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REVIEW PAPER OPEN ACCESS

Neonatal calf diarrhea induced by rotavirus and coronavirus: a review

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Abstract

Diarrhea is one of the most serious diseases in neonatal calves .It causes serious economic damages by reducing of weight gain and increasing mortality rate. Calves are at the greatest risk of diarrhea in a first month of life. Neonatal calf diarrhea is a complex syndrome with various etiologies. Several families of viruses cause diarrhea. However, rotavirus and coronavirus are two major causes of diarrhea in newborn calves. This review study summarizes the results of some studies on rota and corona viral diarrhea in calves. Most of these results indicate that rotavirus and coronavirus are widespread in diarrheic calves with considerable differences in prevalence rates in various geographical regions and seasons.

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Introduction

Calf diarrhea has been recognized for decades as a serious problem. The incidence risk of calf diarrhea in calves less than 30 days old, estimated by several studies between 15% to 20 % with mortality rate between 1/5% to 8% (Bendali *et al.,* 1999; Waltner Towes *et al.*, 1986). Diarrhea in neonatal calves causes poor growth and even death because of dehydration and electrolyte imbalance. Calf diarrhea is a complex syndrome (Fuente *et al.*, 1998; Reidy *et al.*, 2006). The etiology of diarrhea is multifactor and may include infective (Table 1), environmental, nutritional and management factors such as calves being born from a heifer, being born during summer, low serum IgG concentration and large herd size (Blom *et al.*, 1982; Frank and Kaneene,1993; Svensson *et al.*, 2006).Some of studies show that the most important pathogen agents in calf diarrhea are rotavirus, coronavirus, enterotoxigenic E.Coli, salmonella species and cryptosporidium (Reynolds *et al.*, 1986; Steiner *et al.*, 1997). 75% to 90 % of calf diarrhea is related to rotavirus, coronavirus, enterotoxigenic E.Coli and cryptosporidium (Radostits *et al.*, 2007).

Several families of viruses cause diarrhea in neonatal farm animals include: Reoviridae, Corona viridae, Toroviridae, Parvoviridae, Calciviridae and Astroviridae (Deng *et al.*, 2003).

Rotavirus and coronavirus are the most common causes of viral neonatal calf diarrhea (Mayameei *et al.*, 2010). Rotavirus and coronavirus can produce high-morbidity outbreaks of diarrhea in neonatal calves. In some reports, rotavirus is the most prevalent pathogen in less than one month old diarrheic calves (Radostits *et al., 2007*; Reynolds *et al.*, 1986; Snodgrass *et al.*, 1986).In a study in Britain ,rotavirus and coronavirus were detected in 208 (42%) and 69 (14 %) of 490 calves respectively (Reynolds *et al.*, 1986).

The prevalence of pathogens can vary in different geographical location of the farms. Calf diarrhea is a complex disease because of multifactorial nature. So considering the risk factors of each pathogen along with detecting the pathogens by laboratory diagnostic tests and farm management can be useful for controlling of calf diarrhea.

The aim of this study is to evaluate the role of rotavirus and coronavirus in diarrheic calves in various aspects. Also the prevalence of rota and corona viral diarrhea in different studies and the main risk factors of disease outbreaks are described.

Virus structure and transmission

Rotavirus

Rotaviruses of family reoviridae are the most causes of diarrhea in farm animals. This pathogen is double stranded RNA virus. The genome of this virus consists of 11 unique double helixes molecular of RNA. Each helix is segment numbered 1 to 11. The RNA is surrounded by a three- layered of protein capsid. Virions are about 60-80 nm in diameter. Virus replication occurs in cytoplasm. Seven serogroups of rotaviruses have been recognized (A to G). Each of these serogroups are classified by specificity of the outer capsid proteins, Vp7 (G serotype) and Vp4 (P serotype). Group A rotaviruses are the most frequently detected virus in farm animals especially neonatal calf diarrhea. However, group B rotaviruses are usually isolate from adult diarrheic calves (Fenner *et al.*, 1993; Radostits *et al.*, 2007).

