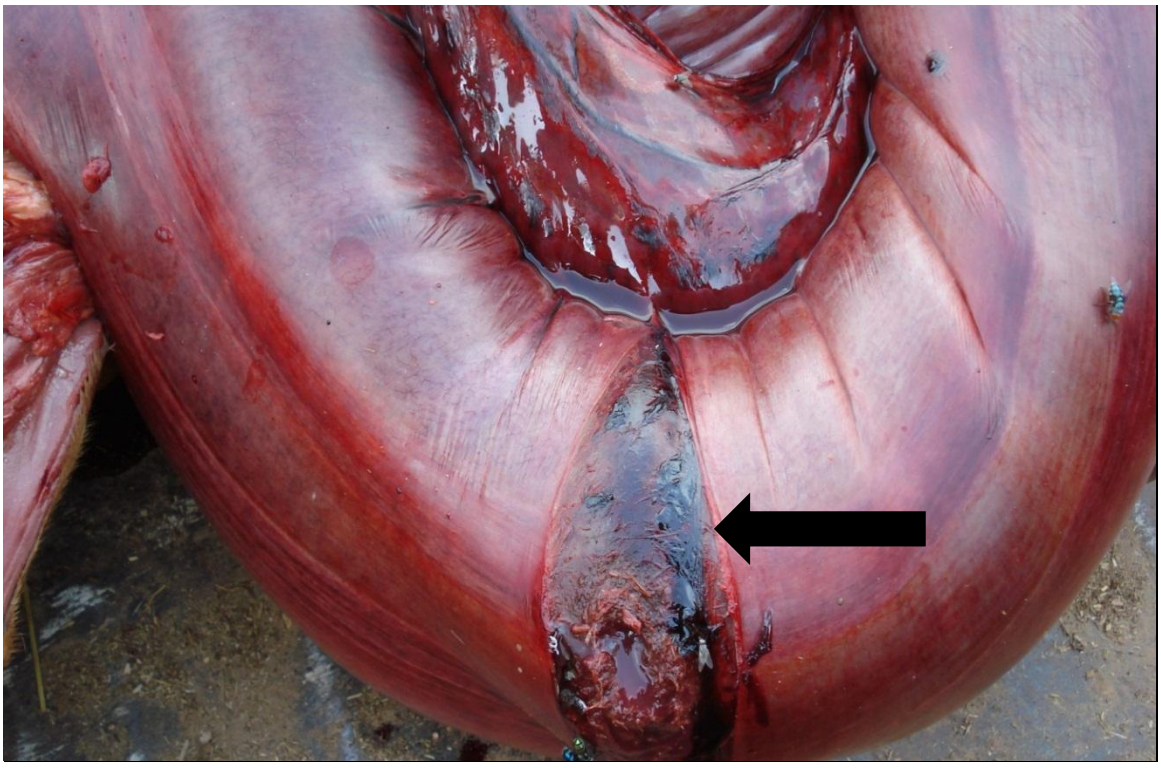

Plate IX: Ruptured colon (arrowed)observed in a mare at post-mortem after episode of severe colic due to impaction with poor quality hay.

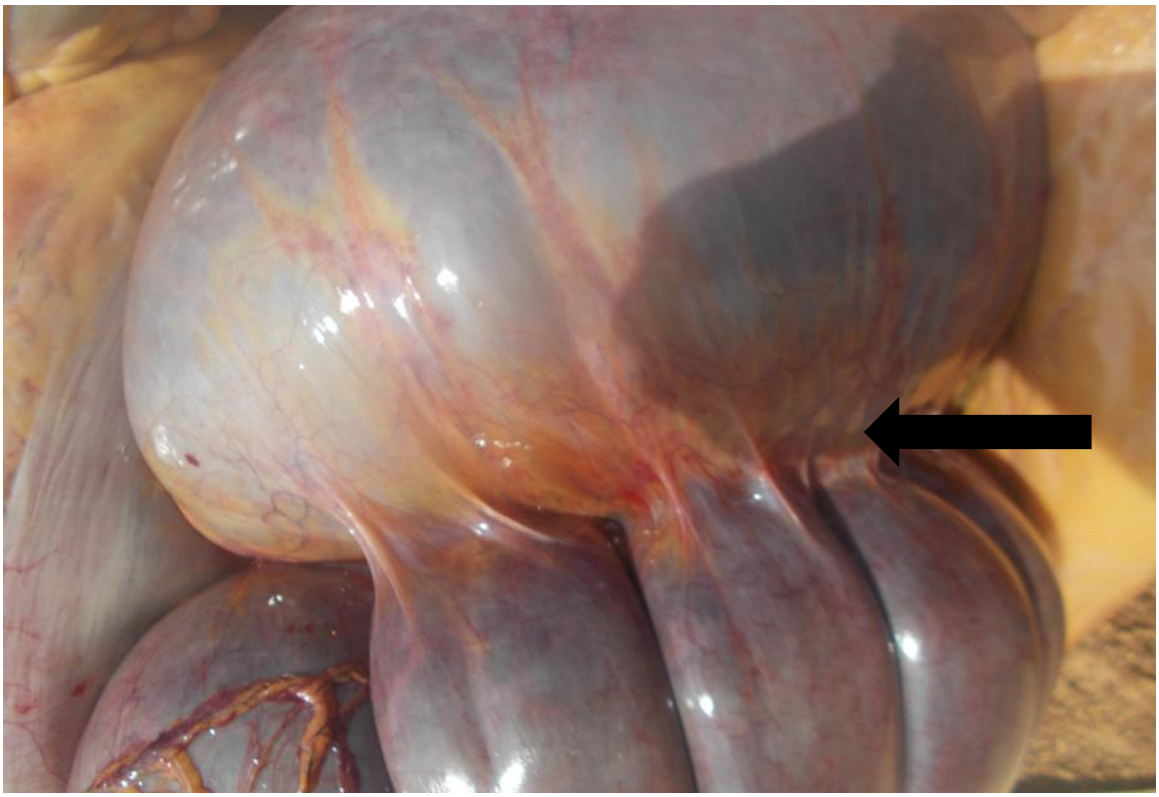

Plate X: Evidence of caecocolic adhesion (arrowed)observed in a mare at post-mortem after episode of severe colic.

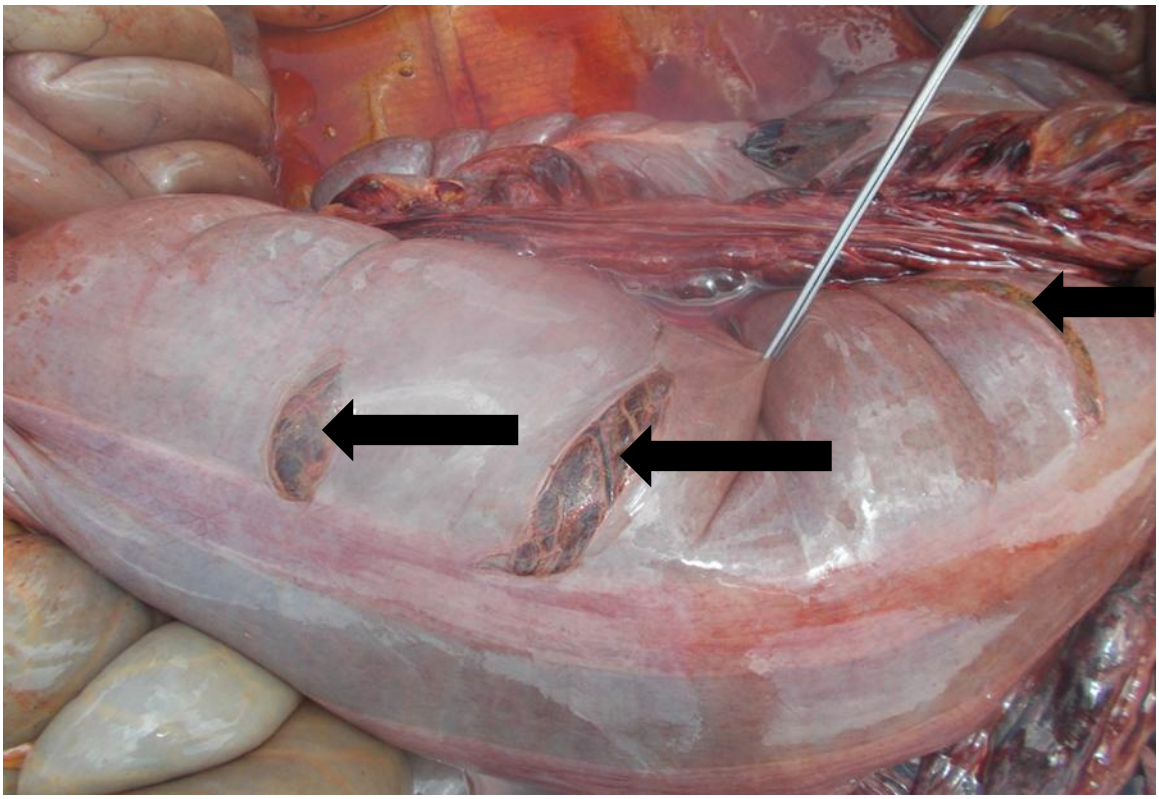

Plate XI: Distended caecum with multiple ruptures (arrowed)due to caeco-colic adhesion observed in a mare at post-mortem after episode of severe colic.

