Journal of Current Veterinary Research

ISSN: 2636-4026

Journal homepage: http://www.jcvr.journals.ekb.eg

Microbiology

Serotypes, Virulence Factors and Antibiograms of *Escherichia coli* Isolated from Diarrhetic Calves in Egypt: A review

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ABSTRACT

Colibacillosis is the main trouble confronted in cattle outputting, causing considerable economic losses. The infected or carrier calves and cows shed the bacteria in the feces and causing the transmission of pathogenic *E. coli* to calves at the environment. Diagnosis of *E. coli* infection in calves relies on history, clinical signs, the culture of bacteria, and serotyping of bacteria. Colibacillosis requires immediate response to colibacillosis is variable, centered on isolation and treatment of dehydration &antimicrobial therapy. Parental antibiotics can give a good result if given in the early stage, but not without rehydration therapy. The prevalence of colibacillosis differs from 5.4 to 100%, and it is roughly estimated that calf mortality connected with colibacillosis of 20% may reduce net profit to 40%. The emergence of multi-drug resistant *E. coli* isolated from diarrhetic calves has been raised as a new concern for public health and food safety authorities. Routine monitoring of *E.coli* isolated from diarrhetic calves will help reduce the transmission to humans and help select the most effective antibiotics. In conclusion, dam vaccination before calving, improve hygiene around calving and proper colostrum administration considered the main factors to control and prevent the disease. In addition, vigilant monitoring of *E. coli* isolates recovered from diarrhetic calves for antimicrobial sensitivity pattern will help choose the appropriate antibiotic and decrease the transmission of theses isolates to humans.
Keywords: *E. coli*, calves, serotype, virulence.

INTRODUCTION

Diarrhea in newly born calves is one of the more generic diseases affecting calves after birth and even till three months old (Svensson, *et al.*, 2003). Calf diarrhea did not perceive it a trouble by beef producers while in dairy producers was considered as minor trouble (Roderick, and Hovi, 1999), and still the main cause of economic and productivity loss to cattle producers and like previously leading to high morbidity and mortality in the cattle industry worldwide (Uhde, *et al.*, 2008; Bartels, *et al.*, 2010). There are many infectious agents causing diarrhea in newly born calves (Smith, 2009) including bacteria (*E. coli*, *Salmonella*, and *Clostridium*), viruses (*bovine coronavirus*, *bovine viral diarrhea virus*, and *bovine rotavirus*) and protozoa (*Cryptosporidium*) (Bhat, *et al.*, 2012; Bhat, *et al.*, 2013; Singla, *et al.*, 2013). *E. coli* and *Salmonella* are the main pathogens isolated and characterized in scouring calves (Acha, *et al.*, 2004), leading to severe intestinal lesions, alterations in nutrient transport mechanisms and modification in enzyme activity. *E. coli* has been emerged as a major infectious agent of diarrhea in newly born calves (Nguyen, *et al.*, 2011), and usually associated with considerable economic wastage, involving elevation morbidity and mortality rates, dwindled growth rate, altitude treatment costs, and wasted the time for mangement with the diseased animals (Ok, *et al.*, 2009). *E. coli* is gram-negative bacteria, facultative anaerobic, rod-shaped, non-sporulating, and flagellated bacterium of the family Enterobacteriaceae (Conway, 1995). There are many types of pathogenic *E. coli* as enteropathogenic *E. coli* (EPEC), enterotoxigenic *E. coli* (ETEC), enterohaemorrhagic *E. coli* (EHEC) and Shiga-toxin producing *E. coli* (STEC) (Nagy, and Fekete, 2005; Andrade, *et al.*, 2012; Aref, *et al.*, 2018). Enterotoxigenic *E. coli* ETEC has been characterized as a the main cause not caused of diarrhea in calves, while the others are isolated from diarrhea as well as normal feces (Nagy, and Fekete, 2005; Nguyen, *et al.*, 2011; Andrade, *et al.*, 2012; Kolenda, *et al.*, 2015). STEC produces *Stx1* toxins and *Stx2* toxins, which were known as Vero toxin or Shiga-like toxin because of their similarity to the Shiga toxin produced by *Shigella dystenteriae* and *Shigella sonnei*. The *Stx1* and *Stx2* can prevent protein synthesis and outputted apoptosis in target cells also *Stx1* produces 10-fold more powerful cytotoxic effect than does *Stx2* in Vero cells (Melton-Celsa, 2014). The role of the STEC as a causative agent of diarrhea in calves is not yet determinative. There are reports of cases of fatal STEC incidence in cattle (Kolenda *et al.*, 2015). In humans, it causes hemolytic uremic syndrome (HUS) and hemorrhagic colitis (Fakih, *et al.*, 2017; Griffin, *et al.*, 1991). STEC carried by healthy cattle may be forming a potential hazardous to humans.

Molecular identification of virulence factors assists in *E. coli* classification, depending on the existence of virulence markers is vital for the differentiation of *E. coli* pathotypes employing the widely using multiplex PCR (Vidal, *et al.*, 2005; Müller, *et al.*, 2007; Nguyen, *et al.*, 2011). Additionally, identification of virulence factors can help expect the prognosis based on the pathogenicity of each type that varies significantly according to the integrated virulence factors. The STEC, EPEC, and NTEC are opportunistic pathogens, which are isolated from non-diarrhetic calves (Osek, 2001; Mainil, 2000; Herrera-Luna, *et al.*, 2009). The objective of the present study was to show the most important serotypes of *E. coli* isolated from diarrehetic calves and the antibiotic resistance patterns of these isolates with the reference to the isolates recovered from diarrhetic calves in Egypt.

TRANSMISSION

fecal-oral contact, fecal aerosol are the main sources of infection due to the presence of the organism in these secretions which excretion during the preclinical bacteremic phase. The transmission in groups of calves can occur by urinary and respiratory aerosols, fecal-oral contact and direct nose-to-nose contact (Gruenberg, 2014). The feces of infected animals encompass the healthy neonates, healthy dams, and newborn animals suffering from diarrhea which is considered complications of the organisms. The incursion of *E. coli* through oropharyngeal mucosa and nasal mucosa and also, through intestine trans umbilical veins and the umbilicus. Infection with *E. coli* (Septicemic strains) leading to shock and rapid death due to the release of endotoxin. Subclinical bacteremia is characterized by the speedy development of septicemia and endotoxemic shock leading to death. within a long time of course occur localization of infection, meningitis, polyarthritis and may be leading to nephritis and uveitis appear with less virulent strains (Bashahun, and Amina, 2017).

EPIDEMIOLOGY OF COLIBACILLOSIS IN CALVES

Epidemiological investigators revealed that different species of animals may act as a reservoir of *E. coli* O157: H7 (Nelson, *et al.*, 1998) *E. coli* O157: H7 was a dominant VTEC serotype in many parts of the world (Karamali, 1989). In addition *E. coli* O157: H7 was isolated from feces of young cattle in dairy farms associated with two cases of haemolytic uremic syndrome (HUS) (Wells, *et al.*, 1991). Divergences prevalence of *E. coli* has been observed by many studies. Masud, *et al.*, (2012) reported 22 (44%), Dereje, (2012) reported 25 (43.1%) and also, Paul *et al.*, (2010) reported 76 (76%). This high and low occurrence of *E. coli* may be due to the difference in the study area, age of calves, farm size, and sample size, management, and hygiene measurements. For example, in the study conducted by Nabila (1995), who collected rectal fecal samples from 343 diarrhetic cattle calves and 245 diarrhetic buffalo calves, 29.2% and 33.9% were positive for *E. coli* respectively. Perez *et al.*, (1998) studied the infectious agents associating with diarrhea of calves. They found that *E. coli* was detected in 94% of the examined fecal samples, but only 3 (1.83%) of the isolates from diarrhetic calves contained the K99 antigen. Another study, where out of bacteriologically examined 38 faecal swabs collected from calves aged 5 – 25 days (30 with diarrhoea and 8 was clinically healthy) 40% were positive for *E. coli* either alone or in association with *Proteus* Spp., or *Kliebsilla* Spp., or *Pseudomonas* Spp. or *Campylobacter* Spp. and/or *Salmonella* Spp. (Sadiek, and Sohair, 1999). Singla *et al.*, (2013) recorded that 850 (15.6%) of calves died before 6 months of age was due to *E. coli* infection. The overall postnatal mortality with colibacillosis was higher in males (17.21%) than in females (15.21%). *E. coli* mortality was 4.5% up to one month, 3.5% between 1 and 2 months, 2.9% between 2 and 3 months, 1.4% between 4 and 5 months and 1.8% between 5 and 6 months of age.

