EVALUATION OF ULTRASONOGRAPHY AS DIAGNOSTIC AND PROGNOSTIC MODALITY IN COWS AND BUFFALOES SUFFERING FROM CAECAL DILATATION

Thesis

Submitted to the Guru Angad Dev Veterinary and Animal Sciences University in partial fulfillment of the requirements for the degree of

MASTER OF VETERINARY SCIENCE
in
VETERINARY SURGERY AND RADIOLOGY
(Minor Subject: Veterinary Anatomy)

By

Vinod Kumar Shukla
(L-2018-V-96-M)

Department of Veterinary Surgery and Radiology
College of Veterinary Science

Ludhiana – 141 004

2020

CERTIFICATE I

This is to certify that the thesis entitled, **"Evaluation of ultrasonography as diagnostic and prognostic modality in cows and buffaloes suffering from caecal dilatation"** submitted for the degree of **M.V.Sc.,** in the subject of **Veterinary Surgery and Radiology** (Minor subject: **Veterinary Anatomy**) of the Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, is a bonafide research work carried out by **Vinod Kumar Shukla (L-2018-V-96-M)** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

(Dr. Ashwani Kumar)
Major Advisor
Professor
Department of Veterinary Surgery and Radiology
Guru Angad Dev Veterinary and Animal Sciences University
Ludhiana – 141 004, Punjab, India

CERTIFICATE II

This is to certify that the thesis entitled, **"Evaluation of ultrasonography as diagnostic and prognostic modality in cows and buffaloes suffering from caecal dilatation"** submitted by **Vinod Kumar Shukla (L-2018-V-96-M)** to Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, in partial fulfillment of the requirements for the degree of **M.V.Sc.** in the subject of **Veterinary Surgery and Radiology** (Minor subject: **Veterinary Anatomy**) has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an external examiner.

(Dr. Ashwani Kumar)
Major Advisor

(Dr. Vivek Malik)
External Examiner
Associate Professor-cum-Head
Department of Veterinary Surgery and Radiology, COVS
Sardar Vallabh Bhai Patel University of Agriculture and Technology
Modipuram, Merrut

(Dr. Navdeep Singh)
Head of the Department

(Dr. Sanjeev Kumar Uppal)
Dean, Postgraduate Studies
Guru Angad Dev Veterinary and Animal Sciences University
Ludhiana, Punjab

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ABSTRACT

The study was conducted in 3 parts on 53 animals. Part I (4 cows and 4 buffalo cadavers for gross and histomorphometric study of caecum); Part II divided into healthy control (group 2a; 5 cows and 5 buffaloes) and disease control (group 2b; 5 cows and 15 buffaloes) and Part III (Caecal dilatation, 2 cows and 13 buffaloes). As compared to cows, buffalo caecum had significantly ($p<0.01$) shorter ileo-caecal mesentery and the region of caecal apex devoid of ileo-caecal mesentery ($p<0.05$). On micrometry, the thickness of total caecal wall and most of its histological layers in buffaloes were significantly lesser than that in cows. In buffaloes, the total thickness of caecal wall, at apex was significantly ($p<0.05$) more than that at the body, whereas, cows had significantly ($p<0.01$) thin total wall thickness at the apex as compared to that at body. In buffaloes, the thickness of sub-epithelial connective layers of ileo-caecal mesentery was significantly ($p<0.01$) lesser than that of cows. The collagen fibers content of ileo-caecal mesentery ($p<0.01$) and caecal body ($p<0.05$), quantitatively were significantly lesser in buffaloes as compared to that in cows. Ultrasonographically, the caecum in majority of the animals in groups 2a and 2b, were scanned at the right flank or at 12th ICS with mixed or mild gaseous contents. In group 3, distended caecum was scanned at the right flank, upto 12th ICS, 11th ICS or 10th ICS with or without reverberations. Gall bladder was scanned more cranially in group 3 as compared to group 2a and 2b; however, no change in the position of pylorus was found. Pylorus in group 3 had markedly reduced peristalsis with presence of intraluminal fluid. Medicinal therapy (n=8) lead to recovery in 4 animals. Four out of Seven animals that required right flank laparotomy and caecotomy survived on long term follow up. Marked neutrophilic (relative and absolute) leukocytosis, hypokalemia, hypochloraemia and elevated levels of total bilirubin were observed as poor prognostic indicators. Markedly elevated serum levels of creatinine kinase (about 2 times) and lactate (3-4 times) have diagnostic importance. Reduced peritoneal fluid levels of Na, P, Cl, Lactate, Alb and total protein and elevated levels of total bilirubin, CK and LDH are poor prognostic indicators in bovines suffering from caecal dilatation. In conclusions, buffalo caecum is different from cow, grossly and microscopically. Dilated caecum in buffalo is difficult to exteriorize from surgical site as compared to cows. Scanning of dilated caecum, at 11th ICS or cranially require surgical intervention. Severe ileus of small intestines, increased peritoneal fluid with fibrin, dilated duodenum and pylorus with intraluminal fluid are poor prognostic indicators for caecal dilatation.

Keywords: Caecal dilatation, caecotomy, prognostic indicators, ultrasonography

Signature of Major Advisor | **Signature of the Student**

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LIST OF ABBREVIATIONS

%	:	Percent
*	:	asterism
“ ”	:	quotation marks
©	:	copyright
Alb	:	Albumin
Ca	:	Calcium
Ck	:	Creatinine kinase
Cl	:	Chloride
cm	:	centimeter
COVS	:	College of Veterinary Science
DL	:	Dorsal Length
e.g	:	For example
et al	:	*Et alia* (and others)
Etc.	:	et cetera
Fig.	:	Figure
g/dl	:	Gram/deciliter
GB	:	Gall Bladder
GDVASU	:	Guru Angad Dev Veterinary and Animal Sciences University
Hb	:	Haemoglobin
i.e.	:	*Id est* (that’s it)
K	:	Potassium
Kg	:	Kilograms
L	:	Lymphocytes
Lac	:	Lactate
LDH	:	Lactate dehydrogenase
LOS	:	Level of significance
lt	:	left
M	:	Monocytes
mg	:	Milligram
mg/dL	:	Milligram/deciliter
MHz	:	MegaHertZ
min	:	Minute
ml	:	Milliliter
mmol/L	:	Millimole per liter
N	:	Neutrophils
Na	:	Sodium
P	:	Phosphorus
PCV	:	Packed cell volume
rt	:	right
T Bil	:	Total bilirubin
TL	:	Total Length
TLC	:	Total leucocyte count
TP	:	Torus Pyloricus
um	:	micrometer
VL	:	Ventral Length

CHAPTER I

INTRODUCTION

Economy of the Indian farmer largely depends on agriculture and dairy farming. Cows and buffaloes are the major milk producing animals which is influenced by their health status. Among commonly encountered thoraco-abdominal disorders such as traumatic reticuloperitonitis and allied disorders, reticular diaphragmatic hernia, abomasal dilatation and displacement, small intestinal obstruction and intussusception, caecal dilatation with or without retroflexion is one of the economically important disease in dairy cows (Meylan *et al* 2008). Precise and accurate diagnosis of the specific disease condition and early institution of appropriate treatment (medicinal or surgical) is always desirable.

The diagnosis of caecal dilatation is straightforward on per rectal examination, but decision regarding conservative versus surgical treatment is always bewildering. Caecal dilatation may be secondary to traumatic reticulo-peritonitis (Singh *et al* 2017a). Along with dilatation of caecum, displacement, torsion and retroflexion of proximal loop and spiral ansa of ascending colon is also reported to be encountered (Braun *et al* 2012).

The carbohydrates which bypass forestomach digestion are later fermented in caecum. It is large mobile blind sac with caudally directed apex, having no valve or stricture between the caecum, and colon i.e. caecum is in continuous with the colon. At ileocaecocolic junction, the ileum enters into the caecum. Normal location of the caecum is the supraomental recess, but can also be found between greater omentum and right abdominal wall. Dorsally, the caecum is attached to the proximal loop of ascending colon by caeco-colic fold, ventrally with ileum by ileocaecal fold, cranially to the right side of the mesentry and caudally the apex is free which can be felt per-rectally at the pelvic inlet when distended (Fubini 1990).

Clinical presentation of caecal dilatation in animals is non-specific with abnormal general condition and demeanor along with mild colic, altered ruminal motility (may be absent or sluggish), and little (mucoid) or no faeces in the rectum. Laboratory findings mostly include hypocalcemia, hypokalemia, hyponatraemia, hypoproteinemia with increased BUN, TLC, PCV, phosphorus and creatinine (Fubini *et al* 1986, Mohan *et al* 2006, Braun *et al* 2012). The neutrophil to lymphocytic ratio may be reversed (Mohan *et al* 2006).

Ultrasonography is reported as a useful diagnostic tool and supplements clinical findings of caecal dilatation in cows and buffaloes (Braun *et al* 2012, Singh 2016, Singh *et al* 2018), though, presence of luminal gas, produced by the fermentation of carbohydrates, obscures ultrasonography. Usually dilated caecum can be palpated on per-rectal examination, but this is insufficient to distinguish caecal dilatation from other gastrointestinal disorders like right sided abomasal displacement and small intestinal ileus (Braun 2009). The dilated caecum can be imaged at flank, 12^{th}, 11^{th} ICS along with lateral abdominal wall depending on degree of dilatation (Braun *et al* 2002). The dilated proximal loop of the ascending colon and caecum at the right paralumbar fossa may mask the imaging of right kidney and peristaltic movement of small intestine (Khalphallah 2016). These ultrasonographic parameters may be explored for assessing the severity of the caecal dilatation and its pognosis.

Right flank caecotomy is recommended; in standing position to decompress the dilated caecum in cattle with good success rate (Braun *et al* 2012). Clinical studies on larger data in relation to long term outcome of caecal dilatation in buffaloes are unavailable. Recent clinical studies conducted at this university on small sample size reported almost similar success rate following left flank (rumen emptying and caecal kneading) or right flank (caecotomy and flushing) surgery in bovine (Singh *et al* 2018, Singh *et al* 2019). It is a subjective observation that exteriorization of caecum in buffaloes during right flank laparotomy poses difficulty as compared to that in cows and is thought to be associated with short caeco-colic mesentery in buffaloes; however, the scientific evidence is lacking.

Though cows and buffaloes appear similar, but recent studies have highlighted differences in the behaviour, vital clinical parameters, topography of the reticulum and omasum, clinical manifestations of some disease conditions such as traumatic reticulo-peritonitis and pericarditis, and also skin thickness (Abdelal *et al* 2009, Kumar and Saini 2011, Diniz *et al* 2016, Sangwan *et al* 2018). There is paucity of information in literature on the anatomical and morphometric differences in the caecum of cows and buffaloes in relation to surgical exploration. Besides, ultrasonography may be explored for its potential prognostic value in caecal dilatation in cows and buffaloes. Therefore, the present study was planned with the following objectives:

1. To evaluate differences in the morphology of the caecum of cows and buffaloes in relation to surgical exploration.
2. To evaluate diagnostic and prognostic utility of ultrasonography in the caecal dilatation of cows and buffaloes.
3. To evaluate long term outcome of surgically treated cases of caecal dilatation.

CHAPTER II

REVIEW OF LITERATURE

Among large intestinal disorders, caecal dilatation is relatively common disease condition that leads to bowel obstruction in animals. This review updates the information on various aspects of caecal dilatation in cows and buffaloes, under the following subheads:

2.1 Predisposing factors associated with caecal dilatation

2.2 Clinical examination and symptoms of caecal dilatation

2.3 Haemato-biochemical and peritoneal fluid alteration in intestinal obstruction

2.4 Abdominal ultrasonography as diagnostic and prognostic modality

2.5 Success rate of caecal dilatation surgery in bovine

2.6 Topography and histology of caecum in animals

2.1 Predisposing factors associated with caecal dilatation

Waldeland (1982) evaluated the impact of seasonal distribution and feeding alterations on the occurrence of caecal dilatation and torsion in sheep. It was suggested that lush pastures, or the change from either indoor feeding with hay to grass silage and concentrates, or from grass with relatively high fibre content to rapidly growing grass were suggested as important predisposing aetiological factors for caecal dilatation and torsion in sheep.

Fubini (1990) reported that caecal dilatation and volvulus were common ailments in dairy cattle, but caecal torsion was not primary finding and it occurs occasionally secondary to the caecal dilatation. Though the actual etiology for caecal dilatation is unknown but possibly occurs in association with large intestinal ileus and production of excessive volatile fatty acid associated with high grain feeding in lactating cattle. The initial 60 days post-partum period was reported as susceptible for occurrence of caecal dilatation. Large colon obstruction and strangulation were considered as rare causes for caecal dilatation. Higher occurrence of caecal dilatation was observed during winter season when lactating cattle are stall fed.

Rameshkumar *et al* (1991) reported a rare occurrence and surgical management of caecal dilatation and torsion in a she-buffalo.

Singh *et al* (2002) reported cases of caecal impaction in animals being maintained on dry fodder and concenterate diet for the last few months.

Anderson and Ewoldt (2005) stated that among various surgical disorders of the gastrointestinal tract, abomasal dislocation and reticuloperitonitis of forestomach and caecal dilatation of colon occur more frequently.

Karanikas *et al* (2007) reported the unusual sequel of taeniasis as the cause of mechanical obstruction of a 40 cm part of the bowel specifically terminal ileum and an obstructive ileus of large bowel due to sigmoid volvulus.

Hasunuma *et al* (2011) highlighted the harmful effects of Napier grass being fed as roughage especially the stem part, leading to intestinal obstruction in Japanese black cows. Necropsy confirmed that all the cows had intestinal obstruction due to phytobezoar derived from Napier grass. It was advised to avoid the use of hard stem Napier grass as roughage to cows so as to prevent intestinal obstruction.

Dharmaceelan *et al* (2015) reported a case of ileus of ileum in a 6 year old 5 months pregnant buffalo associated with mechanical obstruction by phytobezoar, obstructing the intestinal lumen cranial to the caecum.

Singh *et al* (2017b) found higher incidence of intestinal obstruction due to sudden change in the feed.

Nicholas and Fecteau (2018) reported caecal dislocation to be the most frequent sequel of GI tract that occurs after abomasal displacement. The diet rich in rumen resistant starch was considered to be the predisposing factor for the occurrence of caecal dilatation as it causes increased caecal and colon fermentation of the carbohydrates. Hypocalcemia was also found to be associated with this disease condition.

2.2 Clinical examination and symptoms of caecal dilatation

Dehghani and Townsend (1982) performed clinical examination of a six month old Holstein-Friesian steer diagnosed for caecal dilatation and counter-clockwise torsion of about 360^o (viewing from the right flank) involving the proximal portion of spiral colon. The animal had a history of bloat and anorexia. Per-rectum examination revealed a distended viscous organ in the pelvic inlet.

Fubini *et al* (1986) reviewed records of 84 cows with caecal dilatation or caecal volvulus. The diagnosis of caecal dilatation (n=21), and caecal volvulus (n=45) was made based on exploratory laparotomy or necropsy findings. The physical parameters like high heart rate, apparent abdominal pain, scant or absence of feces and cranially rotated caecal apex on rectal examination were the most useful criteria for selection of cases for surgery.

Braun *et al* (1989a) investigated 111 clinical cases of heifers and cows suffering from caecal dilatation and reported caecal dilatation and torsion as an acute illness with signs of ileus. Out of 111 cases, 61% were ill for < 24hrs; 58% were presented with disturbed general condition, colic (39%) and abnormal rectal temperature (55%). Whereas 40% and 52% of the animals had abnormal heart rate and respiration rate, respectively. The 85% animals had hypo or no rumen motility and 58% were positive to one or more tests for reticular foreign bodies. The 83% of the animals had positive signs of one or both, swinging auscultation and percussion on the right side. Out of total 111 cases, 95% of the animals had pathological distended, displaced or twisted caecum that was very obvious to palpate during per-rectal examination and 87% of the total animals showed reduced or completely absent feces. In conclusion, rectal examination and swinging and percussion auscultation on the right side was the most reliable diagnostic test for the diagnosis of caecal dilatation.

Green and Husband (1996) studied a case of 4-year-old pedigree Holstein, second lactation cow which was lethargic, with a reduced appetite, signs of colic and reduced milk yield for one day. A small swelling was detected in the right paralumbar fossa and auscultation of this region revealed a tympanitic resonance (ping). An exploratory laparotomy diagnosed sigmoid shaped caecal volvulus and extensive caecal necrosis.

Singh *et al* (2002) reported clinical signs of sudden onset of colic, restlessness, frequent sitting and getting up, kept on straining for a short period but failed to pass feces in buffaloes with cecal impaction.

Mulon and Desrochers (2005) illustrated that dilation of the caecum can occur in calves and in adult cattle, but torsion around the long axis is less frequent and it can be associated with abomasum displacement. The condition was diagnosed by auscultating a ‘ping’ area in the right dorsal abdomen with a distended flank.

Mesaric and Modic (2007) reported clinical findings in 7-year-old, 8 month pregnant Brown Swiss cow diagnosed with caecal dilatation and torsion due to trichobezoar in the proximal part of ascending colon. The cow started showing signs of acute colic, discomfort and kicking on the belly. Rectal and physical examination found mucoid feces in the rectum, a distended blind end structure in the pelvic inlet and ping on the right paralumbar fossa / flank and at the 12th ICS along with mild abdominal distention.

Hasunuma *et al* (2011) reported intestinal obstruction associated with feeding of Napier grass in Japanese black cows. All cows showed sudden anorexia, depression, dehydration with reduced fecal output.

Braun *et al* (2012) investigated clinical signs in 461 cattle with caecal dilatation. 93.1% of these animals had abnormal general body condition and demeanor, 32.1 % had colic, 78.3% had decreased or absent ruminal motility. Hypocalcaemia was an important laboratory finding. Swinging or/ percussion auscultation and rectal examination were concluded to be important diagnostic tools as both showed positive results in 82.6% and 88% of animals, respectively. Animals with caecal torsion or retroflexion were recommended for surgery.

Hussain *et al* (2012) described clinical findings of the 11 buffaloes affected with caecal dilatation. The most typical clinical symptoms on physical and clinical examination were complete anorexia, colic, constipated faeces, reduced to no rumen motility, mild to moderate dehydration, distention of right flank and ping sounds on simultaneous auscultation and percussion of the right paralumbar fossa. Rectal examination revealed dilated caecum at pelvic brim.

Hendrickson and Baird (2013) highlighted that cecal dilatation/volvulus as an important disease condition in dairy cows. The affected animals show a number of clinical signs such as mild colic, decreased appetite, decreased rumen motility, and possible right-sided distention. Often the distended caecum can be detected on rectal palpation and it must be on the differential list when a ping is detected upon auscultation and percussion of the right side.

Khalphallah *et al* (2016) studied the clinical, laboratory and ultrasonographic findings of caecum and colon in apparently healthy and diseased Egyptian buffaloes with dilated caecum. Clinically, buffalo with dilated caecum/colon showed reduced appetite, distended right abdomen, abdominal pain and tense abdomen. Rectal examination indicated empty rectum with the presence of mucus and dilated intestinal loop. Rectal temperature, heart rate, respiration rate were within normal range. Ruminal motility was reduced to nil.

Nicholas and Fecteau (2018) reported caecal dislocation as the most frequent sequel of GI tract that occurs after abomasal displacement. The diagnosis can be easily made on the basis of rectal examination and positive percussion and succession tests. In simple cases of caecal dilatation the apex can be palpated in the pelvic inlet during rectal examination while in case of caecal retroflexion and volvulus it is possible to palpate only the body of caecum, per-rectally as the apex shifts cranio-medially in the abdomen.

Singh *et al* (2018) studied 11 animals (9 buffaloes and 2 cattle) suffering from caecal dilatation (n=6) and caecal impaction (n=5). Per rectal examination along with ultrasonography was used as a confirmatory diagnostic tool for caecal dilatation and caecal impaction.

Singh *et al* (2019) studied clinical features of the 16 animals suffering from caecal dilatation. The animal presented had fever, bloat, and abdominal distention with partial or complete loss of appetite. On per-rectal examination a large distended viscus structure could be palpated from mid to dorsal right abdomen. Mild to moderate signs of abdominal pain like shifting of weight from one hind limb to another, restlessness, sinking of back, kicking and sweating were observed.

2.3 Haemato-biochemical and peritoneal fluid alteration in intestinal obstruction

Pearson and Pinsent (1977) observed hypochloremia as consistent finding and having prognostic value in cases of intestinal obstruction in cattle. Animals with plasma chloride values <55 mmol/L had poor prognosis even after aggressive fluid therapy and effective surgical treatment. Elevated levels of total serum proteins and blood urea were also recorded in cases of bovine intestinal obstruction.

Singh *et al* (1983) investigated sheep suffering from shock due to strangulated obstruction of jejunum and observed increased arterial pH, bicarbonate concentration and base excess while the plasma total protein, albumin and chloride levels were decreased; however, the level of plasma sodium and potassium were not significantly affected. The maximal reduction in plasma chloride level was 12.4 mmol/L, which was non-significant. The rectal temperature remained normal till the terminal stage of shock and hypothermia.

Smith (1985a) studied metabolic status of cows suffering from small intestinal obstruction and observed significantly increased serum level of total protein and creatinine in affected cattle along with compensatory increase in the level of pCO_2. Despite hypokalemia, potassium was found to be continuously excreted in the urine.

Smith (1985b) described a stress leukogram in the early stages and neutropenia or neutrophilia with a left shift in the later stages of intestinal obstruction in cattle.

Tarkiewlez *et al* (1987) evaluated peritoneal fluid in clinically healthy cows and established reference ranges of the following average values per litre as: total protein 20.8 gm, urea 5.23 mmol, phosphate 2.333 mmol. Various fractions of total proteins included albumins (50.1%), α-globulins (12.1%), β-globulins (12%) and T globulins (21.4%).

Archer *et al* (1988) found that cow suffering from intussusceptions had increased, opaque, red peritoneal fluid with a nucleated cell count of 11000/μl, total proteins 6.6 g/dl and red blood cells count 1.26×10^{6} /μl.

Braun *et al* (1989b) conducted haematological and biochemical examination of the blood and rumen fluid in111 heifers and cows suffering from caecal dilatation with or without torsion. The majority of the cattle had normal blood haemogram and the concentrations of chloride were normal in the rumen fluid of 83% animals and higher in the remainder. Twenty-eight per cent had increased blood urea concentrations probably due to dehydration. Out of total, only nine cows had to be slaughtered that had higher bile concentrations than those which were recovered.

Kopcha (1990) studied blood and peritoneal fluid samples to assess the abdominal disorders in cattle. Majority (93%) of the non-survivvors had 1-32% non-segmented neutrophils whereas 60% of those which recovered had 1-13 %.

Saini *et al* (1992) reported an increase in bacterial count in peritoneal fluid during laparotomy in intestinal obstruction cases that decreased significantly 24 hours after surgery. Moreover, peritoneal fluid was considered more reliable than blood for assessing peritoneal status after laparotomy.

Anderson *et al* (1993) did clinco-pathologic testing in 35 cattle with small-intestinal volvulus and revealed azotemia, hypocalcemia, hyperglycemia, and leukocytosis with a left shift. A significant difference was found between survivors and non-survivors as the later had significantly lower mean value of preoperative venous blood pH, mean base excess and higher mean value of serum potassium concentration.

Anderson *et al* (1994) observed an increase in the total nucleated cell count in the peritoneal fluid by a factor of 5 - 8, minor increase in specific gravity and increase in total protein contents by a factor of up to two in cattle that underwent exploratory celiotomy and omentopexy.

Constable *et al* (1997) evaluated medical records of 57 cattle with intussusception and found that these cattle were mildly hyponatremic, hypochloremic, hypocalcaemia, azotemic, and hyperglycaemic. The pCO_2 was significantly less for survivors (46±7 mm Hg) than that of non-survivors (52±6 mm Hg).

Braun *et al* (1998) examined peritoneal fluid in cows suffering from suppurative peritonitis and found that it was exudative having increased specific gravity and total solids with a predominance of neutrophilic leukocytosis.

Ebeid and Rings (1999) examined 31 cases of severe generalized peritonitis in cattle. Most cases occurred during peripartum period. It was opioned that clinical examination alone was inadequate and haematological findings were non-specific to establish the diagnosis.

Mohan *et al* (2006) described the pathophysiological changes of intestinal obstruction in 12 buffaloes. Haematological parameters like PCV, Hb and TLC were within normal limits, whereas neutrophilic to lymphocytic cell ratio was reversed. Blood biochemistry revealed no changes in plasma globulin, sodium and potassium levels but inorganic phosphorus, BUN, and creatinine were increased, whereas, concentrations of total protein, albumin, calcium, and chloride were decreased. Alterations in majority of the biochemical parameters of peritoneal fluid reflected a systemic change. Cytological examination of peritoneal fluid showed no changes while a high rumen chloride value was recorded.

Mesaric and Modic (2007) reported a case of acute caecal dilatation and torsion in a 7-year-old, 8 months pregnant, Brown Swiss cow. Metabolic abnormalities included elevated activity of creatine kinase (565 U/L; reference range, 57 to 280 U/L), decreased phosphorus (1.27 mmol/L; reference range, 1.61 to 2.25 mmol/L), decreased calcium (2.15 mmol/L; reference range, 2.25 to 2.99 mmol/L), and decreased Fe (5µmol/L; reference range, 21 to 45µmol/L). All other electrolytes were within normal range.

Allen and Holm (2008) recommended lactate measurement in critically ill veterinary patients as it can provide valuable information to assess severity of illness. In their opinion, more veterinary studies are needed to establish the value of serum lactate measurements for prognostic and therapeutic purposes.

Hasunuma *et al* (2011) presented 5 cases of acute colic caused by phytobezoar derived from napier grass in Japanese black cows in which biochemical examination showed severe hypokalemia and hypochloremia.

Tharwat (2011) studied 8 cows, 6 calves and 4 buffaloes suffering from intestinal obstruction showing signs of colic, anorexia, absence of feces and abdominal distention. Hemato-biochemical examination revealed neutrophilic leukocytosis, hyperprotienemia, elevated urea nitrogen concentrations and hyperglycemia. Severe hypokalemia and hypochloremia were the most important biochemical findings.

Hussain *et al* (2012) investigated haemato-biochemical alterations in 11 buffaloes suffering from caecal dilatation and compared it with 10 clinically healthy buffaloes as control. Affected buffaloes had significantly higher neutrophil count and lower lymphocytic count than control group indicating differential leukocyte count to be the better indicative of inflammation than TLC. Biochemical analysis showed significant increase of total bilirubin, AST, globulin, lactate and blood urea nitrogen levels and significant reduction in calcium, potassium and chloride.

Hussain *et al* (2015) compared haemato-biochemical parameters of eight animals affected with intestinal affections with 10 healthy cows and 10 buffaloes as control. Hypochloremic and hypokalemic metabolic alkalosis with compensatory respiratory acidosis was found on blood gas analysis. The peritoneal fluid changes were consistent with septic peritonitis. These biochemical changes should be taken into consideration while dealing with intestinal obstruction in cattle and buffaloes.

Khalphallah *et al* (2017) studied the clinical, laboratory and ultrasonographic findings of caecal and colonic dilatation in 20 Egyptian buffaloes and compared it with control group (n=20). Buffaloes with dilated caecum/colon showed significant ($P<0.05$) hypo-proteinemia and hypo-albuminemia with significant ($p<0.05$) increase in blood serum activities of aspartate aminotransferase (AST) and alkaline phosphatase (ALK) as compared to that of control group.

Singh *et al* (2017b) examined the peritoneal fluid in 9 adult animals suffering from intestinal obstruction and found an increase in the mean value of total protein (4.74± 0.41g/dl) and decreased albumin level (1.30 ± 0.24 g/dl).

Nicholas and Fecteau (2018) reported caecal dislocation to be associated with hypocalcemia which appears to be an important predisposing factor to various caecal disorders.

Factaeu *et al* (2018) reviewed rational diagnostic and therpautic options for bovine with acute abdomen. The persistent increase in the serum level of lactate, despite fluid and conservative medication, indicates a need for exploratory surgery or a poor prognosis of cow presented with clinical signs of acute abdomen. Further it was stated that serial monitoring of serum biochemical, blood gas and electrolytes is useful to assess the clinical condition and prognosis.

Singh *et al* (2018) studied 11 animals (9 buffaloes and 2 cattle) suffering from caecal dilatation (n=6) and caecal impaction (n=5). A marked decrease in serum total protein, albumin, chloride, potassium, and calcium levels while elevated levels of lactate were recorded. Peritoneal fluid examination revealed an increase in total protein concentration.

Singh *et al* (2019) studied diagnostic and prognostic indicators of caecal dilatation in 16 adult animals which were managed both medicinally and surgically. Serum biochemistry examination revealed hypochloraemic, hypokalemic uncompensated metabolic alkalosis. A significant difference was found between survivors and non-survivors. Tachycardia, ruminal stasis, leukocytosis and elevated levels of lactate were found as poor prognostic indicators.

Singh et al (2020) reported that most animals with caceal dilatation and torsion may develop hypochloremic, hypokalemic metabolic alkalosis with haemoconcentration and azotaemia which are similar to animals with bowel obstruction.

Purohit and Bhokre (2020) stated that peritoneal fluid reflects the health status of peritoneal cavity and abdominal organs. The total amount of peritoneal fluid in an apparently healthy bovine is about 1ml/kg body weight. It is transparent with a total protein 0.1-3.1 g/dL and 1:1 polymorphonuclear to mononuclear ratio.

2.4 Abdominal ultrasonography as diagnostic and prognostic modality

Braun *et al* (1995) analyzed small intestine of 35 heifers and cows with an ileus of the duodenum, jejunum or ileum. The animals were examined ultrasonographically from the right flank and thorax with a 3.5MHz linear transducer and the findings were confirmed by right flank laparotomy or post mortem. Only one intestinal loop was usually visible from the flank or from the 12^{th}, 11^{th} or 10^{th} intercostal spaces in animals suffering from duodenal ileus. Instead in animals with an ileus of jejunum or ileum more than five dilated lops of intestine were usually visible. At 12^{th} intercostal space the largest diameter measured in case of duodenal ileus was between 6.5 to 9.9 cm. And in case of jejunal ileus and ileal ileus the largest diameter of the intestinal loop measured was between 6.5 to 9.9 cm and 4.4 to 5.5 cm, respectively. In the majority of the cows, the contents of the intestines were predominantly echogenic.

Braun and Amrein (2001) evaluated the large intestine of 10 cows, ultrasonographically, using 3.5 MHz transducer. The caecum was visualized from the middle region of the abdominal wall in the right flank and at 12^{th} ICS. The lateral wall of caecum appeared as a thick echogenic crescent shaped line. The spiral ansa of colon and descending colon were situated dorsal to the caecum. The spiral ansa was seen ventral to the descending colon. Spiral colon had the appearance of a garland, when in contracted state.

Braun *et al* (2002) studied 32 cows with caecal dilatation using 3.5 MHz linear transducer. Dilated caecum was imaged from right flank, 12^{th}, 11^{th} and 10^{th} ICS and it had hypoechogenic contents. Rectal examination supplemented ultrasonographic findings for diagnosing caecal dilatation.

Braun *et al* (2005) observed that ultrasonography, sometimes in combination with radiography and other tests, was well suited for evaluating abdominal disorders in cattle. The most important disease were foreign body-associated lesions in the reticulum and peritoneum, left and right displacement of the abomasum, the ileus of the small intestine, dilation and displacement of the caecum.

Kofler and Hittmair (2006) stated that ultrasonography is of great benefit to every veterinary clinician and practitioner in continuing the clinical examination. Unlike all other diagnostic imaging methods, ultrasound is considered a safe procedure for the patient, the sonographer and nearby personnel, allowing it to be performed at any location without the need for specific safety precautions.

Streeter and Step (2007) revealed that the use of diagnostic ultrasound equipment was becoming widespread within various sectors of veterinary practice. Ultrasonographic examination had several advantages over other imaging modalities and it could be applied in hospital and ambulatory settings. It had the potential for widespread use in the diagnosis of disorders of several body systems such as gastrointestinal, hepatobiliary, cardiothoracic, urogenital, and umbilical disorders in food animal species. Accurate and timely use of this diagnostic modality requires a modest amount of training and practice, but it allows relatively rapid, inexpensive, and non-invasive acquisition of clinically relevant data.

Braun (2009) found that the cranial part of the duodenum was easily identified because it started at the abomasum and was in close contact with the liver and gallbladder. The descending duodenum can almost always be imaged and was identified as a horizontal structure running caudally between the two serosal layers of the greater omentum immediately adjacent to the abdominal wall. The jejunum and ileum cannot be differentiated ultrasonographically and represent the longest part of the small intestine. In most healthy cows, using a 3.5 MHz-linear transducer with a penetration depth of 17 cm, more than 10 loops of small intestine were seen, usually in cross-section but sometimes in longitudinal section, in the flank and 9th–12th intercostal spaces. He further reported that large intestine was always visible from the flank and was situated medial to the descending duodenum, whereby the colon was more dorsal and the proximal loop of the colon and caecum were more ventral.

Kumar (2010) suggested that the majority of the small intestines in apparently healthy animals were scanned in cross section with constantly changing lumen. The mean lumen diameter of the intestinal loops in healthy cows and buffaloes was 3.1 ± 0.23 cm. The wall thickness measured was between 3 to 4 mm in cows and buffaloes. No significant difference in visualization, motility, luminal diameter or wall thickness was observed in cows and buffaloes.

Imran and Tyagi (2014) performed ultrasonographic scanning of the large intestine dorsal to the imaginary line drawn from the distal third of the femur up to the 8th ICS parallel to the longitudinal axis of the cow. Only the near wall of the large intestine adjacent to the abdominal wall could be imaged ultrasonographically. Based on the topographical anatomy, the ultrasonographic images of the caecum and the proximal loop of the ascending colon (PLAC), resembling the 'arc of a circle', were observed in the mid to dorsal right paralumbar fossa and the 12th ICS; however, the caecum and the PLAC could not be differentiated with certainty using ultrasonography. Similarly, the ultrasonographic images of the spiral loop of the ascending colon (SLAC), resembling a 'cycloid', could be imaged through the 12th to 11th ICS and in the dorsal right paralumbar fossa; yet, ultrasonographically, it was difficult to differentiate the SLAC from the descending loop of the ascending colon, transverse colon, and descending colon, respectively. It was concluded that ultrasonographic imaging of various parts of the bovine large intestine should be interpreted with caution.

Khalphallah *et al* (2016) studied the clinical, laboratory and ultrasonographic findings of caecal and colonic dilatation in forty Egyptian buffaloes (*Bubalus bubalis*). The study was conducted in two groups: control group (n= 20) and diseased group (n= 20). Each of the diseased animals was subjected to clinical, rectal, laboratory and ultrasonographic examinations. Ultrasonographically, the dilated caecum and proximal loop of colon occupied the last right three intercostal space particularly their ventral part, intertangled with the liver dorsally in these ICSs without hindering in its visibility. The visibility of the right kidney, loops and peristaltic movement of the small intestine at the right flank were jeopardized by the dilated caecum/colon. The closest wall of the dilated caecum and proximal loop of the colon was imaged as thick semi-circular echogenic line and the furthest wall and contents of dilated caecum/colon were not imaged.

Munday and Mudron (2016) examined six healthy 500—600 kg Holstein Friesian cattle trans-abdominally with ultrasound. The six healthy cattle had an average cranial duodenum wall thickness of 2.45mm, an average jejunum wall thickness of 1.90mm, and an average colon wall thickness of 3.02mm. The statistical analysis revealed a significant difference between the jejunum and the colon wall thickness ($P<0.01$).

Singh *et al* (2018) studied 11 animals (9 buffaloes and 2 cattle) suffering from caecal dilatation (n=6) and caecal impaction (n=5). Per rectal examination along with ultrasonography was used as a confirmatory diagnostic tool for caecal dilatation and caecal impaction. Right flank typhlotomy was done in the remaining five animals having impacted caecum for decompression of the dilated caecum. The 9 out of 11 animals recovered. The ultrasonography was found useful to diagnose caecal dilatation from caecal impaction.

Saravanan *et al* (2019) stated that in addition to physical examination, ultrasonographic examination in cattle with empty rectum is very useful diagnostic aid in differentiating the various gastro-intestinal disorders. Abdominal ultrasonography were performed in total twenty nine cattle suffering from various gastro-intestinal disorders which revealed peritonitis in 31.03%, paralytic ileus with peritonitis and pericarditis in 10.34% each, uroabdomen, intussusceptions, caecal dilatation, abomasal dilatation and peritonitis with intussusception in 6.90% each and diaphragmatic hernia, reticular abscess, omasal impaction and peritonitis with pericarditis in 3.45% each.