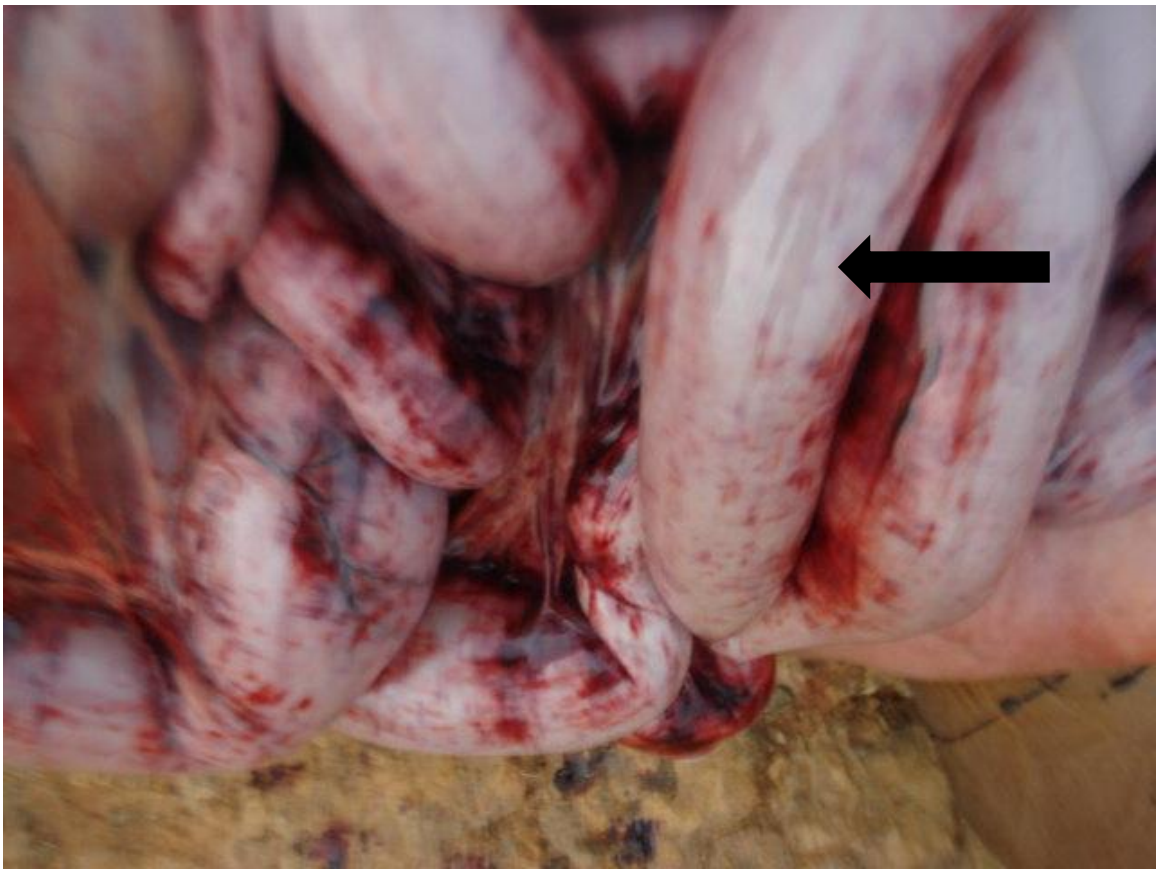

Plate XII: Oedematous viscera (arrowed)observed in a mare at post-mortem after severe colic.

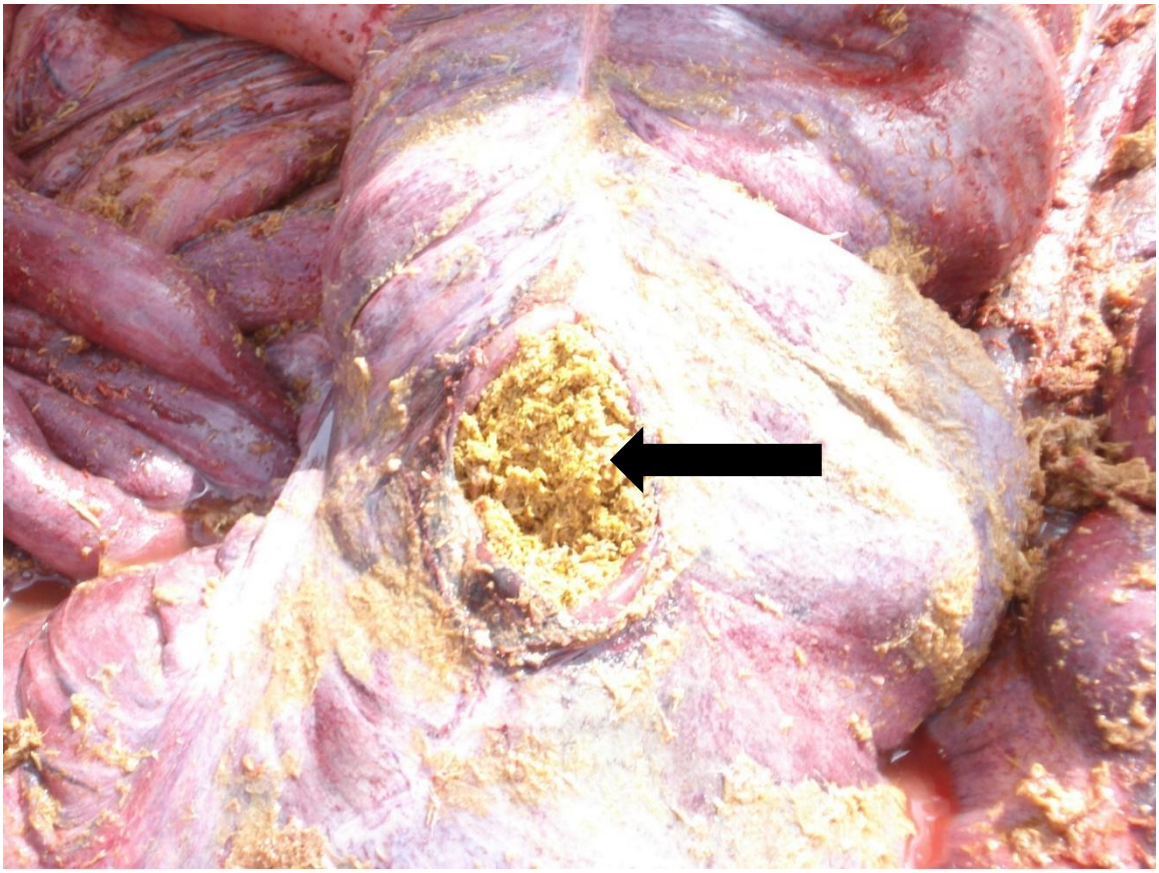

Plate XIII: Perforated caecum (arrowed)due to impaction with poor quality hay, observed in a mare at post-mortem after episode of severe colic.

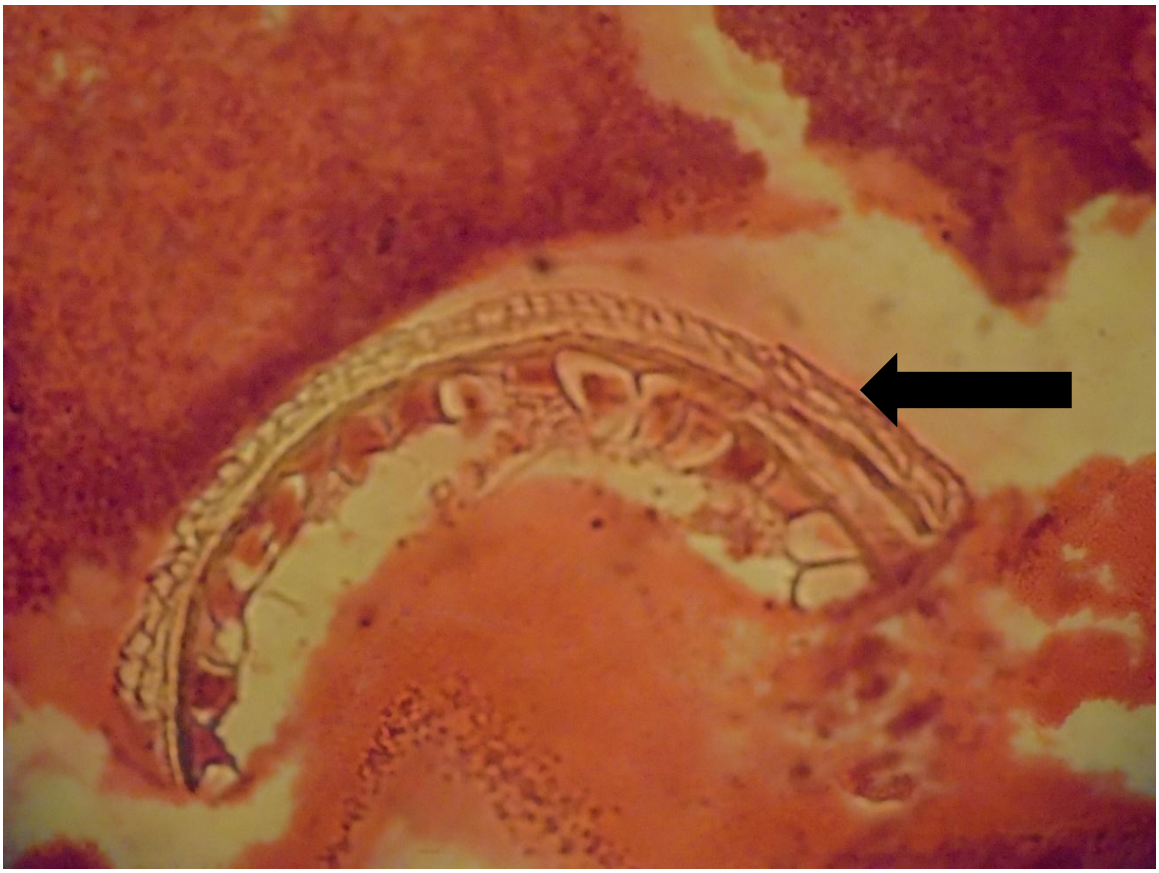

Plate XIV: Histopathology of the perforated caecum, showing the presence of an awn (arrowed)within the mucosa of the caecum of a mareat post-mortem after an episode of severe colic.