SEROTYPES OF *E. COLI.*

Regarding the prevalence of *E. coli* isolation in several Middle Egypt Governorates, in El-Fayoum (71.4%) due to highly intensive calves rearing systems, in Giza (66.7%) and Beni-Suef Governorate (57.1%) due to the lower intensive calf rearing and production systems. Regarding the prevalence of serogroups O26 (21.1%), O103 (18.4%), O86 (13.2%), O111 (10.5%). Serogroups O119, O127, O157 (5.3%) while serogroups O18, O44, O158 (2.6%). and untyped *E. coli* (13.2%) (Abed, and Menshawy, 2019). The prevalent *E. coli* serotypes in Egypt which were isolated from calves suffering from diarrhea were O26, O103 and O119 (23.52%), (19.6%) and (17.64%) followed by O86, O157, and O111 (5.88%); O44, O128, and O125 (3.92%) while O78 (1.96%) finally untyped *E. coli* (7.84%) (Abd-Elrahman, 2013). In another study, O26 and O103 (17.7%), O127 (14.6%), O119 (13.6%), O86, O111, O157 (5.2%), O44, O158 (4.2%), O78 (3.1%) and untyped E. coli isolates (9.4%) (El-Seedy, *et al.*, 2016). Badouei *et al.*, (2010) recovered serotypes from diarrhetic and non-diarrhetic calves O157:H7, O111, and serogroup O26 (18.4%). The Data presented in Figure 1 summarizes the serotypes of *E.coli* commonly isolated from calves suffering from diarrhea in Egypt during the period from 2011 till 2020.

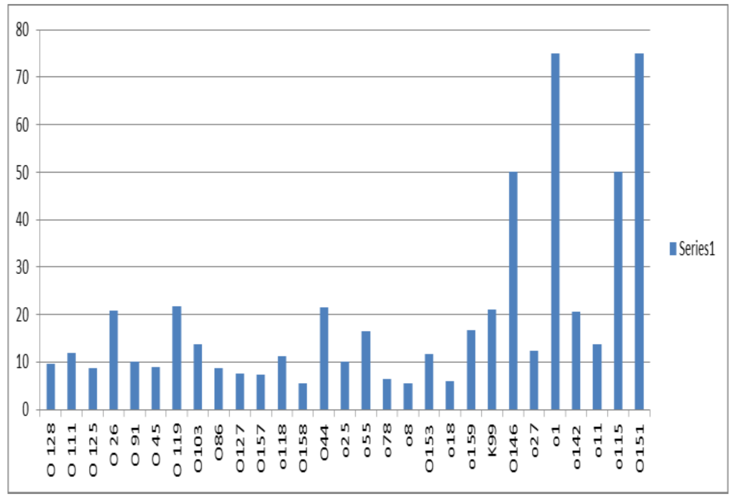

Fig. (1): Serotypes of *E.coli* commonly isolated from calves suffering from diarrhea in Egypt (2011-2020).(Abd-Elrahman 2011, Atwa.et al ., 2012, Galal, *et al.*, 2013, Mona, et al ., 2013, El Bably, et al ., 2016, El-Seedy, et al ., 2016, Abd El-Tawab et al ., 2017, Hakim, et al ., 2017, Abed, *et al.*, 2019, Khalifa et al. 2019, Mohammed et al.2019, Algammal, *et al.*, 2020).

Serotypes of *E.coli* commonly isolated from calves suffering from diarrhea in Egypt (2011-2020) were O151(75%), O1(75%),O115(50%), O146(50%), O119(21.64%), O44(21.43%), K99(21.1%), O26(20.76%), O142(20.69%), O159(16.78%), O55(16.50%), O103(13.84%), O11(13.8%), O27(12.3%), O111(11.93%), O153(11.62%), O118(11.11%), O91(10.1%), O25(10%), O128(9.60%), O45(8.9%), O125(8.76%), O86(8.72%), O127(7.61%), O157(7.35%), O78(6.34%), O18(5.96%), O8(5.51%) and O158(5.5%).

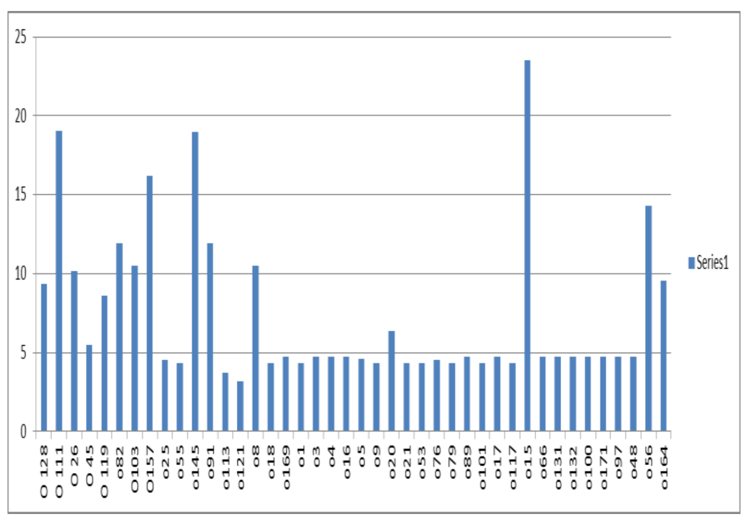

Fig. (2): Serotypes of *E.coli* commonly isolated from calves suffering from diarrhea in countries otherthan Egypt during 2010-2020. (Vagh, *et al.*, 2010; Vagh, *et al.*, 2010; Nizza, *et al.*, 2010, Nguyen, *et al.*, 2011, Irshad *et al.*, 2012, Wani *et al.*, 2013, Shahrani, et al ., 2014, JAROS, et al ., 2016, Habets ,*et al.*, 2020).

Serotypes of *E.coli* commonly isolated from calves suffering from diarrhea in countries otherthan Egypt during 2010-2020 were O15 (23.5%), O111(19.03%), O145(19%), O157(16.18%), O56(14.28%), O82(11.9%), O91(11.9%), O8(10.52%), O103(10.49%), O26(10.16%), O164(9.52%), O128(9.35%), O119(8.6%), O20(6.38%),O45(5.5%), O169(4.76%), O3(4.76%), O4(4.76%), O16(4.76%), O66(4.76%), O131(4.76%), O132(4.76%), O100(4.76%), O171(4.76%), O97(4.76%), O48(4.76%), O17(4.76%), O89(4.76%), O5(4.60%), O76(4.53%), O25 (4.53%), O9(4.3%), O79(4.3%), O21 (4.3%), O53(4.3%), O101(4.3%), O117 (4.3%), O1(4.3%), O18(4.3%), O113(3.73%) and O121(3.2%). In conclusion, serotypes O151, O115, O146 and O1 in are commonly isolated in Egypt while in O15, O111, O145 and O157 are commonly isolated from other countries.

PATHOGENESIS AND VIRULENCE FACTORS

Connecting *E. coli* strains with individual cases or outbreaks of diarrhea among neonatal calves, pigs, lambs, and humans have assisted to restrict specific virulence factors that could use to characterize between commensal strains and pathogenic (Okerman, 1987). Ingestion of contaminated vegetables and fruits with the animal feces leading to the significant numeral of STEC-outbreaks and in humans is mainly associated with hemorrhagic colitis and hemolytic uremic syndrome. STEC has main public health significance, since incrimination in triggering numerous food-borne outbreaks (Nguyen, *et al.*, 2015).