Singh *et al* (2019) studied ultrasonographic features of caecal dilatation in 16 adult animals out of which 6 were cattle and 10 were buffaloes and stated usefulness of ultrasonography as a diagnostic modality in animals suffering from caecal dilatation. The scanning of distended caecum and/or colon at the right flank and extending cranially as long as up to 11^{th} intercostal space further suggests caecal dilatation. Dilatation and ileus of small intestines (duodenum and jejunum) were also reported.

Mohindroo *et al* (2020) updated the scope and application of ultrasonography for the diagnosis of various abdominal disorders in animals. Ileus was described as non-specific findings consequent to delayed passage of contents through GIT associated with lesions in the small or large intestines. Ultrasonographic scanning of dilated vicus from the right flank, 12^{th}, 11^{th} and 10^{th} ICS suggests dilatation of caecum and/or proximal loop of ascending colon which are not possible to distinguish from each other, ultrasonographically.

2.5 Success rate of caecal dilatation surgery in bovine

Duelke and Whitlock (1976) observed persistent dilatation of the caecum for ten months without evidence of impaired appetite or milk production and observed that caecal dilatation in cattle is usually manifested by a syndrome of intestinal obstruction requiring surgical intervention.

Dehghani and Townsend (1982) reported a case of 6-month old Holstein-Friesian steer suffering from distended caecum, which was about 1.37 m (4.5 feet) long and more than 30 cm (one foot) in diameter. A counter-clockwise torsion of about 360^o (viewing from the right flank) involving the proximal portion of spiral colon was detected. A caecotomy was performed to remove a large quantity of rapeseeds. The torsion was reduced and the animal appeared to make an uneventful recovery but died suddenly six weeks later.

Waldeland (1982) studied caecal dilatation and displacement in 8 sheep with surgical correction and observed clinical symptoms and did post mortem study. Surgical correction had very good prognosis even in the animals which were severely affected.

Fubini *et al* (1986) reviewed records of 84 cows with caecal dilatation (n=21), and caecal volvulus (n=45). Eighteen cows were diagnosed by physical examination alone for caecal dilatation and responded to medical management. Good prognosis was reported in cattle with caecal dilatation unless there was severe vascular compromise of the caecum after surgery. There was only 10% recurrence rate recorded in operated animals and in those cows a partial typhlectomy was performed.

Klein *et al* (1994) evaluated wound infection and postoperative performance after a single intra-abdominal administration of 9g sodium ampicillin in cows operated for caecal dilatation or torsion (n = 33). In 25 animals that left the clinic in good health (76% short-term survival), no wound infection occurred. Postoperative performance was normal in 21 of these animals (84%). Single intra-abdominal administration of sodium ampicillin during surgery provides good protection against infection without negative effects on the postoperative performance.

Green and Husband (1996) reported a case of 4-year-old pedigree Holstein, second lactation cow diagnosed for caecal dilatation and volvulus. An exploratory laparotomy revealed a sigmoid shaped caecal volvulus and extensive caecal necrosis. The condition was corrected surgically by a total typhlectomy. Recovery was slow for the first week after surgery but uneventful thereafter. One month later the cow was healthy, with normal faecal consistency, and in the milking herd. The cow had satisfactory production performance during subsequent lactations.

Singh *et al* (2002) reported that cectootmy is required in severe cases only. Many cases suffering from cecal dilatation / impaction will respond to left flank rumentomty, admininstrtaion of laxatives like paraffin and massage of the caceum / colons.

Anderson and Ewoldt (2005) recommended right paralumbar fossa under paravertebral nerve block as preferable site to approach for intestinal surgery as the left paralumber fossa allows limited access to various parts of small and large intestines.

Umakanthan (2003) treated cases of caecal dilatation and torsion in milch cows successfully with oral drenching of ginger, sodium bicarbonate, common salt and magnesium sulphate in warm water in addition to allowing animals to swim.

Mulon and Desrochers (2005) illustrated that dilatation of the caecum can occur in calves and in adult cattle, but torsion around the long axis is less frequent and also can be associated with displaced abomasum. If no improvement occurs after medical treatment, surgical correction of the dilated caecum is warranted within 24 hrs. In caecal torsion, partial or total caecal amputation can be performed if the caecal wall appears to be nonviable because of an excessive dilatation or the presence of necrotic foci. The caecum is exteriorized from right flank laparotomy, and an enterotomy is performed at its apex. If an amputation is needed, a Doyen forceps is positioned preserving the ileocecal valve, ligatures on the vessels in the ileocecal mesentery are positioned, and a typhlectomy is performed.

Mesaric and Modic (2007) stated that caecal dilatation and torsion can occur due to trichobezoar obstruction in the proximal part of the ascending colon. On performing right flank laparotomy under paraverteberal nerve block, they found distended caecum just medial to the incision site and the apex of the caecum was present craniomedially. Then incision was made on caecal apex and appox 10lt. of greenish black fluid was vacated. On further examination a trichobezoar was found in the proximal part of ascending colon occluding the whole lumen. Cattle passed greenish watery feces within first 24 hrs of surgery in post operative care.

Meylan (2008) observed that caecal dilatation in cows and large intestinal atresia in neonatal calves, are the most important disease conditions of the bovine large intestine amenable to surgical correction under field conditions. Surgery for correction of caecal dilatation, with and without retroflexion or torsion, can be performed under field conditions. In contrast, only anal reconstruction after atresia ani or colostomy in the case of atresia coli are amenable to field surgery; more complicated bypass procedures with anastomosis for atresia coli are best performed in hospital settings.

Kunz-Kirchhofer *et al* (2010) studied the myoelectric activity of different parts of large colon (caecum, proximal loop of ascending colon and spiral colon) and ileum of small intestine in cows suffering from caecal dilatation and dislocation. The bipolar silver electrodes were placed in the various parts of colon and ileum to record the myoelectric activity at every 8 hours of interval, post-operatively. It was found out that the myoelectric activity of ileum became apparently normal on the first post-operative day; but, the myoelectric activity of the different parts of large intestins gets normalized slowly over a period of time.

Hendrickson and Baird (2013) illustrated caecal dilatation/volvulus to be a predominat dairy cow condition. The better prognosis of case depends on the early surgical intervention. The choice of treatment in case of simple caecal dilatation without volvulus or retroflexion is typhlotomy, while complete typhlectomy is suggested in patients with volvulus where blood supply is compromised. The partial typhlectomy is suggested in the patient which again showing the signs of caecal dilatation after typhlotomy.

Dharmaceelan *et al* (2015) performed right flank laparotomy and enterotomy under general anesthesia to remove large lemon shaped mass (phytobezoar) cranial to the caecum, caudal to which all loops were collapsed and non-motile.

Gupta *et al* (2017) reported a case of caecal dilatation and torsion in 3.5 month pregnant cattle with signs of intermittent colic, abdominal distention, anorexia and cessation of feces from last 12 days. Caecal torsion was confirmed on right flank laparotomy which was relieved with typhlotomy and rotation of the caecum on its longitudinal axis. Animal was successfully recovered on day 6^{th} post-operatively.

Ranjithkumar *et al* (2017) reported management of two cases of caecal dilatation and distention in kangayam bullock and in dairy cattle. The cases were diagnosed on the basis of physical examination like ping sound on auscultation, per-rectal examination, ultrasonography, and clinical signs that were tail thrashing, mild abdominal pain and partial or complete cessation of feces with mucus in rectum. Both the cases were successfully managed medicinally with polyionic fluids along with neostigmine, bethanechol (@0.07mg/kg subcutaneously, at 8 hours for 2 days)and calcium borogluconate.

Singh *et al* (2017a) conducted study on 7 bovine diagnosed with caecal dilatation. Per rectal examination along with ultrasonography was used as a confirmatory diagnostic tool for caecal dilatation. Animals (n=3) having potential foreign bodies in the reticulum were treated by left flank laparo-rumenotomy and dilated caecum was massaged. In remaining animals (n=4) right flank cecotomy was done to decompress dilated caecum. 4 out of 7 animals survived which underwent surgery and were healthy up to 5 months on long term follow up.

Factaeu *et al* (2018) reviewed current diagnostic and treatment options in cattle with acute abdomen and stated that in many cases with acute abdomen, exploratory laparotomy was the most economical diagnostic and therapeutic option.

Nicholas and Fecteau (2018) reported caecal dislocation to be the most frequent sequel of abomasal displacement. The surgical treatment has to be done in the patient with caecal retroflexion or caecal torsion. The right paralumbar fossa is the definite surgical approach to exteriorize the caecum. The typhlotomy and partial typhlectomy has to be done according to the condition of caecum with good prognosis.

Singh *et al* (2018) studied 11 animals (9 buffaloes and 2 cattle) suffering from caecal dilatation (n=6) and caecal impaction (n=5). Per rectal examination along with ultrasonography was used as a confirmatory diagnostic tool for caecal dilatation and caecal impaction. Left flank laparo-rumenotomy was performed in six animals with dilated caecum along with colonic faecolith. Post rumenotomy, these animals were treated with massage of caecum along with kneading of colonic faecolith. Right flank typhlotomy was done in the remaining five animals having impacted caecum for decompression of the dilated caecum. 9 out of 11 animals recovered. The ultrasonography was found useful to differntially diagnose caecal dilatation from caecal impaction.

Singh *et al* (2019) investigated 16 clinical cases (6 cows and 10 buffaloes) suffering from caecal dilatation and successfully treated 9 out of 16 animals (56.25%). The post caecal obstruction (colon impaction or fecolith) as a cause for caecal dilatation was highlighted.

2.6 Topography and histology of caecum in animals

Sisson *et al* (1975) stated that caecum is caudally directed blind pouch with the average length of 75cm, diameter of about 12cm and capacity of upto 8L in large ruminants like ox that lies caudodorsally to the right side of the pelvic inlet. Cranially caecum is a continuous structure with proximal colon with no change in diameter, the only demarcation between these two is the entrance of ileum which is medial to it and usually ventral to the last rib. Cranial 2/3rd of caecum is attached to the mesentry on the right side. Dorsally and ventrally it is attached to short caeco-colic fold to proximal loop of colon and ileocecal fold of ileum, respectively.

Maala and Sack (1981) studied the arterial supply of caecum, ileum and proximal loop of ascending colon in ox. The arterial supply of ileum includes mesenteric iliac artery, first ilial artery, by ileal branches of caecal artery. The caecum was mainly supplied by caecal branches of caecal artery and ileocaeco-colic arch. The proximal loop of ascending colon was supplied by three colic branches of ileocolic artey.

Maala and Sack (1983) described the venous supply of caecum, ileum and proximal loop of ascending colon in ox. The venous supply of caecum includes caecal and accessory caecal veins which are joined by 7-10 oblique anastomoses. The ileum was supplied by ileal branches of caecal veins and cranial mesenteric vein. The proximal loop of the ascending colon was supplied by ileocolic vein.

Fubini (1990) stated that the caecum is a large, mobile sac and has apex which is directed caudally. The caecum opens in the colon cranially without any valve or stricture between these two. Thus, both the structures can be differentiated anatomically only on single demarcation where ileum enters at the ileocecocolic junction. Usually caecum lies within the supraomental recess, but may be found outside it between the greater omentum and right abdominal wall. It has dorsal and ventral attachments, dorsally with the proximal loop of ascending colon and ventrally with the ileum by caeco-colic fold and ileo-caecal fold, respectively. Cranially caecum is attached to right side of mesentry and opens into the ascending colon which has three parts; proximal loop of ascending colon, spiral colon and distal loop of ascending colon. The distal loop of ascending colon continues with the short transverse colon, which opens into descending colon. The decending colon suspended by mesocolon and travels caudally to form rectum.

Ghosh (1998) described caecum as blind sac of 75 cm in length and 12 cm diameter with a capacity of about 7 to 8 lt. The caudal end of the caecum is a blind sac act as apex which is extended upto right side of pelvic inlet. Sometimes the apex is physiologically curved ventrally. Cranio-dorsally caecum is in continuous with proximal loop of colon and ventrally with ileum. The cranial right aspect is in contact with the caudal duodenal flexure. The opening through which ileum opens into caecum is very small.

Braun and Amerin (2001) described the anatomy and position of large intestine in cattle. Large intestine of cattle consists of caecum, colon and rectum and approximately 6 to 14 m in length. Caecum is a very important part of large intestine regarding its clinical significance. Caecum is a cylindrical and slightly sigmoid structure having length of 50 to 70 cm and diameter of about 10 cm. Most of its cranial portion is attached with the mesentery of large intestine and with the ileocaecal fold and the caudal one third portion is devoid of any attachments and is freely movable. This free rounded blind end lies caudally on the right side of the pelvic inlet. Cranially caecum is in continuous relation with the ascending colon. The ascending colon has three parts; proximal ansa, spiral ansa and distal ansa. The proximal ansa has further three parts; ventral gyrus which is in continuous relation with caecum and travels cranially upto12^{th} rib having the same diameter as that of caecum. The ventral gyrus then forms middle gyrus of proximal ansa travelling dorso-laterally at the level of 12^{th} rib, below the right kidney. Then the middle gyrus of the proximal ansa travels medio-dorsally to form a disk shaped structure of smaller lumen diameter called as spiral ansa of the colon at the level of the left kidney. The spiral ansa has alternative centripetal and centrifugal coils which end into transverse colon and then into descending colon and rectum.

Meylan (2008) described the anatomy of bovine large intestine consisting of caecum, ascending, transverse, descending colon and rectum. The caecum usually lies within the supraomental recess. The caecal apex is directed caudally towards the pelvic inlet. Ventrally, the nervous and blood supply to the caecum is given by ileocaecal fold of ileum. Dorsally, the caecum is attached to the proximal loop of ascending colon by a short caeco- colic mesenteric band. The PLAC is continued at ileocaeco-colic junction without any transition. Then PLAC travels cranially upto the level of 12^{th} rib, where it turns caudo-laterally until it reaches the caudal flexure of duodenum. Then it forms spiral colon which itself is embedded in its mesentry with it’s two centripetal and two centrifugal folds placed alternatively to form a flat oval. The spiral colon travels caudally to form the distal colon which terminates into short transverse colon. This transverse colon comes to the left side of abdomen and forms descending colon which terminates into the rectum. The rectum lies mostly in the peritoneal part of pelvic cavity.

Dyce *et al* (2009) Stated that caecum is the widest part of gut which enters into colon with no change in diameter. The only demarcation between caecum and proximal colon is entrance point of ileum. The caecal apex is rounded blind end that is caudally directed from the supraomental recess. When gas filled, caecal apex floats high touching the verterbral coloumn and sinks when heavier contents are present. The surgical correction is necessary when caecum is distended with gas for a long period of time.

Kadam *et al* (2011) compared caecum of adult cattle, sheep and goat histologically and stated that caecum consists of tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa in all the species, investigated in the current study. In comparison to sheep and goat, cattle had largest tunica submucosa. Tunica serosa appeared as loose connective tissue and the mucus secreting glands and serous secreting glands were present near lamina muscularis and at the apical end of tunica mucosa, respectively.

Bruan *et al* (2012) studied the clinical course of caecal dilatation in 461 cattle and described that caecal dilatation or distention can be accompanied by displacement, torsion or retroflexion of the organ and additional distension of the spiral colon. In simple distention the caecal apex is directed more caudally towards the pelvic inlet and can be palpable during rectal examination. And in torsion caecum rotated around its longitudinal axis but still apex can be palpated via rectal examination. But in retroflexion the caecum folds dorsally or ventrally in the ileocaecal region where apex of the caecum is not palpable.

Konig and Liebich (2013) described the caecum of domestic animal. The caecum of ruminants is comparatively smaller than other species (such as equine) without any taenia or haustra. The caecum lies in the supraomental recess in the right half of abdomen with apex directed caudally. After leaving the caecum the ascending colon forms a sigmoid flexure, the first part being cranially convex, the second part being caudally convex. Then it turns ventrally to form ansa spiralis with two centripetal coils which is reversed by one central flexure to form two centrifugal coils. The last centrifugal coil forms distal loop which opens into transverse colon and it continues caudally into descending colon. Descending colon forms a sigmoid flexure before opening into rectum, the looseness of which allows free range of hand motion during rectal examination.

Hendrickson and Baird (2013) described caecum to be a blind-ended tubular organ of normal diameter of 12 cm. The blind end of caecum also called as caecal apex extends caudally from ileocaecal junction towards pelvic inlet. The caecum can cover the right quadrant of pelvic inlet sometimes left side also in case of dilatation. The apex is mobile but the base of caecum is amotile and is attached to mesentry.

Singh *et al* (2020) reported that in cattle, free end (apex) of caceum is devoid of mesentry that make it prone for rotation or torsion in cases of caecal dilatation. The caecum of camel and buffaloes is not predisposed to caecal torsion because blind end of caceum is not devoid of mesentery.

CHAPTER III

MATERIALS AND METHODS

The present study was conducted at Department of Veterinary Surgery and Radiology, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana. The study was duly approved by the Institutional Animal Ethical Committee. The study was carried out in three parts; Part 1 (Cadaveric study); Part 2 (Healthy and Diseased control); Part 3 (Clinical study).

3.1 PART 1

Part 1 included 8 apparently healthy animals (4 cows and 4 buffaloes) that died or euthanized due to reason(s) unrelated to gastrointestinal ailments. The caecum was identified, isolated and was subjected to gross and microscopic study to document anatomical differences in the apex and body of the caecum, and ileo-caecal mesentery, if any, between the cows and buffaloes (Fig. 1).

3.1.1 Gross morphometric study

In this part, various measurements (cm) were made using inch tape. The length of apex of the caecum devoid of mesentery (i.e. the distance between the point of apex of caecum up to the ileocecal fold / mesentery), length of the ileo-caecal mesentery with status of fat content, length and diameter/width of the caecum were measured using inch tape (Fig. 2 (A-E) (Table 1 & 2).

3.1.2 Histological Study

The tissue samples collected from different parts of the caecum i.e. apex (A), body (B) and ileo-caecal mesentery (C) (Fig. 1) of cattle and buffalo were fixed in 10% neutral buffered formalin for 2 days prior to further processing. The tissues were washed in running water for overnight, dehydrated in ascending grades of ethyl alcohol and acetone. Dehydrated tissue samples were cleared in benzene and embedded in paraffin wax (Pathak *et al* 2019). The prepared paraffin blocks were cut into 4-5 µ thick sections with a hand operated microtome. The cut sections were placed on the microscopic slides, fixed and passed through sequential steps of deparaffinization in xylene, rehydration through descending grades of ethyl alcohol to running water. Sections were stained with routine Haematoxylin and Eosin (H&E) stain for histomorphology (Luna 1968), Verhoeff's stain for elastic fibers (Sheehan and Hrapchak 1973) and Picrosirius Red for collagen fibers (Junqueira *et al* 1979).

3.1.3 Microphotography and Histometry

Stained sections were examined and photographed using a light microscope (Nikon 80i) attached with a digital camera. Images were processed and histometrical measurements of each layer i.e. tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa were made, along with the total measurement of whole section i.e. from tunica mucosa to tunca serosa (as described in Table 1) using Fiji (Image J) software (Schindelin *et al* 2012).

Table 1. Different parameters taken during gross morphometery and histo-micrometery in cadaveric samples

Gross morphometry (cm)	Histo-micrometery (μm)
Caecal apex devoid of mesentery (from caudal most point of the caecal blind sac to the start point of ileocaecal mesentery)	Thickness of tunica mucosa
Caecal body diameter	Thickness of tunica submucosa
Caecal body total length (from the point of caecal apex to the point of ileum entering into caecum)	Thickness of tunica muscularis
Width of ileo-caecal mesentry (from point of attachment to the caecum to the point of attachment to ileum)	Thickness of tunica serosa
	Total wall thickness

Table 2. **Qualitative status of fat content of ileo-caecal mesentery during gross examination**

Fat status in ileo-caecal mesentery	Remarks
No or little fat in ileo-caecal mesentry	Absent
Marked amount of fat present in whole ileo-caecal mesentry	Present

3.1.4 Quantification of Collagen

Collagen content in the form of area fraction was calculated using Fiji (Image J) software (Schindelin *et al* 2012). The images were split into RGB stack and threshold to level of exact collagen occupied area. The area and area fraction were measured.

3.1.5 Qualitative scoring of Collagen and Elastic Fibers

The qualitative analysis / grading of collagen and elastic fibers was done on the basis of microscopic presentation of collagen/elastic fibers in the microscopic slide ie. Their number or amount (nil to abundant) and on their arrangement whether they are loosely arranged or densely packed as described in Table 3.

Table 3. Microscopic qualitative grading of collagen and elastic fibers

Amount of collagen fibers	Qualitative grade
Nil	-
Very few	+
Significant number (but loosely packed)	++
Abundant(but loosely packed)	+++
Densely packed	*

3.2 PART 2 (N=30)

This part of study included two sub groups; healthy control (2a) and disease control (2b). In group 2a, caecum in apparently healthy bovine (5 cows and 5 buffaloes) was assessed clinically and ultrasonographically to record its topography, size, consistency and contractions. In group 2b, topographic status of caecum in cows and buffaloes suffering from other abdominal affections (n=20, 5 cows and 15 buffaloes) such as foreign body syndrome, reticular diaphragmatic hernia, peritonitis etc. were investigated clinically, ultrasonographically and by palpation during clinical (trans-rectal) examination.

3.3 PART 3 (N=15)

The Part 3 of study included 15 clinical cases suffering from caecal dilatation and having a primary complaint of scanty or no passing of faces, during one year of study (April 2019 to March 2020). All the animals were subjected to detailed investigation including abdominal ultrasonography, haemato-biochemical and peritoneal fluid analysis. All the animals were subjected to standard conservative therapy which included intravenous administration of 0.9% normal saline (12-15L), lignocaine hydrochloride @ 1.3 mg/kg. Cattle with signs of visceral pain were given dicyclomine @ 0.5 mg/kg/day, I.M. Antibiotics and anti-inflammatory therapy included inj. Ampicillin + Cloxacillin @ 10mg/kg b.i.d and Meloxicam @

0.25mg/kg/day, IM. Electrolyte deficiencies were corrected with calcium borogluconate intravenously for hypocalcaemia, sodium chloride and glucose solution intravenously for hyponatraemia and hypochloraemia, potassium chloride @ 200ml/head once a day for hypokalaemia. Four animals responded to conservative therapy and passed faeces within 1-3 days of treatment. Out of 12 animals non-responsive to medicinal or conservative treatment, seven presented for surgical intervention and these were subjected to right flank exploratory laparotomy and caecotomy to empty caecal or colonic contents (decompression).

Right flank laparotomy was performed under local anaesthesia in standing position as per procedure described earlier (Singh *et al* 2019). Following laparotomy, attempt was made to exteriorize caecum by grasping it from the apex, or to move the body of caecum out of incision site after reflecting the omentum cranially from the surgical site. When both of above manoeuvres failed to exteriorize caecum, then abdominal cavity was packed with a layer of drape and caecal body was sutured with incised skin margins before caecotomy. In one case, it was not possible to reflect the omentum cranially due to formation of adhesions as the animal was suffering from generalised peritonitis. In this case, incision was made on the omentum ventrally protecting underlying descending duodenum to reach out caecal body. Short term (15 days post-surgical) and long term outcome (more than 15 days to 3 month post-surgical) including intra-operative complications, if any, were recorded

Table 4: Distribution of animals in different groups according to study as cattle and buffalo (n=53)

Groups		Cows	Buffaloes	Total (n=53)
Group 1 (Cadaver study)		4	4	8
Group 2 (control group)	**2a (Healthy control)**	5	5	10
	2b (Disease control)	5	15	20
Group 3 (Caecal Dilatation)		2	13	15

The details of various parameters recorded in group 3 animals, during pre, intra and post-operative period have been described below:

3.3.1 Signalment

At the time of presentation, detailed signalment including species, age, breed, sex, weight, production (milk yield) and reproductive (calving and pregnancy) status was recorded in all the animals.

3.3.2 History

Following observations regarding history were enquired from the owners on the day of presentation:

1. **Appetite and water intake:** The feed and water intake by the animals were recorded and graded as: normal, reduced or anorectic.
2. **Milk yield:** It included whether there had been any loss in milk production, if yes, then its extent and nature i.e. whether it was sudden or gradually decreased.
3. **Fever:** History regarding the presence and nature of fever was noted whether it was single episode or persistent in nature.
4. **Duration of illness:** Duration of illness was recorded and calculated in days according to the onset of symptoms observed by the owners till the presentation of the case.
5. **Faecal output/Types of faeces:** History regarding the faecal output was recorded as normal, scanty, mucoid or absent, diarrhoea.
6. **Reproductive status**: Reproductive status of the animals was recorded and graded as: non-pregnant or pregnant (early pregnant - up to 6 months of gestation and advance pregnant - more than 6 months of gestation) and calving (recent or late).
7. **Tympany:** History of tympany was taken from the owners in relation to frequency and nature such as absent, persistent or recurrent.
8. **Abdominal contour:** The contour of the abdomen was viewed from the rear and lateral sides from an oblique angle. It was graded as collapsed, normal or distended.
9. **Pain:** History regarding the status of pain was taken from the owners and recorded as absent or present (single episode, persistent or intermittent).

3.3.3 Physical examination

Physical examination in a systematic manner was carried out in all the animals to record respiration and heart rates (beats/min), rectal temperature (°F), color of mucous membranes (anaemic, congested or normal) and rumen motility (number of rumen contractions /3 minutes). Per-rectal examination was done in all the animals to assess the status of intestines as collapsed, normal or dilated; presence of faeces and the extent of caecal dilatation including presence of retroflexion of caecal apex.

3.3.4 Haematological evaluation

At the time of presentation, blood sample (1ml) was collected, aseptically, from jugular /ear vein and transferred to a vial containing EDTA @ 2 mg/ml. The haematological parameters included Hb (%), packed cell volume (%), total leukocyte count (/μL), differential leukocyte count (Neutrophils, lymphocytes, Monocytes, Eosinophils and Basophils as %) and platelets (/μL).

3.3.5 Serum biochemical evaluation

Another blood sample (2 ml) was stored in a vial without any anti-coagulant and allowed to clot. After clotting, these samples were centrifuged to separate serum which was stored at -20°C for further investigation. The VITROS DT-II Chemistry system (Ortho-Clinical Diagnostics, Johnson and Johnson Company) was used for estimation of Sodium (mEq/dL), Potassium (mEq/dL), Chloride (mEq/dL), Lactate (mmol/L), Total Protein (g/dL), Albumin (g/dL), Calcium (g/dL), Phosphorous (g/dL) and Creatinine Kinase (U/L).

3.3.6 Tissue sample:

Tissue sample (n=2) were collected from the site of caecotomy to evaluate histopathological changes associated with caecal dilatation.

3.3.7 Peritoneal fluid analysis

Samples of peritoneal fluid were collected during laparotomy / surgery. The samples were stored in heparinized vials and subjected to cytology including differential cell counts and biochemical estimations (total protein, calcium, sodium, potassium, chloride, creatinine kinase and lactate).

3.3.8 Ultrasonographic Examination

Ultrasonographic examination was carried out from the right abdominal wall in standing non-sedated animals restrained in a crate as described previously (Braun 2009). The hair at the examination area were clipped and cleaned with soap and savlon to clear off debris and hair remnants. The examination area was smeared with acoustic gel. Using 2 to 5 MHz curvilinear transducer (Fig. 3) on GE Health Care Logic F8 Ultrasound machine (Fig. 4), the animals were examined dorso-ventrally beginning at the mid flank or paralumbar fossa and extending cranially to the fifth intercostal space on right side. In the abdomen, caecum along with the contents and status of adjoining abdominal organs for lumen diameter, contents, peritoneal effusions were examined.

Scanning procedure for caecum and other adjoining abdominal organs

For ultrasonography of the caecum and other adjoining organs in cows and buffaloes, an area from the tuber coxae to the eighth intercostal space and from the transverse processes of the lumbar vertebrae to the linea alba on the right side was examined. The location and content of pyloricus was noted by identifying its anatomical landmark torus pyloricus (TP) (Trent 1990) (Fig. 5). The dorsal and ventral margins of torus pyloricus, as seen ultrasonographically, were marked on the right body wall using chalk. Then the distance from dorsal mid spine to the dorsal margin of pyloricus and from ventral midline to the ventral margin of pyloricus were measured using inch tape (cm) and remarked as dorsal length and ventral length, respectively (Fig.6). The topographic location (intercostal space) and motility of pyloricus was also noted. The appearance and motility of loops of small intestine (duodenum and jejunum) was assessed. Distended SI, based on motility were classified as distended with mild peristalsis, distended with swirling motility and distended with complete ileus. The differentiation of small intestine and large intestine was done according to anatomical location and criteria described by Braun *et al* (1995).

The caceum was scanned from the right flank, medial to the descending duodenum, where the colon was more dorsal and the proximal loop of the colon and caecum are more ventral. The large intestines were differentiated from the small intestine based on its marked gas content as described previously (Braun and Amrein, 2001). The topographic position of the caecum and contents were noted. These ultrasonographic findings were correlated with per rectal examination and laparotomy findings.

3.3.8 Confirmatory diagnosis

The confirmatory diagnosis of caecal dilatation was made from clinical signs, clinical examination, ultrasonographic findings and right flank exploratory laparotomy.

3.3.9 Treatment protocol

a) **Conservative treatment:** All the animals initially received conservative therapy i.e. intravenous fluids, broad spectrum antibiotics, anti-inflammatory, anti-pyretic agents for first 24-48 hours as described earlier. After conservative treatment for

24 hours, 7 animals were subjected to right flank laparotomy that did not respond to the medicinal treatment.

b) Surgical treatment: Laparotomy from right flank approach was performed in 7 animals (1 cow and 6 buffaloes) under local anaesthesia using lignocaine 2% in standing animals restrained in cattle crate. The right flank area was shaved and prepared for aseptic surgery. A mid flank, caudo-cranially oblique, skin incision of 20-25 cm was made in the right paralumbar fossa, starting 4-5 cm below the transverse processes of lumbar vertebrae. Abdominal cavity was assessed by retracting greater omentum cranially after incising muscles and peritoneum for associated abnormalities such as peritoneal fluid and small intestines, colons and caecal volvulus or dislocation.

The very first attempt was made to retract the caecal apex from the incison site or to move the caecal body to the surgical site. When the caecum was distended with gas, it was decompressed using 16G needle attached to the suction pump. When both the attempts were failed, the body of caecum was moved close to the incision site and sutured with body wall using continuous stay sutures. All these attempts were made after reflecting the omentum cranially. In one buffalo, the attempt to reflect the omentum cranially failed due to some adhesions of omentum with the underlying organs, and then an incision was made on the omentum carefully protecting the underlying duodenum to reach to the caecal body. Following suturing of the caecal body with abdominal wall, caecotomy was done via longitudinal incision. The caecum was emptied by repeated flushing with tap water. Wound edges of the caecal wall were cleaned with normal saline and sutured with a double row of Lambert and Cushing suture pattern using chromic catgut no. 2. After closing the caecum, it was reposited in abdomen and further exploration of abdominal cavity was carried out to find out any other abnormality or fecolith which were treated using suitable methods. Abdominal incision was closed in a routine manner.

3.4 Statistical analysis

The objective data on various parameters in different groups were processed for mean ± S.D. using Microsoft Excel and analysed for level of significant difference at $p<0.01$ and $p<0.05$ using t-test. Subjective parameters analysed for percent and correlated with clinical, ultrasonographic or response to medicinal or surgical treatment and outcome.

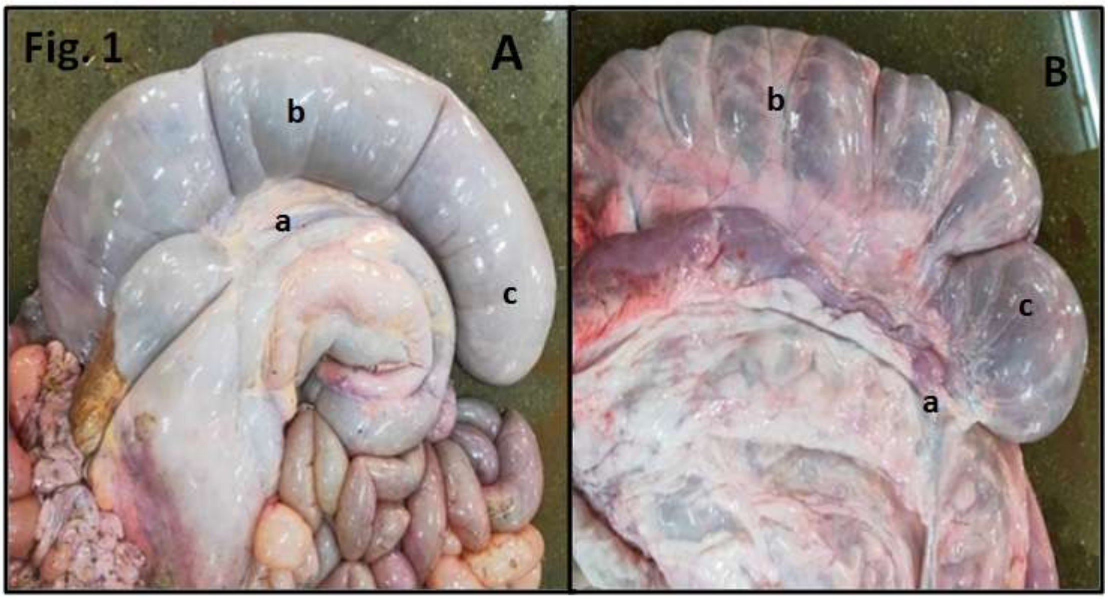

Fig. 1. Photographs showing caecum of cow (A) and buffalo (B) along with ileo-caecal mesentery (a), caecal body (b) and caecal apex (c).

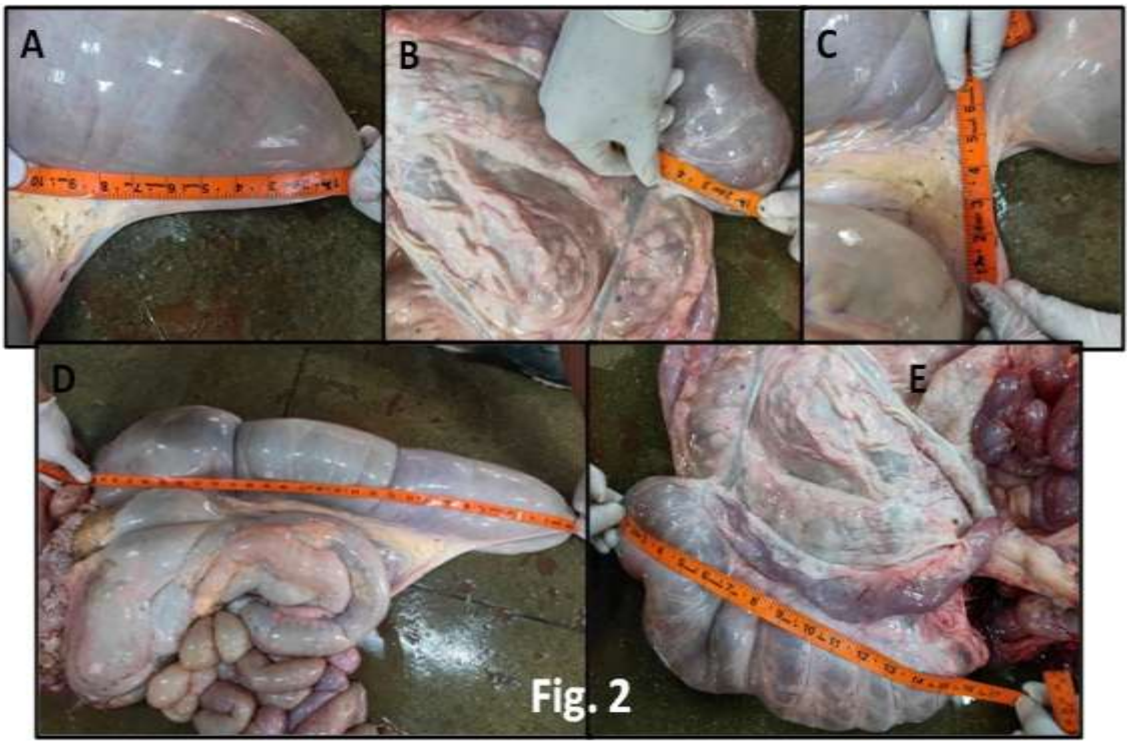

Fig. 2. Photographs showing morphometrical examination of gross specimen of caecum of cows and buffaloes from different sites. A= measuring the length of caecal apex (area devoid of ileo-caecal mesentery) in cow, B= measuring the length of caecal apex in buffalo, C= measuring the width of ileo-caecal mesentery in cow, D=total length of caecal body in cow, E= measuring the total length of caecal body in buffalo.

Fig. 3. Photograph showing curvilinear transducer of 2-5 MHz.