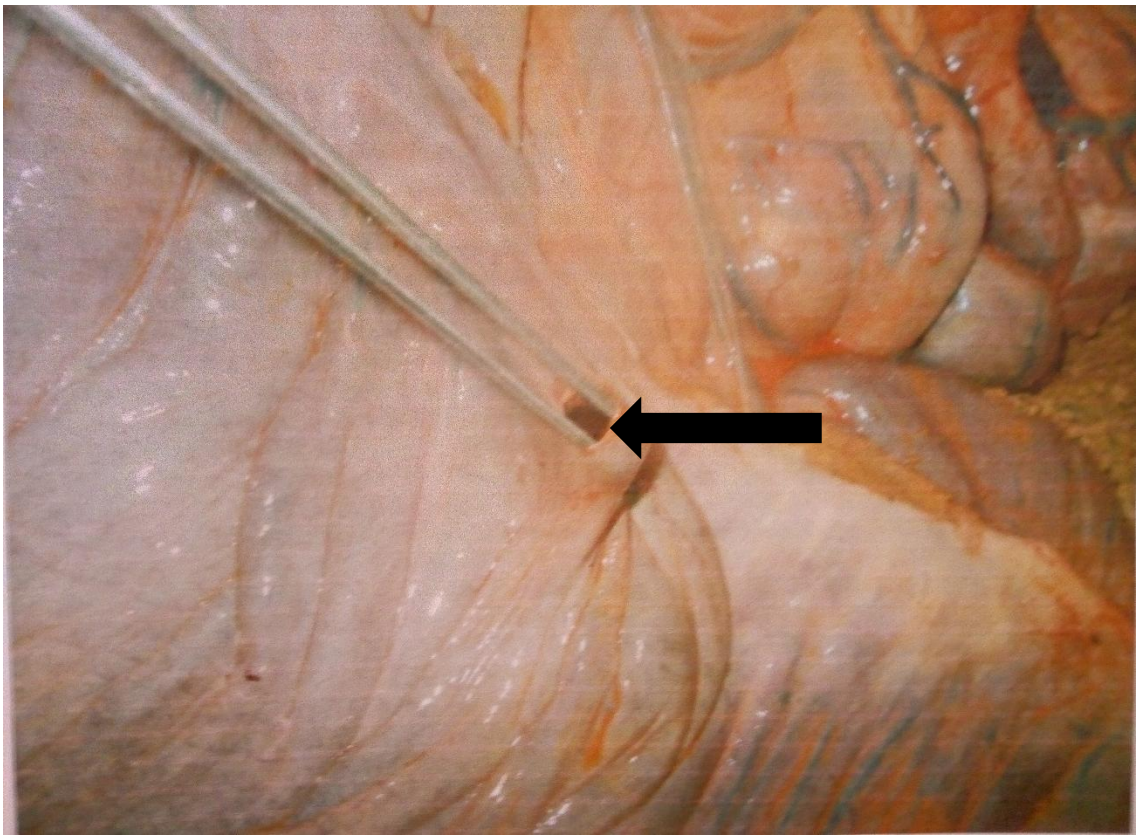

Plate XV: Perforation (arrowed) on the serosal surface of the colon (forceps inserted) observed in a gelding at post-mortem after an episode of severe colic.

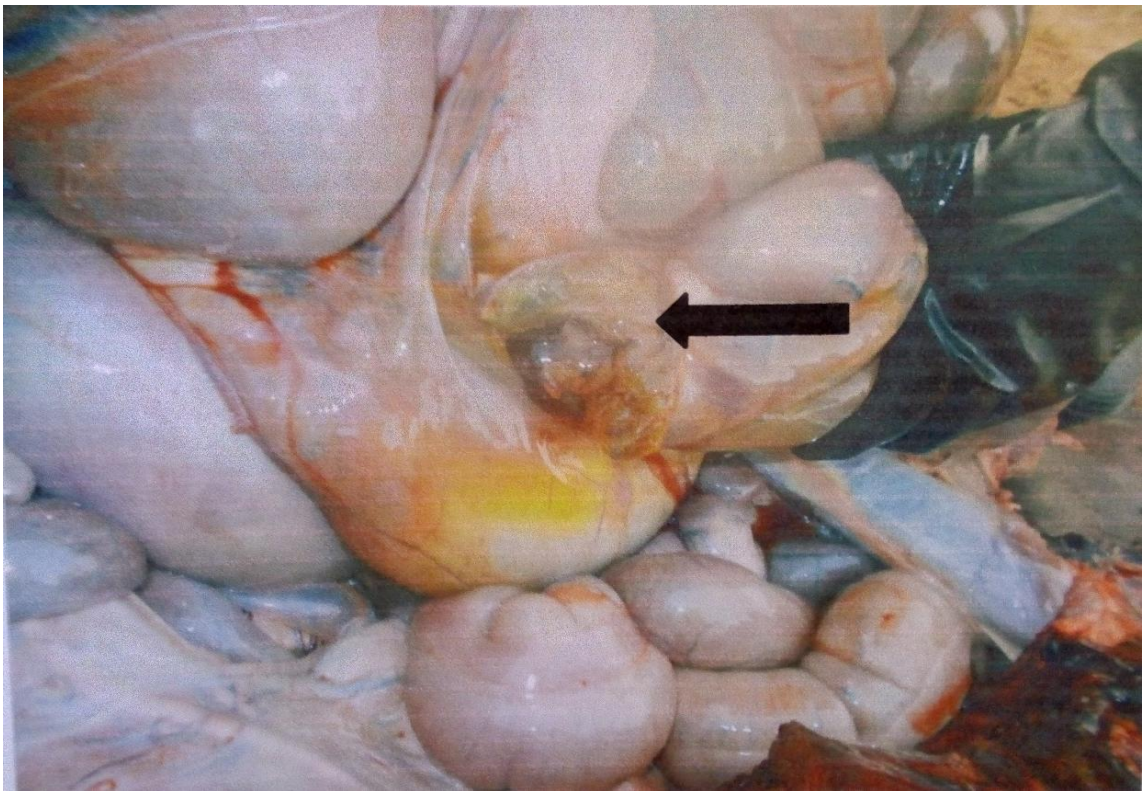

Plate XVI: Ruptured ileocaecal junction (arrowed) observed in a gelding at post-mortem after severe colic.

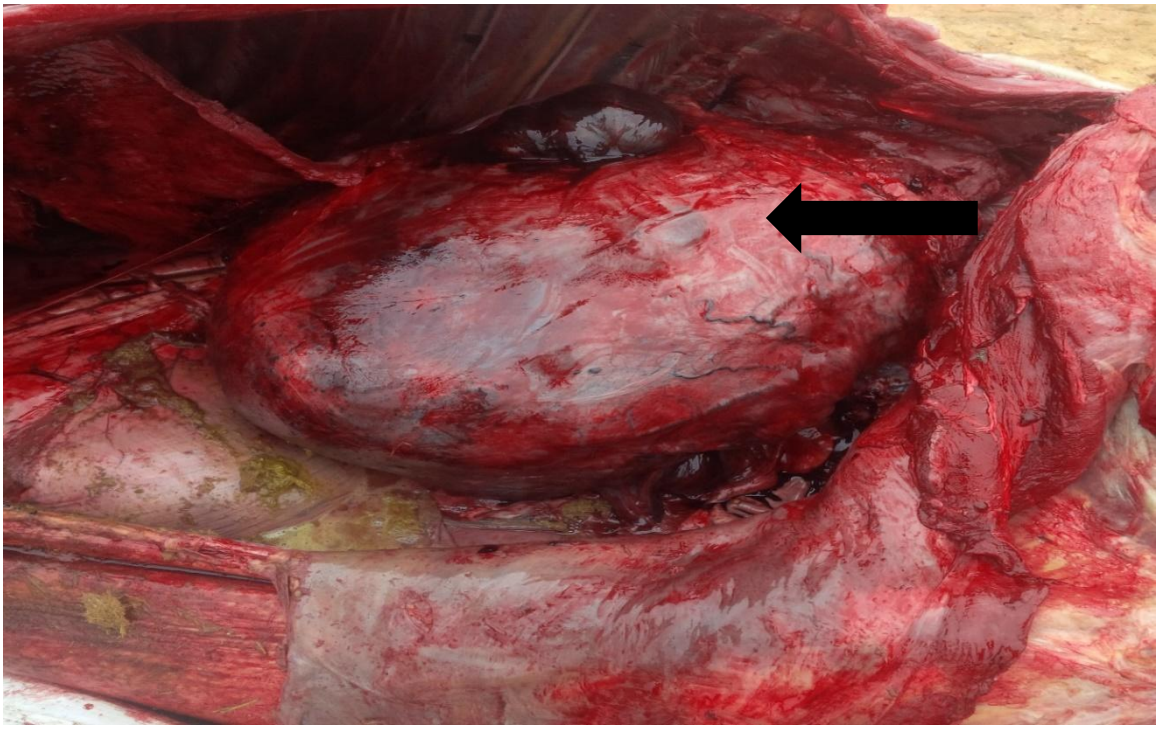

Plate XVII: Melanoma (arrowed) of the right kidney *in situ*observed in a mare at post-mortem after severe colic.

Plate XVIII: Ruptured diaphragm (arrowed) observed in a gelding at post-mortem after severe colic.