Its pathogenicity is attributed to the expression of fimbrial antigens, such as F5, and amplifying of one or more enterotoxins such heat-labile enterotoxins (LT) and heat-stable enterotoxins (ST) (Welch, 2006). Afterward, EPEC pathotype causing attaching and effacing (AE) lesions on intestinal cells due to the production of the intimin (protein in nature) which causing diarrhea in young calf and dysentery (Moxley, and Smith, 2010; Mainil, and Fairbrother, 2014). Intimin enhances adherence of *E. coli* to the enterocyte, causing obliteration of the brush border microvilli and destroys the gastric microvillus brush border (Franck, *et al.*, 1998; Nataro, and Kaper, 1998). The virulence of *E. coli* determined by the presence of virulence-associated factors (VAFs) and affected by animal numbers, health status, isolate number, VAF prevalence, serotypes, diagnostic methods, and biological assays (Kolenda, *et al.*, 2015). Virulence factors in *E. coli* involve the competence for resistance phagocytosis, killing by serum, utilization of highly efficient iron acquisition systems, producing colicins and adhering, colonizing, and invading the hosts' cells. In addition, the secretion systems, producing of cell surface molecules, transmit and siderophore composition were considered as virulence determinants of *E. coli*. Several virulence factors are connected with the pathogenicity of STEC (O157:H7) involving Shiga toxin 1, Shiga toxin 2, enterohaemolysin and intimin (Kang, *et al.*, 2004).

Fimbrial adhesins and enterotoxins are considered the main virulence factors causing diarrhea connected with enterotoxigenic *E. coli*. Fimbrial (pili) antigens are more distinguished virulence factors characterized for ETEC strains which enabling the bacteria to adhere and colonize the luminal surface of the small bowel and elaborating of one or more enterotoxins that influence the secretion of fluids in the intestine (Holland, 1990) through increased cellular concentrations of cyclic AMP (cAMP) or cGMP. Also, the connectively with serotypes or serogroups does not confer virulence, the consequence of many studies have reported that ETEC strains are limited to a few serotypes or serogroups (Soderlind *et al.*, 1988). The main detected fimbriae on ETEC from calves suffered from diarrhea are F5, also named K99 and F41, but strains with F165 fimbriae have also been identified (Contrepois, *et al.*, 1989). K99 antigen is a fimbrial adhesion distinctively from K antigens (capsular polysaccharide) (Orskov, *et al.*, 1975), virulence factors (F5 and F41) have been associated with diarrhea in animals (Kolenda, 2015; Toledo, *et al.*, 2012), also these genes are discovered at the decreased frequency with increasing age. *E. coli*-connected F17 fimbrial adhesions have been characterized from animals and humans with diarrhea with or without septicemia (Le Bouguenec, *et al.*, 1999). On the contrary, STEC is not ordinarily connected with the disease in cattle and is discovered more frequently in healthy animals (Kolenda, 2015). Fimbrial adhesins (F5, F17, and F41) mediate the conjunction of bacteria to epithelial surfaces in the small intestines, and so, facilitation bacterial colonization with both heat-stable (STa and STb) and heat-labile (LT) enterotoxins; the toxins enhancing the excretion of fluids and electrolytes from the intestinal epithelial cells, which eventually lead to diarrhea (Guler, *et al.*, 2008; Vu-Khac, and Cornick, 2008; Vu-Khac ,*et al.*, 2007), and mainly associated with Shiga-toxin producing *E. coli* in calves (Nagy, and Fekete, 2005).

The most prevalent virulence genes *Stx1* and *Stx2* connected with STEC, which are responsible for the pathogenesis and assisted by the intimin gene (eaeA) (Sandhu, and Gyles, 2002; Constable, *et al.*, 2017). The LT gene is the more prevalent enterotoxin gene which accompanied the ETEC strains isolated from calf suffering from diarrhea, either alone or with the sta and or the f 41 genes (Algammal, *et al.,* 2020).

Enterohemorrhagic *E. coli* (EHEC), considered a highly virulent strain of STEC, harbors numerous genes coding for (*Stx1* and *Stx2*) Shiga toxins, the protein intimin (*Eae*), and the plasmid encoding *E. coli* hemolysin (*hly*A) (Law, 2000; Kamel, *et al.,* 2015). EHEC strains from animals that produce Shiga toxins and induced AE lesions are termed AESTEC (Piérard, *et al.*, 2012; Fakih, *et al.*, 2017; Thiry, *et al.*, 2017). The bacteriophages play an important role in the transmission of stx genes. The stx-phages are sharing an analogous sequence that identical to lambdoid-phages. The existence of stx genes in the phage lysis-portion illustrates the link between the productions of Shiga-toxins, during the lytic growth released of phage. (Aref, *et al.*, 2018; Hashish, *et al.*, 2016). There are "factors" produced by certain strains of *E. coli*, which leads to necrosis in rabbit skin tests. These factors was called cytotoxic necrotizing factor (CNF). It has a molecular mass of approximately 115 Kda, the pathogenic countenance of *E. coli* O157: H7 involve the producing of Shiga toxin 1 (*Stx1*) and/or Shiga toxin 2 (*Stx2*), the possession of a locus of enterocyte effacement containing an *eae* A gene that encodes a protein called intimin, and the possession of an ~ 60 – Mda plasmid that encodes a hemolysin (Ngeleka, *et al.,* 2019).

ANTIBIOGRAM OF BACTERIA CAUSING DIARRHEA IN CALVES

Antibiograms are more dependable for detection of antibiotic resistance than genotypic resistance gene detection (Scaria, *et al.,* 2010). The fear from drug resistance are propagated and transferred of these resistance genes not only to other bacteria but also to other hosts like humans.Therefore, drug resistance can be transferred to bacteria which never exposed to the drug if overusing of antimicrobials for the prophylaxis and treatment of agricultural animals and people (Wellington, *et al.*, 2013; Aly, and Albutti, 2014; Levy, and Marshall, 2004). The modified bacteria with the integrable resistance genes could be infective for new hosts including humans.

High resistance to tetracyclines and streptomycin (penicillin-streptomycin mix) due to use of these broad-spectrum antibiotics by farmers and paramedical people (Sobhy, *et al.,* 2020). None of the isolates was resistant to imipenem, which is not amazing because there is no commerce medicine for veterinary use that contains imipenem as an energetic ingredient in Egypt.

(FDA, 2020) reported high resistance to trimethoprim-sulfamethoxazole as Egyptian paramedical people use this drug as a selector to any gut infection. Also there are no veterinary trade drugs that include ceftazidime, nalidixic acid or aztreonam as active components (FDA, 2020), resistance was discovered against them. This may be due to using of human drugs for medicating of diseased animals and moving of human bacteria, in which resistance has really advanced, to animal hosts (Wellington, *et al.*, 2013), excretion of these antibiotics and their metabolites in human sewage and sludge, from which resistant is afterward devolves to animals stub through the using of sludge as a fertilizer or through irrigating with wastewater (Wellington, *et al.,* 2013; Heuer, *et al.,* 2011).

The *E. coli* isolates were highly sensitive to marbofloxacin, enrofloxacin, chloramphenicol, sulfa trimethoprim and gentamycin. But most of them were resistant to neomycin, streptomycin, amoxicillin and tetracycline (Nasr, *et al.*, 2014). Antimicrobial resistance of *E. coli* cefotaxime andAmpicillin,(100%) clindamycin,92.3% followed by kanamycin (50%) followed by kanamycin (50%) (Mohamed, *et al.,* 2019). The antimicrobial resistance is ordinarily connected with pathogenic *E. coli* that could be imputed to the large-scale incorrect using of antibiotics. The multidrug resistance (MDR) is common in *E. coli* and initially connected with numerous genes as; bla-TEM, blaCTX (B-lactamase genes), and B (aminoglycoside resistance gene) and sul1 (sulfonamide resistance gene) (Algammal, *et al.*, 2020; Yamamoto, *et al.,* 2013).