Coronavirus

This pathogen is a member of coronaviridae family. The genome is a single stranded RNA. The most important protein of virus is a nucleo capsid protein. Also, several envelope and spike proteins have been recognized for this pathogen. Coronaviruses replicate in the cytoplasm (Fenner *et al.*, 1993; Radostits *et al.*, 2007).

Newborn calves are usually infected from feces of other diarrheic calves, especially in calving season (Fields *et al.*, 1995).

Pathogenesis

The main place for rotavirus infection is brush border of villous epithelial cells in the small intestine. The infected cells are rapidly replaced with undifferentiated crypt cells and results in reducing activity of lactase in villous (McGavin and Carlton, 1995).

The pathogenesis of coronavirus and rotavirus are similar. However, the coronavirus infections are more virulent and atrophy of both small and large intestines are more common (McGavin and Carlton, 1995).

Coronavirus in adult cattle leads to winter dysentery which is closely related to the coronavirus causing neonatal calf diarrhea (Radostits *et al.*, 2007; Smith, 2009).

Table 1. Main pathogenic causes of calf diarrhea (Millemann, 2009).

Bacteria	Viruses	Parasites
E.Coli:ETEC[1],EPEC[2],EHEC[3]	Rotavirus	Cryptosporidium
Salmonella	Coronavirus	Giardia
Clostridium	Torovirus(Breda)	Eimeria bovis or zuernii
Campylobacter	BVD[4]	Candida
	Calcivirus(Norovirus)	Toxocara
		Strongyloides

1-Enterotoxigenic E.coli. 3-EnterohemorrhagicE.coli.

2-Enteropathogenic E.coli. 4- Bovine Viral Diarrhea.

Clinical diagnosis

Viral diarrhea usually occurs in explosive outbreak by a sudden onset of a liquid diarrhea. Feces are usually mucoid and voluminous. Nevertheless, some studies showed that there was no significant correlation between characters of feces and clinical signs with the enteropathogens (Barrington *et al.*, 2002; Radostits *et al.*, 2007).

In some cases of corona infection, clinical signs of mild respiratory disease occur between 2 and 16 weeks of age, because bovine coronaviruses addition to intestinal disease, can replicate in respiratory system too (Fenner *et al.*, 1993).

Some common symptoms such as: hyperthermia, metabolic acidosis (because of bicarbonate losing that leads to high blood levels and low cellular levels of potassium) and progressive dehydration (leads to sunken eyes and reduction in skin turgor) are usually seen in diarrheic calves (Barrington *et al.*, 2002; Millemann,2009).

Laboratory diagnosis

Diagnosis is done through collecting feces of diarrheic calves by a rectal swab or intestinal content (Castro and Heuschele, 1992) and then using laboratory diagnostic tests such as: direct electron microscopic test, ELISA, latex agglutination, polyacrylamide gel (Parwani *et al.*, 1992; Radostits *et al.*, 2007) and RT-PCR (Izzo *et al.*, 2011).

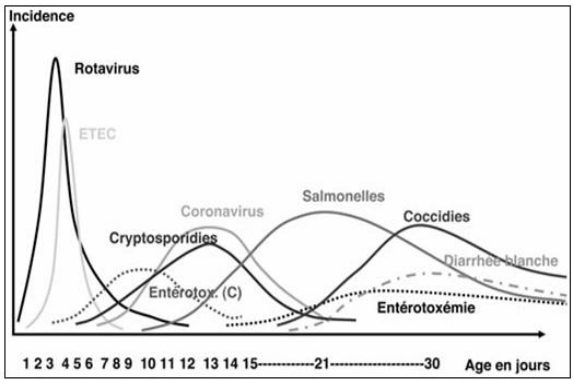

Fig. 1. Prevalence of common causes of calf diarrhea according to the age (Naylor, 2002).