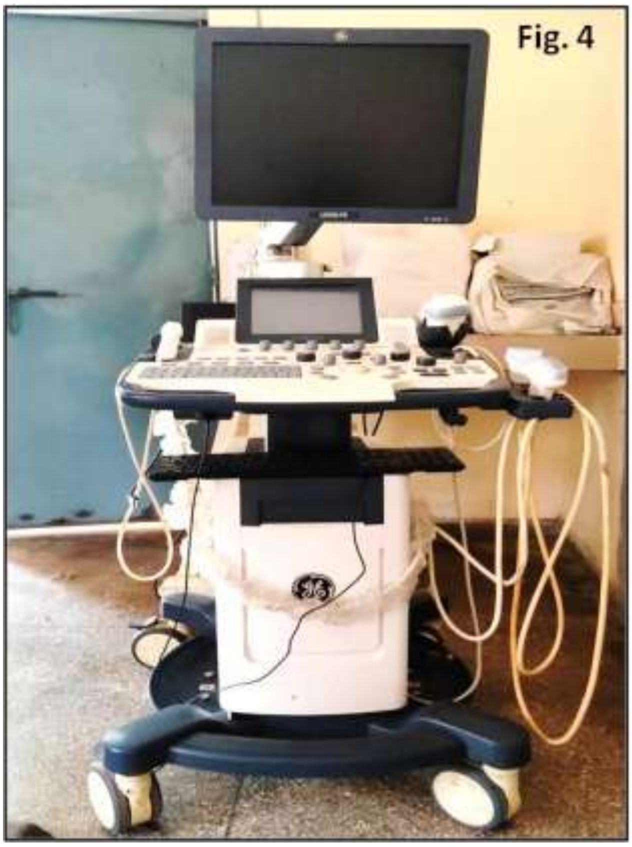

Fig. 4. Photograph showing GE Health Care Logic F8 Ultrasound machine used for the study.

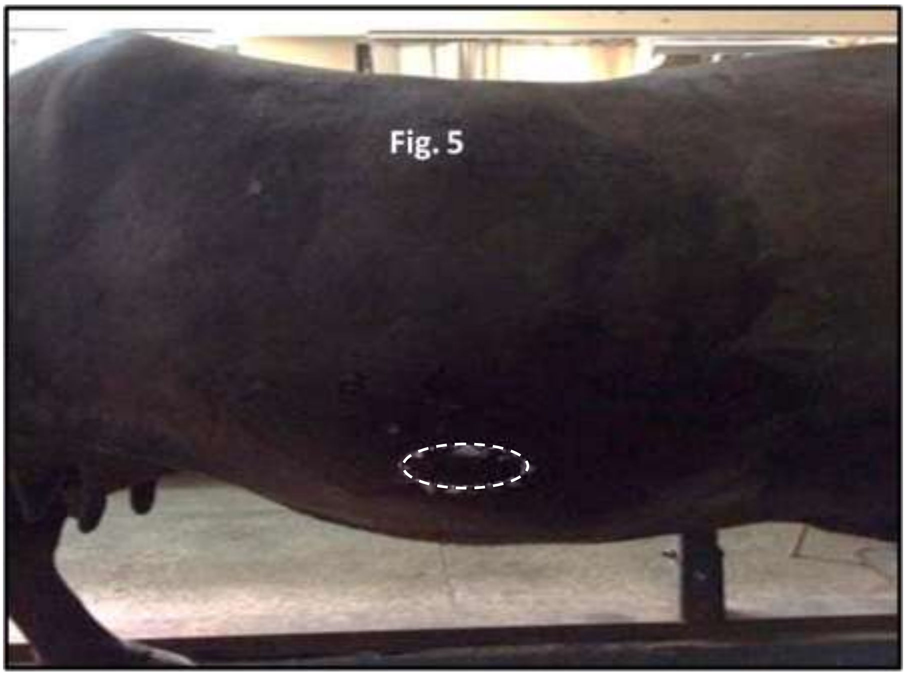

Fig. 5. Photograph showing the topographical locating torus pyloricus Ultrasonographically

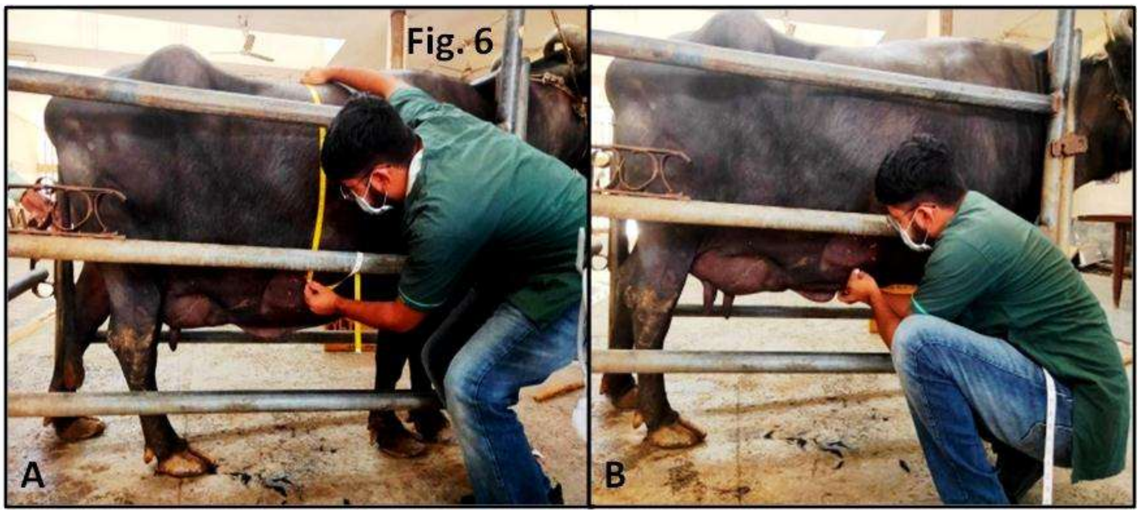

Fig. 6. Photograph showing measuring the distance of torus pyloricus from dorsal spine to dorsal margin of torus pyloricus (DL) (A), ventral midline to ventral margin of torus pyloricus (VL) (B).

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted in total 53 animals, 8 animals (4 cows and 4 buffaloes) for cadaveric study, 10 animals (5 cows and 5 buffaloes) as healthy control, 20 animals (5 cows and 16 buffaloes) as disease control and 15 clinical cases suffering caecal dilatation, referred to the Department of Veterinary Surgery and Radiology, GADVASU, Ludhiana during April 2019 to March 2020. The findings obtained in Part I (Cadaveric study), Part II (Healthy control (2a) and Disease control (2b)), Part III (Clinical study) are presented below:

4.1 PART I: CADAVERIC STUDY

A total of 8 animals (4 cows and 4 buffaloes) that died (sudden death, regurgitation, prolonged dystocia, pneumonia) or euthanized (bilateral tibia fracture, bilateral hip dislocation, and prolonged recumbency) due to causes unrelated to GIT were included in this part of study and detailed results are depicted in Table 5 (Fig. 7).

Gross Morphometric Examination

The mean length of caecal apex devoid of ileo-cecal mesentery in buffaloes was 11.27±1.32cm, which was significantly ($p<0.05$) lesser than that in cows (22.22±5.63 cm). Similarly, the mean length of ileocaecal mesentry in buffalo was 4.57±1.21cm, which was significantly ($p<0.01$) lesser than that in cows (12.7±2.92cm). The mean length and diameter of caecal body in buffaloes were 46.68±4.80 and10.36±0.76 cm, which was significantly lesser than that in cows (66.67±14.27cm and 15.57±3.93cm), respectively. Amount of fat in caecum of cadavers were classified as per Table no 2. Fat in ileo-caecal mesentry was absent in 75% of buffalo cadavers, while fat in ileo-caecal mesentry was present in 100% of cadaveric samples of cow (Table 5).

HISTOPATHOLOGICAL STUDY

Histomorphological Observations on Caecum of Cattle:

The comparative micrometric values of various layers of caecum at the apex and body in cows have been depicted in Table 6 (Fig. 8). The caecum of cattle was composed of four layers viz; Tunica mucosa, Tunica Submucosa, Tunica Muscularis and Tunica Serosa (Fig. 9A).

Table 5. Gross morphometeric findings of healthy caecum in cattle and buffaloes

S. No.	Parameters	Buffalo (Mean ± SD) (Range)	Cattle (Mean ± SD) (Range)
1	**Age (yrs)**	4.88 ± 0.25 (4.5-5.0)	4.25 ± 1.19 (2.5-5.0)
2	**Length of caecal apex devoid of mesentery (cm)**	11.27±1.32* (9.52-12.7)	22.22±5.63* (15.24-27.94)
3	**Ileo-cecal mesentery length (cm)**	4.57±1.21** (3.81-6.35)	12.7±2.92** (10.16-15.24)
4	**Caecal body diameter (cm)**	10.36±0.76 (9.65-11.43)	15.57±3.93 (10.16-19.2)
5	**Total caecal body length (cm)**	46.68±4.80 (41.91-50.8)	66.67±14.27 (48.26-76.2)
6	**Presence of fat at ileo-cecal mesentry**		
	Absent	3/4=75%	0
	Present	1/4=25%	100%

*=5% LOS, **=1% LOS between cattle and buffalo

Table 6: Micrometric thickness of various luminal layers (mean ± SD) of caecal apex and body in cows (H&E stained)

Caecum	Tunica mucosa (µm) (range)	Tunica submucosa (µm) (range)	Tunica muscularis (µm)(range)	Tunica serosa (µm)(range)	Total wall (µm) (range)
Body	632.58± 55.92 (573.18-681.75)	1077.02± 134.90^{aa} (888.46-1175.18)	2014.73± 21.39^{bb} (1989.48-2039.37)	165.92± 16.46 (146.44-185.47)	3890.70± 137.56^{cc} (3719.64-4006.31)
Apex	666.76± 52.10 (590.85-709.00)	567.10± 51.62^{aa} (497.00-619.33)	1096.21± 118.38^{bb} (969.35-1130.59)	184.01 ± 19.66 (158.34-199.61)	2434.08± 299.18^{cc} (1994.12-2634.97)

Values with same superscripst differs significantly at 1% level of significance

Tunica mucosa: It was further comprised of lamina epithelialis, lamina propria and lamina muscularis mucosae (Fig. 9B) both at the apex and body of caecum. Lamina epithelialis had simple columnar epithelium with goblet cells. Lamina propria was comprised of loose connective tissue lined by intestinal glands. Intestinal glands were located basally towards lamina muscularis mucosae (Fig. 9B). The lamina muscularis mucosa was comprised of thick smooth muscle layers (Fig.9B). These observations are in conformity with findings of Kadam *et al* (2011) in cattle. The mean thickness of tunica mucosa in cattle at the body of caecum was 632.58±55.92µm, whereas, at the apex of caecum it was 666.76±52.10 µm.

Tunica submucosa: Tunica submucosa in cattle was composed of connective tissue fibers, predominantly collagen fibers both at the apex (Fig.9B, 9C, 9D), and body of caecum (Fig, 10C, 10D, 11A, 11B). The elastic fibers were few in submucosa both at the apex and body of caecum and were prominent in the wall of blood vessels (Fig, 11C, 11D). Apart from connective tissue fibers blood vessels, lymphatic's, neuronal elements and abundant adipose tissue was observed in submucosa both at the apex and base of caecum. The distribution of adipose tissue varied in the apex and the body of caecum. In the region of apex adipose tissue was present in the form of islands and enclosed by connective tissue fibers (Fig. 9B, 9C) which were mainly collagen fibers. Some areas in the submucosa at the apex of caecum were devoid of adipose tissue and mainly collagen fibers were present in these areas (Fig. 9D). In the region of body of caecum a continuous layer of adipose tissue was observed in submucosa (Fig. 10C,10D) and it was enclosed by collagen fibers toward the side of lamina muscularis mucosae (Fig. 11A, 11B). The mean thickness of submucosa at the apex of caecum in cattle was 567.10±51.62 µm, whereas at the body of caecum it was 1077.02±134.90 µm and was the thickest layer. Kadam *et al* (2011) also reported that tunica submucosa of cattle was thicker as compared to sheep and goat which supports the findings of the present study.

Tunica muscularis:

The tunica muscularis in cattle was arranged in inner circular and outer longitudinal layers (Fig.10A &10B) at the apex of caecum. The outer longitudinal layer was arranged in the form of fascicles (Fig.10A), however at different locations within the tunica muscularis random arrangement of muscle fibers was also observed. In the body of caecum randomly arranged muscle fibers were frequently observed (Fig.10C, 10D). The tunica serosa in cattle was composed of connective tissue layer lined by mesothelium. The average thickness of tunica musculris at the apex of caecum in cattle was 1096.21±118.38 µm, whereas at the body of caecum it was 2014.73±21.39 µm.

Tunica Serosa: The tunica serosa was a connective tissue layer both at the apex and body of caecum comprising of abundant collegen fibers, blood vessels, lymphatics and neuronal elements (Fig.10A, 10C). The average thickness of tunica serosa at the apex and body of caecum was 184.01 ± 19.66 µm and 165.92±16.46 µm, respectively. Similar observations were made by Kadam *et al* (2011) in cattle and Mohammed *et al* (2018) in camel.

Various layers of caecal apex and body wall in cattle were compared (Table no. 6) statistically. The submucosa (p=7.28E-03), muscularis (p=4.62E-04) and total wall (p=4.47E-03) of the caecum were found significantly thicker at the body of caecum as compared to that at the apex in cows. However, the mucosa and the serosa at the caecal apex were observed non-significantly thicker than that at the body in cows.

Histomorphological observations on caecum of buffaloes

The caecum of buffalo was also composed of the four tunics namely tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa (Fig.12A). The comparative micrometric values of various layers of caecum at the apex and body in buffaloes have been depicted in Table 7 (Fig. 16).

Tunica mucosa: The tunica mucosa of the buffalo caecum was composed of lamina epithelialis having simple columnar epithelium, lamina propria composed of loose connective tissue and lined by intestinal glands and lamina muscularis mucosae composed of smooth muscles both at apex (Fig.12A) and body of caecum. The mean thickness of tunica mucosa at the apex and body of buffalo was 258.51 ± 16.47µm and 203.36 ± 26.25 µm, respectively. These observations are in conformity with the findings of Kadam *et al* (2011) in cattle and Abd-El-Hady *et al* (2013) in dogs.

Tunica submucosa: The tunica submocosa was predominantly composed of collagen fibers and few elastic fibers, blood vessels, lymphatics, neuronal elements and connective tissue cells. Similar observations were made by Kadam *et al* (2011) in cattle. However adipose tissue was scanty in submucosa of buffalo both at the apex and body of caecum (Fig.12B) which was in contrast to the findings in caecum of cattle. The collagen fibers were predominant constituent of submucosa in buffalo both at the apex and body of caecum (Fig.12C &12D). Very few elastic fibers were observed in submucosa of buffalo both at the apex and body of caecum and were mainly present in the wall of blood vessels (Fig.13C,13D). The mean thickness of tunica submucosa at the apex and body of buffalo caecum was 243.47 ± 20.88µm and 112.30±4.43µm, respectively.

Tunica musularis: Tunica muscularis was composed of inner circular and outer longitudinal smooth muscle layers, however randomly arranged smooth muscle bundles were frequently observed in caecum of buffalo both at the apex and body of caecum (12D, 13A). The muscle bundles in tunica muscularis were separated by well developed connective tissue containing abundant collagen fibers (12D, 13B) and forming fascicles. The average thickness of tunica muscularis in apex and body of caecum of buffalo was 823.45 ± 46.60 µm and 833.05 ± 78.86 µm, respectively.

Tunica serosa: The tunica serosa was a thick connective tissue layer both at the apex and body of caecum in buffalo comprising of abundant collegen fibers, blood vessels, lymphatics and neuronal elements (Fig.12A, 12C, 13A). Similar observations were made by Kadam *et al* (2011) in cattle and Mohammed *et al* (2018) in camel. Occasional adipose tissue was also observed in tunica serosa. The mean thickness of tunica serosa at the apex and body of caecum of buffalo was 142.57 ±18.97 µm and 176.09 ±5.96 µm, respectively.

The comparative micrometric values of various layers of caecum at the apex and body in buffaloes have been depicted in Table 7 (Fig. 16). The mucosa (p=0.04), submucosa (p=1.64E-03) and total wall (p=0.02) of the caecal apex were significantly higher than at the body of the caecum of buffaloes. However, the sub-mucosa at the body of caecum in cows was significantly thicker than at the apex (Table 6).

Table 7: Micrometric thickness (mean ± SD) of various luminal layers of cecal apex and body in buffaloes (H&E stained)

Caecum	**Tunica mucosa (µm) (range)**	**Tunica submucosa (µm) (range)**	**Tunica muscularis (µm) (range)**	**Tunica serosa (µm) (range)**	**Total wall (µm) (range)**
Body	203.36± 26.25^{a} (170.69-233.92)	112.30± 4.43^{bb} (108.53-117.10)	833.05 ± 78.86 (720.70-895.69)	176.09 ± 5.96^{c} (170.10-183.33)	1386.65± 73.50^{d} (1298.20-1473.90)
Apex	258.51 ± 16.47^{a} (235.19-273.98)	243.47 ± 20.88^{bb} (230.35-274.59)	823.45 ± 46.60 (764.69-892.75)	142.57 ± 18.97^{c} (123.29-166.37)	1464.36± 46.05^{d} (1406.78-1504.83)

Values with same superscripts differs significantly at 5% (single superscript) and 1% (double superscript) level of significance

The serosal layer thickness at the body of the caecum was significantly (p=0.04) more than that at the apex in buffaloes; whereas, the muscularis layer of the cecal body wall was found non-significantly thicker than that at the apex in buffaloes.

Comparison of histological micrometry of caecum in cattle and buffaloes

Caecal body

The detailed micrometric values of various layers of caecal body wall in cows and buffaloes have been depicted in Table 8 (Fig. 17). The thickness of mucosa (p=1.04E-04), submucosa (p=7.33E-04), muscularis (p=3.14E-05) and total wall (p=1.42E-06) of caecal body in buffaloes was significantly lesser as compared to that in cows. However, the serosa of the caecal body wall in buffaloes was found non-significantly thicker than in cows.

Table 8: Comparative micrometric thickness (mean ± SD) of various liminal layers of caecal body wall between cows and buffaloes (H&E stained)

Species	Tunica mucosa (µm) (range)	Tunica submucosa (µm) (range)	Tunica muscularis (µm) (range)	Tunica serosa (µm) (range)	Total wall (µm) (range)
Cows	632.58± 55.92^{aa} (573.18-681.75)	1077.02± 134.90^{bb} (888.46-1175.18)	2014.73± 21.39^{cc} (1989.48-2039.37)	165.92± 16.46 (146.44-185.47)	3890.70± 137.56^{dd} (3719.64-4006.31)
Buffaloes	203.36± 26.25^{aa} (170.69-233.92)	112.30± 4.43^{bb} (108.53-117.10)	833.05± 78.86^{cc} (720.70-895.69)	176.09± 5.96 (170.10-183.33)	1386.65± 73.50^{dd} (1298.20-1473.90)

Values with same superscripts differs significantly at 1% level of significance

Caecal apex

The detailed micrometric values of various layers of caecal apex in cows and buffaloes have been depicted in Table 9 (Fig. 18). In the cecal apex, all the layers; mucosa (p=2.29E-04), submucosa (p=3.33E-04), muscularis (p=0.01), serosa (p=0.02) and total wall thickness (p=6.69E-03) were significantly lesser in buffaloes as compared to that in cows.

Table 9: Comparative micrometric thickness (mean ± SD) of various liminal layers of caecal apex between cows and buffaloes (H&E stained)

Species	Tunica mucosa (µm) (range)	Tunica submucosa (µm) (range)	Tunica muscularis (µm) (range)	Tunica serosa (µm) (range)	Total wall (µm) (range)
Cows	666.76 ± 52.10^{aa} (590.85-709.00)	567.10 ± 51.62^{bb} (497.00-619.33)	1096.21± 118.38^{cc} (969.35-1130.59)	184.01 ± 19.66^{d} (158.34-199.61)	2434.08± 299.18^{ee} (1994.12-2634.97)
Buffaloes	258.51 ± 16.47^{aa} (235.19-273.98)	243.47 ± 20.88^{bb} (230.35-274.59)	823.45 ± 46.60^{cc} (764.69-892.75)	142.57 ± 18.97^{d} (123.29-166.37)	1464.36± 46.05^{ee} (1406.78-1504.83)

Values with same superscripts differs significantly at 5% (single superscript) and 1% (double superscript) level of significance

Ileo-caecal mesentery of cattle: The mesentery in cattle was lined by mesothelium supported by a thick layer of subepithelial connective tissue (Fig. 14A). The subepithelial connective tissue contained abundant collagen fibers (Fig. 14B). The major constituent of mesentery was adipose cells. Smith (1984) also reported abundant fat in cattle mesentery. Apart from adipose cells, connective tissue cells, collagen fibers and few elastic fibers and blood vessels were observed in the cattle mesentery (Figs.14A, 14C, 15A). The collagen fibers were also seen running into the adipose tissue forming septas below sub-epithelial connective tissue layer (Fig.15A). The mean thickness of subepithelial connective tissue in cattle was 339.55±10.71µm (Table 10). The elastic fibers were abundant in the wall of blood cells (Fig. 15C). Sorenson and Belje *et al* (2014) made similar observations in human mesentery

Ileo-caecal mesentery of buffalo: The buffalo mesentery similar to cattle was lined by mesothelium and supported by subepithelial connective tissue, however the subepithelial connective tissue layer was thin in buffalo as compared to cattle (Fig. 14C). The subepithelial connective tissue contained randomly arranged collagen fibrils (Fig. 14D) The mesentery just like cattle was composed of adipose cells supported by collagen and few elastic fibers, connective tissue cells and blood vessels (Fig. 15B, 15D). Sorenson and Belje *et al* (2014) made similar observations in human mesentery. The mean thickness of subepithelial connective tissue in buffalo was

147.96±9.03 µm (Table 10). The connective tissue septa were not observed in buffalo mesentery, however randomly distributed connective tissue fibers particularly collagen fibers were abundant in the mesentery (Fig. 15B).

Comparison of Ileo-caecal mesentery in cattle and buffaloes: The comparative micrometric values of various layers of ileo-caecal mesentry in cows and buffaloes have been depicted in Table 10. The thickness of sub-epithelial connective layers of ileo-caecal mesentry in buffaloes was found highly significantly lesser (p=2.20E-07) as compared to that in cows.

Table 10: Comparative micrometric thickness (mean ± SD) of ileo-caecal mesentry (µm) between cows and buffaloes (H&E stained)

Parameter / Species	Sub-epithelial connective tissue layer	
	Mean ±SD	Range
Cows	339.55 ± 10.71^{aa}	328.43-353.05
Buffaloes	147.96 ± 9.03^{aa}	139.78-158.98

Values with same superscript differs significantly at 1% level of significance

Histomorphology of collagen fibers in cattle (Table 11 &12) (Fig. 19)

Collagen was scanty in tunica mucosa. It was present in the basement membrane of lamina epithelialis. Loosely arranged collagen fibres were seen in lamina propria of caecal villi. In tunica submucosa thick bundles of collagen fibers were densely arranged around the muscularis mucosae towards the tunica submucosa (Fig. 9C, 9D). Collagen was densely packed in tunica submucosa surrounding the adipose tissue. The orientation of collagen fibers was wavy in appearance (Fig. 9C, 9D). In tunica submucosa collagen fibers were densely packed in caecal apex around the adipose tissue islands and muscle fascicles. Loosely arranged collagen fibers were present around the layer of adipose tissue in submucosa of the body of caecum. Some thin collagen bundles were also seen inside the adipose tissue layer in betweem the fat cells (Fig. 9C, 11A, 11B). In the tunica muscularis collagen fibers surrounded the muscle fascicles. A thin collagen layer was also observed inside the fascicles possibly representing the collagen in the perimycium (Fig 9C, 11A). In tunica serosa layer collagen was densely packed (Fig. 9C).

Histomorphological observations of collagen fibers in buffaloes (Table 11 & 12) (Fig. 19)

In overall qualitative comparison of caecal apex and body of buffalo, the collagen fibers were densely packed in caecal body. Tunica mucosa has scanty to negligible amount of collagen fibers. The orientation of collagen fibres was wavy in appearance. Tunica sub mucosa, tunica muscularis and tunica serosa of the caecal body has more densely packed collagen fibers than that of caecal apex of buffalo and caecal body of cattle (Fig 12C, 12D, 13B).

Table 11: Qualitative scoring of collagen fibers in cattle and buffalo

Different layers	Cattle		Buffalo	
	Apex	Body	Apex	body
Tunica mucosa	+*	+*	-	-
Tunica submucosa	+++*	++	++	++*
Tunica muscularis	++*	++	+	++*
Tunica serosa	+++*	++	++	++*

* indicate densely packed collagen fibres + indicate amount of collagen fibres

Table 12: Quantitative analysis of collagen fibers in cattle and buffaloes (Fig. 21)

Species	Apex	Body	Mesentery
Cattle	24.33 ± 1.96	18.03 ± 1.63*	14.54 ± 1.93**
Buffaloes	22.22 ± 3.47	14.30 ± 1.28*	3.36 ± 0.35**

* Significant difference between cattle and buffaloes at 5% level of significance.

** Significant difference between cattle and buffaloes at 1% level significance.

The collagen fibers of body ($p<0.05$) and mesentery ($p<0.01$) were found to be significantly lesser in buffaloes as compared to cows. However, no significant difference was recorded in the collagen fibers of apex of caecum in two species.

Important microscopic comparative features of caecal wall and ileocaecal mesentry in cows and buffaloes:

1. The distribution of adipose tissue varied in the caecal apex and body of both cattle and buffaloes. There was scanty amount of adipose tissue in buffaloes at both caecal apex and body. In cattle the distribution of adipose tissue in tunica submucosa at region of apex was in form of islands which was enclosed by thick

bundles of collagen fibres. On the other hand the distribution of adipose tissue in submucosa of caecal body was in the form of continuous layer which was lined by loosely arranged (compared to caecal apex) collagen fibres towards the side of lamina muscularis.(Table. 11)

2. Tunica muscularis in both cattle and buffaloes were composed of both inner circular and outer longitudinal muscle layer, however, random arrangement of muscle fibers was also observed in both apex and body of buffaloes. This similar random arrangement was observed in outer longitudinal layer in caecal body of cattle. The outer longitudinal layer wherever present was arranged in the form of fascicles at caecal apex both in cattle and buffalo.

Important comparative microscopic features of collagen fibers in cattle and buffaloes

1. The orientation of collagen fibres was same in both cattle and buffaloes but there arrangement varied. In overall qualitative comparison the amount of collagen fibers was more in cattle than that of buffaloes.
2. Maximum amount of collagen fibers were present in the tunica submucosa and tunica serosa of both cattle and buffaloes. Also, the collagen fibers present in these layers were densely packed qualitatively.
3. The amount of collagen fibers in caecal apex was more and even denser than that of caecal body of cattle. In contrast, the amount of collagen fibers in caecal body was more and even denser than that of caecal apex of buffaloes (Table. 11).
4. Caecal apex of cattle was more densely packed with collagen fibers than that of buffalo caecal apex. While, caecal body of buffalo was more densly packed with collagen fibers than that of caecal body of cattle (Table. 12; Fig 19).

Histomorphological observation of elastic fibers in cattle and buffaloes:

Both cattle and buffalo samples showed very less amount of elastic tissue fibers in both caecal apex and body. Only minute amount of elastic fibers were present around the blood vessels (Fig. 11C, 11D, 13C, 13D).

PART 2: CONTROL GROUP

This part is divided into 2 subgroups: (2a) healthy control (n=10); (2b) diseased control group (n=20). All the animals in group 2a and 2b were subjected to ultrasonographic examination to record various parameters (Table. 13) and location of pylorus with respect to body wall.

Table 13: Comparison of ultrasonographic parameters of healthy control group (2a) and diseased control group (2b)

USG parameters		Healthy control (2a)	Disease control (2b)
Reticular motility (in 3 min scan)		strong biphasic motility	25% of animal had no reticular motility 25% of animal had normal reticular motility 50% had sluggish reticular motility
Location of omasum		Cattle- majority at 8^{th} ICS (with 6^{th} most cranially and 9^{th} most caudally) Buffalo- majority cranially at 7^{th} ICS and caudally at 9^{th} and 10^{th} ICS	Cranial most at 5^{th} ICS and caudal most at 11^{th} ICS
Diameter of small intestine	Duodenum	2.4 ± 0.54 cm (1.5 to 2.9 cm)	1.61 ± 0.83 cm (1.0 to 3.7 cm)
	Jejunum	2.04 ± 0.44 cm (1.6 to .8 cm)	3.07 ± 1.22 cm (1.7 to 6.5 cm)
Location of caecum		Within the flank (except one cow where it was extended upto 12^{th} ICS)	Seen in flank in 17 animals But in 3 animals upto 12^{th} ICS
Content of caecum		4 with no reverberation (anechoic fluid content) 5 with mild reverberation 1 with mixed content	Mixed in 12 animals 8 with mild reverberation
Location of gall bladder		10^{th}-11^{th} ICS	18 animals (4 cows and 14 buffaloes) had GB at 10^{th} or 11^{th} ICS while 2 had cranially located GB (1 cow at 8^{th} ICS suffering from DH; 1 buffalo at 9^{th} ICS suffering from peritonitis/ileus)
Location of pylorus (ICS)		Pylorus seen at 8^{th} ICS (3 cows), 9^{th} ICS (2 cows), at 10^{th} ICS (4 buffaloes) or 11^{th} ICS (1 buffalo)	Pylorus at 7^{th} ICS- 1 buffalo (DH) Pylorus at 8^{th} ICS- 3 cows and 1 buffaloes (DH) Pylorus at 9^{th} ICS-8 animals (2 cows and 6 buffalos) Pylorus at 10^{th} ICS-7 buffaloes

Healthy control (2a) (n=10)

A total of 10 apparently healthy animals (5 cows and 5 buffaloes) that were either non-pregnant or in first trimester of pregnancy, were included in this part of study. Caecum was differentiated from the small intestine on the basis of gaseous content within the caecum. Caecum appeared as thick echogenic, crescent shaped line and only the wall closer to the body wall could be imaged. Similar findings have previously been reported (Braun *et al* 1995, Kumar 2010). On ultrasonographic examination, one apparently healthy cow had filled caecum with mixed contents (Fig. 20) and was seen mildly distended cranially upto 12th ICS. All the remaining animals had caecum seen limiting the flank region. 4 Out of 9 animals had no reverberation (Fig. 21) in caecum region (one cow and 3 buffaloes), while 5 had mild reverberation (Fig 20) seen (3 cow and 2 buffaloes) (Table 13).

Ultrasonographically, all had strong biphasic reticular motility at 5th ICS except one cow that had mild peri-reticular reaction and it was presented for teat fistula repair. The reticulum was identified from its characteristic ultrasonographic features, as described by (Braun and Götz 1994, Braun *et al* 2002, Braun 2009). All the cows had omasum seen cranially at 6th ICS and maximum caudally at 9th ICS, with majority (4 cows) up to 8th ICS. However, in four buffaloes the cranial most margin was seen at 7th ICS except one at 8th ICS and the maximum caudal margin was seen at 9th and 10th ICS (Table no. 13). Omasum size, based on intercostal space, was observed to vary between 3-4 ICS which corroborate to earlier findings (Braun 2009, Diniz *et al* 2016). The 10th-11th ICS was found as the most common site for the scanning of gall bladder in apparently healthy cows and buffaloes (Fig. 22) (Table 13).

The pylorus was seen from 8th (n=3) to 9th ICS (n=2) in cows (Fig. 23A) and at 10th ICS in buffaloes (Fig. 23B) except one where it was seen at 11th ICS (Table 13). It suggested that in non-pregnant or early pregnant cows the pylorus was located at least one ICS cranial in comparison to buffaloes of same physiological status. All the animals had good pyloric contractions (4-5/min) irrespective of species (Fig. 24). In one buffalo the pylorus was mildly fluid filled while it appeared empty in others.

The mean total length of right side of bovine body at the level of pylorus (mid spine to midline ventrally) was 120.75 ± 9.36 cm (110-132.5). This mean length was significantly more in buffaloes as compared to cows (p=0.01)with the mean length of buffaloes to be 127.5 ± 7.07cm and that of cows to be 114 ± 5.75cm. Otherwise the relative position of pylorus when compared from dorsal and ventral midline was not found to be significantly different in cows and buffaloes. The mean distance of pylorus from the dorsal midline was 88.75 ± 10.02 cm (75-102.5) and themean distance of pylorus from the ventral midline was 24.75 ± 2.19 cm (22.5-27.5) in apparently healthy animals. These were not compared in between the species as the height, girth and weight of cows and buffaloes were different.

Table 14: Topographic location of pylorus in group 2a - apparently healthy animals (all females, recently parturated or pregnant in first trimeseter, DL= dorsal length, VL=ventral length, TL=total length)

Species	Age (year)	DL (cm)	VL (cm)	TL (cm)	DL:TL	VL:TL
Cattle (5)	4.50 ± 1.00	81.50 ± 5.48*	25.00 ± 2.50	114.00 ± 5.76**	0.72 ± 0.03	0.22 ± 0.02
Buffaloes (5)	4.20 ± 1.64	96.00 ± 8.02*	24.50 ± 2.09	127.50 ± 7.07**	0.75 ± 0.03	0.19 ± 0.02
Overall	4.35 ± 1.35	88.75 ± 10.02	24.75 ± 2.19	120.75 ± 9.36	0.74 ± 0.03	0.20 ± 0.03

* Significant difference between cattle and buffaloes at 5% level of significance.

** Significant difference between cattle and buffaloes at 1% level of significance.

From the data depicted in Table 14, it was apparent that pylorus was scanned more ventrally in buffaloes as compared to cows because the dorsal length (from dorsal midline to dorsal margin of pylorus) was significantly ($p<0.05$) more in buffaloes as compared to cows. However, total length (from dorsal midline to ventral midline at the pylorus) was found significantly ($p<0.01$) more in buffaloes as compared to cows, so justifying the ventral scanning of the pylorus in apparently healthy buffaloes as compared to cows. This finding was also confirmed from the non-significant difference in the ratio of DL: TL and VL: TL.

The descending duodenum, at flank or at 12^{th} ICS, was seen in all the animals with an average diameter of 2.4 ± 0.54cm (1.5 to 2.9cm) (Fig. 25) with no significant difference between the species (cows and buffaloes). The motility was good to strong in all the animals irrespective of species. The jejunum was seen in all the animals with an average diameter of 2.04 ± 0.44cm (1.6 to 2.8cm) at 10^{th}-11^{th} ICS (Fig. 26) with good to strong motility in all the animals irrespective of species. Kumar (2010) reported that the mean lumen diameter of the intestinal loops in healthy cows and buffaloes was 3.1 ± 0.23 cm. Singh *et al* (2017b) reported similar finding that mean lumen diameter of the small intestine in healthy buffaloes (1.79 ± 0.06) was significantly larger than that of cattle (1.46 ± 0.02). In contrast Kumar (2014) stated that lumen diameter of the small intestine in healthy cattle (1.83± 0.16) was significantly larger than that of buffaloes (1.49 ± 0.19).

Diseased Control Group (2b) (n=20)

A total of 20 animals (5 cows and 15 buffaloes) suffering from various disease conditions (unrelated to bowel obstruction) such as diaphragmatic hernia, pnuemonia, peritonitis, lung cyst, reticular foreign body and pericarditis were included in this group. Eight buffaloes and 2 cows were in 3rd trimester of pregnancy while the rest were non-pregnant or in 1st trimester. Ultrasonographic findings of caecum and adjoining organs have been depicted in Table 13.

In majority of the animals (n=17, 4 cows and 13 buffaloes), caecum was scanned in the flank region, whereas, it was also seen at 12th ICS in the remaining 3 animals. Caceum had mixed contents without reverberations in 12 animals (Fig. 27) (2 cows and 10 buffaloes), while 8 animals (3 cows and 5 buffaloes) had gaseous contents with mild reverberations.

Out of 20, 5 animals had no reticular motility observed in 3 minutes of scan, while 5 had normal biphasic reticular motility and 10 had decreased or sluggish reticular motility. Seven animals had mild free fluid present in between the reticular recesses or jejunal loops while 6 had severe fluid with or without fibrin and 7 had no free fluid seen. Reticular-peritonitis and adhesions lead to reduction the reticular motility (Kumar *et al* 2012, Makhdoomi *et al* 2019).

The omasum was cranial most seen at 5th ICS in animals suffering from DH while the caudal most margin was at 11th ICS which was normal. Gall bladder, in majority of the animals, was seen at 10th (n=10) and 11th ICS (n=8) while in one cow suffering from DH (Fig.28) and one buffalo (peritonitis) of this group, the cranial margin of distended gall bladder was seen at 8th and 9th ICS, suggesting that the position of gall bladder may vary with the disease condition.

