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Study of prevalence and efficacy of antibiotics against foot and mouth disease in cattle at Kurigram district in Bangladesh

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ABSTRACT

A study was carried out to investigate the prevalence and efficacy of commercial antibiotics against the FMD virus in cattle in the char areas of the Kurigram district over a period of six months from October 2014 to March 2015. A total of 472 animals were monitored randomly on the basis of age, sex, breed, and season. More or less similar affected rates were recorded in male (12.68%) and female (12.73%) cattle. There was no statistically significant difference in the affected rate of FMD in indigenous cattle by age and sex. The affected rate in animals of different age groups ranged from 16.67% in cattle up to 12 months of age, 13.33% in 13 to 26 months, 12.83% in 27 to 45 months, and 12.22% in 46 to 60 months age groups in cattle. The affected rate of FMD increased gradually from (7.69) % in October to (9.72) % in November to (16.00) % in December with a peak of (18.88) % in January and then gradually decreased to (15.00) % in February to (7.78) % in March. The affected rate on the basis of breed for indigenous animals was (12.30) % and the cross-breed animals were (13.00) %. Some commercial antibacterial drugs were used to evaluate their efficacy against secondary bacterial infections in the foot-and-mouth disease-affected cattle. Efficacy of commercial antibiotic treatment was observed in four groups of animals. The Amoxicillin for group A, combined Penicillin+Streptomycin for group B, Oxytetracycline for group C, and soda, potassium permanganate, suhaga, and honey for group D. Efficacy results of these antibacterial drugs were compared among the treatment groups on the basis of complete recovery from clinical signs and healing of foot lesions in days required. It was observed that the efficacy of the antibiotic above the mentioned treated group treated with the antibiotic Amoxicillin in group A showed statistically significant results to recover from the foot-and-mouth disease than the other groups B, C, and D.

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Introduction

Livestock is an important sub-sector in Bangladesh, considered to the backbone of agriculture. According to the Department of Livestock Service, Bangladesh loses as much as US$125 million annually due to FMD. In Bangladesh, 20 million households keep 23 million of cattle heads under traditional farming system. The density of livestock population per acre of cultivable land is 7.37. Foot-and-mouth disease (FMD) is endemic in Bangladesh and is predominantly due to FMDV serotype O (Rahman et al., 1985). In 2012, FMD outbreaks were identified in five different districts of Bangladesh (Nandi et al., 2015). Foot and Mouth Disease (FMD) is an important viral disease of various animals. Foot and Mouth Disease (FMD) is a contagious viral disease affecting cloven-hoofed animals, causing fever and vesicular eruption in the mouth, muzzle, foot, and other soft areas (Chowdhury et al., 1994). Foot and Mouth Disease (FMD) has constituted a major threat to the health of livestock for at least 450 years worldwide (Brooksby,1958).The

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highest number of outbreaks occurs among beef cattle farms, followed by feedlot farms and dairy farms (Elnekave et al.2016).The economic losses due to FMD occurs in many ways, mainly loss of production, the expense of control, the interference with movement of animal and animal products (milk, meat) at international levels (Ham-m-van et al., 1994) although the disease is not a killing one (the mortality rate in adults 2% and in young stock 20%) but production (meat and milk) and draught power are seriously impaired in acute cases (Blood and radostits, 1989). In 2010 and 2011, incursions of the FMDV O/SEA/Mya-98 strain, normally restricted to countries in mainland Southeast Asia, caused extensive outbreaks across East Asia (Valdazo-González et al.2013).It is a highly infectious febrile disease of cloven hoofed animals, and it is endemic in Indo-Bangladesh sub- continent widespread outbreaks occur throughout the sub-continent in different seasons (Kamaruddin and Pandit, 1988; Sarma and Hazarika, 1996). A number of factors like migratory animals, fodder, wild animals, newly purchased animals, strong wind and rain, flooding necessitating movements of large number of animals and personnel have been recognized to the possible sources of FMD infection (Ray et al., 1989 a,b ; Ekue et al., 1990). Unfortunately, this has not yet been achieved in Bangladesh due to lack of sufficient epidemiological information on the disease. Moreover, the uncontrolled movements of animals, lack of awareness in reporting the disease as well as lack of systematic procedures for mass vaccination of animals complicate the epidemiology of FMD in Bangladesh. This study justifies the economic impact of FMD including how it varies in different settings and how knowledge of this should be used to guide control policy. This included a synthesis of current literature on the subject. To help appreciate the scale of global FMD impact estimates were made of the direct costs of disease and vaccination in endemic countries as well as outbreak costs in free countries. The findings of this study also emphasis the formulation of more effective disease management and control strategies, including appropriate vaccination policies in Bangladesh. A detailed clinico-epidemiological investigation was undertaken with a view to study the following objectives. To determine the affected rate of Foot and Mouth Disease in cattle on the basis of sex, age, month and breed. To evaluate some antibacterial drugs to control secondary infections in clinical cases of Foot and Mouth Disease.