ELISA is one of the essential methods for virus detection. It is used widely in calves with diarrhea for determination of rotavirus (Al-Robaiee and Al- Farwachi, 2013; Gulliksen *et al.*, 2009; Gulliksen *et al.*, 2008; Langoni *et al.*, 2004; Moosakhani *et al.*, 2012; Okur Gumusova *et al.*, 2007) and coronavirus (Gulliksen *et al.*, 2009; Okur Gumusova *et al.*, 2007).

ELISA have some advantages than other laboratory diagnostic tests such as being inexpensive for examination of many samples and being much more sensitive (Mayameei *et al.*, 2010).

Necropsy

The length of the infected villous will be shorter and atrophy. As a result of this change, hyperplasia occurs in intestinal cells. In mixed infections of rotavirus and coronavirus with enteropathogenic E.coli, destruction is more sever (Fenner *et al.*, 1993; McGavin and Carlton, 1995).

Rotavirus and coronavirus Risk factors

There are some important risk factors for occurring diarrhea in calves such as: age of animal, immune system, presence of mixed enteropathogens and amount of pathogens (Radostits *et al.*, 2007).

Age of calves

The most common age of occurrence for rotavirus is 5-15 days and for coronavirus is 5-21 days (Fig. 1). Coronavirus is more common in older calves than rotavirus (Smith, 2009).The most percentage of rotavirus and coronavirus morbidity is in less than one month old diarrheic calves.

Immune system status in calves

Immunoglobulins of colostrum are IgG1, IgG2, IgM and IgA. 80% of the total immunoglobulins are IgG1 (Blom, 1982). In calves, passive transfer of maternal antibodies occurs in the first 20-48 hours after birth via colostrum. An important characteristic of rotavirus and coronavirus for infecting calves is dependent on the presence of colostrum antibodies in the lumen of calves. Because of antibody protection, rotavirus diarrhea does not occur in the first days of birth. Lack of specific antibody in diarrheic calves can explain the cause of increasing rate of mortality in these calves as a

result of infections (Barrington *et al.*, 2002; Kohara and Tsunemitsu, 2000).

In calves, two major serum acute phase proteins have been determined: serum amyloid A (SAA) and haptoglobulin (HP) (Horadagoda *et al.*, 1993).

According to a study in Iran in 2011, SAA and HP significantly increased in diarrheic calves especially in Enterotoxigenic E.Coli (ETEC), combined rotavirus+ cryptosporidium and coronavirus+ cryptosporidium infections (Pourjafar *et al.*, 2011).

The fetal stresses as a result of dystocia or environment, immature immune system, inability to consume or an inadequate supply of colostrum are some physiological causes of immune system suppression in neonatal calves. Viral infections such as bovine viral diarrhea (BVD) destroy T and B lymphocytes and increase the susceptibility of the calf to other infections (Roussel and Hjerpe, 1990).

Seasonal effects

Rotavirus

In many studies, the rate of rotavirus incidence have been reported higher in cold season (Brandt *et al.*, 1982; Nourmohammadzadeh *et al.*, 2012), because it has determined that low temperature and relative humidity, increase the survival of rotavirus (Brandt *et al.*, 1982; Fields *et al.*, 1995). In addition, titer of IgG colostrum from dairy cows in winters is lower than IgG concentration in other seasons (Gulliksen *et al.*, 2008).

In a study made by Brenner *et al.* (1993) on 483 fecal samples from diarrheic calves, the highest incidence of rotavirus reported in the month of December, January, February and March.

Coronavirus

In a study made by Trotz Williams *et al.* (2007), prevalence of coronavirus was estimated 2% in summer and 9% in winter.

The number of coronavirus diarrhea in calves is higher during winter in some studies, because of increasing survival of coronavirus in cold season (Radostits *et al.*, 2007).

In contrast with some studies, in a research in Iran, there was no significant relationship between coronavirus prevalence and season (Moosakhani *et al.*, 2012).