The pylorus was seen cranial most at 7th ICS in one animal (1 buffalo suffering from DH) & 8th ICS in 4 animals (3 cows out of which 1 cow had DH and 1 Buffalo suffering from DH). The most common location of pylorus in Group 2b was 9th-10th ICS and was distended fluid filled with decreased or no motility (Fig. 29). The pyloric contractions were good/normal in only 5 animals while sluggish or no contractions in rest of the animals.

The mean distance of pylorus from the dorsal most spine (DL) was 85.77 ± 9.09 cm (75-102.5). The mean distance of pylorus from the ventral midline (VL) was 30.19 ± 11.57 cm (20.0-55.0) The mean total length of right side of bovine body at the level of pylorus (mid spine to midline ventrally) was 123.27 ± 12.01 cm (102.5-140.0).

The duodenum was seen in all the animals with an average diameter of 1.61 ± 0.83cm (1.0 to 3.7cm). The motility was good to strong in 8 animals, while decreased in 5 and no motility was seen in 7 animals. The jejunum was seen in all the animals with an average diameter of 3.07 ± 1.22cm (1.7 to 6.5cm) at 10th-11th ICS. The motility was decreased in 16 animals and was absent in 4, with 4 animals having fluid filled distended jejunal loops (Fig. 30).

PART 3: CLINICAL CASES

Signalment and history

A total of 15 animals (2 cows and 13 buffaloes) were referred for diagnosis and treatment of caecal dilatation during the study period of 1 year. Both the cows recovered, where one was treated surgically and one medicinally. However, out of 13 buffaloes, only 46.17% (n=6) survived. The average age of animals presented was 7.3 ± 3.21 years (range 3 to 15 yrs). This finding is in conformity with Singh *et al* (2019). Most of the animals presented were more than 6yrs old (11/15=73.33%) and 3 buffaloes were more than 10 yrs of age. The middle age animals, showed 100% recovery from the condition. Four animals (buffaloes) were in the third trimester of pregnancy (4/15=26.67%). Three animals were in first trimester of pregnancy (3/15=20%). Eight animals had a history of recent parturition from one day back to maximum of 3 months back (8/15=53.33%). This finding was in conformity with Fubini (1990) as the first 60 days after parturition or during the peak lactation, because they were being fed with high concenterate diet. Out of 8, 5 were parturited within 15 days of developing illness and reported a gradual decrease in milk yield. Most of the animals in 3rd trimester of pregnancy recovered from the condition (75%). Least survivability was seen in young and those in 1st trimester and 1st parity. Most of the animals developed illness in late gestation or just after parturition (7/15=46.67%). Four animals were in 1st parity (4/15=26.67%), 2 in 2nd parity (2/15=13.33%), 4 in 3rd parity (4/15=26.67%), 2 each in 4th and 5th parity (2/15=13.33%) and one in 11th parity (1/15=9.09%). Out of total 15 animals presented 11 (11/15=73.33%) were active at presentation (including one cow) and 4 were dull (4/15=26.67%). This finding is in contrast with findings of Braun *et al* (2012), according to which most of the animal presented with abnormal demeanour. The survivability was seen more in dull animals. The animals with intermittent anorexia survived the condition, also those with chronic illness showed 50% survivability.

Out of 15 animals, 3 had brick red, 5 had pale and 7 had normal mucous membranes. To surprise, maximum mortality was seen in animals with normal mucous membranes. Most of the animals (n=11) had body temperature within the normal range (Green and Husband 1996 and Mesaric and Modic 2007), but more than 50% of them were non-survivors. While among those with elevated body temperature (n=4), 75% were survivors.

Cattle of any breed, age and sex can suffer from various types of intestinal obstructions (large or small) during any time, or season of the year (Anderson and Ewoldt 2005). Clinical signs of cattle suffering from various intestinal onstruction are abdominal pain, scanty or absent feces, abdominal distention, dehydration and toxemia (Anderson and Ewoldt 2005).

History of pain and inappetance/anorexia (Table 15)

In the present study, most of the animals (n=6) presented had no history of pain and once in starting (n=4), both had 50% of survival rate. Fubini (1990) stated that the cattle suffering from caecal dilatation were usually asymptomatic. Out of 6, 4 animals were treated medicinally with 50% survivability and 2 animals were treated surgically. Out of two, one animal survived. The number of animals presented with history of continuous pain were 3, out of which only one survived and that too medicinally. 2 animals had history of intermittent pain and both survived. Navetat *et al* (1998) stated that calves with caecal dilatation and volvulus had unstable appetite, with signs of colic in the beganing.

Anorexia in most of the animals presented for caecal dilatation in present study was in conformity with Fubini (1990), Dehghani and Townsend (1982), Mesaric and Modic (2007), Meylan (2008), Braun *et al* (2012), Singh *et al* (2019), Gupta *et al* (2017). Most of the presented animals had history of anorexia since 5-10 days (n=7), and the survivability was only 28.6% i.e. only 2 cases (surgically). Out of total animal (n=15) presented for caecal dilatation only 3 animal were eating intermittently with 100% survival rate, 2surgically and 1 medicinally. Other remaining have had history of anorexia for less than 4 days (n=3) and more than 10 days (n=2), with survival rate of 66.67% and 50%, respectively.

Table 15: Survivability in relation to various parameters

S. No.	Parameter	No. presented	Survived	Non-survivor
1	Species			
	Cow	2	2/2=100%	0
	buffalo	13	6/13= 46.15%	7/13=53.85%
2	Age			
	≤3.5yrs	4	1/4=25%	3/4=75%
	<3.5 to 7yrs	2	2/2=100%	0
	>7yrs	9	5/9=55.56%	4/9=44.44%
3	Reproductive / Productive Status			
	3rd trimester of pregnancy	4	3/4=75%	1/4=25%
	First trimester of pregnancy	3	1/3=33.33%	2/3=66.67%
	Recent parturition (<15 days)	5	2/5=40%	3/5=60%
	Parturited (> 15 days back)	3	2/3=66.67%	1/3=33.33%
4	Parity			
	1st	4	1/4=25%	3/4=75%
	2nd	2	2/2=100%	0
	3rd	4	2/4=50%	2/4=50%
	4th	2	2/2=100%	0
	5th	2	0	2/2=100%
	11th	1	1/1=100%	0
5	Status			
	Active	11	5/11=45.45%	6/11=54.54%
	Dull	4	3/4=75%	1/4=25%

S. No.	Parameter	No. presented	Survived	Non-survivor
6	Anorexia / Inappetance			
	≤4 days	3	2/3=66.67%	1/3=33.33%
	5-10 days	7	2/7=28.6%	5/7=71.4%
	>10days	2	1/2=50%	1/2=50%
	Intermittent	3	3/3=100%	0
7	Response to Treatment			
	Surgical	7	4/7=57.14%	3/7=42.86%
	Medicinal	8	4/8=50%	4/8=50%
8	Mucous Membrane Color			
	Brick red	3	2/3=66.67%	1/3=33.33%
	Pale	5	4/5=80%	1/5=20%
	Normal	7	2/7=28.57%	5/7=71.43%
9	Rectal Temperature			
	≤102.8^{o}F	11	5/11=45.45%	6/11=54.54%
	>102.8^{o}F	4	3/4=75%	1/4=25%
10	H/o of Type of Feces			
	Scanty	1	1/1=100%	0
	Absent	3	1/3=33.33%	2/3=66.67%
	Mucoid	11	6/11=54.54%	5/11=45.45%
11	H/O Diarrhea			
	Present	5	4/5=80%	1/5=20%
	Absent	10	4/10=40%	6/10=60%
12	Days of passing abnormal feces/no feces			
	≤5	6	4/6=66.67%	2/6=33.33%
	>5	9	4/9=44.44%	5/9=55.55%
13	H/O Pain			
	No pain	6	3/6=50%	3/6=50%
	Once in starting	4	2/4=50%	2/4=50%

S. No.	Parameter	No. presented	Survived	Non-survivor
	Continuous pain	3	1/3=33.33%	2/3=66.67%
	Intermittent pain	2	2/2=100%	0
14	Hand movement on per-rectal examination			
	Restricted	11	6/11=54.54%	5/11=45.45%
	Free	4	2/4=50%	2/4=50%
15	Rumen consistency			
	Firm	5	2/5=40%	3/5=60%
	Doughy	5	2/5=40%	3/5=60%
	Collapsed	4	3/4=75%	1/4=25%
	Resilent	1	1/1=100%	0
16	Status of small intestines on per-rectal examination			
	Severely gas distended	5	3/5=60%	2/5=40%
	Severely fluid distended	3	1/3=33.33%	2/3=66.67%
	Not palpable	4	3/4=75%	1/4=25%
	Normal	3	1/3=33.33%	2/3=66.67%
17	Status of caecum on per-rectal examination			
	Gas distended	7	5/7=71.43%	2/7=28.57%
	Fluid distended	5	2/5=40%	3/5=60%
	Not palpable	2	0	2/2=100%
	Firm	1	1/1=100%	0
18	Type of contents per-rectal examination			
	Mucous only	8	4/8=50%	4/8=50%
	Mucoid feces	4	2/4=50%	2/4=50%
	Scanty feces	3	2/3=66.67%	1/3=33.34%
19	USG findings			
	Pleural fluid			
	No	8	3/8=38.5%	5/8=62.5%
	Mild (<4cm)	4	3/4=75%	1/4=25%
	Moderate (<6cm)	2	1/2=50%	1/2=50%
	Severe (>6cm)	1	1/1=100%	0

S. No.	Parameter	No. presented	Survived	Non-survivor
	Reticular motility			
	Present, normal	5	3/5=60%	2/5=40%
	Present, reduced amplitude	5	2/5=40%	3/5=60%
	Absent	5	3/5=60%	2/5=40%
	Liver			
	Normal	11	7/11=63.63%	4/11=36.36%
	Congested CVC	4	1/4=25%	3/4=75%
	Omasum			
	Normal-7th ICS	4	2/4=50%	2/4=50%
	Cranial-6th ICS	7	4/7=57.14%	3/7=42.86%
	Caudal-8th ICS	3	1/3=33.33%	2/3=66.67%
	Dorsal-7th ICS	1	1/1=100%	0
	Peritonitis			
	Mild free fluid b/w SI loops	5	2/5=40%	3/5=60%
	Moderate free fluid b/w loops	2	0	2/2=100%
	Severe free fluid with fibrin	2	1/2=50%	1/2=50%
	Mild peri-reticular reaction	2	2/2=100%	0
	Severe per-reticular reaction	1	0	1/1=100%
	Fibrin b/w loops, spleen and reticulum	1	1/1=100%	0
	Small intestines			
	Distended with mild peristalsis	5	2/5=40%	3/5=60%
	Distended with swirling motility	2	2/2=100%	0
	Distended with complete ileus	7	3/7=42.86%	4/7=57.14%
	Collapsed intestines with ileus	1	1/1=100%	0

S. No.	Parameter	No. presented	Survived	Non-survivor
	Caecum			
	Distended in flank with no reverberation	3	2/3=66.67%	1/3=33.33%
	Distended in flank with reverberation present	4	2/4=50%	2/4=50%
	Distended upto 12 ICS with reverberation present	4	2/4=50%	2/4=50%
	Distended upto 11 ICS with reverberation present	3	2/3=66.67%	1/3=33.33%
	Distended upto 10 ICS with reverberation present	1	0	1/1=100%
20	Passing of feces after surgery			
	Within 12 hrs	2 (S)	2/2=100%	0
	12- 24 hrs	2 (1M+1 S)	1/2=50%	50%
	24-48hrs	3 (2M+1S)	3/3=100%	0
	48-72hrs	3 (1M+2S)	2/3=66.67%	33.33%

History of bloat and fecal output

Only 2 animals (one buffalo and one cow) had the history of bloat 3 and 8 days back, while the rest had no bloat suggesting that bloat is uncommon in animals with ceacal dilatation (Table 15). As per history, one cow was passing loose faeces (1/15=6.67%), 3 buffaloes were passing nothing (3/15=20%) while remaining were passing mucous only (11/15=73.33%). This finding of scanty feces or mucoid discharge in present study was in conformity with Khalphallah *et al* (2016), Mesaric and Modic (2007), Braun *et al* (2012), Meyaln (2008), Singh *et al* (2019), Gupta *et al* (2017). The cow passing loose feaces recovered with only medicinal treatment; however, those which were not passing feces had high mortality of 66.67% and those passing mucous only had mortality of 45.45%. Among those passing mucous, 3 recovered only with medicinal treatment and 3 with medicinal and surgical. Among 2 which were not passing anything, one died with only medicinal treatment while one recovered which underwent surgery also.

Five animals, including 2 cows had history of diarrhea before the onset of caecal dilatation, similar finding was noted by Dehghani and Townsend (1982) in 6 month olf HF steer, suffering from caecal torsion. Out of these, 80% (n=4) recovered (3 with medicinal treatment and one required surgery). Among those animals which had less chronic problem (n=6) of passing abnormal feces had better medicinal and surgical survival compared to those with chronic problem (n=9) of more than 5 days. Regarding pain, animals with intermittent pain (n=2) had 100% survival, while those with no (n=6) or only once pain in start (n=4) had 50% survival.

Clinical Examination

Per rectal findings (Table 15)

On per rectal examination, 11 animals had restricted hand movement and 6 survived (3 each with only medicinal and surgical treatment). Similarly, with those having free hand movement on per-rectal examination (n=4), 50% survived, 2 each from only medicinal and medicinal plus surgical treatment.

On per rectal examination, the rumen was classified as doughy (n=5), collapsed (n=4), firm (n=5) and resilient (n=1). Among those which recovered by only medicinal treatment, 2 had firm rumen and one each as doughy and collapsed. And among those recovering from surgical treatment, 2 had collapse and one each as resilient and doughy. So, taking overall outcome, the collapsed and resilient rumen had very good survival rate.

The small intestines classified as normal, fluid distended, gas distended and reaching upto pelvic inlet and cannot be palpable. In 5 animals the small intestines were severely distended with gas and out of those only 3 survived (one with only medicinal treatment and 2 with surgery). 3 animals had fluid distended small intestines, of which only one survived that too after surgical treatment. The small intestines were not palpable in 4 animals, of which 3 recovered (2 by medicinal treatment only and one by surgery). Three animals had normally felt small intestines, out of which only one recovered by medicinal treatment only.

The caecum was classified as firm, gas filled, and fluid filled and not palpable. Most of the animals had gas distended caecum (n=7), out of which 5 recovered (one with medicinal treatment and 4 with surgical treatment). Fluid filled caecum was felt in 5 animals, of which only 2 recovered and both by medicinal therapy only. In above all animals caecum was distended caudally upto pelvic inlet and cranially along side the right abdominal wall, similar finding was recorded by Fubini *et al* (1990), Mesaric and Modic (2007), Meylan *et al* (2008), Braun *et al* (2012), Khalphallah *et al* (2016), Singh *et al* (2019). In 2 animals, the caecum could not be felt on per-rectal examination and both the animals died, indicating some other cause of death. In one bovine, the caecum was firm on palpation and it recovered by medicinal treatment only.

The types of contents found in the rectum on per-rectal examination were classified as mucous only, mucoid feces, scanty feces and near normal feces. A total of 8 animals had only mucous on per-rectal examination, this finding is in accordance with Mesaric and Modic (2007), Meylan *et al* (2008), Braun *et al* (2012), Khalphallah *et al* (2016) and Singh *et al* (2019) and 4 of them recovered but all required surgical intervention. Four animals had mucoid feces on per-rectal examination of which 2 recovered and both by medicinal treatment only. Scanty feces were passed by 2 animals and one recovered by medicinal treatment. Normal feces was passed by only one bovine which responded to medicinal therapy alone.

Abdominal contour

Abdominal contour was normal to mildly distended abdomen in all the animals presented for caecal dilatation (Fig. 31) either treated medicinally or surgically, as also stated by Mesaric and Modic (2007).

Ultrasonographic findings (Table 15)

Multiple parameters were recorded in ultrasonography in relation to caecum abnormality in all the animals.

Pleural effusions

None of the animals included in the study had increase in pericardial fluid. Pleural fluid was found increased in nearly 50% of the animals. No increase in pleural fluid was recorded in 8 buffaloes (8/15=53.33%). Four animals (4/15=25%), including one cow had mild increase in pleural fluid (<4cm column), while 2 had moderate increase (<6cm) in pleural fluid (2/15=13.33%) and one cow had significant pleural effusions (Fig. 32) but recovered from medicinal therapy only. It was inferred that caecal dialtation may occur secondary to other disease conditions. As one cow with severe pleural effusions recovered from the condition, while those with no pleural effusions had 38.5% survival.

Reticulum

The biphasic reticular motility was present in 10 animals (10/15=66.67%), including one cow, however, it had decreased amplitude in 5 animals (Fig. 33A) (5/10=50%), suggesting possibility of adhesions. Five other animals had no reticular motility recorded on ultrasonography (5/15=33.33%). One bovine which had normal reticular motility also had a 10cm anechoic pocket near reticulum, and the buffalo did not recover (Fig. 33B). Even, reticular motility was not found directly correlated with the survival outcome as 5 animals with normal motility, reduced motility and absent reticular motility had equal survival outcome (60%) to those with normal and absent motility.

Omasum

In 7 animals (7/15=46.67%) the cranial boundary of omasum was seen at cranially than normal, i.e at 6th ICS, which might be due to the intestines/caecum pushing it cranially. However, in 3 animals omasum was seen one ICS caudally than normal i.e at 8th ICS (Fig. 34A), which could be due to the fact that sometimes the filled colon go underneath omasum on right side and lift and push it caudally and dorsally. On USG of caecum, in 2 of these 3 animals, the caecum was greatly distended in the right flank. The surgery was done in one of these animals and had severely impacted colon underneath the omasum, thus correlating the findings. Out of these 3 animals, only one recovered (1/3=33.33%). Thus, caudal displacement of omasum at 8th ICS, may be of poor prognostic value for cecal/colon impaction. One bovine had omasum pushed dorsally. In 4 animals, the omasum was seen at normal position, and out of them 2 survived (2/4=50%).

Peritonitis

Peritonitis was defined as the presence of fluid with fibrin in between the small intestines. Mild amount of free fluid without fibrin was present in between the small intestinal loops in 5 animals (5/15=33.33%) and only 2 animals survived out of them (2/5=40%). Two animals had moderate free fluid in between the intestinal loops and both died. Two animals had severe free fluid with fibrin in between the loops and one cow had increased peritoneal fluid when scanned near udder along with dilated caecum (Fig. 34B) which survived (50%). Two animals had mild perireticular reaction near reticulum and both survived (100%) while one had severe reaction and died. One bovine had fibrin in between spleen and reticulum and the loops but recovered. Singh *et al* (2019) recorded significant peritonitis in cases of caecal dilatation.

Small Intestine

The small intestines were classified as normal (<3.5cm) or distended (>3.5cm). Distended SI, based on motility were classified as distended with mild peristalsis, distended with swirling motility and distended with complete ileus. Five animals had small intestines distended with mild peristalsis (Fig.35) (5/15=33.33%) and out of them 2 recovered after treatment (2/5=40%). Two animals had distended small intestines with swirling motility (2/15=13.33%) and both recovered (100%). Seven animals had distended small intestines with complete ileus (Fig. 36) (7/15=46.67%) and out of them 3 recovered after treatment (3/7= 42.86%). One bovine had collapsed adhered intestines with ileus (1/15=6.67%) but recovered with only medicinal treatment (100%).

Caecum

Ultrasonographically, the caecum was defined as thick echogenic crescent shaped line just adjacent to right lateral body wall distended in flank upto 12th ICS-11th ICS or in one case even upto 10th ICS, with or without reverberation. This was similar to the findings of Braun and Amerin (2002) and Khalphallah *et al* (2016). Three animals had caecum distended in flank with no reverberation (3/15=20%) and out of them 2 recovered after treatment (2/3= 66.67%), one only medicinally and one with surgery. 4 animals had caecum distended in flank with reverberation (Fig. 37) (4/15=26.67%) and out of them 2 recovered with medicinal treatment only (2/4=50%). Another 4 animals had distended caecum upto 12 ICS cranially with reverberation present (Fig. 38) (4/15=26.67%) and 2 out of them recovered one each after medicinal and surgical treatment (2/4=50%). Three animals had distended caecum upto 11th ICS (3/15=20%) with reverberation (Fig. 39) and 2 out of them recovered each after medicinal and surgical treatment (2/3=66.67%). One bovine had caecum distended upto 10th ICS with reverberation and could not recover after medicinal and surgical treatment.

The content of caecum varies from gas to mixed fluid content which appear as reverberation and thick echogenic semi-circular lines (Braun *et al* 2002). In buffaloes dilated loops in the right flank masked the right kidney, loops and peristaltic movement of small intestine with the dilated caecal wall adjacent to the body wall extending upto last three intercostal spaces (Khalphallah *et al* 2016).

Haematological parameters (Table 16)

The mean ± SD values of hemoglobin and packed cell volume did not differ significantly among survivors and non-survivors in different groups; however, total leukocyte count and absolute neutrophil count in non-recovered animals (surgical as well as medicinal) was markedly but non-significantly high as compared to recovered animals, irrespective of therapeutic protocol (Table 16). Differential leukocyte count showed reversal of neutrophils to lymphocyte count in all the animals with caecal dilatation as compared to normal reference ranges reported in literature (Radostitis *et al* 2000) and it corroborated with previous findings (Mohan *et al* 2006, Hussain *et al* 2012). Total platelets count was within normal reference ranges but a significantly ($p<0.05$) elevated level of total platelet count was recorded in medicinally recovered group in comparison to medicinally non-recovered group. Braun *et al* (1989b) found normal blood haemogram in 111 cattle suffering from caecal dilatation with or without torsion. Smith (1985a) described a stress leukogram in the early stages and neutropenia or neutrophilia with a left shift in the later stages of intestinal obstruction in cattle.

Serum biochemistry parameters (Table 16)

The mean ± SD values of various serum biochemical parameters are depicted in Table 16. Mean values of sodium (Na) in serum were within normal physiological range. However, significantly ($p<0.01$) reduced serum value of Na in medicinally recovered group as compared to medicinally non-recovered group was recorded. Although no significant difference was recorded in the serum level of potassium (K) among various groups; but markedly low levels of K in non-recoverd (medicinal) as well as (surgical) group as compared to recovered (medicinal) as well as (surgical) groups, respectively, were recorded suggesting hypokalemia being a poor prognostic indicator in caecal dilatation affected animals. There was no significant difference in the serum level of calcium (Ca) and Phosphorus (P) in various groups but marginally low level of Ca and P was observed in medicinally non-recovered as compared to medicinally recoverd group, inferring that hypocalcaemia and hypophosphataemia, pre-operatively, indicates poor medicinal prognosis in cases of caceal dilatation; but it did not apply to surgically treated groups.

In the current study, hypochloraemia was recorded as an overall poor prognostic indicator irrespective of treatment groups. The mean serum levels of total protein, albumin and total bilirubin differed non-significantly among various groups; however, markedly high values of total protein, albumin and total bilirubin were found as poor prognostic indicators. In general, high serum levels of lactate (about 3-4 fold increase) and creatinine kinase (CK) (about 2 folds increase) as compared to reference ranges reported in the literature were observed suggesting their diagnostic importance. Marginally low levels of lactate and CK were observed in medicinally non-recovered group as compared to medicinally recovered group; however, in surgically treated animals, low level of lactate and CK were associated with good prognosis.

Similarly, elevated serum levels of lactate dehydrogenase (LDH) was observed as good prognostic indicator in medically treated cases while poor prognostic indicator in surgically treated cases suffering from caecal dilation. The mean levels of serum fibrinogen were observed to be within normal reference range and could not be correlated with prognostic indicator.

Hussain *et al* (2012) reported significant increase of total bilirubin, AST, globulin, and lactate levels and significant reduction in calcium, potassium and chloride in buffaloes with caecal dilatation. Mesaric and Modic (2007) observed elevated activity of creatine kinase, decreased calcium and phosphorus levels in the serum of a case of acute caecal dilatation and torsion in 7-year-old 8 months pregnant Brown Swiss cow. Laboratory findings in cattle suffering from caecal dilatation reported hypocalcemia, hypokalemia, hyponatraemia with leukocytosis and elevated PCV (Braun *et al* 2012).

Table 16: Hematology, serum and peritoneal fluid biochemistry (M=medicinally, S=surgically, */ LOS at 5and 1% between medicinally and surgically recovered, $^{\#\#}$ LOS between recovered and not recovered at 1%, $^{\$}$ LOS between overall and medicinally recovered at 5%, $^{@/@@}$ LOS between medicinally recovered and medicinally not recovered)**

S. No.	Para-meters	Ref range Cattle/buff	Mean ±SD (range) (15)	Recovered (n=8)	Not-recovered (n=7)	M recovered (n=4)	M Not-recovered (11)	S recovered (n=4)	S Not-recover (n=3)
Hematology									
1	**Hb (g/dl)**	**8-15**	10.84±1.43 (7.5-12.6)	10.63±1.89 (7.5-12.6)	11.08±0.7 (10.4-11.8)	10.87±1.75 (8.8-12.6)	10.83±1.40 (7.5-12.5)	10.37±2.26 (7.5-12.5)	11.2±0.79 (10.3-11.8)
2	**TLC ($x10^3$/ul)**	**4-12 $x10^3$**	14592±16800 (4500-69700)	9509±2942 (6020-15730)	20401±23971 (4500-69700)	8660±2219 (6020-10670)	16749±19351 (4500-69700)	10358±3655 (7680-15730)	15420±16149 (4500-33970)
3	**N%**	**15-33**	72.93±11.18 (50-94)	75.5±7.15 (64-88)	70±14.61 (60-94)	71±4.76 (64-74)	74±13 (50-94)	80±6.53 (72-88)	74.67±22.47 (50-94)
	N Abs. count	**600-4000/** 1360-6450	11201±13504 (2250-52972)	7181±2402 (2250-52972)	15795±19302(2250-52972)	6112±1436 (4334-7629)	13052±15509 (2250-57972)	8250±2889 (6758-12584)	13471±16111 (2250-31932)
4	**L%**	**62-63**	27.07±11.18 (6-40)	24.5±7.15 (12-36)	30±14.61 (6-50)	29±4.76 (26-36)	26±13 (6-50)	20±6.53 (12-28)	25.33±22.47 (6-50)
	L Abs. count	**2500-7500/** 2180-10500	2388±942 (922-3956)	2328±931 (922-3841)	2456±1024 (1673-3956)	2549±957 (1686-3841)	2329±977 (922-3879)	2107±989 (922-3146)	1949±355 (1558-2250)
5	**PCV (%)**	**24-46**	33.12±3.29 (27-37.3)	32.91±4.01 (27.3-37.3)	33.35±2.56 (30-36)	33.05±4.13 (28.8-37.3)	33±3 (27-36)	32.73±4.75 (27.3-36.1)	32.33±1.87 (31-34)
6	**Pl ($x10^3$ /ul)**	**100-800$x10^3$**	297±118 (21.6-421)	323±111 (61-421)	262±128 (21.6-363)	368±36$^{@}$ (35-421)	268±128$^{@}$ (21.6-363)	278±148 (61-388$x10^3$)	354±7.5 (350-363)
Serum biochemistry (n=15)									
1	**Na (mEq/L)**	**136-144/** 122.5-174	141.87±7.87$^{\$}$ (131-156)	143.75±7.52 (133-154)	139.71±8.28 (131-156)	136±2.16**$^{\$@}$ (133-138)	142.72±8.05$^{@}$ (131-156)	148±4.55** (143-154)	145±9.8 (137-156)

S. No.	Para-meters	Ref range Cattle/buff	Mean ±SD (range) (15)	Recovered (n=8)	Not-recovered (n=7)	M recovered (n=4)	M Not-recovered (11)	S recovered (n=4)	S Not-recover (n=3)
2	**K (mEq/L)**	**3.6-4.9/** 2.85-6.65	4.69±1.65 (1.8-6.8)	5.39±1.27 (4.0-7.6)	3.77±1.73 (1.8-6.8)	5.47±1.80 (3.5-7.6)	4.37±1.59 (1.8-6.8)	5.27±0.86 (4.0-5.9)	4.67±1.85 (3.5-6.8)
3	**Ca (mg/dL)**	**8-11/** 8.55-13.4	8.39±1.60 (3.1-9.8)	8.54±0.61 (7.6-9.7)	8.21±2.34 (3.1-9.8)	8.9±0.45 (8.4-9.5)	8.37±1.87 (3.1-9.8)	8.65±0.7 (8.3-9.7)	9.1±0.45 (8.6-9.5)
4	**P (mg/dL)**	**5.6-8/** 4.39–7.85	5.85±1.9 (3.2-9.8)	6.2±1.90 (3.7-9.8)	5.44±1.96 (3.2-8.7)	5.78±1.90 (3.2-7.4)	5.27±1.65 (3.2-8.7)	4.97±1.13 (4.4-6.2)	5.2±3.04 (3.2-8.7)
5	**Cl (mEq/L)**	**99-107/** 79.83–106.16	91.2±14.7 (58-111)	99.63±11.20$^{\#\#}$ (76-111)	81.57±2.46$^{\#\#}$ (58-96)	93.5±11.93 (76-102)	89.27±15.09 (58-96)	102.75±8.26$^{\wedge}$ (93-111)	89.33±6.11$^{\wedge}$ **(**84-96**)**
6	**Lac (mMol/L)**	**0.6-2.2**	6.71±2.63 (2.1-12)	7.44±2.22 (5.4-12.0)	5.89±3.0 (2.1-12.0)	7.17±3.27 (4.7-12)	6.41±2.58 (2.1-12.0)	7.35±1.59 (5.4-9.3)	7.5±3.94 (4.7-12)
7	**Alb (g/dL)**	**2.5-3.8/2-4.4**	2.57±0.62 (1.7-3.5)	2.54±0.63 (1.7-3.3)	2.61±0.65 (1.7-3.5)	2.37±0.53 (1.7-3.0)	2.61±0.66 (1.7-3.5)	2.6±0.76 (1.8-3.3)	2.87±0.57 (2.4-3.5)
8	**TP (g/dL)**	**6.7-7.5/** 5.25-9	6.35±1.35 (4.3-8.3)	6.51±1.36 (4.5-8.3)	6.16±1.41 (4.3-7.6)	6.12±1.15 (4.5-7.2)	6.41±1.44 (4.3-7.6)	6.85±1.59 (4.8-8.3)	7.47±0.23 (7.2-7.6)
9	**T Bil (mg/dL)**	**0-1.6/** 0.1-0.8	1.21±1.21 (0.1-4.2)	0.96±1.01 (0.1-2.5)	1.5±1.42 (0.1-4.2)	0.93±0.95 (0.1-2.3)	1.52±1.27 (0.1-4.2)	1.55±1.17 (0.1-2.5)	2.57±1.52 (1.2-4.2)
10	**Ck (U/L)**	**0-350/** 47-287	627.8±608.05 (28-2000)	798.63±584.28 (168-2000)	432.57±617.28 (28-1661)	781.75±832.61 (168-2000)	485.45±491.28 (28-1661)	578±156.55 (377-737)	949±665 (345-1661)
11	**Fibri-nogen (mg/dL)**	**100-600/** 200-800	560±304.25 (200-1000)	550±350.51 (200-1000)	571.43±269.04 (200-1000)	550±341.56 (200-1000)	581.82±289.20 (200-1000)	600±365.15 (200-1000)	400±200 (200-600)
12	**LDH (U/L)**	**309-938/** 186.72–917.43	863±399 (352-1955)	902±226 (680-1310)	819±554 (352-1955)	1061±216* (798-1310)	791±433 (352-1955)	743±68* (680-837)	1271±597 (858-1955)

S. No.	Para-meters	Ref range Cattle/buff	Mean ±SD (range) (15)	Recovered (n=8)	Not-recovered (n=7)	M recovered (n=4)	M Not-recovered (11)	S recovered (n=4)	S Not-recover (n=3)
		Peritoneal Fluid cytology and Biochemistry (only surgical cases, n= 7, surgically recovered (4), surgically not recovered (3))							
1	**TLC ($x10^3$/ul)**		3814±405.91					4100±216.02	3433±208.16
2	**Na (mEq/L)**		139.8±57.63 (131-150)					141.50±6.56 (135-150)	137.67±9.86 (131-149)
3	**K (mEq/L)**		Non-measurable					Non-measurable	Non-measurable
4	**Ca (mg/dL)**		0.73±0.29 (0.4-1.2)					0.63±0.25 (0.4-0.9)	0.83±0.35 (0.5-1.2))
5	**P (mg/dL)**		4.21±2.20 (0.3-7.1)					4.37±2.88 (0.3-7.1))	4±1.4 (3-5.6)
6	**Cl (mEq/L)**		103.14±10.32 (85-111)					103.5±12.56 (85-113)	102.67±9.07 (93-111)
7	**Lac (mMol/L)**	**0.19-1.31**	5.76±3.24 (1.1-8.9)					6.15±3.45 (1.1-8.9)	5.23±3.58 (1.3-8.3)
8	**Alb (g/dL)**	**0.27-2.39**	3.54±1.86 (0.8-5.4)					3.83±2.07 (0.8-5.4)	3.17±1.90 (1.2-5)
9	**TP (g/dL)**	**0.56-4.18**	6.6±3.07 (1.7-9.7)					6.85±3.60 (1.7-9.7)	6.27±2.92 (2.9-8.0)
10	**T Bil (mg/dL)**		2.97±1.96 (0.1-5.3)					2.53±1.78 (0.1-4.4)	3.57±2.42 (0.8-5.3)
11	**Ck (U/L)**		21.42±6.11 (17-35)					18.75±1.5 (17-20)	25±8.66 (20-35)
12	**LDH (U/L)**	**233-960**	401±133 (278-663)					324±33.01 (278-356)	502.67±155.27 (353-663)

Khalphallah *et al* (2016) reported significant hypoproteinemia, hypoalbuminemia with significant increase in the blood serum activities of AST and ALK in buffaloes with dilated caecum and colon. Singh *et al* (2018) recorded a marked decrease in serum total protein, albumin, chloride, potassium, and calcium levels while levels of lactate were elevated in cases of intestinal obstruction. Singh *et al* (2019) studied diagnostic and prognostic indicators of caecal dilatation and reported tachycardia, ruminal stasis, leukocytosis and elevated levels of lactate as poor prognostic indicators.

Biochemistry of Peritoneal fluid

The mean ± SD values of various parameters of peritoneal fluid examination are presented in Table 16. Non-significantly elevated levels of Na, P, Cl, Lactate, Alb and Total protein in the peritoneal fluid were observed in surgically recovered animals as compared to surgically non-recovered animals. It suggested good prognostic indicators for favourable surgical outcome. Markedly but non-significantly high levels of total bilirubin, CK and LDH in the peritoneal fluid were observed as poor prognostic indicators in operated cases suffering from caecal dilatation. Peritoneal fluid examination revealed an increase in total protein concentration (Singh *et al* 2018). There was no significant differcence found in the TLC level of peritoneal fluid in surgically recovered group when compared with surgically non-recovered group.

The pylorus was severly fluid distended with mild to no motility and opening into distended cranial duodenum (Fig. 40A & 40B), in most of the cases presented for caecal dilatation. Only two animals had hypermotile pylorus and both of them recovered. Out of which one was cow (recovered surgically) and other was buffalo (recovered medicinally). One buffalo had normally motile but severly fluid distended pylorus, which recovered medicinally. Out of total 15 animals, 5 had amotile pylorus (Fig. 41) out of which only one animal survived (surgically), 4 animals died (2 surgically and 2 medicinally). Remaining 7 animals had mildly motile pylorus out of which 4 animals recovered (2 surgically and 2 medicinally). From medicinally recovered animals one was cow. From the above findings it was concluded that amotile and severly fluid distended pylorus bears poor prognostic value.