Nasr, *et al.*, (2014) reported that the antibiotic resistance of *E. coli* isolates to ampicillin (71.4%), amoxicillin (64.3%), sulfa trimethoprim (50%), gentamicin, and kanamycin (42.8%), whereas, the *E. coli* isolates were highly sensitive to trimethoprim-sulfamethoxazole, ciprofloxacin, norfloxacin, and tetracycline (100%), then less sensitive to cephalosporin group and amikacin (71.4%).

CLINICAL FINDING

The degree of morbidity and mortality had be changed in a specific flock of animals according to *E. coli* strain (Ahmed, *et al.*, 2013; Nolan, 2013). Calves suffering from a varying degree of diarrhea depending on their hydration case (Naylor, 2002; Radostits, *et al.*, 2007).

In mild cases, the animal had good suckling and can be standing without helper, we are observed sternal recumbency and weak suckling in moderate cases, loss of consciousness, lateral recumbency and no suckling in severe cases. The manifestation of eyeball and skin elasticity test helps us in the observed hydration case of calves suffering from diarrhea. In mild case mild skin tenting without considered changes in the eyeball, while in moderate cases obvious skin tenting and mild to moderate sunken eyeball and in severe cases we observed severe losses in skin elasticity and moderate to severe sunken eyeball and noticed cardiac arrhythmia following by dangerous changes as metabolic acidosis, hyperkalemia and hypovolemia. Also, omphalophlebitis, ophthalmitis, polyarthritis and meningitis may occur within the first days of infection (Gruenberg, 2014) and may cause sudden death in calves through the first days of age due to toxemia or septicemia (HMD, 2010).

Salmonella spp, *Pasteurella*, *Diplococcus* and *Streptococcus* causing acute septicemias may simulate colibacillosis in calves. There are three forms to syndromes connected with colibacillosis (Gay, 1964). The first, colisepticemic form is leading to rapid death of the calves and is associated with an *E. coli* bacteremia. While there are many strains of *E. coli* have been isolated from calves suffering from colisepticemia. The second enteric-toxemic form is also, connected with collapse and rapid death of the animal, but it is connected with the proliferation of certain specific strains of *E. coli* in the small intestine. Without bacteremia. Toxemia leading to death. The third enteric form weakness, dehydration, diarrhea and abdominal distention may be leading to death due to hypovolemic shock (Gruenberg, 2014) or not according to the severity of the physiological disturbance produced.

DIFFERENTIAL DIAGNOSIS

Salmonellosis

Animal suffering from high temperature, depression, diarrhea characterized by the presence of fibrin and blood. Calves are ordinarily affected at six days of age or oldest. This proximally to the age of the *coronavirus* infection and the infection is dangerous in young or emaciated animals. On necropsy finding in the intestine membrane like coating is strong hypothetic substantiates for presentation of *salmonella* (Hudson, and White, 1982).

Coronavirus

The infection in calves by virus occur over five days after birth. Firstly the virus infected the herd, and affect animals suffering from scour up to six weeks of age or oldest. Calves are not as depressed as in case of infection with *rotavirus*, but the fecal material may have the same manifested, fecal material may contain clear mucus that likens the white of an egg, Diarrhea may continue from several hours to several days. The mortality rate from 1 to 25% (Hudson, and White, 1982).

Rotavirus

The infection in calves by virus occurs 24 hours after birth. Firstly the virus infected the herd, and affect animals up to 30 days of age or oldest. The diseased animals suffering from terribly depression, drooling of saliva and watery diarrhea yellow to green in colour (Hudson, and White, 1982). Infection with rotavirus alone causes there is no diagnostic gross lesions in the intestine, but present in a large amount in the large and small intestine.

Bovine Virus Diarrhea

This virus causing diarrhea from two to three days after infection and may continue for some time and death in young calves. Clinically we are found ulcers in the mouth, lips and tongue (Hudson, and White, 1982).

Cryptosporidium

This is a protozoan parasite infected calves from 1 to 3 weeks in age, has the ability to adhere to the cells that comports the small intestine and to damage the microvilli. *Cryptosporidium* is a protozoan parasite that is much smaller than *coccidia*. It has the ability to adhere to the cells that line the small intestine and to damage the microvilli. This is discovered in combination with *rotavirus*, *coronavirus*, and/or *E. coli* (Hudson, and White, 1982).

<u>Coccidiosis</u>

Coccidiosis can be infected calves at three weeks of age and oldest, normally the infection is due to stress, overcrowding, sudden changes of feed and poor sanitation, it often occurs in calves of 7 to 14 days after they are relocated from the calving lots onto pasture (Hudson, and White, 1982). Sometimes, clinically in the fecal material appear very few parasites with bleeding. Death may occur firstly in the acute period or later from secondary multipliers

ZOONOTIC IMPORTANCE

Many studies showed that, diarrhea in livestock is significant because of the public health consequence. Food animals and their products are considered the main sources of infectious pathogens for humans. Healthy and calves suffering from diarrhea harbor STEC in their intestine (Roopnarine, *et al.,* 2007) and shed the bacteria in large amounts for many months (Widirasih, *et al.,* 2004).

Diseases in young animals, leading to massive economic and productivity losses to bovine industry worldwide (Cho, and Yoon, 2014). Several infectious agents triggering diarrhea in animals have zoonotic importance and have been connected with food-borne diseases (Trevejo, *et al.,* 2005). Infections in humans are due to consumption of raw or undercooked meat of food animals or any foods polluted by animal faces, raw milk, unpasteurized cheese, unpasteurized juice and foods contaminated by infected food workers via fecal-oral and by contact with STEC-positive animals or with their habitat (Paton, and Paton, 1998; Sabin, 2006).

Primary reservoirs of *E. coli* O157:H7 were dairy and beef cattle which shed in their feces (Bach, *et al.*, 2002). *E. coli* and their subtypes (O26, O111, O118 and O157) are firmly associated with apparent food-borne diseases, particularly Shiga toxin-producing *E. coli* (STEC). In humans, EHEC a sub of STEC is connected with hemolytic-uremic syndrome (HUS), haemorrhagic colitis (HC), and thrombotic thrombocytopenic purpura (TTP), especially in infants, young children and in the elderly (Nataro, and Kaper, 1998).

REFERENCES

Abd El-Tawab, A.A., Hofy, F.I., Mohamed, S. R. and Salim, R.A. (2017):Bacteriological and molecular studies on some bacterial agents from neonatal calf diarrhea. BENHA VETERINARY MEDICAL JOURNAL, VOL. 33, NO. 2: 465-475.

Abd-Elrahman, A.H. (2011): Colibacillosis in Newly Born Buffalo Calves and Role of Lacteol Fort in Preventing Recurrence of Calf Diarrhea Life Science Journal;8(4): 497-502.

Abdulgayeid, M., Shahin, H., Foad, S., Madiha S. and Ibrahim, M .S. (2015): Molecular Characterization of Escherichia Coli Isolated from Buffalo Calves in El-Behera Governorate Alexandria Journal of Veterinary Sciences 47: 90-96.

Abed, A.H. and Menshawy, A.M.S. (2019): Escherichia coli Neonatal Calf Diarrhea in Middle Egypt: Prevalence, Phenotypes, Genotypes and Pathotypes World Journal of Veterinary Science, 7, 14-23.

Achá, S. J., Kühn, I., Jonsson, P., Mbazima, G., Katouli, M., and Möllby, R. (2004): Studies on calf diarrhoea in Mozambique: prevalence of bacterial pathogens. Acta Vet Scand. 45(1–2): 27–36.