Prevalence

Rotavirus

Rotavirus was detected first time in diarrheic calves by mebus in 1969 (Mebus *et al.*, 1971). Several studies in some different regions indicated that cryptosporidium and rotavirus were the most common isolated pathogens in diarrheic calves (Moosakhani *et al.*, 2012; Reynolds *et al.*, 1986; Sherwood *et al.*, 1983; Snodgrass *et al.*, 1986). Rotavirus prevalence in some countries such as: Italy,Germany,France,Japan and USA has been reported in high percent, because multiple hosts and serotypes have been recognized for this pathogen (Castrucci *et al.*, 1988; McKercher *et al.*, 1984).

Researche conducted by Shah and Jhala (1992), Ishizaki (1995), Al Robaiee and Al- Farwachi (2013) reported the rate of rotavirus infection in diarrheic calves about 20%, 22% and 15.5%.

In a study in Brazil, 203 fecal samples of less than one month old diarrheic calves were examined by Capture ELISA and rotavirus was recognized as the highest prevalence pathogen alone in 25.15% and combined with cryptosporidium in 41/7% of fecal samples (Langoni *et al.*, 2004).

In another research in Australia, screened by RT-PCR, rotavirus was the most common pathogen identified in 79/9% of 597 fecal samples (Izzo *et al.*, 2011).

In contrast with many studies, prevalence of rotavirus in Norway (Gulliksen *et al.*, 2009) and Austria (Haschek *et al.*, 2006) were reported only 9/9% and 9/1%. The reduction rate of pathogen in these regions is possibly because of restrictive rules in trade of animals and high level of hygiene in farms.

Coronavirus

Coronavirus in neonatal calf diarrhea was detected first time by Stair *et al.* in 1972. In two studies in Austria, corona was the most common pathogen in diarrheic calves (Haschek *et al.*, 2006; Herrera-Luna *et al.*, 2009). There are differences in corona prevalence between various locations in some researches such as: Turkey 1/96% (Okur Gumusova *et al.*, 2007), Costa Rica 9% (Perez *et al.*, 1998) and Switzerland 7/8% (Uhde *et al.*, 2008).

According to Gulliksen *et al.* (2009) report, coronavirus was not found in any of 191 fecal samples

were collected from 135 herds in Norway. In this study researchers used antigen ELISA for first time and RT-PCR for second time, however the results were similar.

In another study in Finland, there was not any corona infected sample (Pohjola *et al.*, 1986).

Combined infections with other enteropathogens

Mixed infections of rotavirus with enterotoxigenic E.coli (ETEC) or bovine viral diarrhea (BVD) in diarrheic calves result in a more sever disease (Verdier Klingenberg., 2000).

In a study made by Fuente *et al.* (1999), rate of mixed infections from 218 diarrheic fecal samples for cryptosporidium + rotavirus and cryptosporidium + coronavirus were 87% and 11/1%.

In another study in Spain, rotavirus and coronavirus were found in 42/7% and 7/3% of fecal samples from diarrheic calves. Mixed pathogens of rotavirus and coronavirus were found in 5/1% of the total samples
(Fuente *et al.*, 1998).

Langoni *et al.* (2004) found combined rotavirus + cryptosporidium infections in 17/7% from 203 diarrheic fecal samples in less than 30 days old calves.
Angus *et al.* (1983) reported that the prevalence of combined rotavirus + cryptosporidium infections were the most mixed pathogens in comparison with other enteropathgens.

Control and management

There is no specific treatment for viral diarrhea, but
therapy based on rehydration and the supply of electrolyte buffer (oral or parenteral fluid therapy) is essential. Oral electrolyte treatment is ineffective in calves with severe clinical dehydration. Sodium bicarbonate is the alkalizing agent that is a good choice for decreasing acidosis in the diarrheic calves (Radostits *et al.*, 2007).

Fasting is not recommended for more than 48 hrs. Milk feeding times should not be ignored in diarrheic
calves and also milk should be fed in a small amount and more times per day (Smith, 2009).