Table 17: Topographic location of Pylorus observed on ultrasonography in different animals

S. No	Species, Age	DL	VL	TL	DL:TL	VL:TL	ICS	Motility	Intraluminal fluid	Treatment	Outcome
1	Buffalo, 6yrs	77.0	40.0	124.5	0.62	0.32	11	Amotile	Distended severly with fluid	M+S	Recovered
2	Buffalo, 8yrs	106.0	22.0	135.5	0.78	0.16	9	Mild	Distended sverely with fluid	M+S	Recovered
3	Buffalo, 3.5yrs	81.3	25.4	114.2	0.71	0.22	10	Mild	Distended severly with fluid	M+S	Died
4	Buffalo, 15yrs	99.0	27.0	133.5	0.74	0.20	10	Mild	Distended severly with fluid	M+S	Recovered
5	Buffalo, 8yrs	119.0	20.0	146.5	0.81	0.14	8	Amotile	Distended severly with fluid	M+S	Died
6	Cow, 8yrs	96.0	27.0	130.5	0.74	0.21	8	Hyper	Moderately distended	M+S	Recovered
7	Buffalo, 10 yrs	101.6	33.0	142.1	0.71	0.23	9	Amotile	Distended severly with fluid	M+S	Died
8	Buffalo, 10yrs	106.7	22.9	137.1	0.78	0.17	8	Amotile	Distended severly with fluid	Only M	Died
9	Buffalo, 3.5yrs	142.2	7.6	157.3	0.90	0.05	10	Mild	Distended severly with fluid	Only M	Died
10	Buffalo 8yrs	71.0	53.0	131.5	0.54	0.40	10	Hyper	Moderately distended	Only M	Recovered
11	Cow, 3yrs	121.9	7.6	137.0	0.89	0.06	10	Mild	Severly distended with fluid	Only M	Recovered
12	Buffalo, 6yrs	121.9	7.6	137.0	0.89	0.06	10	Normal	Sverly distended with fluid	Only M	Recovered
13	Buffalo, 8yrs	109.2	7.6	124.3	0.88	0.06	10	Mild	Severly distended with fluid	Only M	Died
14	Buffalo, 9yrs	132.0	38.0	177.5	0.74	0.21	9	Mild	Severly distended with fluid	Only M	Recovered
15	Buffalo 3.5yrs	91.4	30.5	129.4	0.71	0.24	9	Amotile	Severly distended with fluid	Only M	Died

Table 18: Comparison of topographic location of pylorus in cases of caecal dilatation with apparently healthy and disease control group (DL= dorsal length; VL=ventral length; TL=total length)

Group	**DL(cm)**	**VL (cm)**	**TL(cm)**	**DL:TL**	**VL:TL**
Apparently healthy(2a)(n=10)	88.75 ± 10.02*	24.75 ± 2.19	120.75 ± 9.36*	0.74 ± 0.03	0.20 ± 0.03
Disease control (2b) (n=20)	85.77 ± 9.09^{a}	30.19 ± 11.57	123.27 ± 12.01^{a}	0.75± 0.09	0.19 ± 0.09
Ceacal dilatation (n=15)	105.08 ± 20.21^{*a}	24.61 ± 13.44	137.19 ± 15.00^{*a}	0.76± 0.10	0.18± 0.10

$^{*,\ a}$ = same superscript showing significant difference between the groups at $p<0.05$

The mean distance of pylorus from the dorsal most spine (DL) was 105.08 ± 20.21cm in groups 3, which was significantly ($p<0.05$) higher than mean DL of both groups 2a and 2b (Table 18). The mean distance of pylorus from the ventral midline (VL) was 24.61 ± 13.44 cm, which was non-significanlty lesser than VL of both groups 2a and 2b. The mean total length of right side of bovine body at the level of pylorus (mid spine to midline ventrally) was 137.19 ± 15.00 cm, which is significantly higher than the TL of both groups 2a and 2b.

From this above depicted data in Table 18 it was apparent that pylorus was scanned more ventrally in animals suffering from caecal dilatation, because dorsal length (from dorsal midline to dorsal magin of pylorus) was significantly ($p<0.05$) more in animals suffering from caecal dilatation than other two groups (2a and 2b). Also, the total length (from dorsal midline to ventral midline at the pylorus) was found significantly ($p<0.05$) more in the animals with caecal dilatation, so justifying the ventral scanning of the pylorus in animals with caecal dilatation. This finding was also confirmed from the non-significant difference in the ratio of DL: TL and VL: TL. This could also be due to the reason that most of the animals in group 3 were buffaloes as described earlier in group 2a (Table 14).

Reticulum

The reticulum was identified from its characteristic ultrasonographic features, as described by Braun and Götz (1994), Braun *et al* (2002), Braun (2009). The normal biphasic reticular motility was found in all the animals in group 2a in a 3minute scan. In group 2b, reticular motility was normal biphasic to nil in 3 minute scan at 5^{th} ICS and post-xiphoid region. In group 3, 5 out of 15 animals had no reticular motility, 5 animals had biphasic motility with decreased amplitude and 5 animals had normal biphasic reticular motility. The survivability among animals having no reticular motility and having normal reticular motility was 60%. The survival rate among animals having reticular motility with decreased amplitude was 40 %. Among normal motile reticulum, 2 were surgically treated, out of which only 1 animal (cow) recovered and 3 animals were treated conservatively out of which 2 animals recovered. Among animals having decreased reticular amplitude, 3 were treated surgically, out of which 2 animal recovered and 2 animals were treated medicinally with no survivability. Among animals with no reticular motility, 2 were treated surgically out of that 1 recovered (cow) and 3 were treated medicinally, out of which 2 animals recovered.

Table 19: Comparison of different ultrasonographic parameters among the groups (C=Cow, B=buffaloes)

USG parameters	Group 2a	Group 2b	Group 3
Location of caecum	Within flank in all animals	17 (4C+13B) had in flank, 3 (1C+2B) had upto 12th ICS (DH, lung cyst, generalized peritonitis)	Flank to 11th ICS-3 Flank to 10th ICS-1 Cranial flank to 12th ICS-11 (2 cows and 9 buffaloes)
Content of caecum	4 (2C+2B) had anechoic fluid content, 5 (3C+3B) had mild reverberation 1 cow: mixed content	12 (2C+ 10B) had mixed contents 8 (3C+5B) had mild reverberation	3 had no reverberation with mixed content. 12 bovine had reverberation (4 at cranial flank, 4 at 12th, 3 at 11th, 1 at 10th ICS)
Reticular motility (in 3 min scan)	Strong biphasic motility in all animals. 1C had mild peri-reticular effusions.	5 (2C+3B, 25%) had no reticular motility. 10 (1C+9B, 50%) had sluggish reticular motility, 5 (2C+3B, 25%) had normal reticular motility.	5 (1 C+ 4B) had normal biphasic motility; 5 buffaloes had normal biphasic motility but amplitude is decreased; 5 animals (1 C+ 4B) had no reticular motility.
Location of omasum	Cattle- cranial margin at 6th ICS, caudal at 8thICS Buffaloes: cranially at 7th ICS, caudally at 9th and 10th ICS	Cranial most at 5th ICS (DH) and caudal most at 11th ICS.	7 animals (46.67%) had cranial margin at 6th ICS. Normal location (at 7th ICS) in 5 (2 C+3B). In 3 buffaloes at 8th ICS and in one at dorsal 7th ICS. Caudal margin at 8th-9th ICS in 11 animals (1C+10B), 3 (1C+2B) had at 11th ICS and one at 10th ICS

USG parameters		Group 2a	Group 2b	Group 3
Location of gall bladder		At 10^{th}-11^{th} ICS in all animals	18 (4 C+14B) at 10^{th} - 11^{th} ICS, 2 had cranial (1C at 8^{th} having DH+ 1B at 9^{th} ICS suffering from peritonitis)	9 animals (1 C+ 8B) at 8^{th} ICS; 5 animals (1C+ 4B) at 9^{th} ICS; 1 Buffalo had at 12^{th} ICS (caecum was not retracted out during surgery)
Pylorus Location (ICS)		At 8^{th} ICS (3 C), 9^{th} ICS (2C), 10^{th} ICS (4 B), 11^{th} ICS (1 B)	At 7^{th} ICS- 1 buffalo (DH), At 8^{th} ICS- 3 C+ 1 B(DH), At 9^{th} ICS-8 (2 C+ 6B) At 10^{th} ICS-7 B	At 8^{th} ICS-3 (1 C+ 2B), At 9^{th} ICS- 4B, At 10^{th} ICS-7 (1C+6B) At 11^{th} ICS- 1 B
Diameter of small intestine	Duodenum	2.4 ± 0.54cm (1.5 to 2.9cm)	1.61 ± 0.83cm (1.0 to 3.7cm)	3.72±0.4cm (2.05 to 5.43 cm)
	Jejunum	2.04 ± 0.44cm (1.6 to 2.8cm)	3.07 ± 1.22cm (1.7 to 6.5cm)	6.13± 0.46cm (4.49 to 8.64 cm)
Peritoneal effusions		One cow had mild peri-reticular effusions	No peritoneal reaction -11 (3C+ 8B) Mild reaction- 4 (2C+2 B) Moderate reaction <6cm – 2 B Severe reaction >6cm -3 B	Mild free fluid b/w SI loops-5 B, Moderate free fluid b/w loops-2 B Severe free fluid with fibrin-2 (1C+ 1B), Mild peri-reticular reaction-2 (1 C+1B) Severe peri-reticular reaction-1 buffalo Fibrin b/w loops, spleen and reticulum-1

Omasum

Animals in group 2a & 2b had cranial and caudal margins of omasum at 6th& 8th ICS in cows and 7th& 9th ICS in buffaloes, which is in accordance with the findings of Braun (2009). In comparison to group 2a and 2b, group 3 animals presented with caecal dilatation had cranially shifted proximal margin of omasum at 6th ICS in most of the animals (n=7). In 5 animals the cranial margin was located at 7th ICS and it was located at 8th ICS in 3 animals. Animals (n=7) with proximal margin of omasum at 6th ICS had the dilatation of caecum upto 10th, 11th and 12th ICS out of which 5 animals recovered (surgically 3 out of 4 and medicinally 1out of 3). Animals having cranial margin of omasum at 7thICS (n=5) had caecum distended upto cranial flank out of which 3 animal recovered (surgically 1 out of 2 and medicinally 2 out of 3). Animals having cranial margin at 8th ICS (n=3) had caecum distended upto cranial flank to 12th ICS out of which 1 animals recovered (surgically 0 out of 1 and medicinally 1 out of 2).

Small Intestine

The findings of Group 2a and Group 2b are in accordance with findings of (Braun 2009).

Table 20. Comparison of luminal diameter in cases of caecal dilatation with apparently healthy and disease control groups

Small intestine	**Group 2a**	**Group 2b**	**Group 3**
Duodenum	$2.4 \pm 0.54cm^{***/**}$	$1.61 \pm 0.83cm^{***/**}$	$3.72 \pm 0.4cm^{***}$
Jejunum	$2.04 \pm 0.44cm^{***/*}$	$3.07 \pm 1.22cm^{***/*}$	$6.13 \pm 0.46cm^{***}$

Values with same superscript differs significantly at 5% (single superscript), 1% (double superscript), 0.1% (triple superscript) level of significance.

The mean diameter of duodenum and jejunum in group 3 was 3.72 ± 0.4cm (2.05 to 5.43 cm) and 6.13 ± 0.46cm (4.49 to 8.64 cm), respectively, which is significantly ($p<0.0001$) more than that of group 2a and 2b. This could be due to back flow of the content as the obstruction was more caudally upto caecum.

Caecum

Ultrasonographically, the lateral wall of caecum appeared as thick, echogenic and crescent shaped line adjacent to the body wall. There was no motility of large intestine that could be appreciated under ultrasonography. The lumen or entire intestine was unable to be visulaised due to gaseous content, imposing the reverberation artifact. Differentiating caecum from the colon ultrasonographically was difficult. These findings are similar as reported in the cattle by Braun and Amerin (2001), Imran and Tyagi (2014), Blond and Buczinski (2009), Khalphallah *et al* (2016). The caecum was located within the flank in all the animals in group 2a and in most of the animals (n=17) in group 2b. In group 3, caecum was located at cranial flank to 12th ICS in most of the animals (n=11). Out of that, 3 animals had caecum distended upto 11th ICS and 1 animal had caecum distended upto 10th ICS. These findings are in accordance with the findings of Braun *et al* (2002).

Animals of both group 2a and 2b had mild reverberation and mixed consistency. Most of the animals in group 3 were having reverberation (n=12) and 3 animals were having mixed consistency. The findings in all the groups were similar as described by Braun and Amerin (2001) and Braun *et al* (2002).

Gall bladder

The common ultrasonographic location of gall bladder was at 10th and 11th ICS in group 2a and 2b. Gall bladder in group 2a was located with in single ICS (Braun 2009). Whereas, in group 2b and caudal margin of gall bladder was visualized in more than one ICS as it is distended due to inappetance (2b) and anorexia (Group 3). The cecal dilatation appeared to push the gall bladder cranially. The caudal margin along with most of distended gall bladder was seen at the 8th (Fig. 42) and 9th ICS in majority of the animals with caecal dilatation.

Intra-operative findings in animals operated for caecotomy (Table 20)

Standing right flank laparotomy was performed under local anaethesia (paravertebral and linear infilteration) as described by Fubini (1990), Green and Husband (1996), Mesaric and Modic (2007), Singh *et al* (2019). A mid flank caudo cranial incison of 20-25 cm length was made in the right paralumbar fossa, starting 4-5 cm below the transverse process of lumbar vertebrae. Abdominal cavity was explored by retracting greater omentum cranially after incising muscles and peritoneum (Fig. 43). Following laparotomy, attempt was made to exteriorize caecum by grasping caecal apex, which was successful in the cow operated for caecal dilatation after reflecting the greater omentum cranially (Fig. 44A &B). In the cow, it was possible to exteriorize caecal apex easily (Fig. 45). In contrast to this, it was not possible to exteriorize dilated caceum in none of the buffaloes. The gas in the caecum was suctioned using 16G needle and suction pump, to help exteriorization of caecal apex (Fig. 46A). But even this manevour could not help in exteriorization of caecal apex in bufflaoes, sufficiently, as most of the cases presented were of caecal impaction. So, in buffaloes after reflecting greater omentum cranially the caecal body was moved to the incision site and sutured with body wall with stay sutures (Fig. 46B).

In two buffaloes, {one having adhered omentum (Fig. 47 A&B) and second with severe caecal impaction}, the greater omentum was incised ventrally protecting underlying descending duodenum to exteriorize caecal body and sutured it with body wall (Fig. 48A) for caecotomy (Fig. 48B). A tissue sample from the site of caceotomy was examinated, histologically, which revealed mild chronic inflammation with necrotic changes but these could not be correlated to survival rate of animals. Similar findings were reported by Kumar (2014).

The caecal incision was closed after flushing with normal saline in double row of lambert and cushing suture pattern using chromic catgut no. 2. Abdominal incision was closed in routine manner. Short (15 days post-surgical) and long term outcome (more than 15 days to 3 months post-surgical) including intra-operative complications, if any, were recorded.

In all the 7 animals operated, the caecum was found overfilled with contents which were removed from the caecum and colon by flushing and kneading. In one bovine the colon was also found severely impacted and was adhered with the underlying organs as the animal was suffering from generalized peritonitis, thus could not be attempted for emptying even after incising greater omentum. Two animals had fecolith in large colon which were kneaded following caecal emptying. Out of this one was cow and one was buffalo. Both animals passed feces within 12hrs of surgery. Both the animals were healthy and passing feces normally upto 6 months. These findings are in accordance with the findings of Dehghani and Townsend (1982), Mesaric and Modic (2007) as cow operated for caecal dilatation and torsion passed feces within 24 hrs of surgical correction and was healthy and passing feces normally upto 2months. Singh *et al* (2019) stated post caecal obstruction (colon impaction or fecolith) was the major reason for caecal dilatation in animals. In the current study, one bovine had impacted small intestines with no motility and the fecal material was kneaded and forwarded. This bovine had small intestinal ileus on ultrasonographic examination also. The bovine had regurgitated before surgery and had open mouth breathing and died next day. In one bovine caecum could not be exteriorized due to severe impaction and adhesions and the animal died after 2 days. Two animals passed feces within 24 to 72 hrs of surgery but died due to regurgitation prior to surgery and other dehydration reasons. All the animals whether treated surgically of medicinally, first passed hard feces and later loose for 2-3 days. Some animals even had diarrhoea for few days. The similar findings were observed after surgical correction of sigmoid caecal volvulus by Green and Husband (1996), as cattle first passed hard fecal balls on 5th day post-operatively, followed by diarrhoea. The chronicity of the disease leads to poor prognosis in animals due to severe dehydration, altered acid-base and motility disorders. On an average animals that were surgically treated passed feces earlier in comparison to those treated medicinally.

Table 21: Intra-operative findings and follow up outcome in different cases

S. No.	Species / Age	Treatment	Intra-operative findings	Short term follow up	Long term follow up
1	Buffalo, 6yrs	Right flank caecotomy	Caecal impaction	Passed mucoid hard feces= 3rd day Diarrhoea =4th day Normal feces = after 5th day	Animal died after 2months unrelated to caecum.
2	Buffalo, 8yrs	Right flank caecotomy	Caecal impaction	Passed feces =2nd day , Diarrhoea= 3rd day, Loose feces=for 10 days	Animal died after 20 days with unrelated to caecum
3	Buffalo, 3.5yrs	Left flank laparotomy	Caecal impaction SI impacted and amotile was kneaded	Animal died day 1 of surgery (regurgitation before surgery) Passed feces before death	
4	Buffalo, 15yrs	Right flank caecotomy	Fecolith in the LC, kneaded into the impacted caecum	Eating and passed feces= 8hrs after surgery	Animal was healthy upto 6 months
5	Buffalo, 8yrs	Right flank laparotmy	Caecum can't be exteriorized (severe distention and adhesions)	Animal died after 2 days	
6	Cow, 8yrs	Right flank laparotomy	Caecum with gas (suctioned) and some liquid contents, Fecalith in the LC removed	Passed feces= 12 hrs after surgery Normal appetite=12hrs	Healthy upto 8 months then euthanized due to hip dislocation
7	Buffalo, 10yrs	Medicinal treatment		Died	
8	Buffalo3.5yrs	Medicinal treatment	No improvement in condition after 5 days and animal died on 7th day before surgery		
9	Buffalo, 8yrs	Medicinal treatment	Feces in rectum=in 24 hrs, Single hard dry ball passed=48hrs, Diarrhea=3rd day, Near Normal feces=5th day, Normal feces=		Healthy

S. No.	Species / Age	Treatment	Intra-operative findings	Short term follow up	Long term follow up
			30days, Appetite=20 days		
10	Cow, 3yrs	Medicinal treatment	Passed feces= 3 days (hard dry feces), Diarrhoea =4^{th} day , Normal feces=15 days, Normal Appetite: 15 days		Healthy
11	Buffalo, 6yrs	Medicinal treatment continued for 15 days	Passed hard dry feces= 2^{nd} day, Then no feces. Loose feces=15 days, Normal feces=one month		Healthy
12	Buffalo, 8yrs	Medicinal treatment	Animal did not recover and died on the 6^{th} day of the treatment		
13	Buffalo, 9yrs	Medicinal treatment continued for 10 days	Passed feces = 24 hrs, rectum was filled with loose diarrhoeic feces, normal appetite =10 days , loose faecs=upto 60 days, Normal feces=60 days		Healthy
14	Buffalo, 3.5yrs	Medicinal treatment	Animal died after 2 days		
15	Buffalo, 10 yrs	Right flank laparotomy	Colon severly impacted, could not be retrieved, caecum and proximal colon emptied partially	Animal passed feces on 3^{rd} day post-op only and died after 10 days post -operatively	

(SI=small intestine, LC=large colon)

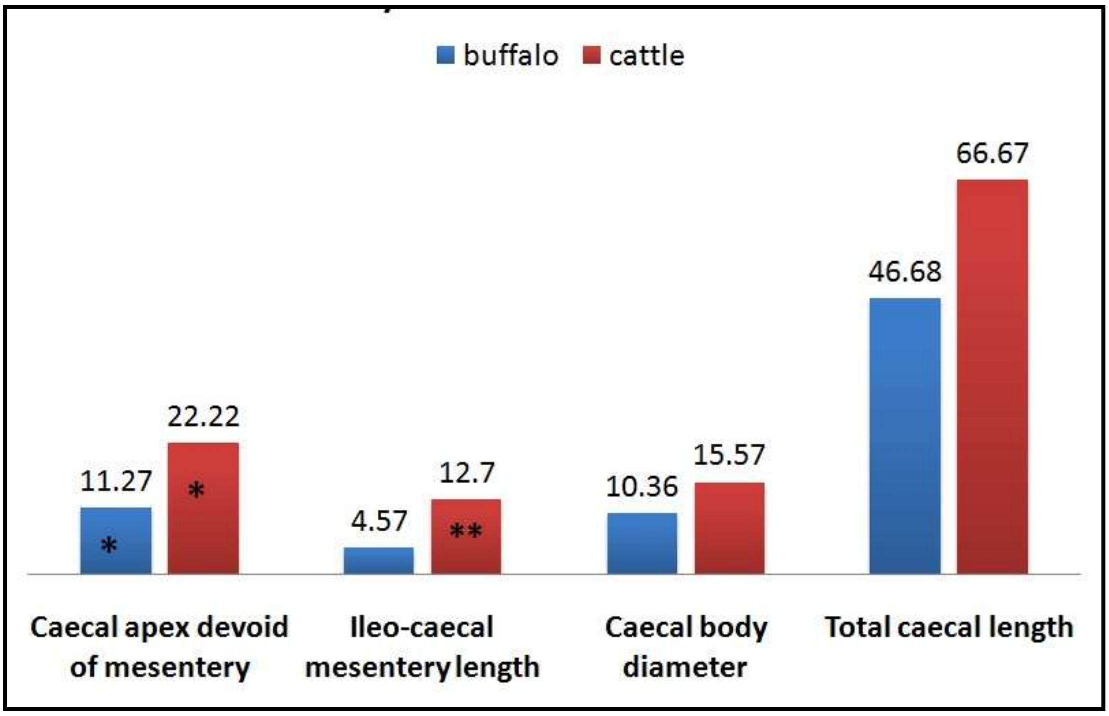

Fig. 7. Bar Graph showing comparative mean gross morphometery (in cms) of healthy caecum in cattle and buffaloes.

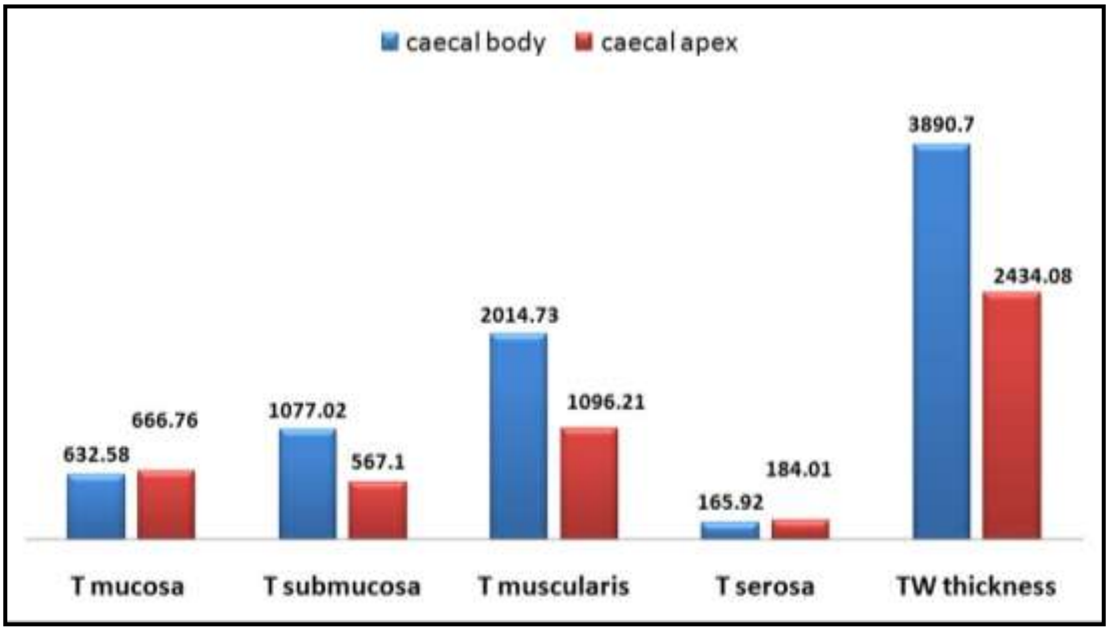

Fig. 8. Bar Graph showing comparative mean micrometry (µm) of various layers of caecal apex and body in cows (H&E stained) (T=tunica, TW=total Wall)

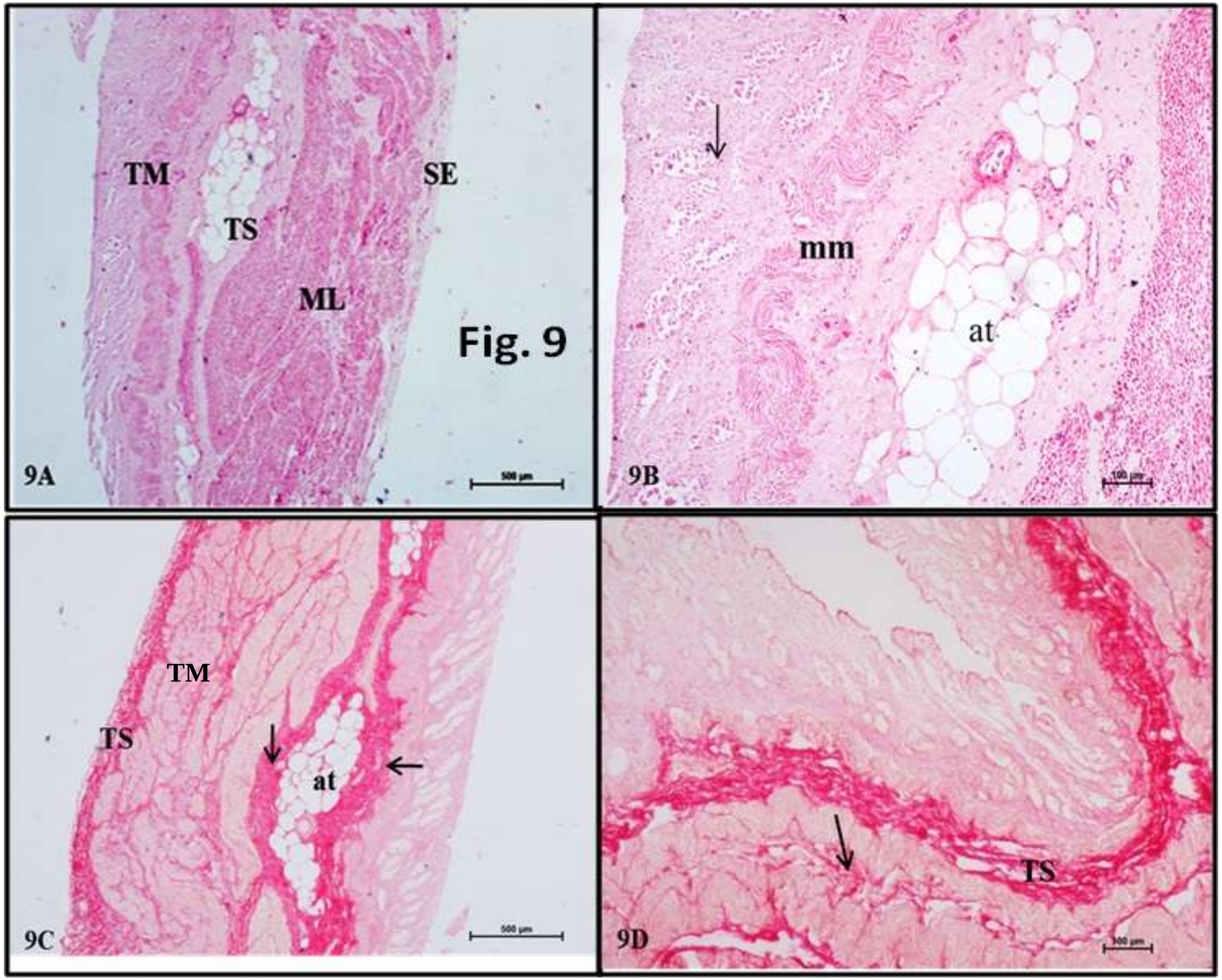

Fig. 9. Section of apex of cattle caecum showing; (A) Tunica mucosa (TM), tunica submucosa (TS), tunica muscularis (ML) and tunic serosa (SE). (H & E, 4x); (B) Tunica mucosa comprising of intestinal glands (arrow) in lamina propria, thick lamina muscularis mucosae (mm) and adipose tissue (at) in submucosa enclosed by connective tissue.. (H & E, 10x); (C) Thick collagen bundles (arrow) surrounding adipose (at) in submucosa. Tunica serosa (TS) and interfascicular connective tissue in tunica muscularis (TM) showing collagen fibers. (Picrosirius Red 4x); (D) Predominant collagen bundles in tunica submucosa (TS) and collagen fibers in inter-fascicular connective tissue (arrow) in tunica muscularis. (Picrosirius Red 10x)

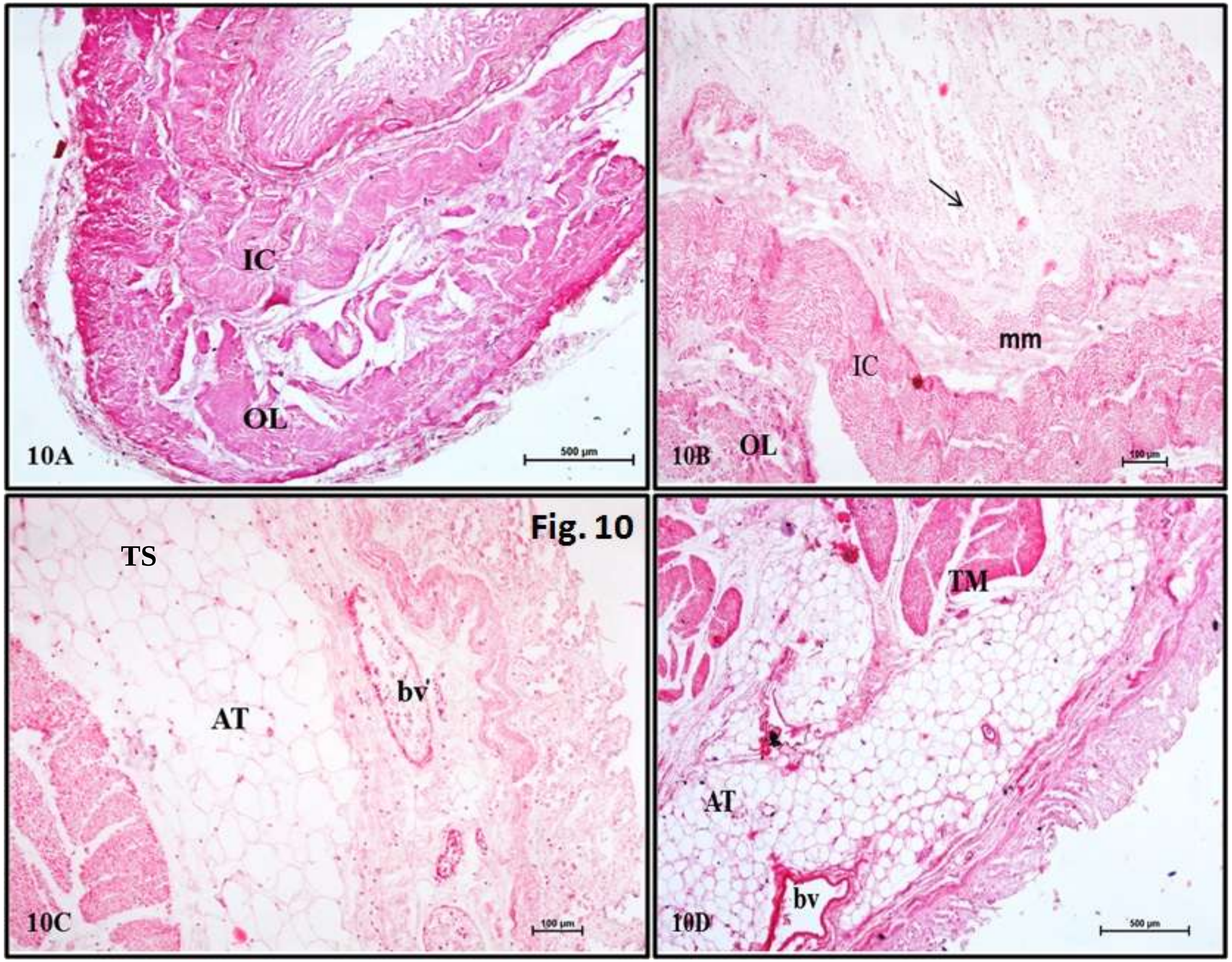

Fig. 10. Section of apex of cattle caecum (H&E 4x) showing; (A) inner circular (IC) and outer longitudinal layers (OL) in tunica muscularis; (B) intestinal glands in mucosa (arrow). Thick lamina muscularis mucosae (mm) and inner circular (IL) and outer longitudinal (OL) layers of tunica muscularis.

Section of body of cattle caecum (H&E 4x) showing; (C) the inner part of tunica submucosa (TS) entirely filled with adipose tissue (AT) and outer part having connective tissue fibers with blood vessels (bv).; (D) adipose tissue (AT) with blood vessels (bv) extending into the tunica muscularis (TM) with randomly arranged muscle bundles.

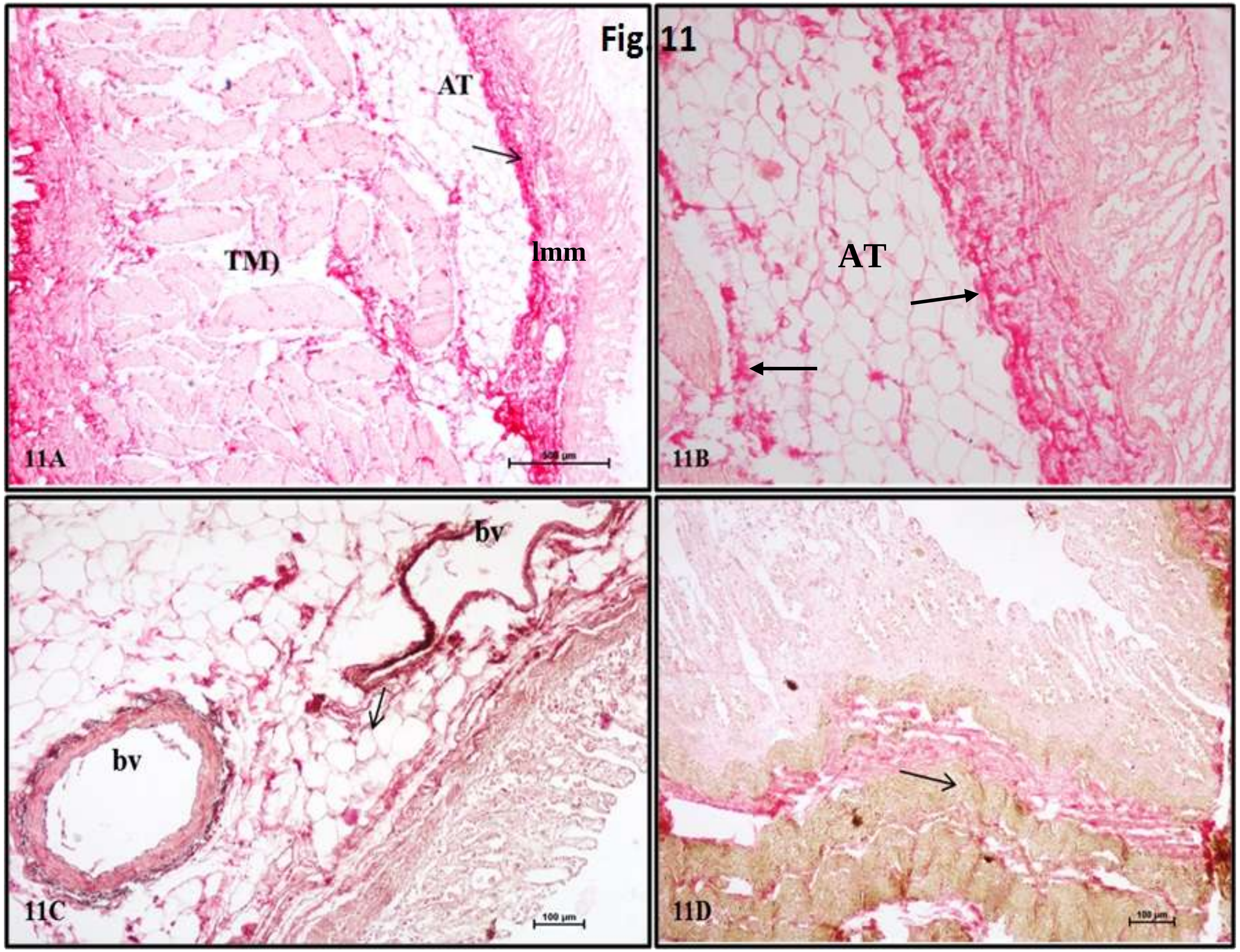

Fig. 11. Section of body of cattle caecum showing; (A) collagen bundles (arrow) close to lamina muscularis mucosae (lmm) . Inner part of submucosa entirely filled by adipose tissue (AT). Tunica musclaris (TM) showing randomly arranged muscle bundles. (Picrosirius Red 4x); (B) abundant adipose tissue (AT) in submucosa and few collgen fibers (arrow). (Picrosirius Red 10x); (C) elastic fibers in blood vessels in submucosa. Rest of submucosa is entirely filled with adipose tissue (AT). (Verhoeff Vangieson 10x); (D) Section of apex of cattle caecum showing very few elastic fibers in submucosa. Collagen fibers (arrow) are predominant. (Verhoeff Vangieson 10x).