Afema, J.A., Davis, M.A. and Sischo, W.M. (2019): Antimicrobial use policy change in preweaned dairy calves and its impact on antimicrobial resistance in commensal Escherichia coli: a cross sectional and ecological study. BMC Microbiology 19: 217.

Ahmed, M., Youssef, F. and Rahman, A. (2013): Differentiation between E. coli strains causing diarrhea in broiler chicken by using multiplex PCR. Proc. 6th Inter. Conf. Vet. Res. Div., NRC, Cairo, Egypt, Pp. 33-47.Alexandria Journal of Veterinary Sciences, 43: 8-16.

Algammal, A. M., Ali W. El-Kholy, A. W. , Riad, E .M., Mohamed , H. E., Elhaig ,M .M ., Al Yousef, S . A., Wael N. Hozzein, W. N. and Ghobashy, M. O. I.(2020): Genes Encoding the Virulence and the Antimicrobial Resistance in Enterotoxigenic and Shiga-toxigenic E. coli Isolated from Diarrhetic Calves .Toxins : 12, 383.

Aly, S.M. and Albutti, A. (2014): Antimicrobials use in aquaculture and their public health impact. J Aquac Res Dev.5: 1–6.

Andrade, G.I., Coura, F.M., Santos, E.L.S., Ferreira, M.G., Galinari, G.C.F., Filho, E.J.F., de Carvalho, A.U., Lage, A.P. and Heinemann, M.B. (2012): Identification of virulence by multiplex PCR in Escherichia coli isolated from calves in Minas Gerais, Brazil. Trop Anim Hlth Prod 2012; 44: 1783-90.

Aref, N. M., Abdel-Raheem, A. A., Hanaa, F. K., and Soher, Z. H. (2018): Clinical and sero-molecular characterization of E. coli with an emphasis on hybrid strain in healthy and diarrhetic neonatal calves in Egypt. Open Vet J. 8(4): 351–359.

Astorga, F., Navarrete-Talloni, M. J. , Mir o, M .P., Ver onica Bravo,V., Toro, M J., Blondel, C. J. , Herv e-Claude , L .P .(2019): Antimicrobial resistance in E. coli isolated from dairy calves and bedding material. Heliyon 5 e02773 .

Atwa, E. L., Sharaf, E. M. And Zakary, E.M. (2012): bacterial diarrhoea in newly born calves in MENOUFIEA governorate .Assiut Vet. Med. J. Vol. 58 No. 135.

Bach, S.J., McAllister, T.A., Veira, D.M., Gannon, V.P. and Holley, R.A. (2002): Transmission and control of Escherichia coli O157:H7. Can. J. Anim. Sci. 82: 475-490.

Badouei, M.A., Salehi, T.Z., Khorasgani, M.R., Tadjbakhsh, H., Brujeni, G.N. and Nadalian, M.G. (2010): Virulence gene profiles and intimin subtypes of Shiga toxin-producing Escherichia coli isolated from healthy and diarrhetic calves. Vet. Rec. 167(22): 858–861.

Bartels, C., Holzhauer, M., Jorritsma, R., Swart, W., and Lam, T. (2010): Prevalence, prediction and risk factors of enteropathogens in normal and non-normal faeces of young Dutch dairy calves. Prev. Vet. Med. 93: 162–169.

Bashahun, G. M. and Amina, A. (2017): Colibacillosis in calves: A review of literature .Jimma University, College of Agriculture and Veterinary Medicine. School of Veterinary Medicine, Jimma, P. O. Box 307, Ethiopia.

Berkhoff, H.A. and Vinal, A.C. (1986): Congo red medium to distinguish Between invasive and noninvasive E. coli pathogenic for poultry Avian Dis., 30(1), 117-121.

Bhat, S.A., Juyal, P.D. and Singla, L.D. (2013): Bovine cryptosporidiosis: brief review of its distribution in India. Trends Parasitol. Res. 2(2): 5-13.

Bhat, S.A., Juyal, P.D., and Singla, L.D. (2012): Prevalence of cryptosporidiosis in neonatal buffalo calves in Ludhiana district of Punjab, India. Asian J. Anim., Vet., Adv. 7(6): 512-520.

Cho, Y. and Yoon, K. J. (2014): An overview of calf diarrhea-infectious etiology, diagnosis, and intervention. J. Vet. Sci., 15(1), 1-17.

Constable, P.D., Blood, D.C. and Radostits, O.M. (2017): Veterinary medicine: a textbook of the diseases of cattle, horses, sheep, pigs, and goats. St. Louis Missouri: Elsevier.

Contrepois, M., Fairbrother, J.M., Kaura, Y.K. and Girardeau, J.P. (1989): Prevalence of CS31A and F165 surface antigens in Escherichia coli isolates from animals in France, Canada and India. FEMS Microbiol. Lett. 59: 319-323.

Conway, P.L. (1995): Microbial ecology of the human large intestine. In: Gibson GR, Macfarlane GT, editors. Human colonic bacteria: role in nutrition, physiology and pathology. Boca Raton, FL, USA: CRC Press; p. 1-24.

De Verdier, K., Nyman, A., Greko, C. and Bengtsson, B. (2012): Antimicrobial resistance and virulence factors in Escherichia coli from Swedish dairy calves. Acta Veterinaria Scandinavica, 54: 2.

Dereje, W. (2012): Isolation and identification of Enterobacteria species from diarrhetic calves in and around Addis Ababa; Ethiopia. ,6:2474-7637.

Duse , A ., Waller ,K. P., Emanuelson , U .l .f ., Unnerstad , H . E., Persson, Y . and Bengtsson, B. (2015): Risk factors for antimicrobial resistance in fecal Escherichia coli from preweaned dairy calves, J. Dairy Sci. 98 (2015) 500–516.

Edrington,T.S.,Farrow,R.L., Carter,B.H., Islas,A., Hagevoort, G. R.,Callaway,T.R., Anderson,R.C. and Nisbet, D.J. (2012): Age and Diet Effects on Fecal Populations and Antibiotic Resistance of a Multi-drug Resistant Escherichia coli in Dairy Calves. Agric. Food Anal. Bacteriol. AFAB journal.com Vol. 2, Issue 3.

Edwards,P.R.andEwing,N.H.(1972):- Identification of Enterobacteriaceae.3rd Ed. Burgeon publishing, Co. Atlanta,USA ; pp. 208-339.

El Bably M. A., Mohammed, A.N., Mohamed, M.B. and Fahmy, H.A. (2016): Monitoring and molecular characterization of multidrug resistant enteropathogenic E. coli in dairy calves and their Environment. Journal of veterinary medical research, 23 (2): 155-167.

El Behiry, A. (2014): Diagnostic Aspects and Novel Approach for Treatment of Antibiotic-Resistant

Bacteria Isolated from Diarrheal Calves using Silver, Gold and Copper Nanoparticles. J Bacteriol Parasitol 5: 195.

El-Seedy, F.R., Abed, A.H., Yanni, H.A. and Abd El-Rahman, S.A.A. (2016): Prevalence of E. coli and Salmonella inneonatal calves with diarrhea. Journal of Basic and Applied Sciences Cell. Mol. Bio. 62, 21–28.

FDA. (2020): Approved animal drug products. USA. 2020 [cited 2020 April 21]. https://animaldrugsatfda.fda.gov/adafda/app/search/public/ingredientsInformationPdf/Section2ActiveIngredients

Fakih, I., Thiry, D., Duprez, J.N., Saulmont, M., Iguchi, A., Pierard, D., Jouant, L., Franck S.M., Bosworth B.T., Moon H.W. (1998): Multiplex PCR for Enterotoxigenic, attaching and effacing, and Shiga toxin-producing Escherichia coli strains from calves. J. Clin. Microbiol. 36: 1795–1797.

Galal, H . M., Hakim, A.S. and Dorgham, S. M. (2013): Phenotypic and virulence genes screening of Escherichia coli strains isolated from different sources in delta Egypt. Life Science Journal, 10(2).