It is necessary to decrease the stress and exposure of calves to virus. Once the environment becomes contaminated, each new case of scours significantly increases the number of environmental pathogens. Diarrheic calves should be transferred in dry and clean single boxes. Control of population density and hygiene of herd are useful for decreasing risk factors of diarrhea. High risk cattle herds for calf scours include large herds and herds with a high percent of heifers. Boxes should be remained empty for one week before new calving .Changing and disinfecting of calves bedding once a week leads to reduction of the diarrhea risk factors (Barrington *et al.*, 2002; Maddox-Hyttel *et al.*, 2006).

The most important factor for immunity of a new born calf is amount of colostrum intake. At least, 4 liters of colostrum should be fed to neonatal calves during the first 12 hours. To improve the passive immunity of neonatal calves, twice vaccination of the pregnant dams (6 to 8 and 2 to 3 weeks) before parturition with a vaccine containing rotavirus, coronavirus and E.Coli (k99) can be effective (Radostits *et al.*, 2007; Smith,2009).

Conclusion

The rate of rotavirus and coronavirus prevalence in diarrheic calves can be influenced by some risk factors such as: different geographical regions, seasonal effects, neonatal calf immune system status and farm management.
The results of the several studies show the differences
in the prevalence of rotavirus and coronavirus in diarrheic calves in various regions.

Considering the risk factors of calf diarrhea associated with using of suitable preventive management in farms may be effective for decreasing neonatal calf diarrhea.

References

Al-Robaiee IA, Al- Farwachi MI. 2013. Prevalence of rotaviral infection in diarrheic neonatal calves in Mosul city, Iraq . Veterinary world **6(8),** 538-540. http://dx.doi.org/10.5455/vetworld.2013.538-540

Angus KW. 1983. Cryptosporidiosis in man, domestic animals and birds: a review. Journal of the Royal Society of Medicin **76,** 62-70.

Barrington GM, Gay JM, Evermann JF. 2002. Biosecurity for neonatal gastrointestinal diseases. Veterinary Clinics of North America: Food Animal Practice **18(1),** 7-34.

Bendali F,Bichet H, Schelcher F, Sanaa M. 1999. Pattern of diarrhea in newborn beef calves in south-west France. Veterinary Research **30,** 61–74.

Blom JY. 1982. The relationship between serum immunoglobulin values and incidence of respiratory disease and enteritis in calves. Nordisk Veterinary Medicin **34,** 276 -284.

Brandt CD, Kim HW, Rodriguez WJ, Arrobio JO, Jeffries BC, Parrot H. 1982. Rotavirus gastroenteritis and weather. Journal of Clinical Microbiology **16,** 478-482.

Brenner J, Elad D, Markovics A, Grinberg A, Tranin Z. 1993. Epidemiological study of neonatal calf diarrhea in

Israel-a one year survey of fecal samples.Israel Journal of Veterinary Medicine **48(3),** 113-116.

Castro AE and Heuschele WP. 1992. Veterinary diagnostic virology: Mosby-Year Book, St Louis, p.92–96.

Castrucci G, Frigeri FM, Ferrari M, Cilli V, Gualandi GL, Aldrovandi V. 1988. Neonatal calf diarrhea induced by rotavirus. Comparative Immunology, Microbiology and Infectious Diseases **11,** 71-84.
http://dx.doi.org/10.1016/0147-9571(88)90021-5

De Verdier Klingenberg K. 2000. Enhancement of clinical signs in experimentally rotavirus infected calves by combined viral infections. Veterinary Record **147(25),** 717-719.

Deng Y, Batten CA, Liu BL, Lambden PR, Elschner M, Günther H, Otto P, Schnürch P, Eichhorn W, Herbst W, Clarke IN. 2003. Studies of Epidemiology and Seroprevalence of Bovine Noroviruses in Germany. Journal of Clinical Microbiology **41(6),** 2300–2305.
http://dx.doi.org/10.1128/JCM.41.6.2300-2305.2003

Fenner F, MacLachlan NJ, Dubovi EJ, editors. 2011. Fenner's Veterinary Virology, 4th ed, Burlington: Academic Press, p. 288–290 and 394-398.