Plate XIX: Oedematous and cyanotic colon, with strangulation of the colon by the mesentery (arrowed) observed in a gelding at post-mortem after severe colic.

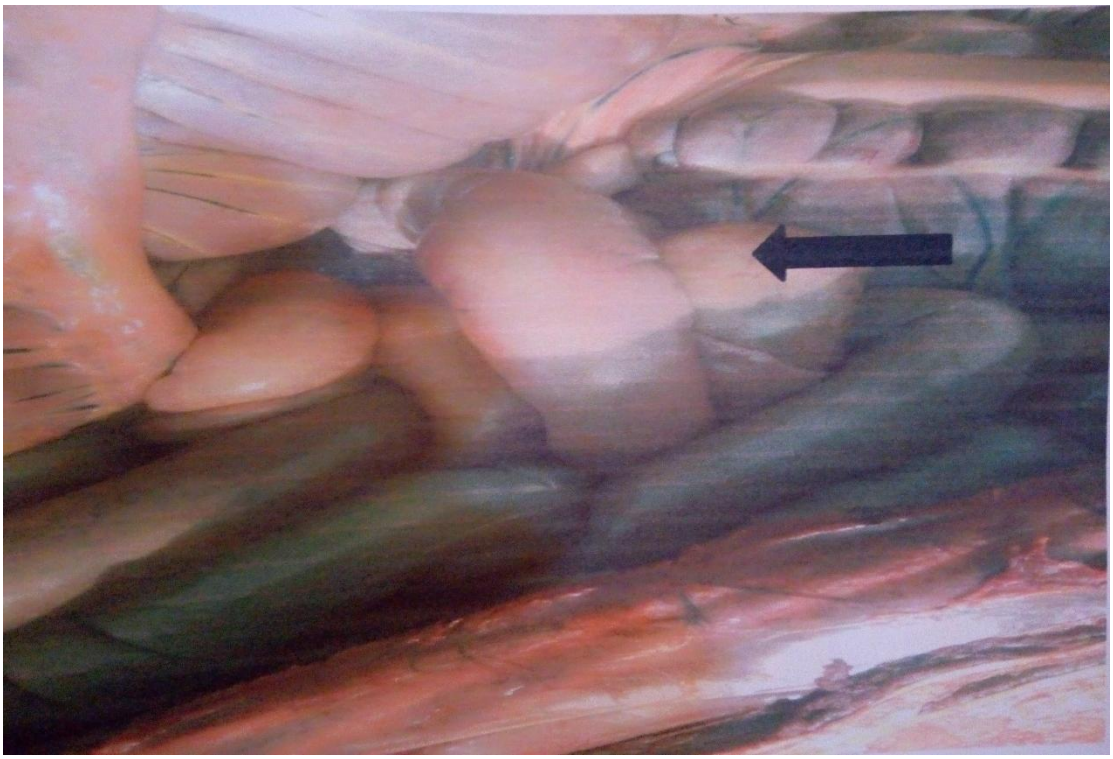

Plate XX: Volvulus (arrowed)observed in a stallion at post-mortem after severe colic.

Plate XXI: A management practice, '*chusa'* that predisposes horses toimpaction colic.

4.2 Diagnostic Approaches Used, Types of Colic Cases Handled and Treatment Regimens Employed in the Retrospective and Prospective Studies

4.2.1 Diagnostic approaches commonly used for equine colic cases

4.2.1.1 Diagnostic approaches used for equine colic cases in the retrospective and prospective studies

The diagnostic approaches used by the attending veterinarians and/or veterinary assistants in both the retrospective and prospective studies to diagnose colic included history, physical examination and rectal examination. The use of history and physical examination for the diagnosis of colic was employed by 77.3% of the respondents, while the use of history, physical examination and rectal examination; or the use of history, physical examination, nasogastric intubation, rectal examination, and post-mortem examination were 9.1% and 13.6% respectively (Table 4.16).

Table 4.16: Diagnostic approach commonly used for colic cases in selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Diagnostic approach used	Respondents		Total
	Veterinarians	Veterinary assistants	
History and Physical Examination	8	9	17
History, Physical examination and Rectal examination	2	0	2
History, Physical examination, Rectal examination and Post mortem examination	3	0	0
Total	**13 (59.1)**	**9 (40.9)**	**22 (100)**

4.2.2 Types of colic cases handled

4.2.2.1 Types of colic cases handled in the retrospective study

Of the 224 colic cases handled at the stables, 184 (82.1%) were spasmodic, 29 (12.9%) impaction, 8 (3.6%) flatulent, 2 (0.9%) gastric and 1 (0.4%) sand colic respectively (Table 4.17). Similarly, the 40colic cases handled at the Veterinary Clinic were made up of 17 (42.5%) spasmodic, 18 (45%) impaction and 5 (12.5%) flatulent colic respectively (Table 4.17) There was a statistically significant association ($\chi^2 = 91.720$; P = 0.000) between the occurrence and type of colic, with most of the cases (76.1%) being spasmodic.

4.2.2.2 Types of colic cases handled in the prospective study

From the prospective study, of the53colic cases handled at the stables, 32 (60.4%) were spasmodic, 16 (30.2%) impaction, 3 (5.7%) flatulent, 1 (1.9%) gastric and 1 (1.9%) sand colic respectively. The Veterinary Clinic recorded 1 (100%) case of spasmodic colic (Table 4.18). There was a statistically significant association ($\chi^2 = 27.949$; P = 0.000) between the occurrence and type of colic, with most of the cases (61.1%)in both the stables and Veterinary Clinic being spasmodic.

Table 4.17: Types colic cases observed in Retrospective study in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Types of colic cases reported	No. of Colic cases recorded per location				Total
	Stables		Veterinary Clinic		
	Frequency	%	Frequency	%	
Spasmodic	184	82.1	17	42.5	201
Impaction	29	12.9	18	45.0	47
Flatulent	8	3.6	5	12.5	13
Gastric	2	0.9	0	0	2
Sand	1	0.4	0	0	1
Total	**224**	**84.8**	**40**	**15.2**	**264**

$\chi^2 = 91.720$; df = 4; P = 0.000

Table 4.18: Types colic cases observed in Prospective study in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Types of colic cases reported	No. of Colic cases recorded per location				Total
	Stables		Veterinary Clinic		
	Frequency	%	Frequency	%	
Spasmodic	32	60.3	1	100	33
Impaction	16	30.2	0	0	16
Flatulent	3	5.7	0	0	3
Gastric	1	1.9	0	0	1
Sand	1	1.9	0	0	1
Total	**53**	**98.1**	**1**	**1.9**	**54**

$\chi^2 = 27.949$; df = 4; P = 0.000

4.2.3 Treatment used for colic cases by Veterinary Personnel

In the management of colic cases, several drugs were employed by Veterinary personnel and these included antispasmodics, nonsteroidal anti-inflammatory drugs (NSAIDs), and a combination of several drugs. The common drugs employed in the management of identified by both retrospective and prospective studies are indicated in Table 4.19.

Table 4.19: Treatments used for colic cases by Veterinary personnel in Kaduna State, Nigeria

Desig.	Treatment regimen used for colic (%)						Total
	Antispasm.	NSAIDs	Antispasm. + Deworm	Antispasm. + M.O.	NSAIDs + Fluid	Sedative	
Vet.	4 (30.8)	4 (30.8)	1 (7.7)	1 (7.7)	2 (15.3)	1 (7.7)	13
Vet. assist.	5 (55.6)	2 (22.2)	1 (11.7)	1 (11.7)	0 (0.0)	0 (0.0)	9
Total	**9 (40.9)**	**6 (27.3)**	**2 (9.1)**	**2 (9.1)**	**2 (9.1)**	**1 (4.6)**	**22**

Key:

Desig.= Designation
Vet. = Veterinarian
Vet. assist. = Veterinary assistants
Antispasm. = Antispasmodic (dipyrone; hyoscine-N-butylbromide and dipyrone)
NSAIDs = Non-steroidal anti-inflammatory drugs (phenylbutazone and flunixin meglumine)
M.O. = Mineral oil
Deworm = Ivermectin, pyrantel pamoate, praziquantel
Fluid = 5% dextrose, Lactated Ringers'solution, Normal saline
Sedative = xylazine, detomidine, acepromazine

4.3 Predisposing Factors for Equine Colic

4.3.1 Role of season in occurrence of colic

4.3.1.1 Role of season in the occurrence of colic in the retrospective study

Of the 264 colic cases during the retrospective study, 188 (71.2%) occurred during the dry/harmattan season, and 76 (28.8%) were in the wet/rainy season (Table 4.20). There was a statistically significant association (χ^2 = 214.119; P = 0.000)between season and occurrence of colic during this study.

4.3.1.2 Role of season in the occurrence of colic in the prospective study

Of the 54 colic cases during the prospective study, 45 (83.3%) were during the dry/harmattan season, and 9 (16.7%) occurred during the wet/rainy season (Table 4.21). There was no statistically significant association (χ^2 = 2.898; P = 0.089)between season and occurrence of colic during this study.

4.3.2 Role of management practice in the occurrence of colic

4.3.2.1 Role of management practice in the occurrence of colic in the retrospective study

Of the 1540 horsesinvolved in this study, 338 had regular 'turn out' periods, and a herd health management programme (HHMP) that included a strategic deworming practice, regular vaccination against African horse sickness (AHS), Equine influenza and tetanus, with 88 (26%) experiencing colic. 216horses had regular 'turn out' periods, a HHMP that included routine deworming, selective vaccination against AHS and tetanus, with 25 (11.6%) experiencing colic. 163horses were stalled, had no HHMP,although they had infrequent deworming, and selective vaccination against tetanus,with 23 (14.1%)

experiencing colic.823other horses were either kept in stalls or tethered, with no HHMP,had infrequent deworming, and selective vaccination against tetanus respectively,with 128 (15.6%) experiencing colic (Table 4.22). There was a statistically significant association (χ^2 =32.539; P = 0.000) between management practice and occurrence of colic with horses in the first group having the highest (26.0%) cases of colic.