Gay, C. C., Mckay, K. A., and Barnum, D. A. (1964): Studies on colibacillosis of calves. II. A clinical evaluation of the efficiency of vaccination of the dam as a means of preventing colibacillosis of the calf. Can. Vet. J., 5, 297-308.

Gharieb, R., Fawzib, E. and Elsohaby. I. (2019): Antibiogram, virulotyping and genetic diversity of Escherichia coli and Salmonella serovars isolated from diarrhetic calves and calf handlers. Comparative Immunology, Microbiology and Infectious Diseases 67: 101367.

Griffin, P.M. and Tauxe, R.V. (1991): The epidemiology of infections caused by Escherichiacoli O157:H7, other enterohemorrhagic E. coli, and the associated hemolytic uremic syndrome. Epidemiol Rev. 13:60–98.

Gruenberg, W. (2014): Diarrhea in Neonatal Ruminants. In: Kahn C, SL, editors. The Merck veterinary manual. NJ, USA: Whitehouse Station; 2014.

Guler, L., Gunduz, K. and Ok, U. (2008): Virulence factors and antimicrobial susceptibility of Escherichia coli isolated from calves in Turkey. Zoonoses Public Health. ; 55:249–57.

Habets, A., Engelen, F., Duprez, J-N., Devleesschauwer, B., Heyndrickx, M., De Zutter, L., Thiry, D., Cox, E. and Mainil, J.(2020): Identification of Shigatoxigenic and Enteropathogenic Escherichia coli Serotypes in Healthy Young Dairy Calves in Belgium by Recto-Anal Mucosal Swabbing . Vet. Sci. 7, 167; doi: 10.3390/vetsci7040167.

Hakim, A. S., Shimaa T. Omara, S. T., Syame, S. M. and Fouad, E. A. (2017): Serotyping, antibiotic susceptibility, and virulence genes screening of Escherichia coli isolates obtained from diarrheic buffalo calves in Egyptian farms. Vet. World; 10(7): 769-773.

Hang, B .P .T ., Wredle, E ., Börjesson,S ., Sjaunja,K . S., Dicksved, J. and Duse, A. (2019): High level of multidrug-resistant Escherichia coli in young dairy calves in southern Vietnam.Tropical Animal Health and Production 51:1405–1411.

Hashish, E.A., El Damaty, H.M., Tartor, Y.H. and Abdelaal, A.M. (2016): Epidemiological study of diarrheagenic Escherichia coli virulence genes in newborn calves. Pak. Vet. J. 36, 54–58.

Hausherr, A ., Becker, J., Meylan, M., Wüthrich, D. , Collaud, A., Rossano, A. and Perreten, V.(2019): Antibiotic and quaternary ammonium compound resistance in Escherichia coli from calves at the beginning of the fattening period in Switzerland (2017). Band 161, Heft 11, 741–748.

Health Management and disease (HMD). (2010): Colibacillosis. Last updated 08 November, 2010.

Hegde, N. V., Cook M. L., Wolfgang, D. R. Love, B. C. Maddox C. C. and Jayarao B. M.(2005):Dissemination of Salmonella enterica subsp. enterica serovar Typhimurium var. Copenhagen clonal types through acontract heifer-raising operation. J. Clin. Microbiol. 43:4208-4211.

Herrera-Luna, C.H., Klein, D., Lapan, G., Revilla-Fernanded, S., Haschek, B., Sommerfeld-Stur, I., Moestl, K. and Baumgartner, W. (2009): Characterizationof virulence factors in E.coli isolated from diarrheic and healthy calves in Austriashedding various enteropathogenic agents. Vet Med. 54: 1–11.

Heuer, H., Schmitt, H. and Smalla, K. (2011): Antibiotic resistance gene spread due to manure application on agricultural fields. Curr Opin Microbiol. 14: 236–43. Hlth Prod; 44: 1783-90.

Holland, R.E. (1990): Some infectious causes of diarrhea in young farm animals. Microbiol. Rev. 3, 345-375.

Hudson, D. and White, R. G. (1982): Calf Scours Causes: Prevention and Treatment, G75-269-A.

Roopnarine, R.R., Ammons, D., Rampersad, J. and Adesiyun, A.A. (2007): Occurrence and characterization of verocytotoxigenic Escherichia coli (VTEC) strains from dairy farms in Trinidad. Zoonoses Public Health. Int J Med Microbiol. 295:443–54.

Irshad, H., AL Cookson, Hotter, G., Besser, T.E., On, S.L.W. and French, N.P. (2012): Epidemiology of Shiga toxin-producing Escherichia coli O157 in very young calves in the North Island of New Zealand, New Zealand Veterinary Journal, 60:1, 21-26.

Islam, A. K. M. A., Rahman, M., Nahar, A., Khair, A. and Alam, M. M. (2015): Investigation of pathogenic Escherichia coli from diarrhetic calves in selective area of Bangladesh .Bangl. J. Vet. Med. 13 (1): 45-51.

Jaros, P., Cookson, A. L., Reynolds, A., Prattley1, D.J.D. M. Hathaway, C. S. and French, N.P. (2016): Nationwide prevalence and risk factors for faecal carriage of Escherichia coli O157 and O26 in very young calves and adult cattle at slaughter in New Zealand. Epidemiol. Infect. (2016), 144, 1736–1747.

Kamel, M., El-Hassan, D.G.A. and El-Sayed, A. (2015): Epidemiological studies on Escherichia coli O157:H7 in Egyptian sheep. Tropical Animal Health and Production, 47, 1161–1167.

Kang, S.J., Ryu, S.J., Chae, J.S., Eo, S.K., Woo, G.J . and Lee, J.H. (2004): Occurrence and characteristics of enterohemorrhagic Escherichia coli O157 in calves associated with diarrhoea. Veterinary Microbiology 98: 323–328.

Karamali, M. A. (1989): Infection of verocytotoxin – producing Escherichia coli. Clin. Microbiol. Rev. 2, 15 – 38.

Khalifa, E., Nossair, M. A., Ayyub, M. A. and Hadad, G. A. (2019): Molecular Characterization of Diarrheagenic E. Coli Isolated From Newly Born Calves and Humans .AJVS. Vol. 60 (1): 55-62.

Kohansal, M., Najafi, A. and Vidal, R. (2020): Molecular characterization of Enterotoxigenic Escherichia coli isolates harboring genetic elements mediating multiple-drug resistance. J HELLENIC VET MED SOC 71(2): 2193-2200.

Kolenda, R., Burdukiewicz, M. and Schierack, P. A. (2015): systematic review and metaanalysis of the epidemiology of pathogenic Escherichia coli of calves and the role of calves as reservoirs for human pathogenic E. coli. Front Cell Infect Microbiol. 5:23.

Law. (2000): Virulence factors of E. coli O157 and other shiga toxin-producing E. coli. Journal of applied Microbiology; 88; 729 – 745.

Le Bouguenec, C. and Bertin, Y. (1999): AFA and F17 adhesins produced by pathogenic *Escherichia coli* strains in domestic animals. Vet Res. 30:317–42.

Levy, S.B. and Marshall, B. (2004): Antibacterial resistance worldwide: causes, challenges and responses. Nat Med.10: S122–29.

Lopez, C., Gonzalez, E.A. and Blanco, J. (2007): Serotypes, virulence genes, intimin types and PFGE profiles of Escherichia coli isolated from piglets with diarrhoea in Slovakia. Vet J. 174:176–87.

Mailk, S., Kumar, A., Verma, A.K., Gupta, M.K, Sharma, S.D., Sharma, A.K. and Rahal, A. (2013): Incidence and Drug Resistance Pattern of Collibacillosis in Cattle and Buffalo Calves in Western Utter Pradesh in India. J Anim. Health Prod. 1(2): 15-19.