Fields BN. Knipe DM. Howley PM. Chanock RM. Melnick JL. Monath TP. Roizman B. Straus SE. 1995. Fields Virology, 3rd ed, Philadelphia: Lippincott-Raven, p.1625-1708.

Frank NA and Kaneene JB. 1993. Management risk factors associated with calf diarrhea in Michigan dairy herds. Journal of Dairy Science **76,** 1313–1323.
http://dx.doi.org/10.3168/jds.S0022-0302(93)77462-7

Fuente R, Garcia A, Ruiz-Santa-Quiteria JA, Luzon M, Cid D, Garcia S, Orden J, Gomez-Bautista M. 1998. Proportional morbidity rates of enteropathogens among diarrheic dairy calves in Central Spain. Preventive Veterinary Medicine **36,**145–152.
http://dx.doi.org/10.1016/s0167-5877(98)00077-4

Fuente R, Luzou M, RuizSantaQiuteria JA, Garcia A, Cid D, Orden JA, Garcia S, Sanz R, Gomez Bautista M. 1999. Cryptosporidium and concurrent infection with other major enteropathogen in 1 to 30 day old diarrheic dairy calves in Central Spain. Veterinary Parasitology **80(3),** 179-185.
http://dx.doi.org/10.1016/s0304-4017(98)00218-0

Gulliksen SM, Jor E, Lie KI, Hamnes IS, Loken T, Akerstedt J, Osteras O. 2009. Enteropathogens and risk factors for diarrhea in Norwegian dairy calves. Journal of Dairy Science **92(10),** 5057–5066.
http://dx.doi.org/10.3168/jds.2009-2080

Gulliksen SM, Lie KI, Solverod L, Osteras O. 2008. Risk factors associated with colostrum quality in Norwegian dairy cows. Journal of Dairy Science **91,** 704–712.
http://dx.doi.org/10.3168/jds.2007-0450

Haschek B, Klein D, Benetka V, Herrera C, Sommerfeld-Stur I, Vilcek S, Moestl K, Baumgartner W. 2006. Detection of bovine Torovirus in neonatal calf diarrhea in Lower Austria and Styria (Austria). Journal of Veterinary Medicine Series B **53,** 160–165.
http://dx.doi.org/10.1111/j.1439-0450.2006.00936.x

Herrera-Luna C, Klein D, Lapan G, Revilla-Fernandez S, Haschek B, Sommerfeld-Stur I, Moestl K, Baumgartner W. 2009. Characterization of virulence factors in Escherichia coli isolated from diarrheic and healthy calves in Austria shedding various enteropathogenic agents. Veterinarni Medicina **54 (1),** 1–11.

Horadagoda A, Eckersall PD, Alsemgeest, SPM, Gibbs HA. 1993. Purification and quantitative measurement of bovine SAA. Research in Veterinary Science **55,** 317-325.
http://dx.doi.org/10.1016/0034-5288(93)90101-k

Ishizaki H. 1995. Persistence of a single electropherotype and serotype (G6P5) of bovine Rotavirus in calves on a closed dairy farm from 1990 to 1993. American Journal of Veterinary Research **56,** 1019-1024.

Izzo MM, Kirkland PD, Mohler Vl, Perkins NR, Gunn AA, House JK. 2011. Prevalence of major entric pathogens in Australia dairy calves with diarrhea, Australian Veterinary Journal **89(5),** 167-173.
http://dx.doi.org/10.1111/j.1751-0813.2011.00692.x

Kohara J and Tsunemitsu H. 2000. Correlation between maternal serum antibodies and protection against bovine rotavirus diarrhea in calves. Journal of Veterinary Medical Science **62(2),** 219-221.
http://dx.doi.org/10.1292/jvms.62.219