Table 4.20: Effect of season in the occurrence of colic during the retrospective study in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Season	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded	OR (95% CI)
		Frequency	%	Frequency	%	Frequency	%	Frequency	%		
Dry	823	730	88.7	93	11.3	178	21.6	10	1.2	188	1.013 (0.988 – 1.037)
Wet	717	650	90.7	67	9.3	68	9.5	8	1.1	76	1(Ref)
Total	**1540**	**1380**	**89.6**	**160**	**10.4**	**246**	**16.0**	**18**	**1.2**	**264**	

$\chi^2 = 214.119$; df = 1; P = 0.000

Table 4.21: Effect of season in the occurrence of colic during the prospective study in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Season	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded	OR (95% CI)
		Frequency	%	Frequency	%	Frequency	%	Frequency	%		
Dry	186	173	93.0	13	7.0	44	23.7	1	0.5	45	1.013 (0.988 – 1.037)
Wet	125	115	92.0	10	8.0	9	7.2	0	0	9	1(Ref)
Total	**311**	**288**	**92.6**	**23**	**7.4**	**53**	**17.0**	**1**	**0.3**	**54**	

$\chi^2 = 2.898$; df = 1; P = 0.089

Table 4.22: Role of management practice in the occurrence of colic observed during the retrospective study in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Management practice	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
A	338	338	100	0	0	88	26.0	0	0	88
B	216	216	100	0	0	25	11.6	0	0	25
C	163	71	43.6	92	56.5	13	8.0	10	43.5	23
D	823	755	91.7	68	8.3	120	14.6	8	6.3	128
Total	**1540**	**1380**	**89.6**	**160**	**10.4**	**246**	**16.0**	**18**	**1.2**	**264**

$\chi^2 = 32.629$; df = 3; P = 0.000

Key:
A = Stabled, regular 'turn out', herd health management practice (HHMP): strategic deworming, regular vaccination against African horse sickness, Equine influenza and Tetanus, hoof care and other health management practices.
B = Stabled, regular 'turn out', herd health management practice (HHMP): routine deworming, selective vaccination against African horse sickness and Tetanus, hoof care.
C = Stalled, no 'turn out', no herd health management practice (HHMP):selective vaccination against Tetanus, infrequent deworming and hoof care.
D = Stalled/tethered, no herd health management practice (HHMP):selective vaccination against Tetanus, infrequent deworming and hoof care.

4.3.2.2 Role of management practice in the occurrence of colic in the prospective study

Of the 311 horses involved in this study, 127 were stabled, had regular 'turn out' periods, and a herd health management programme (HHMP) that included a strategic deworming practice, regular vaccination against African horse sickness (AHS), Equine influenza and tetanus, with 30 (23.6%) experiencing colic. 35horses were stabled, had regular 'turn out' periods, a HHMP that included routine deworming, selective vaccination against AHS and tetanus, with 5 (14.3%) experiencing colic. 23horses were stalled, had no HHMP, although they had infrequent deworming, and selective vaccination against tetanus,with 1 (4.3%) experiencing colic.126other horses were kept in stalls or tethered, with no HHMP,had infrequent deworming, and selective vaccination against tetanus respectively,with 18 (14.3%) experiencing colic (Table 4.23). There was no statistically significant association (χ^2 =3.892; P = 0.273) between management practice and occurrence of colic with horses in the first group having the highest (23.6%) cases of colic.

Table 4.23: Effect of management practice in the occurrence of colic observed during the prospective study in the selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Management practice	No. of equine cases recorded	No. of cases recorded in the stables		No. of cases recorded in the Vet. Clinic		No. of colic cases recorded in the stables		No. of colic cases recorded in the Vet. Clinic		Total no. colic cases recorded
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
A	127	127	100	0	0	30	23.6	0	0	30
B	35	35	100	0	0	5	14.3	0	0	5
C	23	0	0	23	100	0	0	1	0	1
D	126	126	100	0	0	18	14.3	0	0	18
Total	**311**	**288**	**89.6**	**23**	**7.4**	**53**	**17.0**	**1**	**0.3**	**54**

$\chi^2 = 3.892$; df = 3; P = 0.237

Key:
A = Stabled, regular 'turn out', herd health management practice (HHMP): strategic deworming, regular vaccination against African horse sickness, Equine influenza and Tetanus, hoof care and other health management practices.
B = Stabled, regular 'turn out', herd health management practice (HHMP): routine deworming, selective vaccination against African horse sickness and Tetanus, hoof care.
C = Stalled, no 'turn out', no herd health management practice (HHMP):selective vaccination against Tetanus, infrequent deworming and hoof care.
D = Stalled/tethered, no herd health management practice (HHMP):selective vaccination against Tetanus, infrequent deworming and hoof care.

4.3.3 Role of dental health management in the occurrence of colic

Of the 120respondents in the study on the role of dental checks in the occurrence of colic, 28 (23.3%)had encountered dental management practice in horses done once in six months, while 92 (76.7%) had not encountered dental management practice in horses (Table 4.24). Despite the dental care, respondents still encountered cases of colic inthe horses. Results showed that there was a statistically significant association (χ^2 =9.903; P = 0.002) between dental health management and colic, with horses that hadno dental management being 1.974 times more likely to have colic compared to those that had dental health management.

Table 4.24: Response of respondents on role of dental health management in the occurrence of colic in selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Dental checks	**Designation of respondents**						**Total (%)**	**OR (95% CI)**
	Vet.	Vet. assist.	Grooms	Trainers	Managers	Owners		
No dental check done	3 (3.3)	9 (9.8)	66(71.7)	4 (4.3)	3 (3.3)	7 (7.6)	92 (76.7)	1.974 (1.284 – 3.035)
Dental checks done at least once in six months	10(35.7)	15(53.5)	1 (3.6)	1 (3.6)	1 (3.6)	1 (3.6)	28 (23.3)	1 (Ref)
Total	**13(10.8)**	**9(7.5)**	**81(67.5)**	**5 (4.2)**	**4 (3.3)**	**8 (6.7)**	**120(100)**	

$\chi^2 = 9.903$; df = 1; P = 0.002

Key:

Vet. = Veterinarians
Vet. assist. = Veterinary assistants
OR = Odds Ratio

4.4 Knowledge and Practices of Respondents on Colic in Horses

4.4.1 Knowledge of respondents on colic

A total of 120 questionnaires were administered to respondents. Out of which 13 (10.8%) were Veterinarians, 9 (7.5%) were Veterinary technicians, 81 (67.5%) were grooms, 5 (4.2%) were trainers, 4 (3.3%) were stable managers, and 8 (6.7%) were owners. All the 120 respondents (100%) were aware of colic as a condition in horses and they knew the signs of colic in horses (Table 4.25).

4.4.2 Respondents' conventional treatment practices of colic in horses

The respondents' practices with regards to the management of colic in the absence of Veterinary personnel are presented in Table 4.26. Antispasmodics drugs were the most commonly used (45%), followed by NSAIDs (22.4%), a combination of antispasmodics and NSAIDs (17.3%),and laxatives (15.3%). There was no statistically significant association (χ^2 = 9.828; P = 0.155)between the respondents involved and treatment used. Traditional practices for managing colic in the absence of Veterinary personnel included hand walking (65.3%), drenching with lager beer (20.4%), drenching with decoction of herbs (*Azadiractha indica*) (7.1%), drenching with infusion of fox skin '*dilla'*(4.1%), drenching with infusion of the chestnut (3.1%) were the common practices (Table 4.27).

Table 4.25: Knowledge of respondents on colic cases in selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Designation of respondent interviewed	Frequency of encounter with colic	Percentage (%)
Veterinarian	13	10.8
Veterinary Assistant	9	7.5
Groom	81	67.5
Trainer	5	4.2
Manager	4	3.3
Owner	8	6.7
Total	**120**	**100**

Table 4.26: Non-vet. professionals' treatment practices of colic in horses in Kaduna State, Nigeria

Design.	No. interviewed	Treatments used for colic							
		Antispasmodic		NSAIDS		Laxative		Combination	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
Groom	81	35	43.2	18	22.2	12	14.8	16	19.8
Trainer	5	2	40.0	1	20.0	1	20.0	1	20.0
Manager	4	2	50.0	1	25.0	1	25.0	0	0
Owner	8	5	62.5	2	25.0	1	12.5	0	0
Total	**98**	**44**	**45.0**	**22**	**22.4**	**15**	**15.3**	**17**	**17.3**

$\chi^2 = 9.828$; df = 3; P = 0.155

Key:

Design. = Designation
NSAIDs = Nonsteroidal anti-inflammatory drugs
Combination = Combination of the above listed treatments

Table 4.27: Non-vet. professionals' traditional treatment of colic in horses in Kaduna State, Nigeria

Design.	No. interviewed	Traditional treatment used for colic									
		Hand walking		Drench with lager beer		Drench with decoction of herbs		Drench with infusion of fox skin		Drench with infusion of chestnut	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Groom	81	58	71.6	16	19.8	5	6.2	1	1.2	1	1.2
Trainer	5	1	20.0	1	20.0	0	0.0	2	40.0	1	20.0
Manager	4	1	25.0	1	25.0	0	0.0	1	25.0	1	25.0
Owner	8	4	50.0	2	25.0	2	25.0	0	0.0	0	0.0
Total	**98**	**64**	**65.3**	**20**	**20.4**	**7**	**7.1**	**4**	**4.1**	**3**	**3.1**

Key:
Design. = Designation
Freq. = Frequency
Decoction of herbs = Decoction of *Azadiractha indica*
Infusion of fox skin = (H. *'dilla'*) piece of fox skin obtainable from traditional healers

CHAPTER FIVE

5.0 DISCUSSION

The retrospective and prospective studies on the occurrence of colic in horses in the selected stables and a Veterinary Clinic in Kaduna State recorded 17.1% and 17.4% respectively, with an overall occurrence of rate of 17.2%. This figure is within the range of 18.9% recorded by Tinker *et al.* (1994) and Hillyer*et al.* (2002);26%recorded by Akinrinmade and Olusa (2009), and 18.4% by Mayaki (2017).