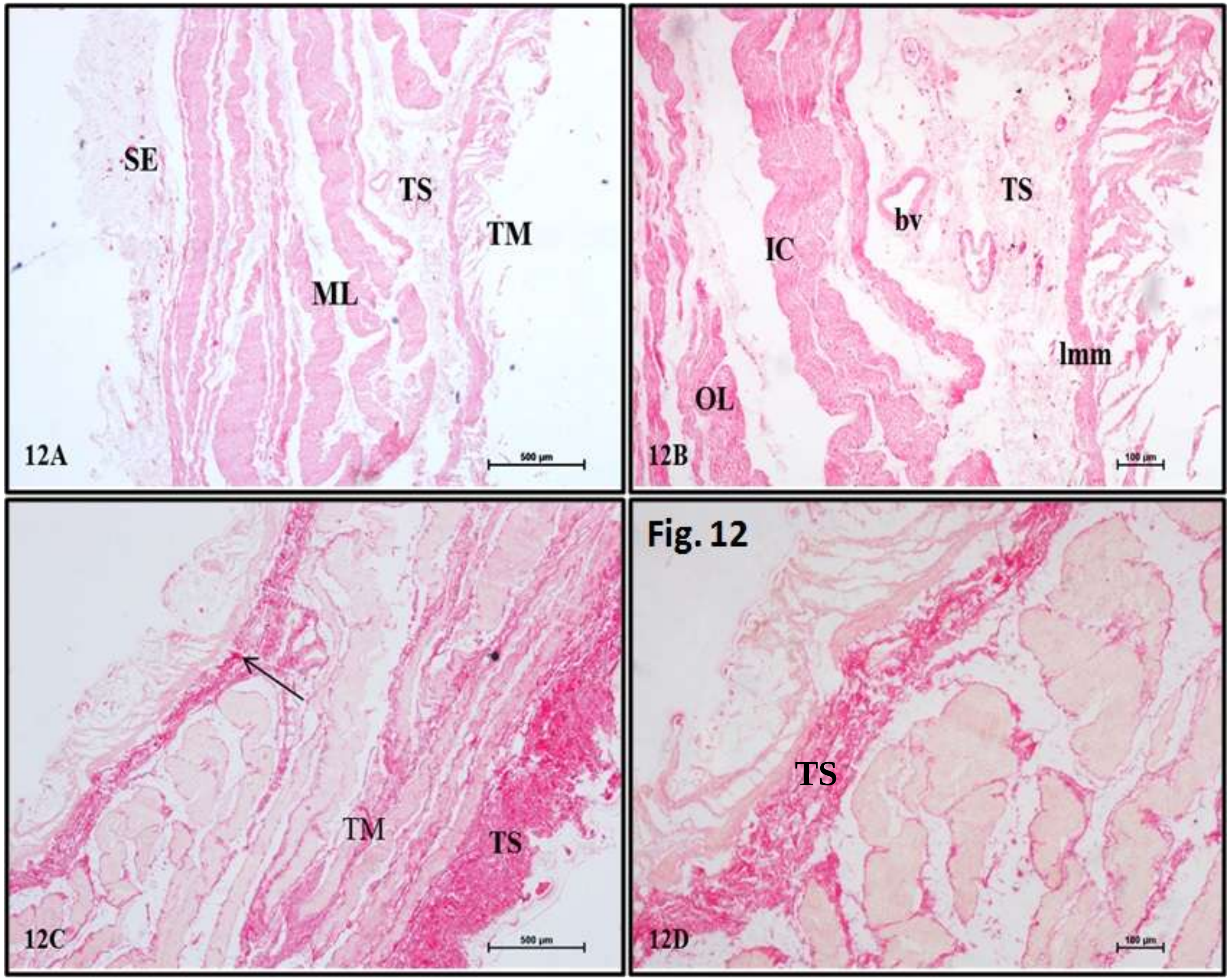

Fig. 12. Section of apex of buffalo caecum showing; (A) tunica mucosa (TM), tunica submucosa (TS), tunica muscularis (ML) and tunica serosa (SE). (H&E 4x); (B) lamina muscularis mucosae (lmm) tunica submucosa (TS) showing connective tissue fibers and blood vessels (bv) and inner circular (IC) and outer longitudinal (OL) muscle bundles separated by large interfascicular connective tissue. (H&E 10x); (C) thick collagen bundles (arrow) in submucosa,tunica muscularis (TM) and thick tunica serosa (TS) with collagen bundles. (Picrosirius Red 4x); (D) abundant collagen fibers in tunica submucosa (TS) and muscle fascicles surrounded by collagen fibers (arrow). (Picrosirius Red 10x).

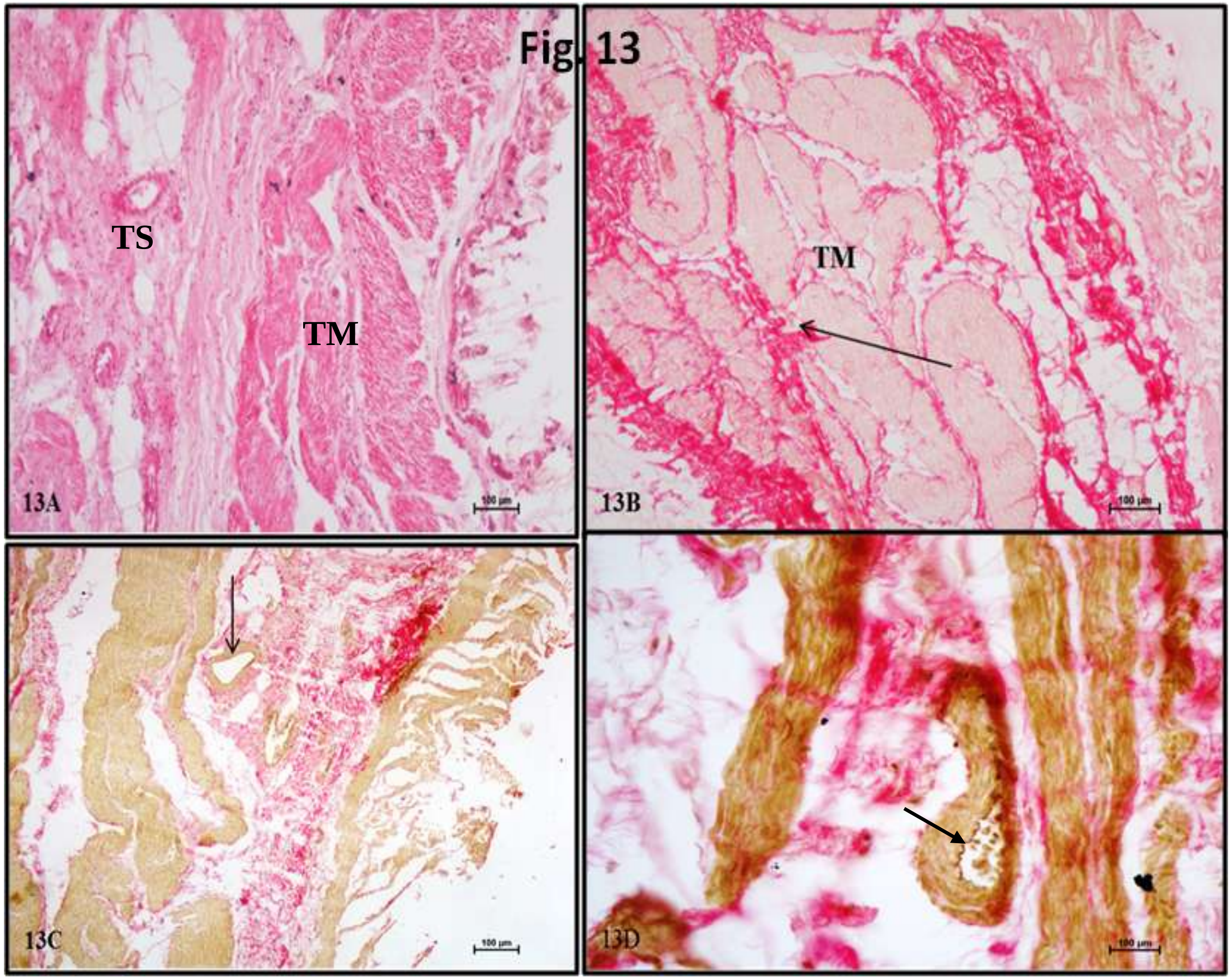

Fig. 13. Section of body of buffalo caecum showing; (A) randomly arranged muscle bundles in tunica muscularis (TM) and thick tunica serosa (TS). (H&E10x); (B) collagen fibers (arrow) in tunica muscularis (TM) (Picrosirius Red 10x); (C) elastic fibers in blood vessels (arrow) of submucosa. (Verhoeff Vangieson 10x); (D) elastic fibers in blood vessels (arrow) between muscle bundles. (Verhoeff Vangieson 40x).

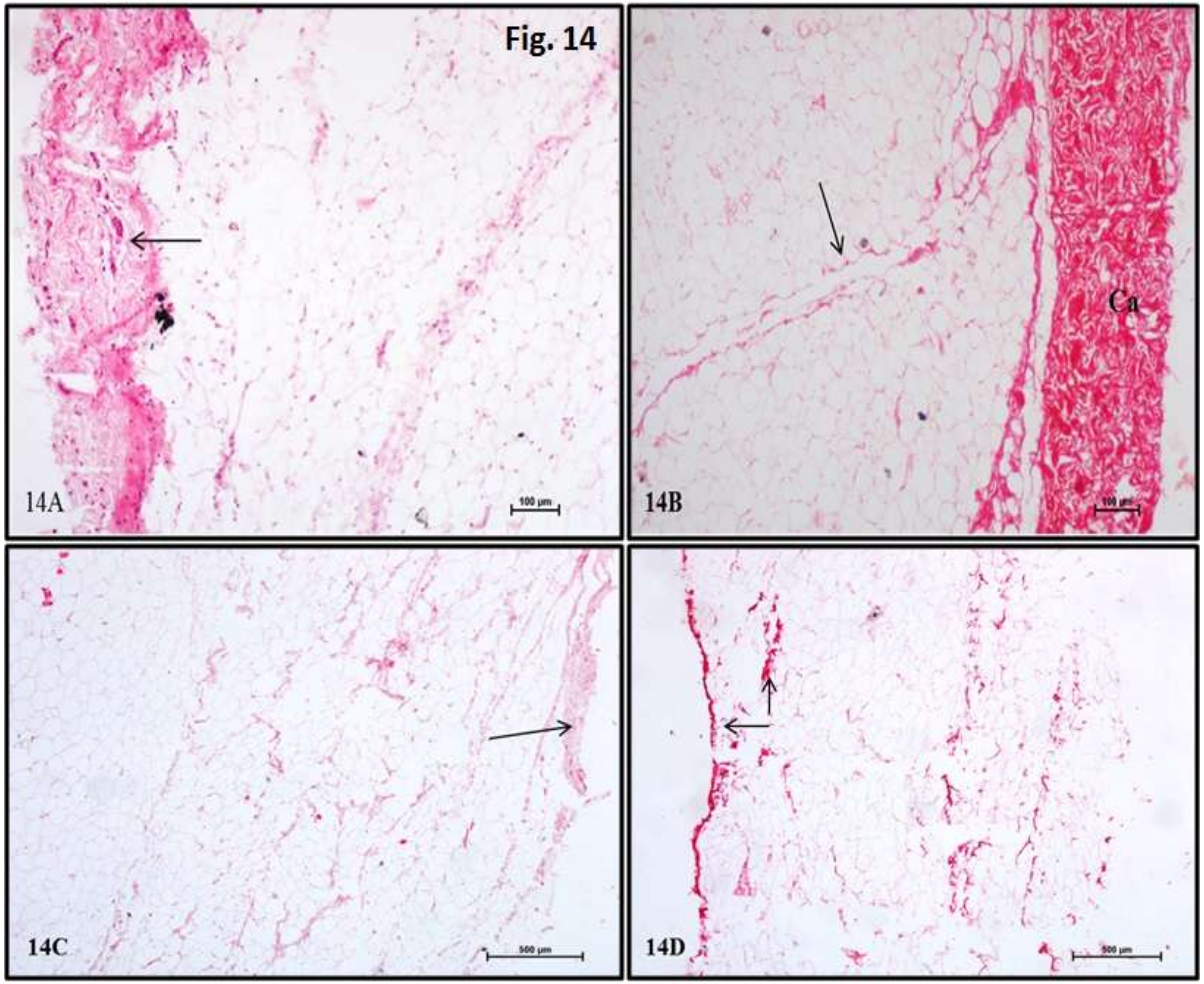

Fig. 14. Section of mesentery of cattle showing; (A) thick subepithelial connective tissue (arrow) and abundant fat. (H&E 10x); (B) abundant collagen fibers (Ca) in subepithelial connective tissue and septa (arrow) extending into adipose tissue. (Picrosirius Red 10x);
Section of buffalo mesentery showing; (C) thin subepithelial connective tissue (arrow) and abundant adipose tissue. (H&E 4x); (D) collagen fibrils (arrow) in subepithelial connective tissue and in between adipose tissue. (Picrosirius Red 4x).

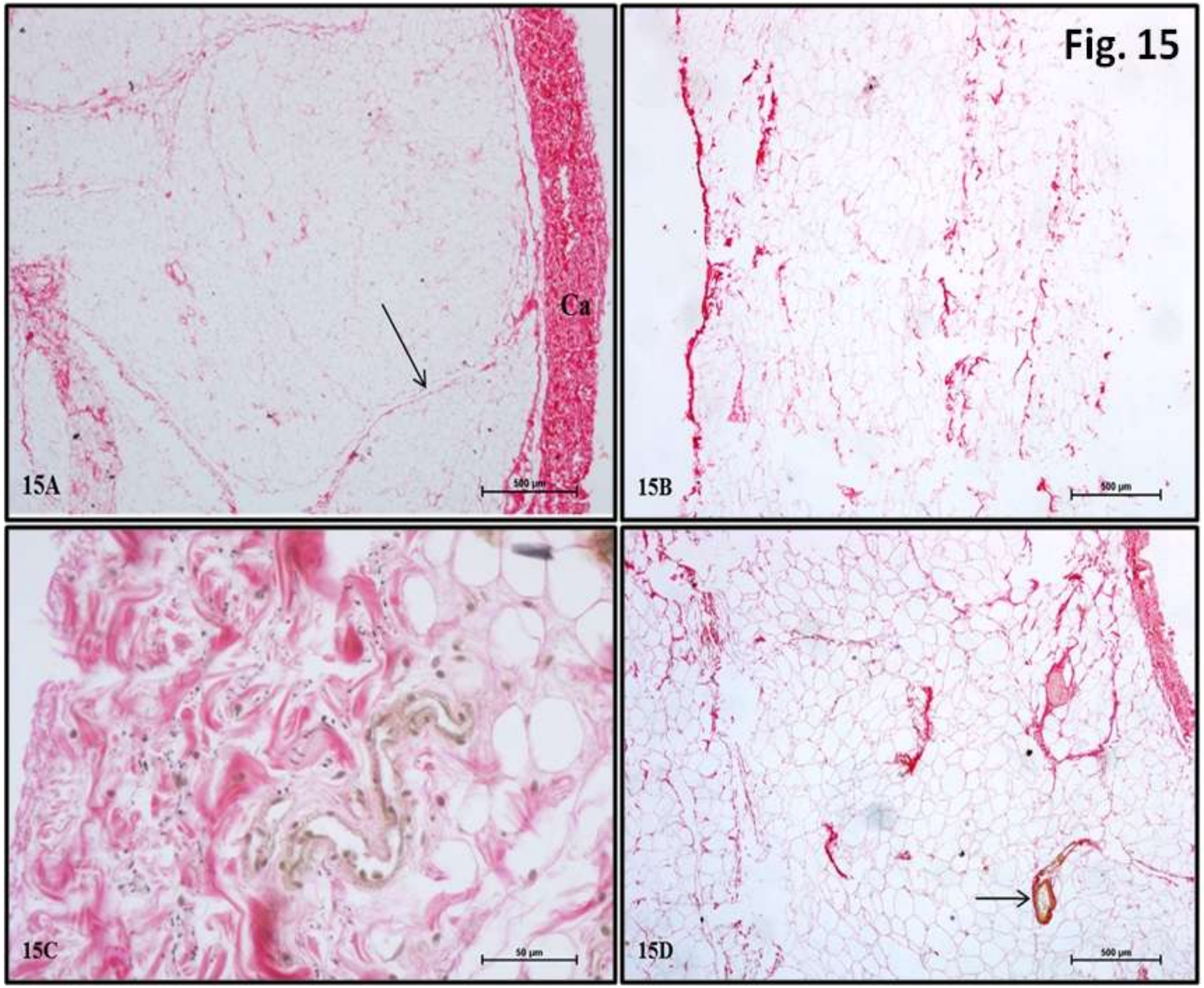

Fig. 15. Section of mesentery of; (A) cattle showing collagen fibers (Ca) and collagen fibers (arrow) in adipose tissue. (Picrosirius Red 4x); (B) buffalo showing thin subepithelial connective tissue with collagen fibers and collagen fibrils in the adipose tissue. (Picrosirius Red 4x); (C) cattle showing elastic fibers in the blood vessels. (Verhoeff Vangieson 40x); (D) buffalo showing blood vessels (arrow) and collagen fibers in the adipose tissue (Verhoeff Vangieson 4x).

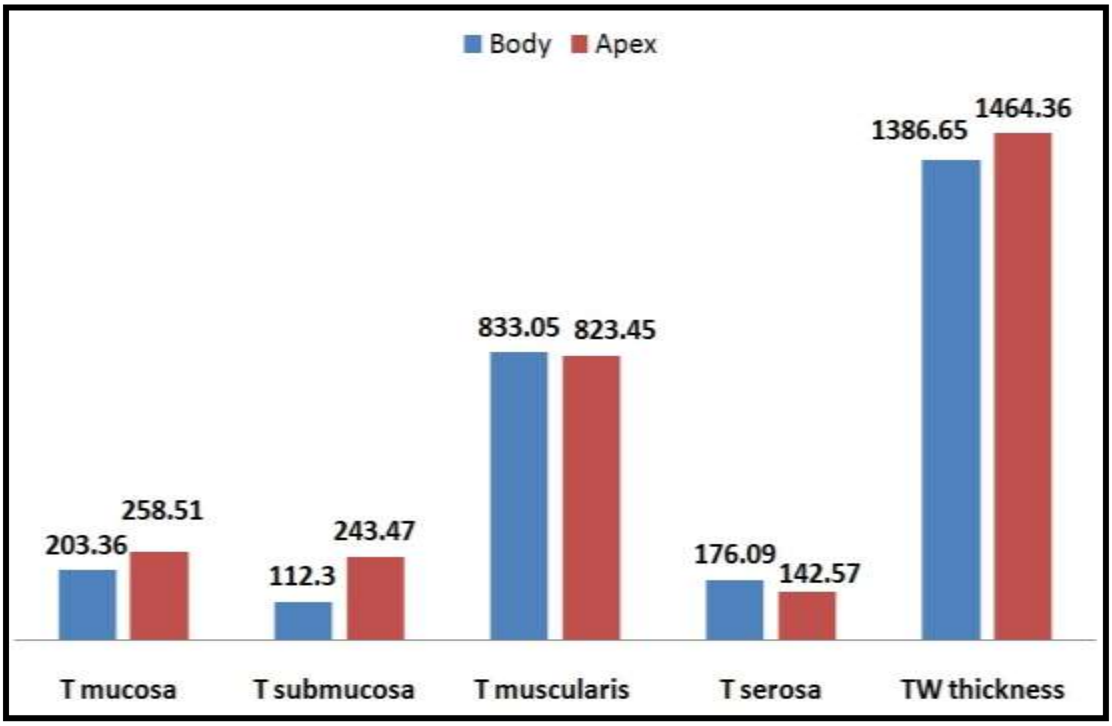

Fig. 16. Bar Graph showing comparative micrometry (mean in µm) of various layers of caecal apex and body in buffalo.

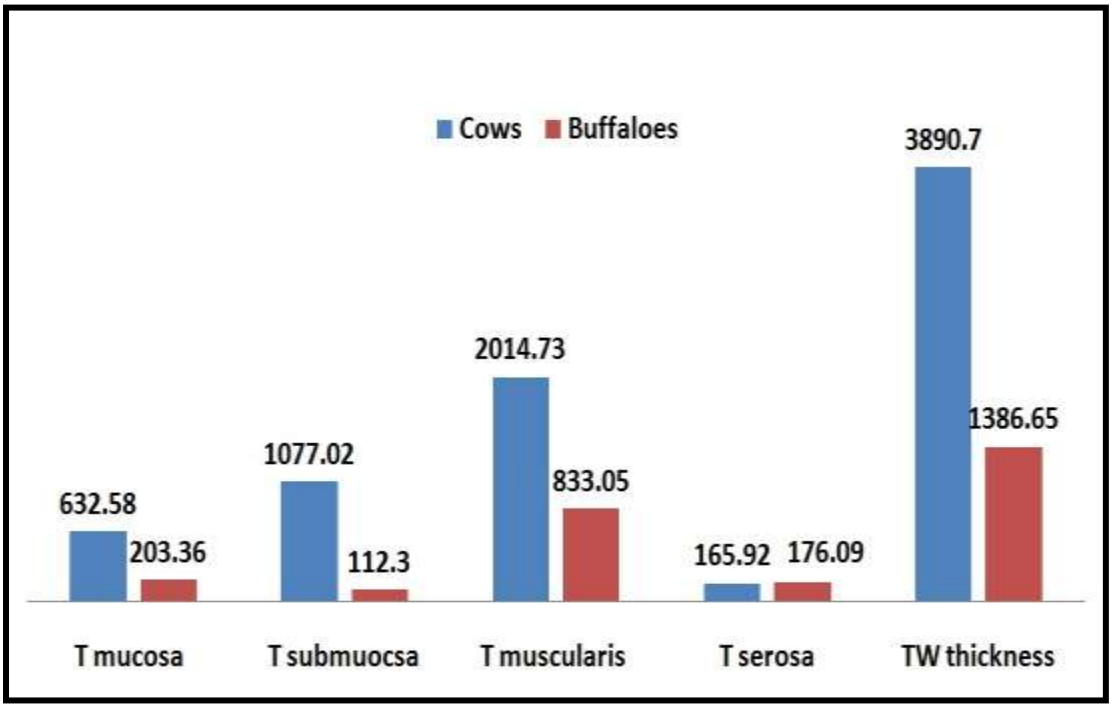

Fig. 17. Bar Graph showing comparative micrometry (mean in µm) of various layers of caecal body wall between cows and buffaloes.

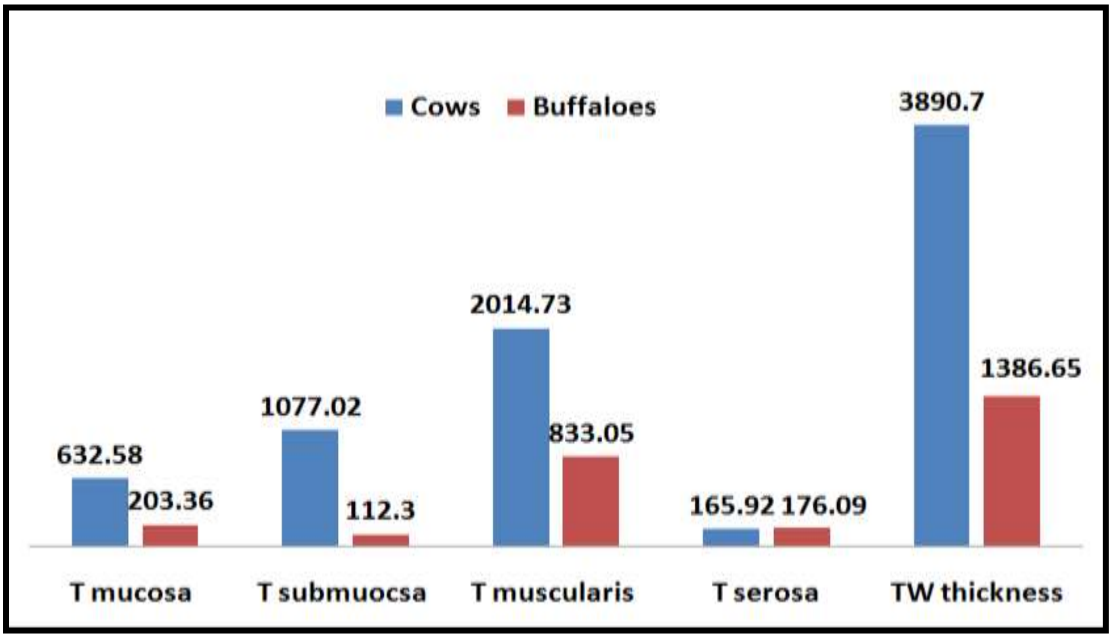

Fig. 18. Bar Graph showing comparative Micrometry (mean in µm) of various layers of caecal apex between cows and buffaloes.

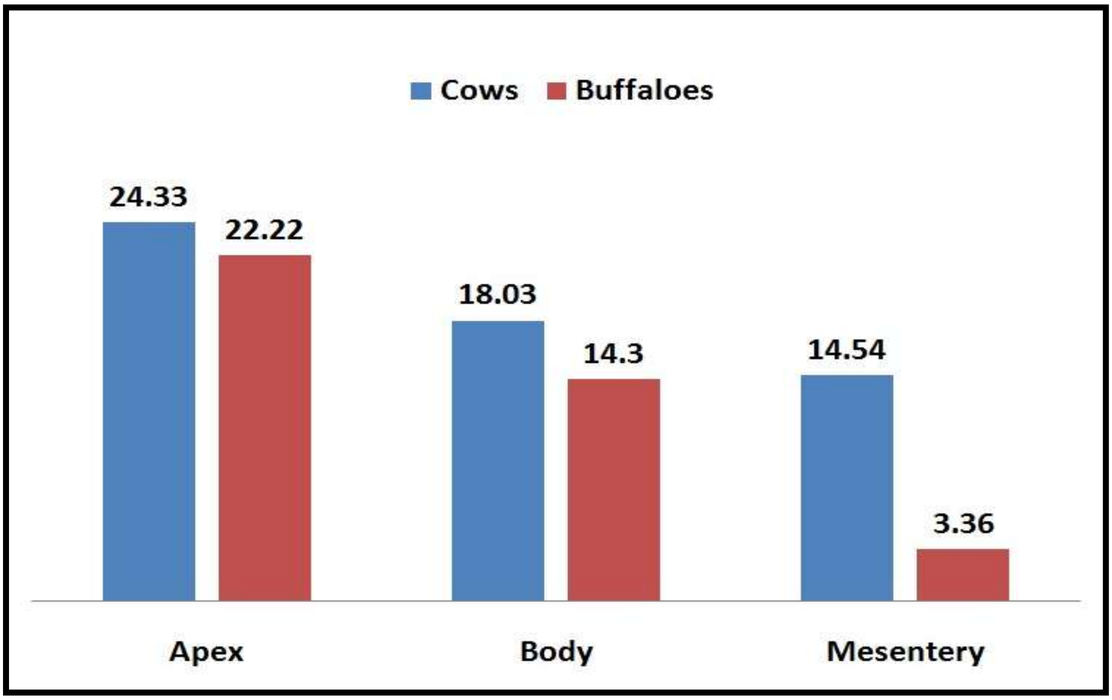

Fig. 19. Bar Graph showing comparative quantitative analysis (Area %) of collagen fibres in cattle and buffaloes.

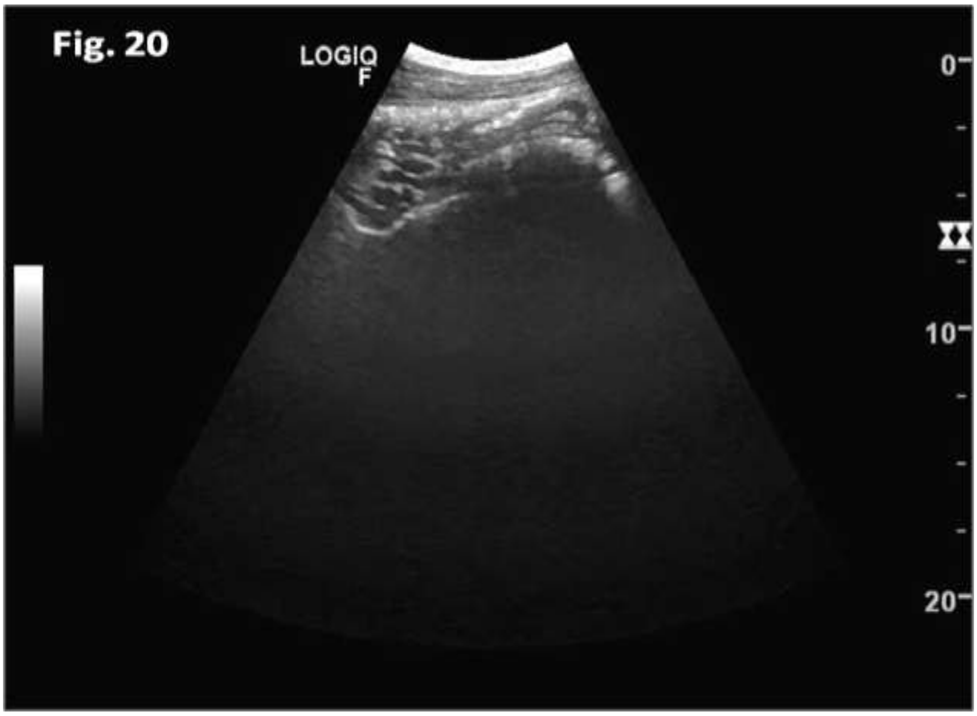

Fig. 20. Ultrasonogram showing caecum of apparently healthy cow at mid flank with mild reverberation and mixed content (Group 2a).

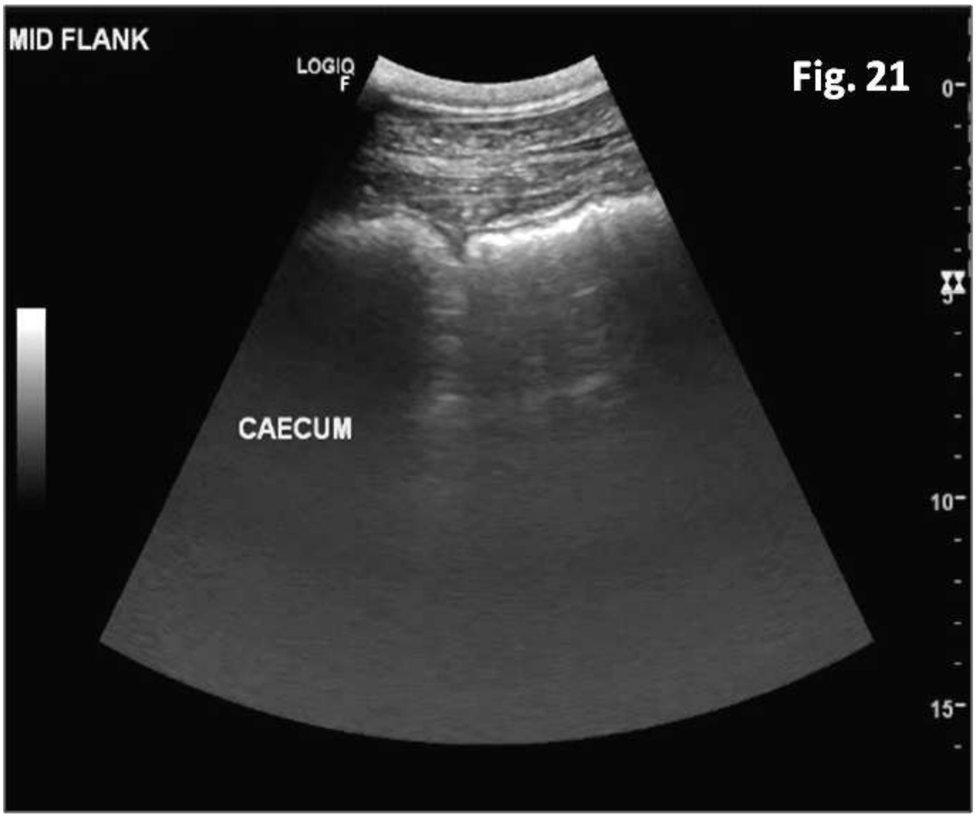

Fig. 21. Ultrasonogram showing caecum at mid flank with mild gaseous content in buffalo (Group 2a)

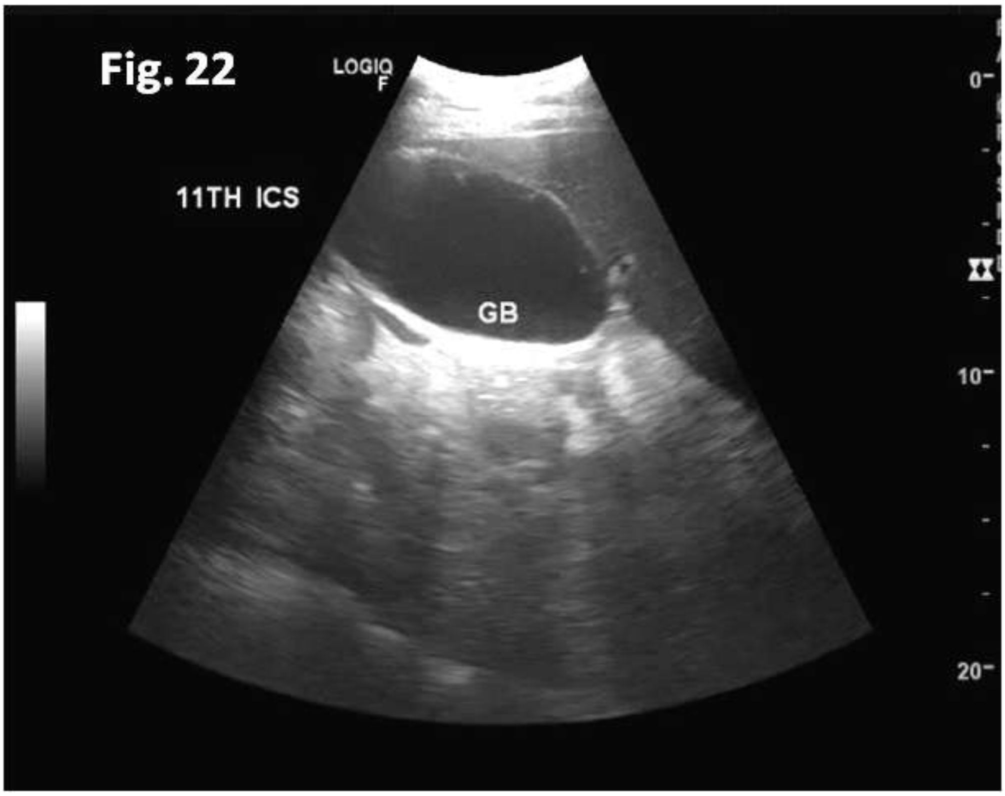

Fig. 22. Ultrasonogram showing Gall bladder of healthy cow at 11th ICS (Group 2a)

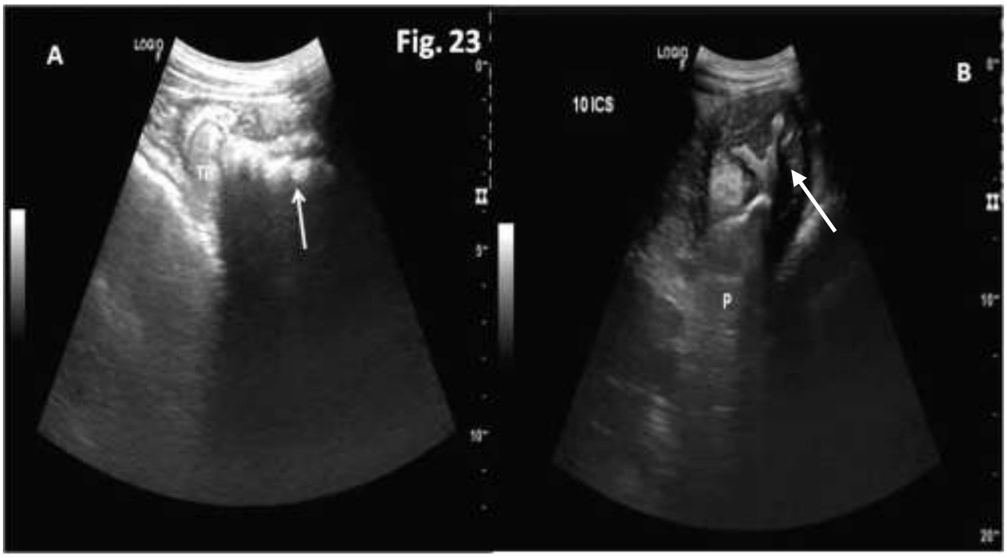

Fig. 23. Ultrasonogram showing pylorus at 9th ICS with rugal folds (white arrow) in abomasum of a healthy cow (A) and at 10th ICS in buffalo (B) (Group 2a). TP = Torus Pyloricus, P = Pylorus