Langoni H, Linhares AC, Avila FA, Da Silva AV, Elias AO. 2004. Contribution to the study of diarrhea etiology in neonate dairy calves in Sao Paulo state, Brazil, Brazilian Journal of Veterinary Research and Animal Science **41(5),** 313-319.
http://dx.doi.org/10.1590/s1413-95962004000500004

Maddox-Hyttel C, Langkjaer RB, Enemark HL, Vigre H. 2006. Cryptosporidium and Giardia in different age groups of Danish cattle and pigs-Occurrence and management associatedrisk factors. Veterinary Parasitology **141,** 48–59.
http://dx.doi.org/10.1016/j.vetpar.2006.04.032

Mayameei A, Mohammadi GH, Yavari S, Afshari E, Omidi A. 2010. Evaluation of relationship between Rotavirus and Coronavirus infections with calf diarrhea by capture ELISA. Comparative Clinical Pathology **19(6),** 553–557.
http://dx.doi.org/10.1007/s00580-009-0920-x

McGavin MD. Carlton W. 1995.Thomson Special Veterinary Pathology, 2nd ed , St. Louis: Mosby, p.48-58.

McKercher DG, Castucci G, Frigeri F, Ferrari M, Cilli V. 1984. A serologic survey of bovine rotavirus infection in Italy. Comparative Immunology, Microbiology and Infectious Diseases **7(3-4),** 165-169.
http://dx.doi.org/10.1016/0147-9571(84)90022-5

Mebus CA, Stair EL, Underdahl NR, Twiehaus MJ. 1971. Pathology of neonatal calf diarrhea induced by reo-like

virus. Veterinary Pathology **8,** 490-505.

Millemann Y. 2009. Diagnosis of neonatal calf diarrhea. Revue De Medecine Veterinaire **160(8-9),** 404-409.

Moosakhani F, Badiei A, Asadi AH, Asadi H, Shaghayegh A, Mozaffari M. 2012. Detection of rota virus, corona virus, E.coli (k99),cryptosporidium and salmonella in diarrheic calves (up to one month old) in Tehran province farms. Journal of veterinary Clinical Research **3,** 1-10.

Naylor JM. 2002. Neonatal ruminant diarrhea In: Large animal internal medicine. Smith BP, 3rd ed, St Louis, Missouri: Mosby, p.352-366.

Nourmohammadzadeh F, Davoudi Y, Abdollahpour GH, Nouri A. 2012. The prevalence of rotavirus in neonatal calf diarrhea using electron microscopic examination,Comparative clinical pathology **21(6),** 1231-1234.
http://dx.doi.org/10.1007/s00580-011-1270-z

Okur Gumusova S, Yazici Z, Albayrak H, Meral Y. 2007. Rotavirus and coronavirus prevalence in healthy calves and calves with diarrhea. Medycyna Weterynaryjna **63(1),** 62-64.

Parwani AV, Rosen BI, Flores J, McCrae MA, Gorziglia M, Saif LJ. 1992. Detection and differentiation of bovine group A rotavirus serotypes using polymerase chain reaction-generated probes to the VP7 gene. Journal of Veterinary Diagnostic Investigation **4(2),** 148-158.
http://dx.doi.org/10.1177/104063879200400206

Perez E, Kummeling A, Janssen MMH, Jimenez C, Alvarado R, Caballero M, Donado P, Dwinger RH. 1998. Infectious agents associated with diarrhea of calves in the canton of Tilaran, Costa Rica. Preventive Veterinary Medicine **33(1-4),** 195–205.
http://dx.doi.org/10.1016/s0167-5877(97)00038-x

Pohjola S, Oksanen H, Neuvonen E, Veijalainen P, Henriksson K. 1986. Certain enteropathogens in calves of Finnish dairy herds with recurrent outbreaks of diarrhea. Preventive Veterinary Medicine **3(6),** 547-558.
http://dx.doi.org/10.1016/0167-5877(86)90033-4

Pourjafar M, Badiei K, Nazifi S, Naghib SM. 2011. Acute phase response in holstein dairy calves affected with diarrhoea. Bulgarian Journal of Veterinary Medicine **14(3),** 142–149.