In the retrospective study, there was no association between the occurrence of colic and age. Though, the highest occurrence of colic was recorded in the 16 to 20 years old age group. In theprospective study, there was an association between the occurrence of colic and age, with the highest occurrence of colic being in the 21 to 25 years old age group and this agrees with reports by Reeves *et al.* (1989), Cohen and Peloso (1996), Kaneene *et al.* (1997) and Cohen*et al.* (1999) that older horses or horses of increasing age and ponies were at an increased risk of suffering from colic.

The observed higher occurrence of cases of colic in geldings in both the retrospective and prospective study is similar to the findings of Blikslager *et al.* (1992), Edwards and Proudman (1994) and Cohen and Peloso (1996) that geldings were at an increased risk of suffering from colic. The clinical implication of this is that certain findings of signalment and management factors may identify geldings to be at an increased risk of suffering from colic.

Colic was recorded most in the Argentine polo ponies compared to the other breeds of horses in the study. This agrees with Tinker *et al.* (1997) and Traub-Dargatz*et al.* (2001) who reported that Thoroughbreds were more likely to develop colic. However, Kaneene*et al.* (1997) reported no association between breed and colic. The occurrence of colic was observed to be more in polo horses which is clinically significant and this could be due to the fact that polo horses had higher levels of activity compared to compared to the other horses in the study area, thus, being prone to changes in their management such as in feeding and housing especially on being transported to different locations for events. The finding agrees with reports by Cohen *et al.* (1999) and Hillyer*et al.* (2001a) who documented that both increases and decreases in activity levels may be associated with colic as exemplified by intensive exercise being associated with increased risk for colic (Pugh and Thompson, 1992; Cohen*et al.*, 1999) and changes in activity often occur concomitantly with changes in stabling and diet (Cohen*et al.*, 1999), and also changes in housing management particularly predispose horses to colic, with a change in housing being often associated with inconsistencies in management practices such as change in feed (Cohen*et al.*, 1999) and a change in the activity from which the horseswere formerly accustomed to (Cohen*et al.*, 1995b; 1999).

Sudden changes in feed were among the causes of colic in horses documented in this study. There was a statistically significant association between the occurrence of colic and changes in feed,with periodic changes in feed, especially the change in the batch of hay and concentrates fed to horses, resulting in episodes of colic. This finding agrees with that of Cohen (2003a, b) who reported that changes in diet, specifically changes in the batch,

type or amount of concentrate, was associated with increased risk of colic. Moreover, Cohen*et al.* (1999) and Hudson*et al.* (2001) had also reported that among the changes in feeding, type of hay remains as the most significant factorthat causes colic.

Similarly, Archer and Proudman (2006) also reported certain feed types and feeding practices being identified as causes of colic. Such as excessive feeding of baled hay or change in the timing of feeding. Holland*et al.* (1998) reported that high percentage of fibre in hay favours impaction of the small intestine by stimulating intestinal motility, resulting in water absorption. Also, coarse roughage or hay of poor quality and low digestibility has been shown to predispose horses to colic (White and Dabareiner, 1997;Cohen*et al.*, 1999). Goncalves*et al.* (2002) also reported that poor quality hay was a risk for colic in horses.Also, the observed cases of colic due to changes in the batch of concentrate, is similar to the reports of Proudman (1992),Cohen*et al.* (1999), Hudson*et al.* (2001), Hillyer*et al.* (2002), McCarthy*et al.* (2004) and Loving (2011) who demonstrated that changes in the quantity or quality of feed, especially concentrates, is significantly associated with colic in horses.

Drugs such as albendazole, ivermectin andimidocarb dipropionateused for the treatment of endo-, ecto- and haemoparasitesrespectively in horses were identified to be associated with colic even when used within the recommended dosages. It can be inferred that the mechanisms of action of these drugs had effect on the normal motility of the GIT, with the resultant manifestation of abdominal pain after administration. Similar observations were made by Proudman (1992) and Kaneene *et al.* (1997) who reported that medicaltreatment

or vaccination increases the risk for equine colic due to stress, especially drugs which may affect intestinal motility. Dowling (2002) also reported that adverse drugs reactions (ADRs) occurred inhorses, and the most common drugs associated with ADRs in horses were antimicrobials, steroidal and nonsteroidal anti-inflammatory drugs, anaesthestics, sedatives and anti-parasitic drugs. Similarly, Karns and Luther (1984) reported adverse effects including signs of colic following use of ivermectin in horses. Kutscha *et al.* (2012) and Abutarbush *et al.* (2013) reported that the use of imidocarb dipropionate in horses was associated serious adverse effects including signs of abdominal pain and diarrhoea. Dayan (2003) and GlaxoSmithKline (2011) also reported abdominal pain as the most frequently reported symptom after dosing with albendazole.

The clinical signs of colic in affected horses described by the respondents included attempts to lie down and pawing, lateral recumbency, rolling with bruises, kicking at the abdomen, flank watching, Flehmen's response, blowing, sweating, biting at the flank and sweating. The respondents' knowledge on the clinical signs of colic in horses were consistent with the findings of other investigators (Mair, 2002; Ashley *et al.*, 2005; UC Davis, 2008; Taylor *et al.*, 2010; Edwards, 2013; Southwood, 2013; Curtis*et al.*, 2015).

The common diagnostic approaches used by the attending veterinarians and/or veterinary technicians todiagnosis colic in horses included the use of history, physical examination, rectal examination and post-mortem findings. This finding is similar to the report ofCurtis

et al. (2015)who reported that Veterinary practitioners' selection of diagnostic tests for the primary evaluation of colic in horses varied with experience and the available resources. The use of sophisticated diagnostic approaches such as the use of fast localized acute sonography for horses (FLASH) as described by Busoni *et al.* (2011) to pinpoint the exact location of lesions in acute abdomen of horses would have been of immense value in the field evaluation of horses with acute abdomen non-responsive to analgesic treatment. These were unavailable to practitioners in the study area.

The types of colic cases handled in both the retrospective and prospective studies were classified as spasmodic, impaction, flatulent, gastric and sand colic, on basis of clinical manifestation. Spasmodic/simple colic can be described as spasms of the GIT which is a common occurrence. Impaction colic involved the occlusion of segments of the GIT by dehydrated masses of ingesta,whereas,flatulent colic manifested as distension of the viscera due to excessive accumulation of gas as a result of consumption of rapidly fermentable feed. The gastric colic describes a ruptured stomach observed at post mortem. The predominant type recorded in the studies was spasmodic colic, also referred to as simple colic. This finding is similar to the classification by Proudman (1992) who reported that studies on horses with colic presented to veterinary practices were reported to have a predominance of simple or spasmodic colic, with impactions diagnosed in approximately 10% of affected horses. Similarly, Kaneene *et al.* (1997) and Tinker*et al.* (1997), reported that approximately 30% of horses with colic were identified by owners but never examined by a veterinarian because the colic was transient or resolved with treatment by the owner.

Also, White (2006) reported that horses presented to Veterinary Teaching Hospitals or practices for evaluation of colic ranked simple colic with impaction as the most common.

The common treatments employed in the management of colic identified by this study were the use of antispasmodics such as Calmagine® (dipyrone) and Buscopan® compositum (hyoscine-N-Butylbromideand dipyrone), followed by the use of non-steroidal anti-inflammatory drugs (NSAIDs)such as Phenylarthrite® (phenylbutazone), Finadyne®(flunixin meglumine) and Metacam® (meloxicam). This finding is similar to reports by White (2006) and Blikslager (2013) that antispasmodics and NSAIDs were the most commonly used drugs for managing pain associated with colic in horses.

With respect to predisposing factors to colic, the study revealed that in the retrospective result, occurrence of colic had an association with season, with most occurrence of colic being in the dry season, though, in the prospective study, occurrence of colic had no association with season. The horses had episodes of colic irrespective of the period of the year (whether dry/harmattan or rainy/wet) but with most occurrence being in the dry season. This finding is similar to the reports by Cohen (1997), McCarthy *et al.* (2001) and Goncalves *et al.* (2002) that despite weather-related factors being associated with the occurrence of colic, there was no statistical relationship to this and the precise conditions predisposing to colic remain ill defined. Similarly, Hillyer*et al.* (2001a) and Archer *et al.* (2004) reported that it is important to consider that seasonal incidence of colic may not be associated with weather factors alone but other potentially alterable management factors

common to that time of the year such as stabling, quantity/quality of the feed or exercise levels.