Mainil, J.G. and Fairbrother, J.M. (2014):- Pathogenic Escherichia coli in domestic mammals and birds. In Pathogenic Escherichia coli: Molecular and Cellular Microbiology; Morabito, S., Ed.; Horizon Scientific Press and Caister Academic Press: Norwich, UK, 2014; pp. 19–43; ISBN 978-1-908230-37-9.

Mainil, J.G., Gerardin, J. and Jacquemin, E. (2000): Identification of the F17 fimbrial subunit- and adhesin-encoding (f17A and f17G) gene variants in necrotoxigenic Escherichia coli from cattle, pigs and humans. Vet Microbiol. 2000; 73:327–35.

Masud, M., Ahmed, M., and Nazir, H. (2012): Isolation of E. coli from apparently diarrhetic calves in Bangladesh and their antibiogram. J. Bang Soc. Agric. Sci. Technol. 9:45–48.

Masud, M., Fakhruzzaman, M., and Nazir, H., (2012): Isolation of E. coli from apparently healthy and diarrhetic calves in Bangladesh and their antibiogram. J. Bang Soc. Agric. Sci. Technol. 9: 45–48. May’17. 2277-1964

Melton-Celsa, A.R. (2014): Shiga toxin (Stx) classification, structure, and function. Microbiol Spectr. 2: 1–21.

Meylan, M. (2008): Prevalence of four enteropathogens in the faeces of young diarrhoeic diary calves in Switzerland .The veterinary record 163(12):362-6.

Mohammed, A. S., Marouf, S., Erfana, M.A., El-Jakee, A.K. J., Hessain, M. A., Dawoud, M.T., Kabli, A.S., and Moussa, M.I. (2019): Risk factors associated with E. coli causing neonatal calf diarrhea. Saudi J Biol Sci. 26(5):1084-1088.

Mohammed, S. A. E.M., Marouf, S.A.E., Erfana, A .M.,El-Jakee, J.K.A.E., Hessain,A.M., Dawoud,T.M., Kabli,S.A. and Moussa,I.M. (2019): Risk factors associated with E. coli causing neonatal calf diarrhea Saudi Journal of Biological Sciences 26 (2019) 1084–1088 .

Mona, A. El-Shehedi, Eraqi, M. M. and Ali, A. R. (2013):Characterization of Escherichia coli from diarrhetic calves with special reference to plasmid profile. Journal of American Science: 9(7).

Moxley, R.A. and Smith, D.R. (2010): Attaching-effacing Escherichia coli infections in cattle. Vet. Clin. N. Am. Food Anim. Pract. 26, 29–56.

Müller, D. ,Greune, L., Heusipp, G., Karch, H., Fruth, A., Tschape, H., and Schmidt, M.A. (2007): Identification of unconventional intestinal pathogenic E.coli isolates expressing intermediate virulence factor profiles by using a novel single-step multiplex PCR. Appl. Environ. Microbiol. 73, 3380-3390.

Nabila, El-Sayed. (1995): Bacteriological studies on Colibacillosis in calves with special references to K-99. P. 63 – 65 Thesis of Dep. Of Micro. Fac. Of Vet. Med.; Cairo Univ.

Nagy, B. and Fekete, P.Z. (2005): Enterotoxigenic Escherichia coli in veterinary medicine. Int J Med Microbiol. 295:443–54.

Nasr, M., Bakeer, N.M., Hammouda, H.A. and Omar, A.A. (2014): Epidemiological, Clinical and Bacteriological Studies on Bacterial Lamb Enteritis at Behera Province, Egypt Alexandria Journal of Veterinary Sciences, 43: 8-16.

Nataro, J.P. and Kaper, J.B. (1998): Diarrheagenic Escherichia coli. Clin. Microbiol. Rev. 11:142-20

Naylor, J.M. (2002):- Neonatal ruminant diarrhea. In: Smith, B.P., ed. Large Animal Internal Medicine, 3rd ed. St. Louis, MO: Elsevier, pp: 352-366.

Nelson, S., Clarke, R. C. and Karamali, M. A. (1998): Verocytotoxin-producing Escherichia coli (VTEC) infection. In palmer, S. R.; Lardsoulsby and simpson, DTH-zoonoses. Biology, Clinical practice and public health control. Oxford University Press. PP. 89 – 104.

Ngeleka, M., Godson, D., Vanier, G., Desmarais, G., Wojnarowicz, C., Sayi, S., Huang, Y., Movasseghi, R., and Fairbrother, J.M. (2019): Frequency of E. coli virotypes in calf diarrhea and intestinal morphologic changes associated with these virotypes or other diarrheagenic pathogens. J Vet Diagn Invest. 31(4):611-615.

Nguyen, T.D., Vo, T.T. and Vu-Khac, H. (2011): Virulence factors in Escherichia coli isolated from calves with diarrhea in Vietnam. J. Vet. Sci. 2011; 12:159–164.

Nguyen, V.D., Bennett, S.D., Mungai, E., Gieraltowski, L., Hise, K. and Gould, L.H. (2015): Increase in multistate foodborne disease outbreaks—United States, 1973–2010. Foodborne Pathog. Dis. 12, 867–872.

Nizza, S., Mallardo, K., Marullo, A., Iovane, V., De Martino, L. and Pagnini,U. (2010) : Antibiotic susceptibility of haemolytic E.coli strains isolated from diarrhoeic faeces of buffalo calves, Italian Journal of Animal Science, 9:1, e26 .

Nolan, L. (2013): Overview of Colibacillosis in Poultry. The Merck Veterinary Manual. Merck Manuals http://www.msdvetmanual.com/poultry/colibacillosis/overview-of-colibacillosis-in-poultry.

Ok, M., L. Gu¨ler, K. Turgut, U¨. Ok, I. S¸ en, Gu¨ndu¨z, I. K.Birdane, M.F. and ¨zelbektes¸H. GU. (2009): The studies on the causative agents of diarrhea in neonatal calves and determination of virulence gene markers of Escherichia coli strains by multiplex PCR. Zoonoses Public Health, 56(2):94-101.

Okerman, L. (1987): Enteric infections caused by non-enterotoxigenic Escherichia coli in animals: occurrence and pathogenicity mechanisms. A review. Vet. Microbiol. 14:33-46.

Orskov, I., Orskov, F. and Rowe, B. (1975): Four new Escherichia coli Oantigens,O158, O159, O160 and O161, and two new Hantigens,H53 and H54. Acta Pathol Microbiol Scand [B] 1975; 83 (2): 116-20.

Osek, J. (2001): Characterization of necrotoxigenic E. coli (NTEC) strains isolated from healthy calvesin Poland. J Vet Med. B 48: 641–646.

Paton, J.C. and Paton, A.W. (1998): Pathogenesis and diagnosis of Shiga toxin-producing Escherichia coli infections. Clin. Microbiol. Rev. 11 (3):450-479.

Paul, K., Khan, M., and Mahmud, S. (2010): Isolation and characterization of E. coli from buffalo calves in some selected areas of Bangladesh. Bangl. J. Vet. Med. 8: 23–26.

Perez, E., Kummeling, A., Janssen, M. M., Jimenez, C., Alvardo, R., Caballero, M., Donado, P., and

Dwinger, R. H. (1998): Infectious agents associated with diarrhoea of calves in the Canton of Tilaran, Costa Rica. Prev. Vet. Med., 33 (1 – 4): 195 – 205.

Piérard, D., De Greve, H., Haesebrouck, F. and Mainil, J. (2012): O157: H7 and O104: H4 Vero/Shiga toxin-producing Escherichia coli outbreaks: respective role of cattle and humans. Veterinary Research, 43, 13

Pourtaghi, H. and Sodagari, H.R. (2016): Antimicrobial Resistance of Entrotoxigenic and Non-Entrotoxigenic Escherichia coli Isolated From Diarrhetic Calves in Iran. Int J Enteric Pathog. 4(2):e34557.

Quinn, P. J., Markey, B. K., Carter, M. E., Donnelly, W. J. C., and Leonard, C. F. (2002): Vet. Microbiology and Microbial disease Textbook; MPG Books LTd; Bodmin; Cornwall P. 111.