Radostits OM, Gay CC, Hinchcliff KW, Constable PD. 2007. Veterinary Medicine - A textbook of the diseases of cattle, horses, sheep, pigs, and goats, 10th ed, USA: Saunders Elsevier, Vol 1and 2, p.260-268 and 1286-1299.

Reidy N, Lennon G, Fanning S, Power E, Oshea H. 2006. Molecular characterisation and analysis of bovine rotavirus strains circulating in Ireland 2002–2004. Veterinary Microbiology **117(2-4),** 242–247.
http://dx.doi.org/10.1016/j.vetmic.2006.05.004

Reynolds DJ, Morgan JH, Chanter N, Jones PW, Bridger JC, Debney TG, Bunch KJ. 1986. Microbiology of calf diarrhoea in southern Britain. Veterinary Record **119(2),** 34–39.
http://dx.doi.org/ 10.1136/vr.119.2.34

Roussel AJ and Hjerpe CA. 1990. Fluid therapy in mature cattle in the Veterinary Clinics of North America: Food Animal Practice, Philadelphia,PA: Saunders Co, **6(1),** p.111-123.

Shah NM and Jhala VM. 1992. Epizootiological investigations on Rotavirus infection in cases of neonatal calf diarrhoea. Indian Veterinary Journal **69,** 5-7.

Sherwood D, Snodgrass DR, Lawson GH. 1983. Prevalence of enterotoxigenic Escherichia coli in calves in Scotland and northern England. Veterinary Record **113(10),** 208-212.
http://dx.doi.org/10.1136/vr.113.10.208

Smith BP. 2009. Large Animal Internal Medicine, 4th ed, St Louis: Mosby Elsevier, p.353-361.

Snodgrass DR, Terzolo HR, Sherwood D, Campbell I, Menzies JD, Synge BA. 1986. Aetiology of diarrhoea in young calves. Veterinary Record **119(2),** 31-34.
http://dx.doi.org/10.1136/vr.119.2.31

Stair SL, Rhodes MB, White RG, Mebus CA. 1972. Neonatal calf diarrhea: purification and electron microscopy of coronavirus-like agent. American Journal of Veterinary Research **33,** 1147-1156.

Steiner L, Busarto A, Burnens A, Gaillard C. 1997. Frequency and etiology of calf losses and diseases before weaning in cow-calf farms. II. Microbiological and parasitological diagnoses in diarrhoeic calves. DTW (Dtsch Tierarztl Wochenschr) **104,** 169–173.

Svensson C, Hultgren J, Oltenacu PA. 2006. Morbidity in 3–7 month old dairy calves in south-western Sweden, and risk factors for diarrhoea and respiratory disease. Preventive Veterinary Medicine **74(2-3),** 162–179.
http://dx.doi.org/10.1016/j.prevetmed.2005.11.008

TrotzWilliams LA, Martin SW, Leslie KE, Duffield T, Nydam DV, Peregrine AS. 2007. Calf-level risk factors for neonatal diarrhea and shedding of Cryptosporidium parvum in Ontario dairy calves. Preventive Veterinary Medicine **82,** 12–28.
http://dx.doi.org/ 10.1016/j.prevetmed.2007.05.003

Uhde FL, Kaufmann T, Sager H, Albini S, Zanoni R, Schelling E, Meylan M. 2008. Prevalence of four enteropathogens in the faeces of young diarrhoeic dairy calves in Switzerland. Veterinary Record **163,** 362–366.
http://dx.doi.org/ 10.1136/vr.163.12.362

Waltner-Towes D, Martin SW, Meek AH. 1986. Dairy calf management, morbidity and mortality in Ontario Holstein herds. II. Age and seasonal patterns. Preventive Veterinary Medicine **4(2),** 125-135.
http://dx.doi.org/10.1016/0167-5877(86)90018-8