In the retrospective study, the occurrence of colic had an association with management practice, with the horses that were stabled recording the highest occurrence, whereas, in the prospective study, the occurrence of colic had no association with management practice. Numerically, the horses that were stabled recorded the highest occurrence. It can be inferred that these horses were paid a lot of attention that involved periodic checks during the day. Thus, it was easy to detect clinical signs of colic whenever it manifested. The finding from this result agrees with the reports by Cohen *et al*. (1995b; 1999), Reeves *et al*. (1996) and Tinker*et al*. (1997) that confinement could generate boredom and serve as a predisposing factor to colic, especially impaction, as horses have limited or no opportunity to exercise on their own, consequently reduced intestinal motility. Cohen *et al*. (1999) and Hudson*et al*. (2001) reported that housing conditions seem to influence the risk for colic in horses.

The study also showed that there was an association between dental health management and colic, with horses that had no dental health management being more likely to have colic compared to those that had dental health management. It can be inferred that with well managed dentition, the feed especially roughages, would be properly masticated resulting in less bulk for easy digestion. Olusa and Akinrinmade (2014) reported a significant association in horses with no routine dental health care and colic, and suggested that routine dental care would be beneficial for the prevention of dental abnormalities that

may predispose to colic. Although, it is generally believed that improperly masticated roughages and concentrates may lead to poor digestibility and subsequent impaction of the colon, there are no sufficient findings to prove whether or not dental abnormalities could predispose horses to colic (Easley, 1996; Dabareiner, 1998; Ferraro *et al.*, 2006).

The study showed that all the respondents had knowledge of colic, and had encountered cases of colic in horses. This can be due to the fact that colic is one of the most common medical emergencies horse keepers deal with, and is one of the most frequent emergency conditions encountered in equine practice (Traub-Dargatz *et al.*, 2001; Edwards, 2013; Bowden *et al.*, 2014; Valberg, 2015).

The study revealed that it was common practice for grooms, trainers, managers and owners to administer antispasmodics and non-steroidal anti-inflammatory drugs (NSAIDs) to horses before the arrival of the veterinarian. This could be due to the fact that colic was always an emergency and they had successfullytreated a number of colic cases with the use of these drugs. Another reason that can be advanced for their action is that there were few veterinarians that have taken up private equine practice and there are few public veterinary practitioners that offered equine services.

Traditional management methods used by grooms, owners, trainers and managers for colic included hand walking of affected horses, drenching with lager beer, drenching with decoction of herbs (*Azadiractha indica*), drenching with infusion of fox (*'dilla'*) skin and drenching with infusion of the chestnut as alternatives. The respondents claimed these

different treatments resolved the condition whenever it arose. Walking of horses with colic could be seen as a form of exercising the horse to promote intestinal motility, hence relaxation of the gastrointestinal tract (GIT), however, it is mostly used to distract the horse from detrimental behaviour such as rolling and thrashing associated with pain. It can be inferred that the use of lager beer by respondents could be due to the presence of foam in it which speeds up the process of degradation of impacted feed material via neutralization of the pH of the GIT with a subsequent decrease in the pressure in the intestinal lumen, and reduction in pain which always accompanies colic. The use of decoction of herbs, infusion of fox skin and chestnut, could be due to their possible effects on the GIT or the fluid distribution along with pain killing properties. Though, there is yet to be scientific investigation to confirm their true effects.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the study, it can be concluded that

1. The overall occurrence of colic in the stables and the Veterinary Clinic was 17.3%.
2. The occurrence of colic in the stables and the Veterinary Clinic during the retrospective and prospective aspects of the study was 17.1% and 17.4% respectively.
3. There was no association (P = 0.085) between the occurrence of colic and age in the retrospective study, though the highest occurrence was in the 16 – 20 years old (32.3%). In the prospective study, there was a statistically significant association (P = 0.031) between theoccurrence of colic and age, with the 21 – 25 years old (57.1%)having the highest occurrence.
4. There was a statistically significant association (P = 0.085) between the occurrence of colic and sexin the retrospective study, though in theprospective study, there was no association (P = 0.435) between the occurrence of colic and sex.
5. There was a statistically significant association (P = 0.013) between the occurrence of colic andbreed in the retrospective study. However, in the prospective study, there was no association (P = 0.150) between the occurrence of colic and breed.
6. There was a statistically significant association (P = 0.001) between the occurrence of colic and use in the retrospective study, whereas, the prospective study did not showany association (P = 0.448) between the occurrence of colic and use.

7. There was a statistically significant association (P = 0.000) between the occurrence of colic and type of colic in both the retrospective and prospective study, with spasmodic colic having the highest occurrence.
8. Causes of colic in horses identified by the study included changes in feed (hay and concentrates), and the use of drugs (albendazole, ivermectin and imidocarb dipropionate) with significant associations (P = 0.000) between the occurrence of colic and these causes.
9. Clinical signs of colic were frequent attempts to lie down and pawing (37.5%), lateral recumbency, rolling with bruises on parts of the body (18.3%), lateral recumbency, flank watching, biting at the flank and sweating (13.3%), kicking at the abdomen (11.8%), Flehmen's response, blowing, sweating (10.0%), standing stretched, straining to urinate (5.8%) and diarrhoea (3.3%).
10. Commonly employed diagnostic approaches by veterinary personnel were the use of history and physical examination (77.3%), use of history, physical and rectal examinations (9.1%), use of history, physical, rectal and post-mortem examinations (13.6%).
11. Predisposing factors observed to influence the occurrence of colic included management practice, season and dental health care.
12. All respondents (Veterinarians, veterinary technicians, grooms, trainers, managers and owners) to questionnaires were knowledgeable about colic in horses.
13. Antispasmodics (45.0%) and NSAIDs (22.4%) were commonly used to treatmost cases of colic.

6.2 Recommendations

1. Horse owners, grooms, managers and trainers should avoid poor quality feed, and maintain regular feeding schedules as much as possible.
2. Horses should be ‘turned out’ as regularly as possible to encourage self-exercise, as stabled horses are at a risk of colic.
3. Grooms, owners, managers, trainers and attending veterinary personnel are advised to consult with more experienced veterinarians with respect to the use of drugs especially those identified to have possible association with colic.

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APPENDIX

APPENDIX I: Research questionnaire to determine knowledge and practices of horse handlers (Veterinarians and Veterinary technicians) to colic in selected stables and a Veterinary Clinic in Kaduna State, Nigeria

Department of Veterinary Medicine, Ahmadu Bello University, Zaria, May 2015

Researcher: Dr. EDEH, Emmanuel Richard. M Sc. Equine Medicine

Designation: Veterinarian …… Vet. assistant ……

Date: ……..…….

Questionnaire No.: ……

1. **Veterinary Staff (Clinicians, Technicians and Workers of the Veterinary Clinics) Experience**
   (i) For how long have you been serving in the stable? (tick as appropriate)
   1-5 years [ ]; 6-10 years [ ]; 11-15 years [ ]; 16 years and above [ ]

   (ii) Have you encountered colic in your practice especially in the stable? (tick as appropriate)Yes [ ];No [ ]

   (iii) If yes above, when did you last encounter it? (tick as appropriate)
   24 hours ago [ ]; 48 hours ago [ ]; 72 hours ago [ ]; 7 days ago [ ]; 2 weeks ago [ ]

   (iv) How often do you come across colic cases in the stable (tick as appropriate)
   1-3 per week[ ]; 4-6 per week [ ]; 7-10 per week [ ]; 1-3 per month [ ]; 4-6 per month [ ]; 7-10 per month [ ]

   (v) Incidence of colic (tick as appropriate)
   Before feeding [ ]; after feeding [ ];
   others……..…
   ……
   ……
   ……

2. **Physical Examination**
   (a) General Inspection performed/observed (tick as appropriate)
   (i) Attitude of horse – depressed [ ]; bright [ ]

   (ii) Behavior – pawing [ ]; attempting to lie down[ ]; glancing at flanks [ ];

   frequent urination [ ]; rolling [ ]

(b) Detailed Inspection (tick as appropriate)

Vitals parameters measured: Heart rate [ ]; Respiratory rate [ ]; temperature [ ]; pulse quality [ ]; gut sounds [ ]; mucous membrane colour [ ]; temperature of extremities [ ]; abdominal distention [ ]

3. **Diagnostic Procedures performed** (tick as appropriate)

(i) **Stomach intubation**: presence of excess fluid [ ]; absence of excess fluid [ ]; Gastric reflux [ ]

(ii) **Rectal examination**(tick as appropriate)

impaction of the large bowel [ ]; displaced bowel [ ]; distended bowel [ ]; distended small bowel loops [ ]; nephrosplenic space, inguinal canal (stallions) [ ]

(iii) **Abdominocentesis**(tick as appropriate)

Yes [ ];No [ ]. If yes, fluid color…….; fluid turbidity……; presence of blood…….; presence of ingesta…….