Radostits, O.M., Gay, C.C., Hinchcliff, K.W. and Constable, P.D. (2007): Veterinary medicine: a textbook of the diseases of cattle, sheep, pigs, goats and horses. Saunders, London.

Roderick, S. and Hovi, M. (1999): Animal Health and Welfare in Organic Livestock systems: identification of constraints and priorities. A report to MAFF. University of Reading.

Ruchi, T., Sujata, B. and Anuradha, D. (2015): Comparison of phenotypic methods for the detection of biofilm production in uro-pathogens in a tertiary care hospital in India. Int. J. Curr. Microbial. App. Sci., 4:840-849.

Sabin R (2006): Spinach E. coli linked to cattle manure on pasture had same strain as bacteria in outbreak San Francisco Chronicle. Journal of Veterinary Medicine and Animal Health 58(3-4):101-113.

Sadiek, A., Sohair, Z. and Hussein. (1999): Acute enteritis in neonate calves in Sohag governorate with special reference to etiology; clinicochemical aspects and therapy. Assuit Vet. Med. J. Vol. 42; No. 83. 200 – 212.

Saidani, M., Tabib, I., Chaouechi, A., Zouaoui, S., Soudani, A., Haenni, M., Daaloul, M., ben chehida, F., Mamlouk, A., Chakroun, C.H., Madec, J-Y. and Messadi, L. (2017): Surveillance of antimicrobial resistance in Escherichia coli strains isolated from cattle and broiler chickens in Tunisia. Journal of new sciences, Agriculture and Biotechnology, CSIEA (25), 2784-2789.

Sandhu, K.S. and Gyles, C.L., (2002): Pathogenic Shiga toxin-producing Escherichia coli in the intestine of calves. Can J Vet Res. 66: 65-72.

Scaria, J., Warnick, L.D., Kaneene, J.B., May, K., Teng, C. and Chang, Y. (2010): Comparison of phenotypic and genotypic antimicrobial profiles in Eschericia coli and Salmonella enterica from the same dairy cattle farms. Mol Cell Probes. 24: 325–45.

Shahrani, M., Dehkordi, F.S. and Momtaz, H. (2014):Characterization of Escherichia coli virulence genes, pathotypes and antibiotic resistance properties in diarrhetic calves in Iran .Biological Research, 47:28.

Singla, L.D., Gupta, M.P., Singh, H., Singh, S.T., Kaur, P., and Juyal, P.D. (2013): Antigen based diagnosis of Cryptosporidium parvum infection in cattle and buffalo faeces. Indian J. Anim. Sci. 83(1):37–39.

Sobhy, N .M . , Yousef, S .G .A ., Aboubakr , H .A ., Nisar , M ., Nagaraja , K .V . and Mor SK, *et al.,* (2020): Virulence factors and antibiograms of Escherichia coli isolated from diarrhetic calves of Egyptian cattle and water buffaloes. PLoS ONE 15(5): e0232890. 1-13.

Srivani, M., Reddy, Y. N., Subramanyam, K. V., M. Ramakoti Reddy, M. R. And Rao, T. S. (2017): Prevalence and antimicrobial resistance pattern of Shiga toxigenic Escherichia coli in diarrhetic buffalo calves. Veterinary World, EISSN: 2231-0916. org/Vol.10/ /11.pdf.

Srivani, M., Reddy, Y.N., Subramanyam, K. V., Lakshman, M., Kavitha, K.L. and Ramani Pushpa, R. N. (2020): Epidemiology, molecular characterization and antimicrobial resistance of Necrotoxigenic Escherichia coli in diarrhoeic calves . The Pharma Innovation Journal 9(9): 287-290 .

Svensson, C., Lundborg, K., Emanuelson, U. and Olsson, S.O. (2003): Morbidity in Swedish dairy calves from birth to 90 days of age and individual calf-level risk factors for infectious diseases. Prev. Vet. Med. 58: 179–197.

Tepper, V. (2018): Antimicrobial resistance in E. coli from Swedish calves and the surrounding environment. Master Degree Project in Infection Biology, 30 credits.

Thiry, D., Saulmont, M., Takaki, S., De Rauw, K., Duprez, J-N., Iguchi, A., Piérard, D., Mainil ,J.G. (2017): Enteropathogenic Escherichia coli O80:H2 in Young Calves with Diarrhea, Belgium. Emerging Infectious Diseases. www.cdc.gov/eid Vol. 23, No. 12.

Toledo, A., Gomez, D., Cruz, C., Carreon, R., Lopez, J., Giono, S. and Castro, A.M. (2012):

Transmission and control of Escherichia coli O157:H7. Can. J. Anim.Sci. 82:475-490.

Trevejo, R.T., Barr, M.C. and Robinson, R.A. (2005): Important emerging bacterial zoonotic infections affecting the immunocompromised. Vet.Res. 36:493-506.

Uhde, F.L., Kaufmann, T., Sager, H., Albini, S., Zanoni, R., Schelling, E. and Meylan, M. (2008): Prevalence of four enteropathogens in the faeces of young diarrhetic dairy calves in Switzerland. Vet. Rec. 163:362-366.

Vagh, A.A. and Jani, R.G. (2010): Prevalence and Comparative Studies of Some Major Serotype of E.coli from Cattle and Buffalo Calf Scour. Veterinary World, Vol.3 (10):458-459.

Vidal, M.; Kruger, E.; Durán, C.; Lagos, R.; Levine, M.; Prado, V.; Toro, C. and Vidal, R. (2005): Multiplex PCR assay to identify simultaneously the six categories of diarrheagenic Escherichia coli associated with enteric infections. Journal of Clinical Microbiology, 43(10):5362-5.

Vu-Khac, H., Holoda, E., Pilipcinec, E., Blanco, M., Blanco, J.E., Dahbi, G., Mora, A., Lopez, C., Gonzalez, E.A. and Blanco, J. (2007): Serotypes, virulence genes, intimin types and PFGE profiles of Escherichia coli isolated from piglets with diarrhea in Slovakia. Vet J. 174:176–87.

Vu-Khac, H. and Cornick, N.A. (2008): Prevalence and genetic profiles of Shiga toxinproducing Escherichia coli strains isolated from buffaloes, cattle, and goats in central Vietnam. Vet Microbiol. 126:356–63.

Wani , S.A. , Hussain ,I., Beg , S.A. , Rather , M.A.,Kabli , Z.A., Mir , M.A. and Nishikawa, Y. (2013):Diarrhoeagenic Escherichia coli and salmonellae in calves and lambs in Kashmir: absence, prevalence and Antibiogram .Rev. sci. tech. Off. int. Epiz., 32 (3). In issue 32-3 of the Scientific and Technical Review.

Welch, R.A. (2006): The Genus Escherichia, Prokaryotes, 6, 60–71.

Wellington, E.M.H., Boxall, A.B.A., Cross, P., Feil, E.J., Gaze, W.H., Hawkey, P.M., et al. (2013):The role of the natural environment in the emergence of antibiotic resistance in Gram-negative bacteria. Lancet Infect Dis.13: 155–65.

Wells, J. G., Shipman, L. D., and Greene, K. D. (1991): Isolation of E. coli serotype O157: H7 and other Shiga-like toxin producing E. coli from dairy cattle. J. Clin. Microbiol. 29 (5): 985 – 989.

Widirasih, D.A., Ido, N., Omoe, K., Sugii, S. and Shinagawa, K. (2004): Duration and magnitude of fecal shedding of Shiga toxin-producing Escherichia coli from naturally infected cattle. Epidemiol. Infect. 132:

Yamamoto S, Iwabuchi E, Hasegawa M, et al. (2013): Prevalence and molecular epidemiological characterization of antimicrobialresistant Escherichia coli isolates from Japanese black beef cattle. J Food Prot. 76(3):394-404.