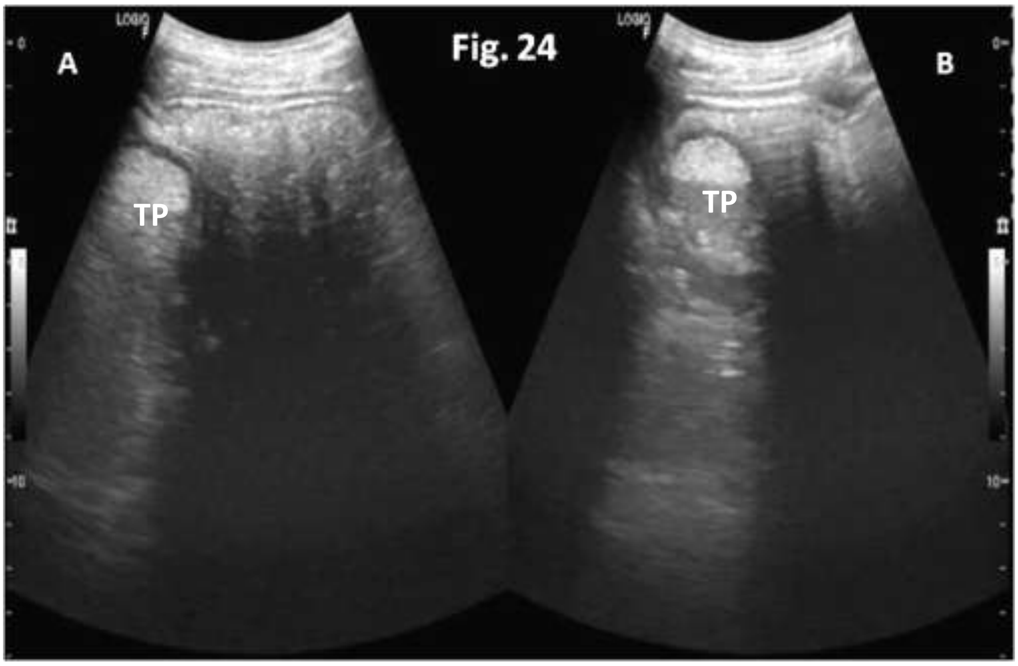

Fig. 24. Ultrasonogram showing pylorus in relaxed phase (A) and contracted phase (B) at 10th ICS in buffalo (Group 2a).TP = Torus Pyloricus

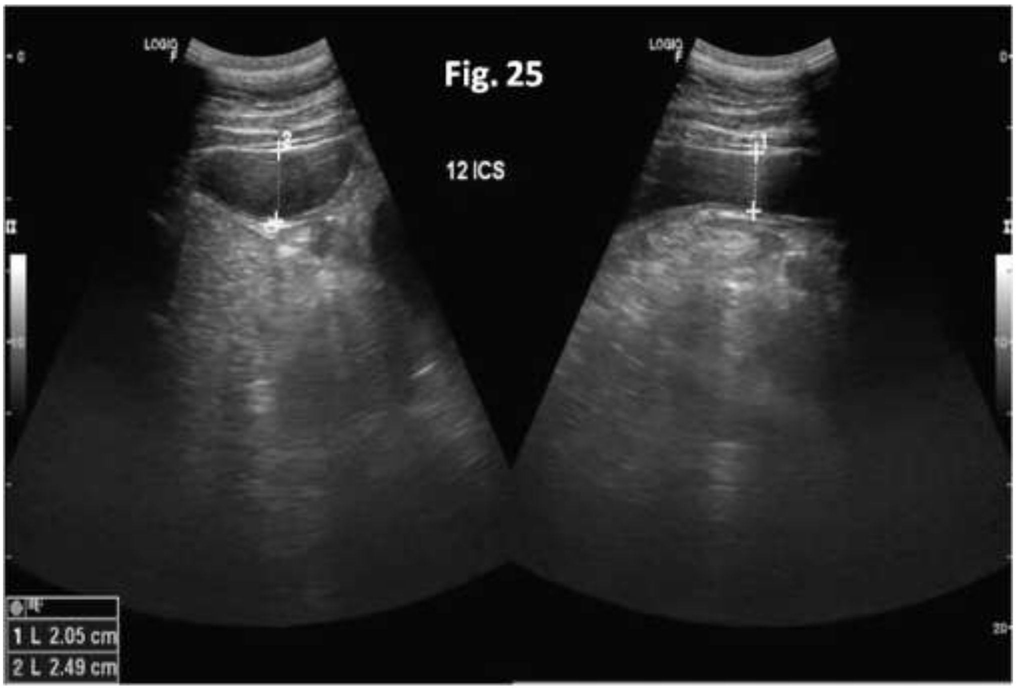

Fig. 25. Ultrasonographic image showing duodenum at 12th ICS in both longitudinal and cross-section view in healthy bovine (Group 2a)

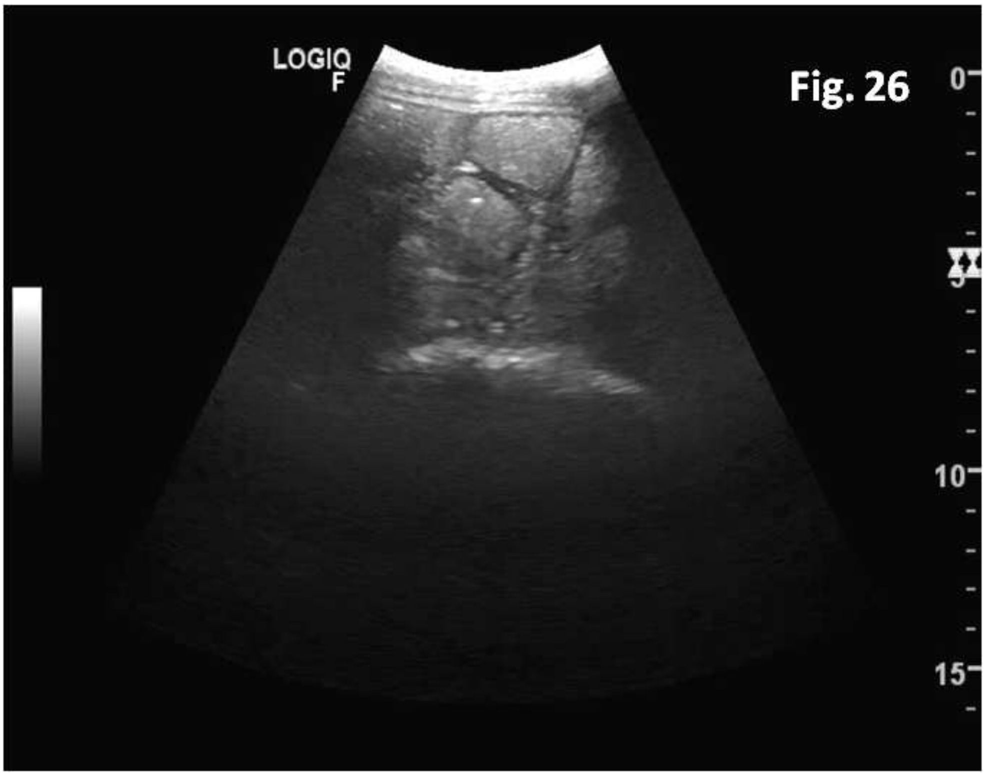

Fig. 26. Ultrasonogram showing jejunal loops at mid 10th ICS of right lateral body wall in healthy bovine (Group 2a)

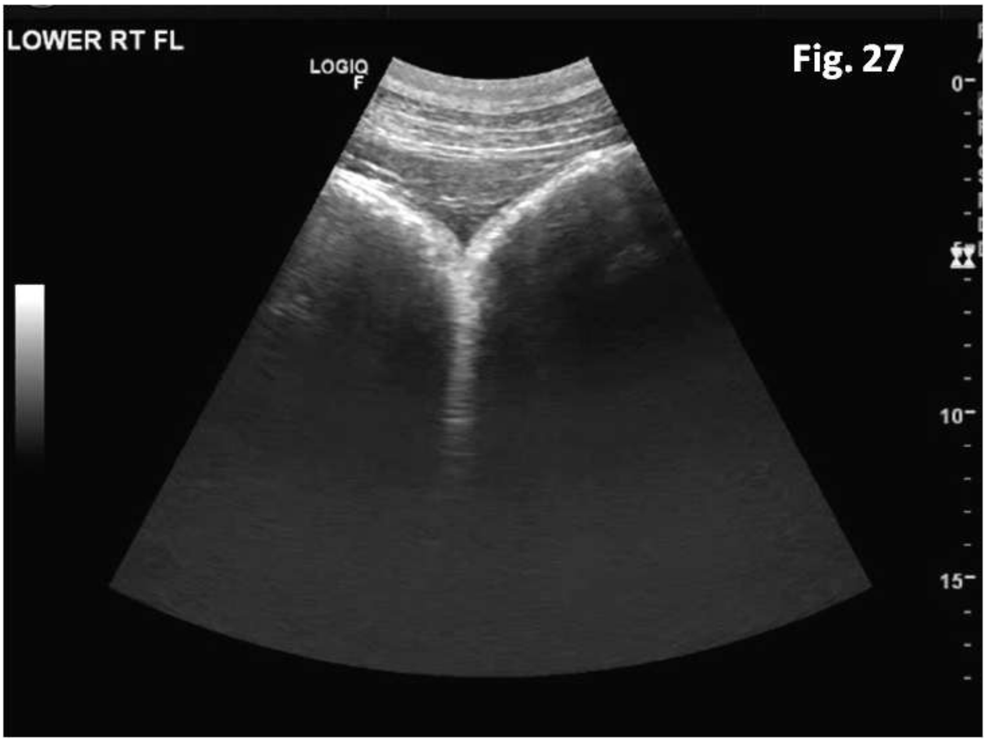

Fig. 27. Ultrasonogram showing distended caecum with mixed anechoic content at lower right flank in buffalo (Group 2b)

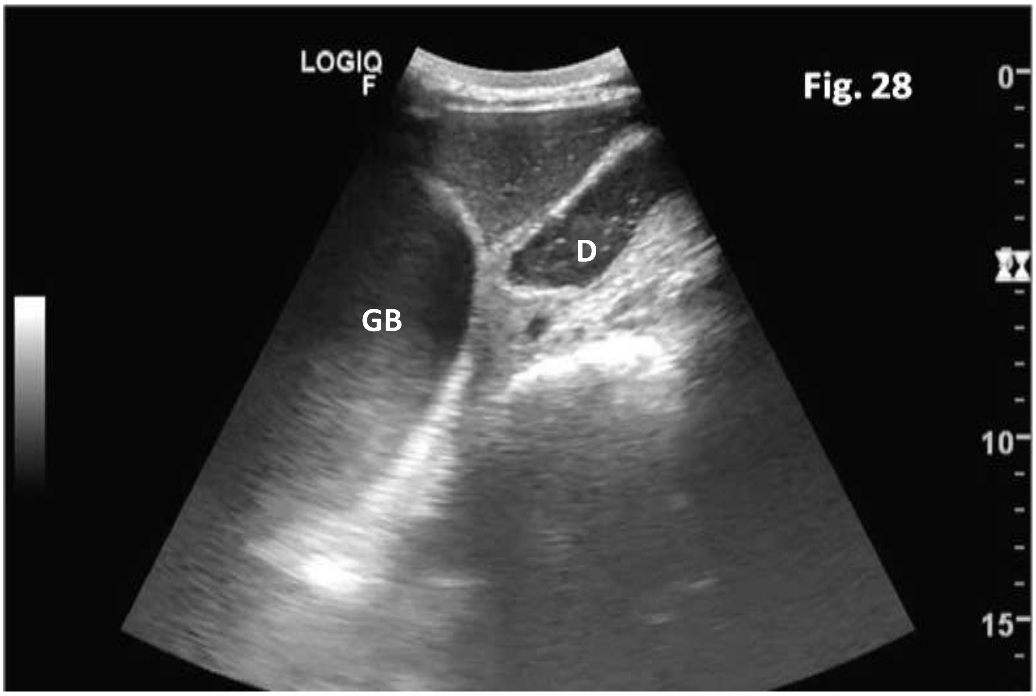

Fig. 28. Ultrasonogram showing distended duodenum (D) ventral to liver at 8th ICS and distended cranial margin of gall bladder (GB) in Cow suffering from DH. (Group 2b)

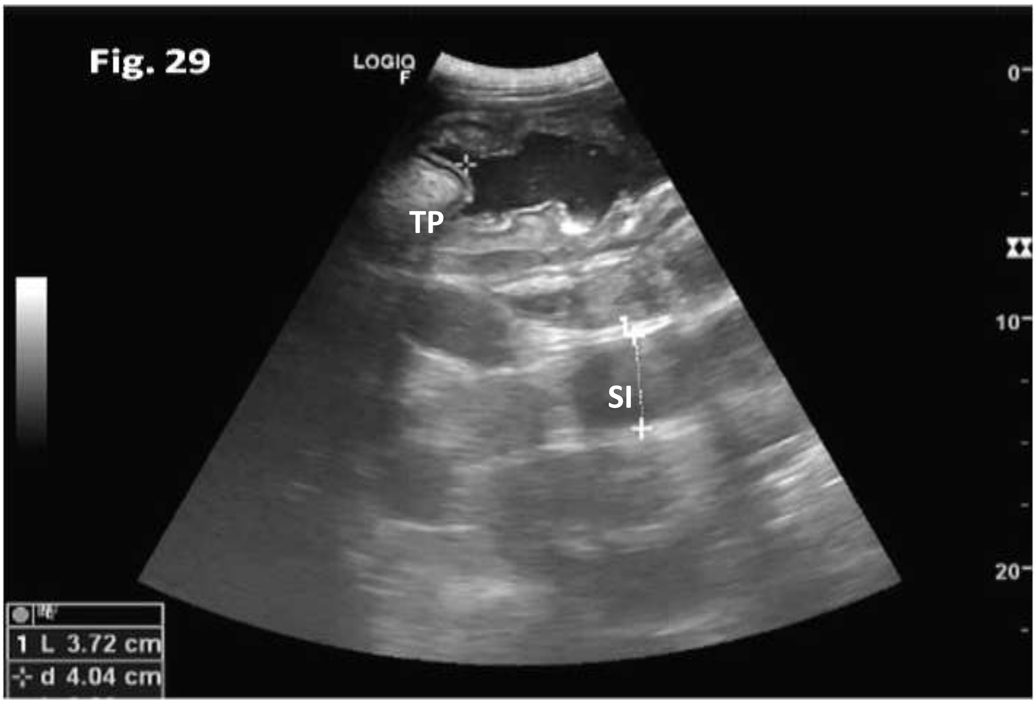

Fig. 29. Ultrasonogram showing Pylorus at 9th ICS with intra luminal fluid (F) in buffalo (Group 2b)

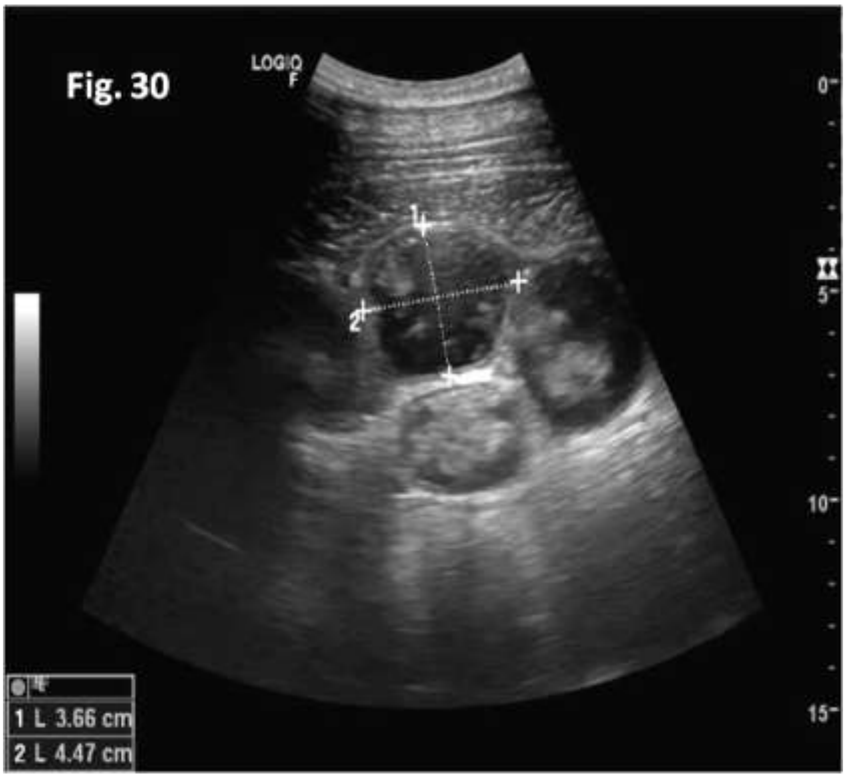

Fig. 30. Ultrasonographic image showing the diameter of distended fluid filled jejunal loops at 11th ICS in buffalo (Group 2b).

Fig. 31. Photograph showing mildly distended abdomen in a cow suffering from caecal dilatation

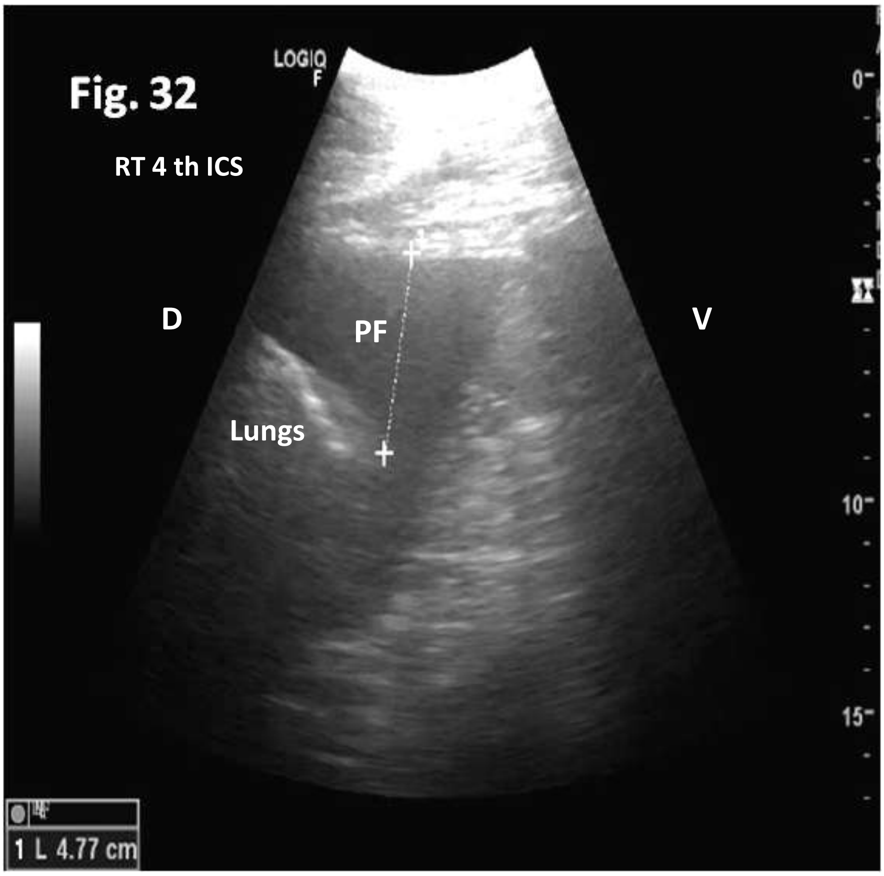

Fig. 32. Ultrasonographic image showing significant free fluid (pleural fluid) in the chest cavity in a cow suffering from caecal dilatation and recovered medicinally (Group 3)

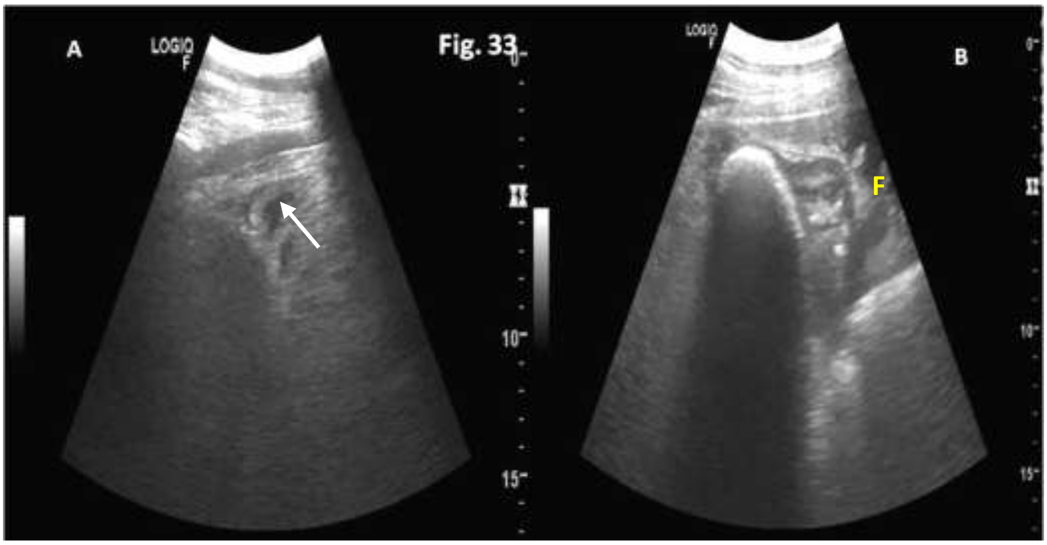

Fig. 33. Ultrasonogram showing reticulum at 5th ICS with moderate (A) and severe (B) free fluid with fibrin (arrow) in reticulo-ruminal recess (Group 3)

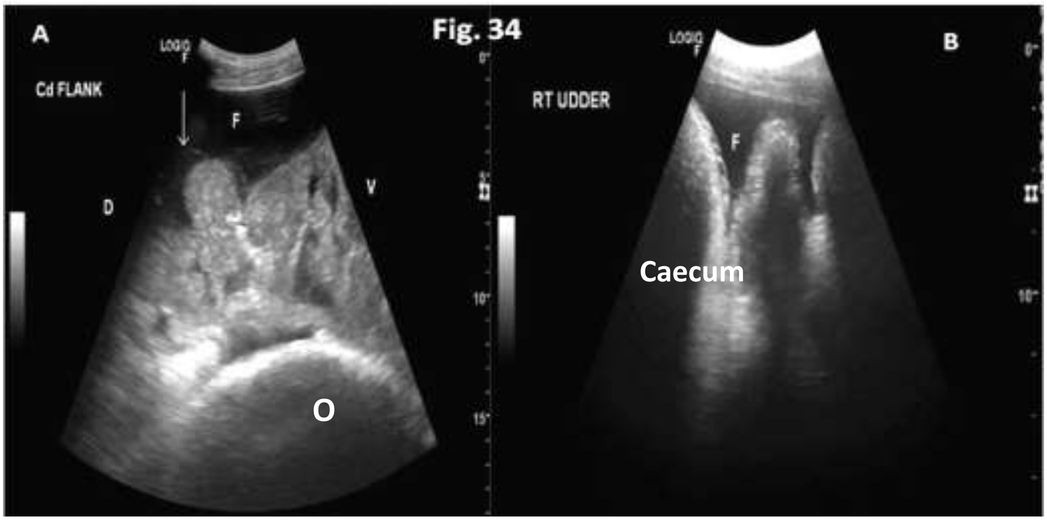

Fig. 34. Ultrasonographic image showing; (A) the dorsal margin of omasum (O) at 8th ICS with severe amount of free fluid (F) and fibrin (white arrow) in the abdominal cavity; (B) dilated caecum and colon with significant amount of peritoneal fluid (F) scanned near udder on right ventral abdomen.

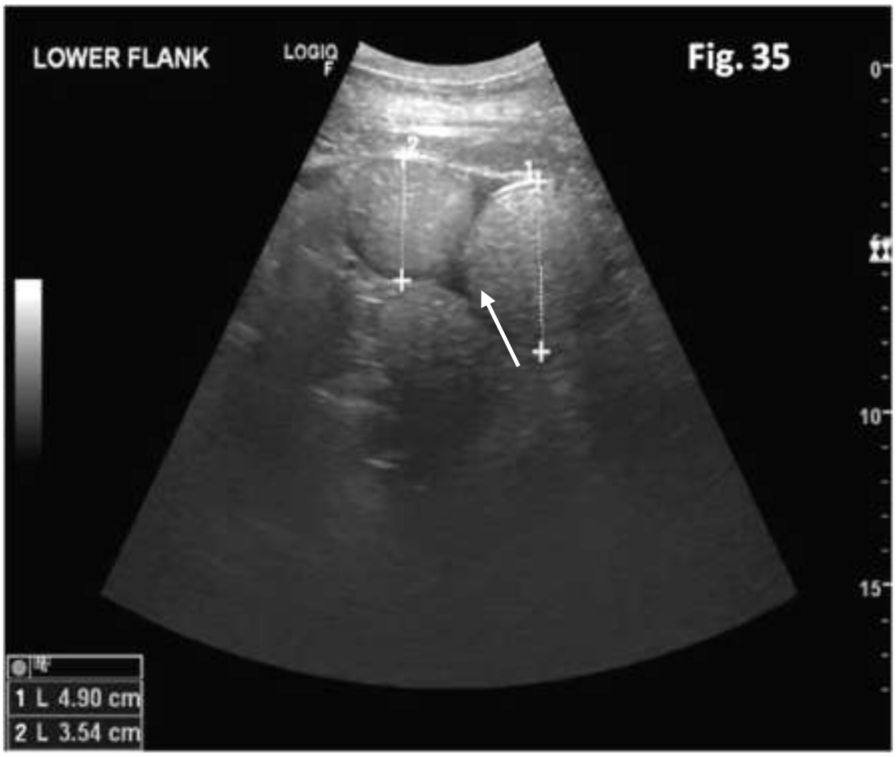

Fig. 35. Ultrasonogram showing distended small intestinal loops of diameter approx. 5 cm with complete ileus and free fluid (arrow) in between loops (Group 3).

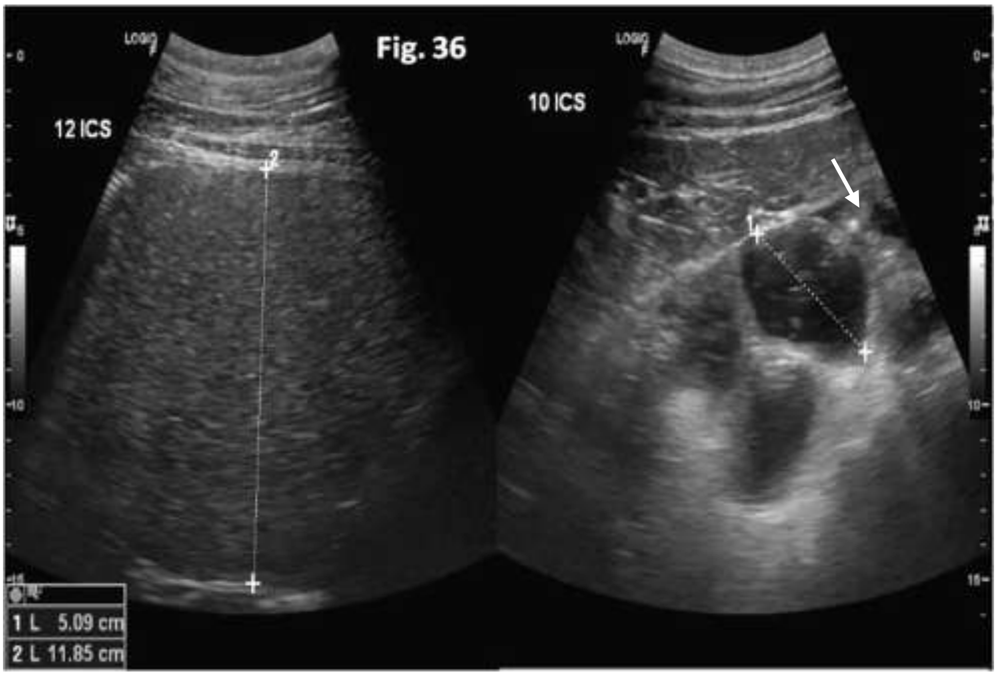

Fig. 36. Ultrasonogram showing distended duodenum with complete ileus at 12th ICS of diameter approx. 12cm and distended fluid filled SI loops of approx. 5cm at 10th ICS with fibrin (arrow) in between loops (Group 3).

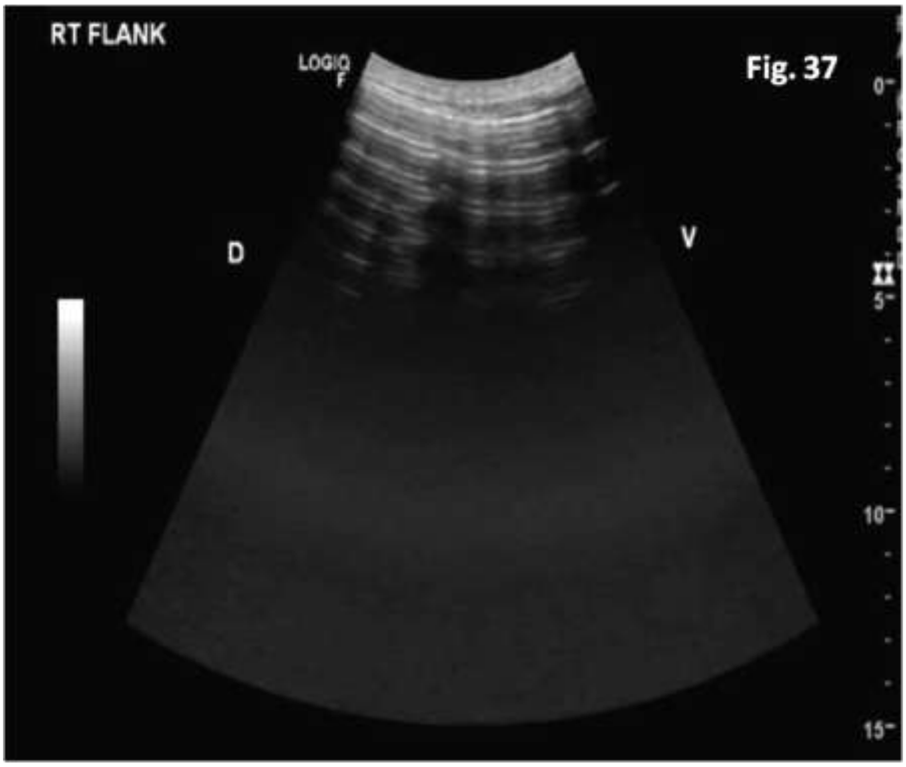

Fig. 37. Ultrasonogram showing a severe gas distended caecum with reverberation at right cranial flank (Group 3).

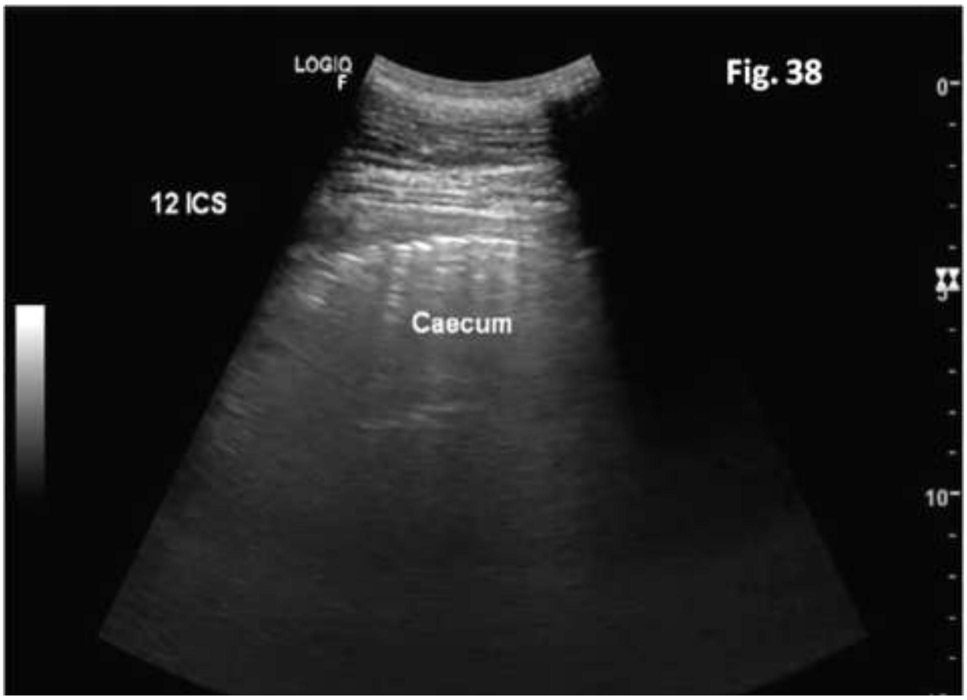

Fig. 38. Ultrasonogram showing a mixed contents with mild reverberation in distended caecum at 12 ICS (Group 3).

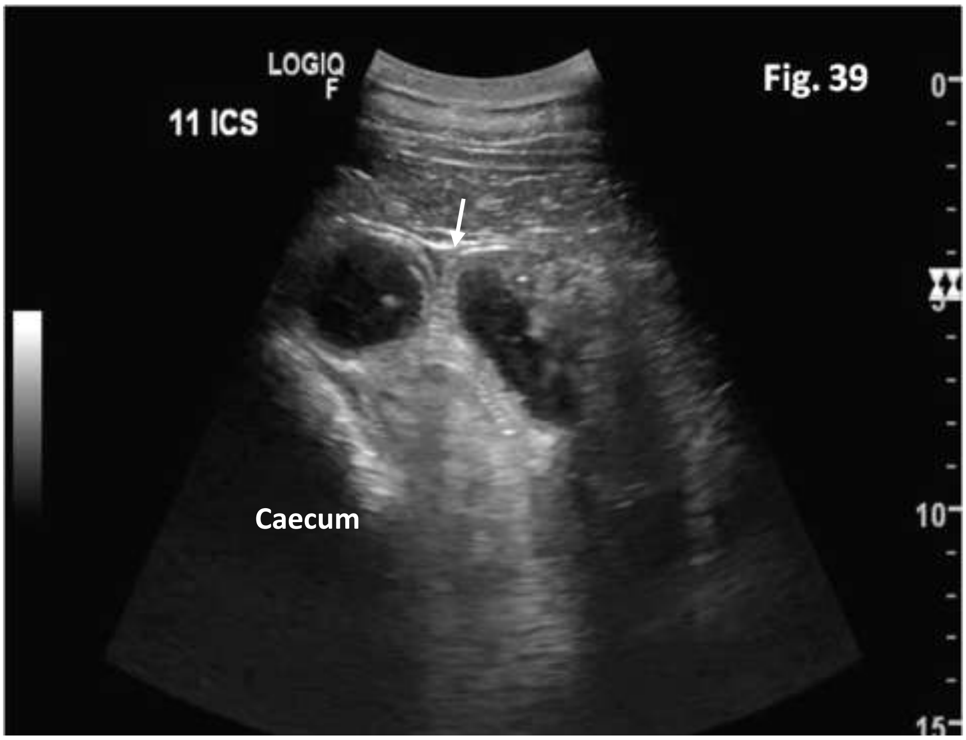

Fig. 39. Ultrasonogram showing fluid filled distended loops with free fluid (arrow) in b/w loops with caecum ventral to the intestinal loops at 11th ICS (Group 3)

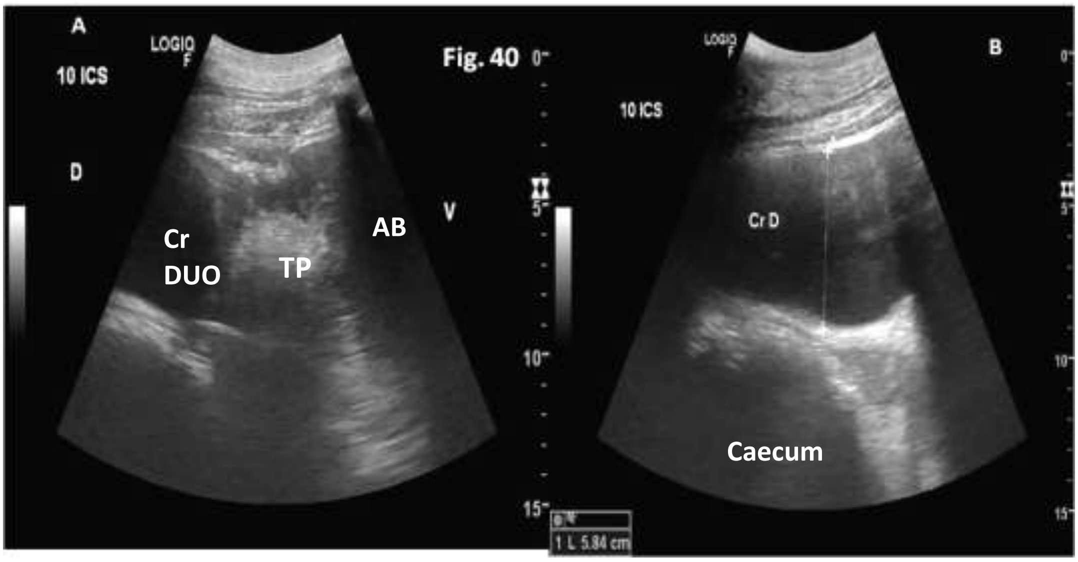

Fig. 40. Ultrasonogram showing; (A) severely distended pylorus (fluid filled) opening into the cranial duodenum at 10thICS (Cr DUO= cranial duodenum, TP=torus pyloricus, AB = abomasum, D= dorsal, V= ventral); (B) distended cranial duodenum of diameter 5.84 cm at mid 10th ICS with caecal wall distended upto 10th ICS (Group 3).