(iv) **Clinical pathology**(tick as appropriate)

hematocrit and total serum/plasma protein [ ]; white cell count and differential[ ]; abdominal fluid: cytology, total protein, bacteriology[ ]; serum/plasma electrolyte values [ ]; plasma/serum fibrinogen [ ]; liver function test [ ]

(v) **Ultrasound**: examination of the liver [ ]; examination of the kidneys [ ]

4. **Differential diagnoses**(tick as appropriate)

(i) Spasmodic colic [ ]; (ii) Large intestine impaction [ ]; (iii) Anterior enteritis [ ]; (iv) Large intestine displacement/torsion [ ]; (v) Gastroduodenal ulcers [ ];(vi) Sand colic [ ]; (vii) Small intestine volvulus and torsion[ ]; (viii) Small intestine intussusception [ ]; (ix) Caecal dilatation [ ]; (x) Peritonitis [ ]; (xi) Colitis [ ]; (xii) Herniation of small intestine through the epiploic foramen [ ]; (xiii) Grain overload [ ]; (xiv) Thromboembolic cranial mesenteric arteritis [ ]; (xv) Enteroliths [ ]; (xvi) Strangulating lipomas [ ]; (xvii) Abdominal tumors [ ]; (xviii) Abdominal abscess [ ]; (xix) Cystic urolithiasis [ ]; (xx) Hepatitis[ ];(xxi) Cholelithiasis [ ]; (xxii) Pleuritis [ ]

5. Disease Management

(i) How many cases of colic have you had in the past year? (tick as appropriate)
1-3 cases [ ]; 4-6 cases [ ]; 7-10 cases [ ]; 11-13 cases [ ]; 14-16 cases [ ];

17-20 cases [ ]

(ii) Which form of colic do they often show? (tick as appropriate)
Simple (resolved without treatment) [ ]; Mild (resolved with/without treatment) [ ]; Severe/fatal (did not resolve with treatment) [ ]

(iii) How many horses were affected out of the total population on the farm/stable? (tick as appropriate)
None [ ]; 1-3 horses [ ]; 4-6 horses [ ]; 7-10 horses [ ]; 11-13 horses [ ]; 14-

16 horses [ ]; 17-20 horses [ ]

(iv) How many horses died of colic? (tick as appropriate)

None [ ]; 1-3 horses [ ]; 4-6 horses [ ]; 7-10 horses [ ]; 11-13 horses [ ]; 14-

16 horses [ ]; 17-20 horses [ ]

(v) Were post-mortem examination(s) performed? (tick as appropriate)

Yes [ ]; No [ ]

(vi) If yes above, what were the findings?

……

……

……

……

……

(vii) Which horse breeds are mostly affected? (tick as appropriate)

Local [ ]; Exotic [ ]; Both [ ]

(viii) Deworming Practice in use (tick as appropriate)

Routine (horses are dewormed at intervals) [ ]; Strategic (horses are dewormed at intervals, but only after determination of the fecal worm egg count [FWEC]) [ ]; None [ ].

(ix) Type of Dewormer(s) used

(specify)……

……..……

……

6. Treatment options used for colic cases

(i) Antispasmodic Yes [ ];No [ ]. (Specify if yes)

Calmagine®(Dipyrone) [ ]; Buscopan® Compositum (Hyoscine-N-butylbromide and Dipyrone) [ ]; Buscopan (Hyoscine-N-butylbromide); Atropine sulphate [ ]

(ii) Anti-inflammatory Yes [ ]; No [ ]. (Specify if yes)

Ketoprofen[ ]; Flunixin meglumine [ ]; Phenylbutazone [ ];

Dexaphenylarthrite []

(iii) Diuretic Yes [ ]; No [ ]. (Specify if yes)

Mannitol [ ]; Furosemide [ ] Acetazolamide [ ]; Aminophylline [ ]

(iv) Mineral oil Yes [ ]; No [ ].

(v) Laxative Yes [ ]; No [ ]. (Specify if yes)

Epsom salt (Magnesium sulfate) [ ]; Glauber's salt [ ]

(vi) Sedatives Yes [ ]; No [ ]. (Specify if yes)

Xylazine [ ]; Detomidine [ ]; Acepromazine [ ]; Others

……

……

(vii) Response to treatment method is best by (tick as appropriate)

(i. alone) [ ]; (ii. alone) [ ]; (iii. alone) [ ]; (iv. alone) [ ]; (combination) [ ]

(viii) What other methods of treatment are used?

……

……

THANK YOU FOR YOUR COOPERATION.

APPENDIX II: Research questionnaire to determine knowledge and practices of horse handlers (Stable managers, grooms, trainers and horse owners) to colic in selected stables in Kaduna State, Nigeria

Department of Veterinary Medicine, Ahmadu Bello University, Zaria, May 2015

Researcher: Dr. EDEH, Emmanuel Richard. M Sc. Equine Medicine

A. Demographic Variable

i. Date:……

ii. Respondent's name: …… (optional)

iii. Stable name: ……...

iv. Horse breed(s) on farm: ……...

v. No. of males ……... No. of females…….

B. Farm/Stable Attributes

i. Location of facility (LGA) ……..……

ii. Source of horses (tick as appropriate): imported [ ]; local markets [ ].

iii. Use of horse: Polo [ ];Racing [ ];Durbar [ ];Draught [ ]; Pleasure [ ]; Armed forces [ ]

iv. When was the stable established? (Tick as appropriate)

1-3 years ago [ ]; 4-6 years ago [ ]; 7 years and above [ ]

v. Do you have a resident/visiting veterinarian on the facility? Yes [ ]; No [ ]

vi. If a groom [ ]/manager [ ]/trainer [ ], for how long have you been serving in the farm/stable? (tick as appropriate)

1-5 years [ ]; 6-10 years [ ]; 11-15 years [ ]; 16 years and above [ ]

vii. How many horses are in the facility (tick as appropriate):

1-10[]; 11-20 [ ]; 21-30 [ ]; 31-40 [ ]; 41-50 [ ]; 51 and above [ ]

viii. Migratory activity of horses: events/tournament for the past year (tick as appropriate)
Polo [ ]; Racing [ ]; Durbar [ ]; Draught [ ]; Pleasure [ ]

ix. Recent transportation (tick as appropriate)Yes [ ]; No [ ]

C. Health-Management interaction

i. Housing (tick as appropriate)

Open field [ ], Stalls/boxes [ ], Mud houses [ ]

ii. Feeds/feeding practice (tick as appropriate)

Bran [ ]; Grains [ ]; Hay [ ]; Pasture [ ]; Water [ ]

Once daily [ ]; twice daily [ ]; *ad lib* [ ]

In troughs [ ]; in buckets [ ]; on the ground [ ]

iii. Incidence of colic (tick as appropriate)

Before feeding [ ], after feeding [ ], others [ ]

iv. Water/watering practice (tick as appropriate)

Once daily [ ]; twice daily [ ]; *ad lib* [ ]

v. Housing arrangement (tick as appropriate)

Stall confinement (strict) [ ]; Stall confinement (with turn out) [ ]; Pasture

[]; Paddock with water [ ]; Paddock without water [ ]

vi. Period of turn out (tick as appropriate)

Before feeding [ ]; After feeding [ ]; Routine [ ]

vii. Deworming Practice?

Yes [ ]; No [ ]

D. Recognition of Signs of Colic

(i) Have you ever encountered colic in a horse? (tick as appropriate)

Yes [ ]; No [ ].

(ii) What signs can you use to tell that a horse has colic? (tick as appropriate)

pawing [ ]; frequent attempts to lie down[ ]; glancing at flanks [ ];

rolling [ ]; sweating [ ]; straining [ ]; frequent urination [ ]; kicking at the abdomen [ ]; Others

……

……

……

(iii) Following recognition of the above mentioned signs, for how long had the pain been present? (tick as appropriate)
30 mins. [ ]; 1 hour [ ]; 2 hours [ ]; 3 hours [ ]; >12 hours [ ]; >24 hours [ ]

(iv) Was the horse given any medication? Yes [ ]; No [ ]

(v) If yes, what medication?

……

(vi) When the horse developed colic, was it sudden or gradual? (tick as appropriate)

Sudden onset [ ]; Gradual development [ ]

(vii) What was the horse eating when it developed the colic? (tick as appropriate)
Hay [ ]; bran [ ]; fresh grass [ ]

(viii) How long ago after the feeding did the colic develop? (tick as appropriate)

1-6 hours ago [ ]; 12 hours ago [ ]; >12 hours ago [ ]

(ix) Is the horse exposed to sand at pasture? Yes [ ] No [ ] Not sure [ ]

(x) Have the horses' teeth with colic been checked recently? (tick as appropriate)
Yes [ ] No [ ] Not sure [ ]

(xi) How often do the horses have their teeth checked? (tick as appropriate)

Every 6 months [ ]; every year [ ]; not checked [ ]

(xii) Was the pain intermittent or continuous?

Intermittent [ ]; continuous [ ]

(xiii) How long has it been since faeces were passed? (tick as appropriate)

30 mins. ago [ ]; 1hour ago [ ]; 2 hours ago [ ]; Not sure [ ]

(xiv) What was the appearance of the faeces? (tick as appropriate)

pellets [ ]; pasty [ ]; watery [ ]; mucoid [ ]

(xv) Has the horse had any other episodes of abdominal pain before this one?

Yes [ ]; No [ ].

(xvi) How many cases of colic have you had in the past year? (specify)

1-3 cases [ ]; 4-6 cases [ ]; 7-10 cases [ ]; 11-13 cases [ ]; 14-16 cases [ ]; 17-20 cases [ ]; > 20 cases [ ]

(xvii) How many horses were affected out of the total population on the farm/stable?

1-3 horses [ ]; 4-6 horses [ ]; 7-10 horses [ ]; 11-13 horses [ ]; 14-16 horses [ ]; 17-20 horses [ ]; > 20 horses [ ]

(xviii) How many horses died of colic? 1-3 horses [ ]; 4-6 horses [ ]; 7-10 horses [ ]; 11-13 horses [ ]; 14-16 horses [ ]; 17-20 horses [ ]

(xix) How do you handle cases of colic in the absence of a Veterinary Doctor?

……

……

……..…..

(xx) Which horse breeds are mostly affected? (tick as appropriate)

Local [ ] Exotic [ ] both [ ] Not sure [ ]

E. Prevention and Control of Colic

(i) How often do you replace the feed of the horses daily (tick as appropriate)
Once [ ]; twice [ ]; thrice [ ]; none [ ]

(ii) How often do you introduce new feed to the horses? (Specify)

……

……

(iii) How often are the horses exercised daily? (tick as appropriate)

Once [ ]; twice [ ]; thrice [ ]; none [ ];

Others……

……

THANK YOU FOR YOUR COOPERATION.