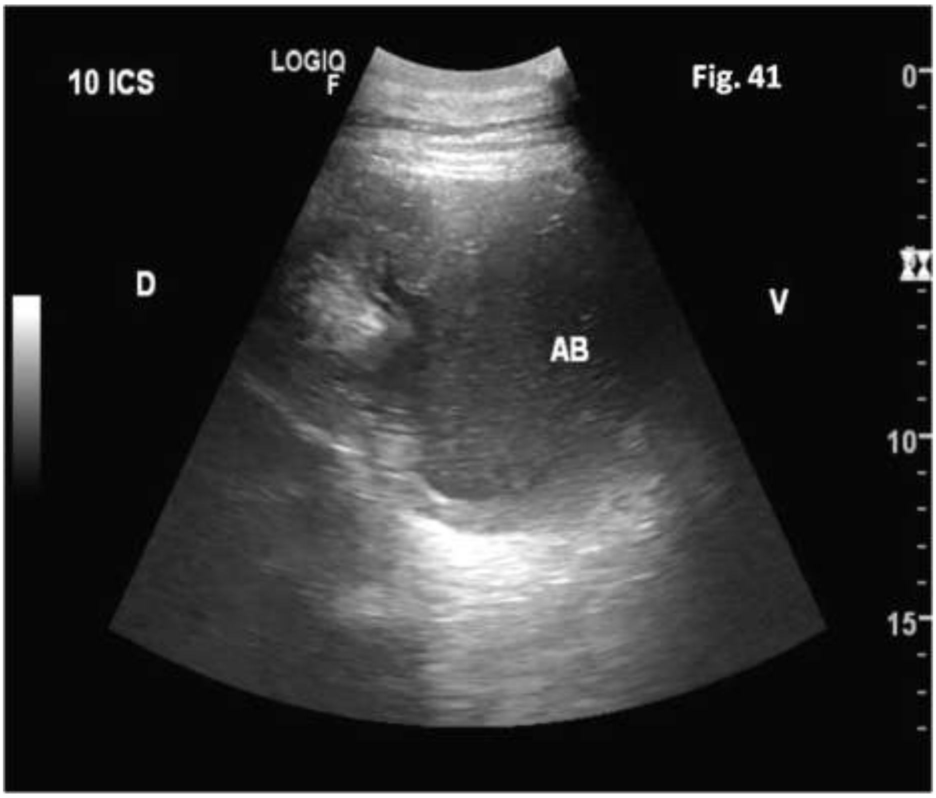

Fig. 41. Ultrasonogram showing distended pylorus (fluid filled) at 10th ICS in buffalo (Group 3) (AB= abomasum, D= dorsal, V= ventral)

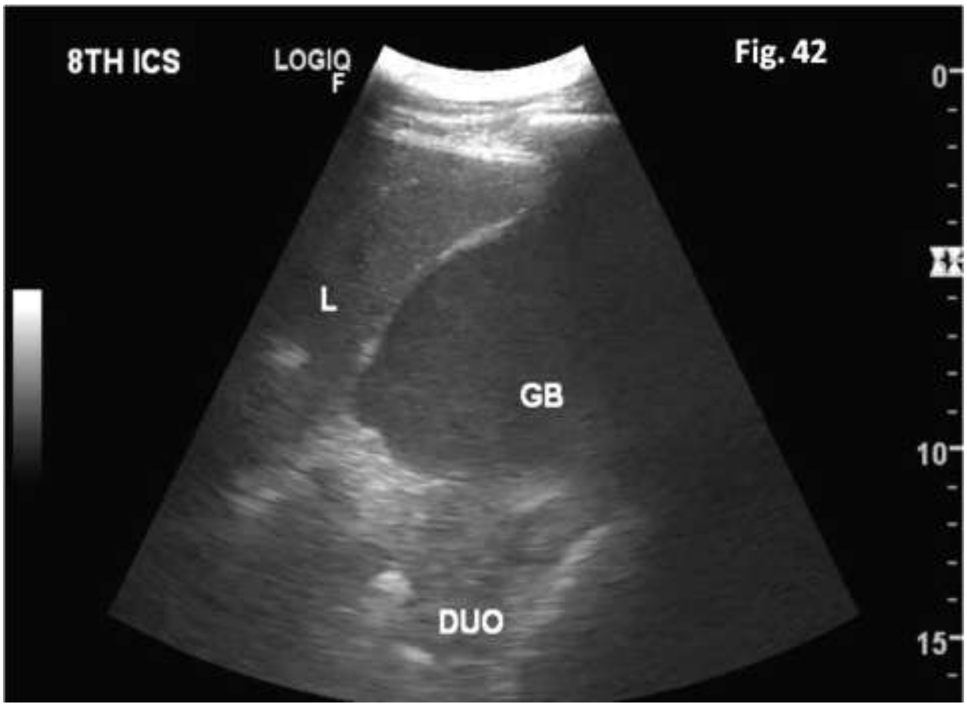

Fig. 42. Ultrasonogram showing distended and cranially pushed caudal margin of GB at 8th ICS in buffalo suffering from caecal dilatation (Group 3)

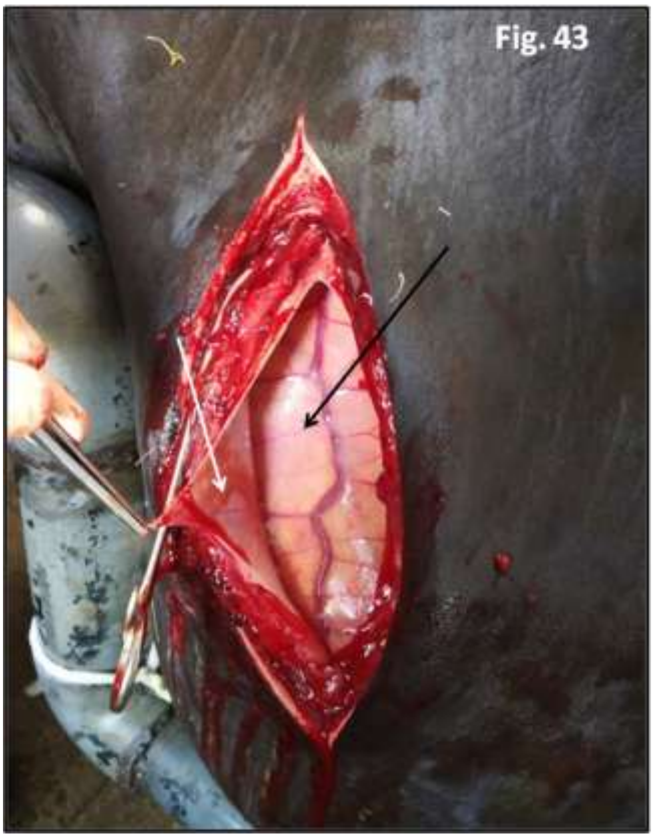

Fig. 43. Photograph showing right flank incision revealing greater omentum (black arrow) after incising peritoneum (white arrow) in a cow.

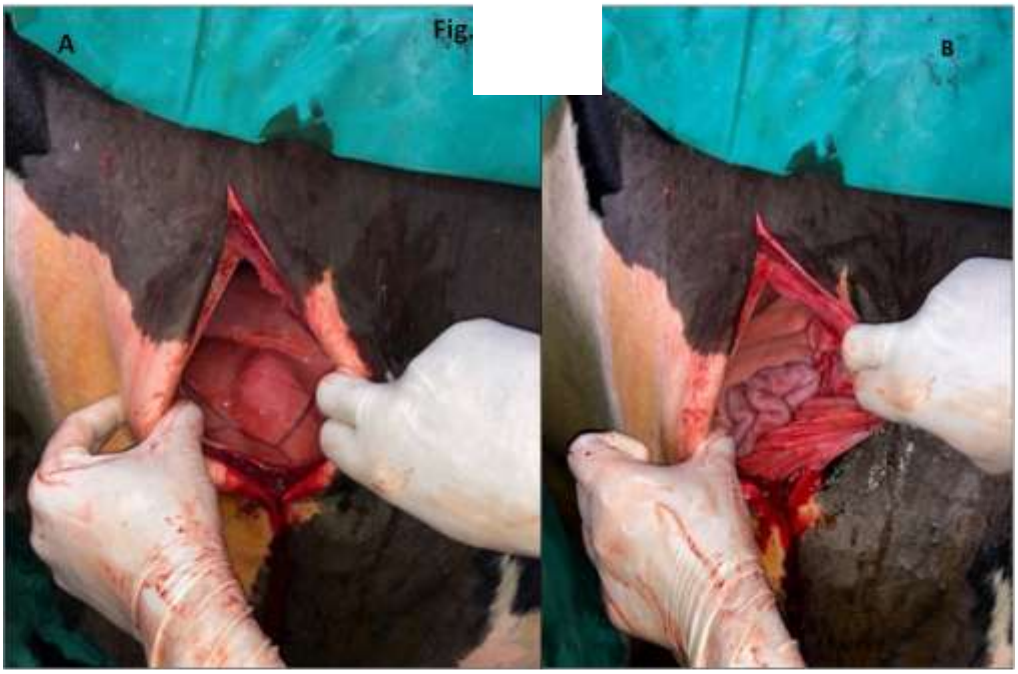

Fig. 44. Photograph showing greater omentum (A) and retracting of greater omentum cranially to visualize caecum (B).

Fig. 45. Photograph showing exteriorizing of caecal apex in a cow.

Fig. 46. Photograph showing suctioning of caecum but still not able to bring the caecum out (A); suturing of caecal body with lateral body wall after decompression in buffalo (B).

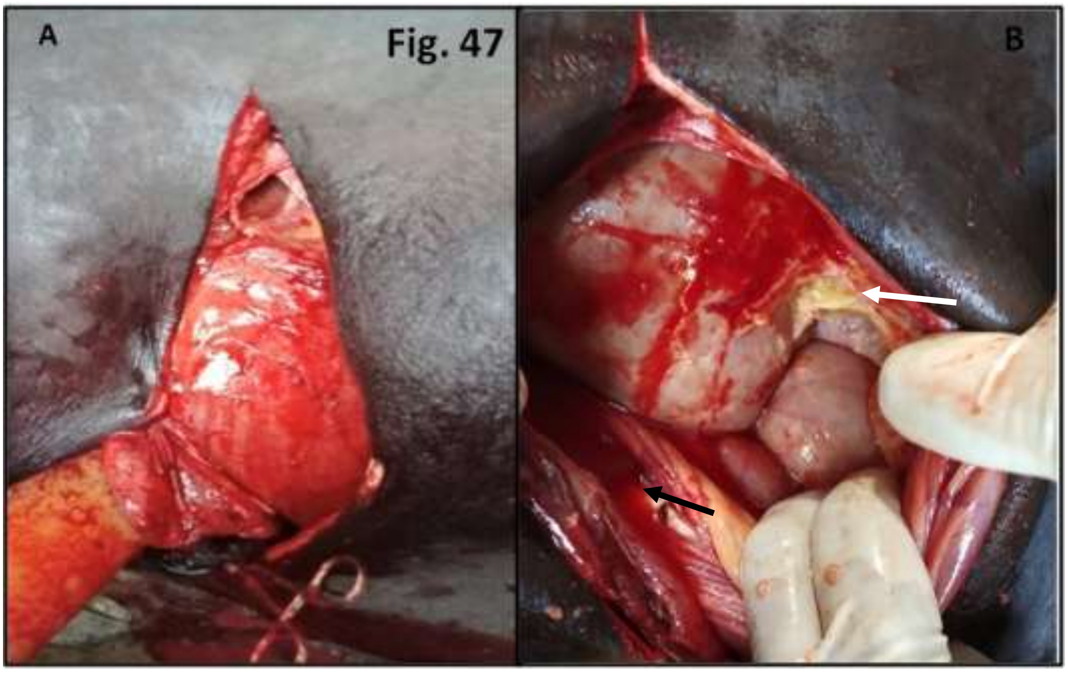

Fig. 47. Photograph showing failure to retract the omentum cranially due to adhesions with adjacent organs in a buffalo (A); severe adhesions (white arrow) formed between caecum and other underlying organs with significant amount of peritoneal fluid (black arrow) in another buffalo not allowing to bring the caecum out (B).

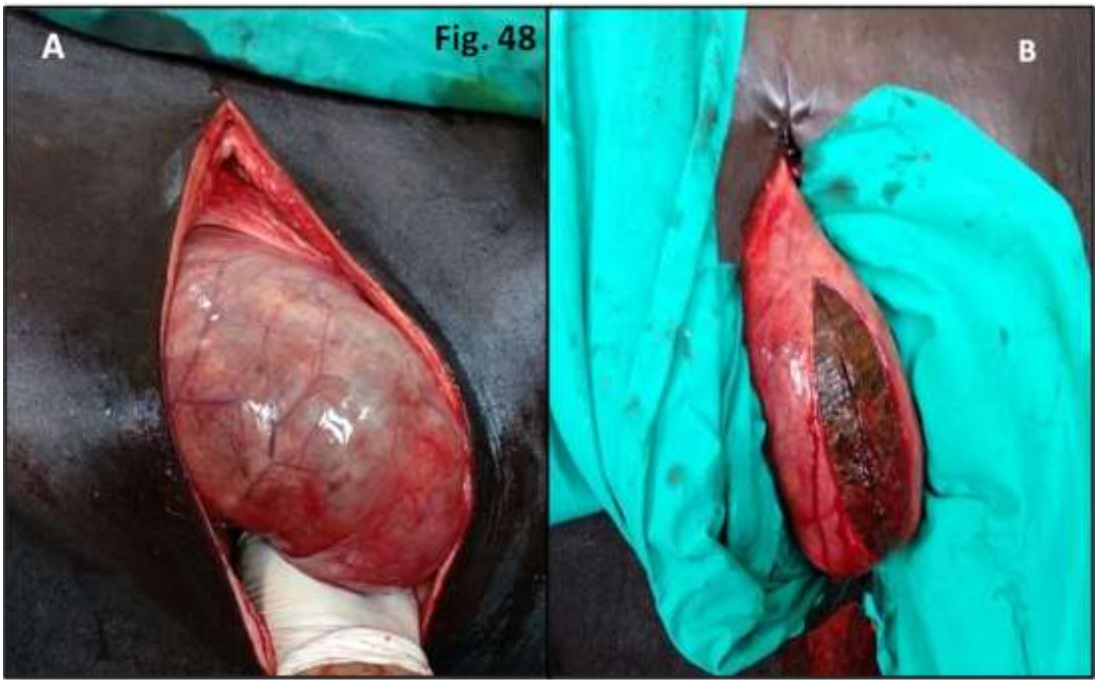

Fig. 48. Photograph showing retraction of caecal body after incising omentum while protecting underlying duodenum in a buffalo (A) and incising the caecum after suturing it to the body wall (B)

CHAPTER V

SUMMARY AND CONCLUSIONS

The study was conducted on total 53 animals, 8cadavers (4 cows and 4 buffaloes); 10 healthy control (5 cows and 5 buffaloes), 20 disease control (5 cows and 16 buffaloes) and 15 clinical cases (2 cows and 13 buffaloes) suffering caecal dilatation.

Part I: Cadaveric study

The part I of study i.e. gross morphometric evaluation of caecum in bovine cadavers recorded marked species-specific differences. As compared to buffaloes (11.27±1.32), cows had significantly ($p<0.05$) longer ileocaecal mesentery (12.7±2.92 cm) with apparently abundant fat in the most specimens (3 out of 4). Besides, the region of caecal apex devoid of ileo-cecal mesentery was significantly ($p<0.01$) longer in cows (22.22±5.63 cm) as compared to that in buffaloes (11.27±1.32). However, the length and width of the caecum was found to differ non-significantly between these species.

Histologically, the bovine (cows and buffaloes) caecum was composed of four layers viz; tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa. Salient species-specific differences were as follow:

- The distribution of adipose tissue varied in the caecal apex and body of both species. Buffalo caecum had scanty amount of adipose tissue at both caecal apex and body. In cattle, the distribution of adipose tissue at region of apex was in form of islands which was enclosed by collagen fibres. On the other hand the distribution of adipose tissue in submucosa of caecal body wall was in the form of continuous layer which was lined by collagen fibres towards the side of lamina muscularis.

- On micrometry, tunica submucosa (567.10±51.62 um), tunica muscularis (1096.21±118.38 um) and total wall (2434.08±299.18 um) at the caecal apex was significantly thinner as compared to tunica submucosa (1077.02±134.90 um) and tunica muscularis (2014.73±21.39um) and total wall (3890.70±137.56 um) at body of caeum in cattle.

- While In buffaloes, the mean thickness of tunica mucosa (258.51 ± 16.47 um), tunica submucosa (243.47 ± 20.88 um) and total wall (1464.36±46.05 um) on micrometry at the caecal apex was significantly thicker as compared to tunica mucosa (203.36 ± 26.25 um), tunica submucosa (243.47 ± 20.88 um) and total wall (1464.36±46.05 um) at body of caecum, respectively.

- In buffaloes, the total mean thickness of the caecal wall, on micrometry of cecal apex (1464.36±46.05um) was significantly ($p<0.05$) more than that at the body (1386.65±73.50um); whereas, cattle had significantly ($p<0.01$) lesser mean total wall thickness at the apex (2434.08±299.18um) as compared to that at body (3890.70±137.56 um).
- Although the orientation of collagen fibers in all tunics were same in both cattle and buffaloes but their arrangement varied between these species. Overall, qualitatively, the amount of collagen fibers was more in cattle than that of buffaloes in all the tunics.
- The amount of collagen fibers in caecal apex was more and denser than that of caecal body of cattle. Whereas, the amount of collagen fibers in caecal body was more and denser than that of caecal apex of buffaloes.
- The thickness of sub-epithelial connective tissue layers of caeco-colic mesentry in cows (339.55±10.71) was found highly significantly (p=2.20E-07) higher as compared to that in buffaloes (147.96±9.03).
- The collagen fibers of body of caecum ($p<0.05$) and mesentery ($p<0.01$) were found significantly higher in cattle as compared to that of buffaloes. However, no significant difference was recorded in the collagen fibers of apex of caecum in between two species quantitatively.
- Both cattle and buffalo samples showed very less amount of elastic tissue fibers in both caecal apex and body. Only minute amount of elastic fibers were present around the blood vessels.

Part 2: Control group study

Part 2 of study was divided into two groups; apparently healthy (Group 2a) and disease control (Group 2b).

Group 2a included, a total of 10 apparently healthy animals (5 cows and 5 buffaloes) that were either non-pregnant or in first trimester of pregnancy. Ultrasonographically, all except one cow had caecum seen in the flank region and in one cow caecum filled with mixed contents was seen cranially upto 12^{th} ICS. Out of the 9, caecum of 4 animals (one cow and 3 buffaloes) had no reverberation, while 5 (3 cow and 2 buffaloes) had mild reverberation. It suggested that excessive reverberations and scanning of caceum cranially beyond 12th ICS may be considered abnormal. Ultrasonographically, all animals showed strong biphasic reticular motility. Omasum size varied between 3-4 ICS, irrespective of species. In cows, the omasum was found located at least 1 ICS cranially as compared to buffaloes. The 8th and 9th ICS was found as the most common site for scanning of gall bladder in apparently healthy cows and buffaloes. The pylorus had good pyloric contractions (4-5/min) irrespective of species and appeared empty with acoustic shadowing. In cows, the pylorus was found to be located at least one ICS cranial as compared to buffaloes. Pylorus was scanned more ventrally in buffaloes as compared to cows but it was found to be associated with more total body wall length in buffaloes as compared to cows. The descending duodenum, at flank, was seen with an average diameter of 2.4 ± 0.54 cm with good to strong motility in both cows and buffaloes. The jejunum was seen in all the animals with an average diameter of 2.04 ± 0.44 cm with good to strong motility in all the animals irrespective of species. No apparent increase in peritoneal fluid was observed in apparently healthy cows and buffaloes.

Group 2b, included 20 animals (5 cows and 15 buffaloes) suffering from various disease conditions (unrelated to bowel obstruction) such as diaphragmatic hernia, pnuemonia, peritonitis, lung cyst, reticular foreign body and pericarditis. Eight buffaloes and 2 cows were in 3rd trimester of pregnancy while other animals were non-pregnant or in 1st trimester of pregnancy.

In majority of the animals (n=17; 4 cows and 13 buffaloes), caecum was scanned in the flank region, whereas it was also seen at 12th ICS in the remaining 3 animals. Caceum had mixed contents without reverberations in 12 animals (2 cows and 10 buffaloes), while 8 animals (3 cows and 5 buffaloes) had gaseous contents with mild reverberations. Out of 20, 5 animals had no reticular motility, while 5 had normal biphasic reticular motility and 10 had decreased or sluggish reticular motility. Seven animals had mild free fluid present in between the reticular recesses or jejunal loops, while 6 animals had severe fluid with or without fibrin and 7 had no free fluid seen on ultrasonography. The omasum seen was cranial most at 5th ICS in animals suffering from DH while the caudal most margin was at 11th ICS which was normal. Gall bladder, in majority of the animals, was seen at 10th (n=10) and 11th ICS (n=8), while in one cow suffering from DH and one buffalo (peritonitis) of this group, gall bladder was seen at 8th and 9th ICS.

The pylorus was seen cranial most at 7th ICS in 2 animals suffering from DH while in others the cranial most margin was at 8th ICS and the caudal most at 11th ICS. The pyloric contractions were good/normal in only 5 animals while sluggish or no contractions in rest of the animals. The mean distance of pylorus from the dorsal most spine was 85.77 ± 9.09 cm. The mean distance of pylorus from the ventral midline was 30.19 ± 11.57 cm and the mean total length of right side of bovine body at the level of pylorus (mid spine to midline ventrally) was 123.27 ± 12.01 cm. The duodenum was seen in all the animals with an average diameter of 1.61 ± 0.83cm. The motility was good to strong in 8 animals, while decreased in 5 and no motility was seen in 7 animals. The jejunum was seen in all the animals with an average diameter of 3.07 ± 1.22cm. The motility was decreased in 16 animals and was absent in 4, with 4 animals having fluid filled distended jejunal loops.

Part 3: Clincal case study

Total 15 animals were referred for diagnosis and treatment of caecal dilatation in study period of 1 year. Out of these 13 were buffaloes (86.67%) and 2 cows. Both the cows recovered for the condition, where one was treated surgically and one medicinally. However, out of 13 buffaloes, only 46.17% survived. The average age of animals presented was 7.3 ± 3.21 years (range 3 to 15 yrs). Most of the animals presented were more than 6yrs old (11/15=73.33%). And 3 buffaloes were more than 10 yrs of age. The middle age animals, showed 100% recovery from the condition. Four animals (buffaloes) were in the third trimester of pregnancy (4/15=26.67%). 3 animals were in first trimester of pregnancy (3/15=20%). Eight animals had a history of recent parturition from one day back to maximum of 3 months back (8/15=53.33%). Out of 8, 5 were parturited within 15 days of developing illness. Most of the animals in 3rd trimester recovered from the condition (75%). Least survivability was seen in young and those in 1st trimester and 1st parity. Most of the animals developed illness in late gestation of after parturition (7/15=46.67%). Four animals were in 1st parity (4/15=26.67%), 2 in 2nd parity (2/15=13.33%), 4 in 3rd parity (4/15=26.67%), 2 each in 4th and 5th parity (2/15=13.33%) and one in 11th parity (1/15=9.09%). Out of total 15 animals presented, 11 (11/15=73.33%) were active at presentation (including one cow) and 4 were dull (4/15=26.67%). The survivability was seen more in dull animals, which might be due to that the buffaloes usually remain active even in chronic conditions. The animals with intermittent anorexia survived the condition, also those with chronic illness showed 50% survivability.

Only 2 animals (one buffalo and one cow) had the history of bloat 3 and 8 days back, while others did not have any history of bloat. Majority of animals were not passing feces or passing thick white mucus only. The cow that was passing scanty loose feaces recovered with only medicinal treatment; however, those passing nothing, the mortality was high (66.67%) and those passing mucous had mortality in 45.45% cases. Among those passing mucous, 3 recovered only with medicinal treatment and 3 animals recovered with medicinal and surgical treatment. Among 2 which were not passing anything, one died after only medicinal treatment while one recovered after surgery. Five animals, including 2 cows had history of diarrhoea before onset of caceal impaction. Among those with history of diarrhea, 80% (n=4) recovered out of them 3 with only medicinal treatment and one required surgery also. Among those animals which had less chronic problem (n=6) of passing abnormal feces had better medicinal and surgical survival compared to those with chronic problem (n=9) of more than 5 days. Animals with intermittent pain (n=2) had 100% survival, while those with no pain (n=6) or with pain in start only once (n=4) had 50% survival.

On per rectal examination, out of 11 animals which had restricted hand movement, 6 survived (3 each with only medicinal and surgical treatment). Similarly, with those having free hand movement on per-rectal examination (n=4), 50% survived, (2 each from only medicinal and medicinal and surgical treatment). On per rectal examination, the rumen was classified as doughy (n=5), collapsed (n=4), firm (n=5) and one as resilient. Among those which recovered by only medicinal treatment, 2 had firm rumen and one each as doughy and collapsed. And among those recovering from surgical treatment, 2 had collapse and one each had resilient and doughy. So, taking overall outcome, the collapsed and resilient rumen showed very good survival rate.

On per-rectal examination, the small intestines were severely gas distended in 5 animals, out of them 3 survived (one with only medicinal treatment and 2 with surgery). 3 animals had fluid distended small intestines, of which only one survived that too after surgical treatment. The small intestines were not palpable in 4 animals, of which 3 recovered (2 by medicinal treatment only and one by surgery). Three animals had normally felt small intestines, out of which only one recovered by medicinal treatment only. The types of contents found in the rectum on per-rectal examination were classified as mucous only, mucoid feces, scanty feces and near normal feces. A total of 8 animals had only mucous on per-rectal examination and 4 of them recovered but all required surgical intervention. Four animals had mucoid feces on per-rectal examination of which 2 recovered and both by medicinal treatment only. Scanty feces were passed by 2 animals and one recovered by medicinal treatment. Normal feces was passed by one bovine which responded to medicinal therapy only.

The caecum was per-rectally classified as firm, gas filled, and fluid filled and not palpable. Most of the animals had gas distended caecum (n=7), out of which 5 recovered (one with medicinal and 4 with surgery). Fluid filled caecum was felt in 5 animals, of which only 2 recovered and both by medicinal therapy only. In 2 animals, the caecum could not be felt on per-rectal examination and both the animals died, indicating some other cause of death. In one bovine, the caecum was firm on palpation and it recovered by medicinal treatment only.

The hemoglobin and packed cell volume did not differ significantly among survivors and non-survivors in various groups; however, total leukocyte and absolute neutrophils counts in non-recovered animals (surgical as well as medicanal non-recovered) was markedly but non-significantly higher as compared to recovered animals (surgically as well as medicinally), irrespective of therapeutic protocol.

Markedly low levels of K was found in non-recovered animals as compared to recovered animals suggesting hypokalemia being a poor prognostic indicator, irrespective of medicinal or surgical treatment, in caecal dilatation affected animals. Marginally low level of Ca and P was found in medicinally non-recovered animals as compared to medicinally recoverd animals, inferring that hypocalcaemia and hypophosphataemia, pre-operatively, indicates poor medicinal prognosis in cases of caceal dilatation. Hypochloraemia was recorded as an overall poor prognostic indicator irrespective of treatment protocol. The mean serum levels of total protein, albumin and total bilirubin differed non-significantly among various groups; however, markedly high values of total protein, albumin and total bilirubin were found as poor prognostic indicators. In general, high serum levels of lactate (about 3-4 fold increase) and creatinine kinase (CK) (about 2 folds increase) as compared to reference ranges were observed suggesting their diagnostic importance. Marginally low levels of lactate and CK were observed in medicinally non-recovered animals as compared to medicinally recovered animals; however, in surgically treated animals, low level of lactate and CK were associated with good prognosis. Similarly, elevated serum levels of lactate dehydrogenase (LDH) was observed as good prognostic indicator in medically treated cases while poor prognostic indicator in surgically treated cases suffering from caecal dilation.

Non-significantly elevated levels of Na, P, Cl, Lactate, Alb and Total protein in the peritoneal fluid were observed in animals of surgically recovered as compared to surgically non-recovered animals suggesting good prognostic indicators for favourable surgical outcome. Markedly but non-significantly high levels of total bilirubin, CK and LDH in the peritoneal fluid were observed as poor prognostic indicators in operated cases suffering from caecal dilatation

Ultrasonographically, three animals had caecum distended in flank with no reverberation (3/15=20%) and out of them 2 recovered from the treatment (2/3= 66.67%), one only medicinally and one with surgery. Other 4 animals had caecum distended in flank with reverberation present (4/15=26.67%) and out of them 2 recovered with medicinal treatment only (2/4=50%). Another 4 animals had distended caecum upto 12 ICS cranially with reverberation present (4/15=26.67%) and 2 recovered one each from medicinal and surgical treatment (2/4=50%). Three animals had distended caecum upto 11th ICS (3/15=20%) with reverberation present and out of them 2 recovered each from medicinal and surgical treatment (2/3=66.67%). One bovine had caecum distended upto 10th ICS with reverberation present and did not recover with the medicinal and surgical treatment.

Distended SI, based on motility were classified as distended with mild peristalsis, distended with swirling motility and distended with complete ileus. Five animals had small intestines distended with mild peristalsis (5/15=33.33%) and 2 recovered from treatment (2/5=40%). Two animals had distended small intestines with swirling motility (2/15=13.33%) and both recovered (100%). Seven animals had distended small intestines with complete ileus (7/15=46.67%) and 3 recovered from treatment (3/7= 42.86%). One bovine had collapsed adhered intestines with ileus (1/15=6.67%) but recovered with only medicinal treatment (100%).

Pleural fluid was found increased in nearly 50% of the animals. Four animals (4/15=25%), including one cow had mild increase in pleural fluid i.e <4cm column, while 2 had moderate increase (<6cm) in pleural fluid (2/15=13.33%) and one cow had significant pleural effusions but recovered from medicinal therapy only suggesting that caecal dilatation in this case could have developed secondarily. One cow with severe pleural effusions recovered from the condition, while those with no pleural effusions had 38.5% survival. However, if present, mild effusions had better prognosis as compared to moderate effusions.

The biphasic reticular motility was present in 10 animals (10/15=66.67%), including one cow, however, it had decreased amplitude in 5 animals (5/10=50%), suggesting possibility of reticulo-peritonitis / adhesions. Five other animals had no reticular motility recorded on ultrasonography (5/15=33.33%). One bovine which had normal reticular motility also had a 10cm anechoic pocket near reticulum, and the buffalo did not recover from the treatment. Even, reticular motility was not found directly correlated with the survival outcome as 5 animals each had normal motility, reduced motility and absent reticular motility, while those with normal and absent motility both had equal survival outcome (60%).

In 7 animals (7/15=46.67%) the cranial omasum boundary was seen an ICS cranial than normal, i.e at 6^{th} ICS, which might be due to the intestines/caecum pushing it cranially. However, in 3 animals omasum was seen one ICS caudally than normal i.e at 8^{th} ICS, which could be due to sometimes the filled colon go underneath omasum on rt side and lift and push it caudally and dorsally. On USG of caecum, in 2 of these 3 animals, the caecum were greatly distended in right flank. The surgery was done in one of these animals and found severely impacted colon underneath the omasum, thus correlating the findings. Out of these 3 animals, only one recovered (1/3=33.33%), thus making the caudal displacement of omasum at 8^{th} ICS, a poor prognostic indicator for cecal/colon impaction. One bovine had omasum pushed dorsally. In 4 animals, the omasum was seen at normal position, and 2 survived (2/4=50%).

Mild amount of free fluid without fibrin was present in between the small intestinal loops in 5 animals (5/15=33.33%) and only 2 animals survived out of them (2/5=40%). Two animals had moderate free fluid in between the intestinal loops and both died. Two animals had severe free fluid with fibrin in between the loops and one cow survived (50%). Two animals had mild peri-reticular reaction near reticulum and both survived (100%) while one had severe reaction and died. One bovine had fibrin in between spleen and reticulum and the loops but recovered. No significant difference in the relative positioning of pylorus was seen in diseased and apparently healthy animals when compared for both species individually or united.

In all the 7 animals operated, the caecum was found impacted with contents. In one bovine the colon was also found severely impacted and could not be emptied. Two animals had fecalith in large colon which was kneaded. One bovine had impacted small intestines with no motility and the fecal material was kneaded and forwarded. This bovine had small intestinal ileus on USG also. The bovine had regurgitated before surgery and had open mouth breathing and died the next day. In one bovine caecum could not be exteriorized due to severe impaction and adhesions and the bovine died after 2 days. Two animals passed feces within 24 to 72hrs of surgery but died due to regurgitation prior to surgery and other dehydration reasons. All the animals whether treated surgically of medicinally, first passed hard feces and later on loose feces for 2-3 days. Some animals even had diarrhoea for few days. The chronicity of the disease leads to poor prognosis in animals due to severe dehydration, altered acid-base and motility disorders. On an average, operated animals passed feces early as compared to those treated medicinally.

Conlcusions:

1. Grossly cow caecum has longer apex devoid of ileocaecal mesentery. Besides, the ileocaecal mesentery has markedly high fat content as compared to that in buffaloes.
2. Histologically, caecal wall at body and apex and its various layers (particularly tunica submucosa and muscularis) are thicker in cows as compared to buffaloes.
3. Cow caecum has more collagen content (qualitatively and quantitatively) as compared to buffalo caecum.
4. Dilated caecum of the buffalo is difficult to exteriorize from surgical site as compared to cows.
5. Haemato-biochemically, neutrophilic leukocytosis, thrombocytosis, hypokalemia, hypochloremia, high creatinine kinase and lactate dehyrogenase are poor prognostic indicators for caecal dilatation. Besides, elevated serum lactate level

(3-4 times than upper normal range) are diagnostic indicators of dilated caecum in bovine but could not be correlated as prognostic indicator.

6. Cows and buffaloes with dilated caecum seen, ultrasonographically, at flank and extending cranially upto 12th ICS and with motile small intestines with diameter (<3 cm) are suitable for conservative therapy.
7. Animals with dilated caecum, seen ultrasographically, at the 11th ICS or cranially require surgical intervention. Severe ileus of small intestines, increased peritoneal fluid with fibrin, dilated duodenum and pylorus with intraluminal fluid are poor prognostic indicators.
8. Long term outcome of caecal dilatation surgery is fair to good. Caecal decompression surgery in buffaloes is a challenging task due to no or poor exteriorization of the dilated caecum that consequently leads to serious intra-operative complications.

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VITA

Name of the student	:	Vinod Kumar Shukla
Father's name	:	Sh. Ramesh Chander Shukla
Mother's name	:	Smt. Malti Devi
Nationality	:	Indian
Date of birth	:	11-04-1995
Permanent home address	:	H.no 812, St. no. 20, North Suraj Nagar, Zira Road, Distt. Moga, Punjab-142001

EDUCATIONAL QUALIFICATION

Bachelor degree	:	B.V.Sc. & A.H.
University	:	GADVASU, Ludhiana
Year of award	:	2018
OGPA/OCPA/% marks	:	7.564/10.00
Master's degree	:	M.V.Sc.
OCPA	:	8.543/10.00
Awards/Distinctions/Fellowships	:	Appreciation award at ISVS 2019 Hisar in Poster presentation. University Scholarship.