Material and Methods

Study areas

The study was conducted in the Fander char, Messerer char, and Krishnopur char of the Ballaver ghas union of the Nageshwari upazila of the Kurigram district. These chars were under a project named Chars Livelihoods Programme (CLP). These chars are situated on the riverside of Gangadhar. It is 40 kilometres away from Sadar Kurigram, Rangpur, Bangladesh.

Study period and animals

The study was conducted at different chars of the Kurigram district from October 2014 to March 2015. The animals were examined at the household to study the prevalence on the basis of chars, age, sex, month, and breed and to study the efficacy of antibiotics against FMD in cattle. Funder char, Messerer char, and char Krishnopur, respectively, 170, 120, and 182 numbers of the cattle population were recorded in three chars during the study period. Among which, 60 animals were affected with FMD.

Epidemiological study

As a livestock officer for the Chars and Livelihoods Program, researchers frequently observed and inspired beneficiaries while also advising them and providing solutions to animal-related difficulties. As a result, epidemiological data were gathered from that observation and from the beneficiaries through a review of their case histories and a clinical examination. Data on age, gender, and month of occurrence were recorded using procedures specified by Prasad et al. (1981) and Singh et al. (1981). Polymerase chain reaction (PCR) and reverse transcription polymerase chain reaction (RT-PCR) are molecular diagnostics that can detect the presence of FMD in clinical specimens (Dubie & Amare,2020).

Clinical examination

Body Condition Score (BCS), behavior, posture, gait, ulcer in mouth and tongue, salivation, anorexia, red lesion hooves and interdigital space, locomotive disturbance were observed by distant visual examination of the patient. Examination of different physical parts of the body of each of the animal clinically attend at char were done by using various close observation techniques. The general clinical examination was performed to determine the posture, behavior, gait, and physical condition of each of the FMD-affected animals. The inspection and palpation were used to examine the mouth and foot. The tongue was checked for injury, ulceration, vesicles, abnormal mobility, and consistency. The foot of each animal was examined on inspection and palpation to detect any lesion on the interdigital spaces and to find the unwillingness to take weight on the limbs.

Prevalence

Prevalence was calculated as number of cases of disease divided by population at risk and multiple by 100.

$$\text{Prevalence} = \frac{\text{Number of disease cases}}{\text{Population at risk}} \times 100$$

Table1. Sex wise prevalence of Foot-and-mouth disease in cattle in Nageshwari upazila

	Male		Female		Total	
		Affected cases (number and %)	Number of animals examined	Affected cases (number and %)	Number of animals examined	Affected cases (number and %)
Funder	75	10 (13.33 %)	95	13 (13.68 %)	170	23 (13.54 %)
Messerer	50	6 (12.00%)	70	8 (11.43 %)	120	14 (11.66 %)
Krishnopur	80	10 (12.50 %)	102	13 (12.74 %)	182	23 (12.63 %)
Total	205	26 (12.68 %)	267	34 (12.73 %)	472	60 (12.71 %)

Grouping of animals for antibiotic therapy

Antibacterial are known to have no effect on the agent in viral infection. The use should be favored for the prevention of subsequent bacterial infections or when a bacterial infection progresses alongside the viral agent. Group A: Consisting of 15 FMD-affected animals, and each animal was treated with amoxicillin (Moxacil vet) at 8-10 mg/kg body weight, i/m ly sid. Group B: Consisting of 15 FMD-affected animals, and each animal was treated with penicillin + streptomycin (SP vet) combined as 40,000 IU/kg body wt. + 15 mg/ kg body wt. i/m ly sid. Group C: Consisting of 15 FMD-affected animals, and each animal was treated with oxytetracycline (Renamycin) at 5-8 mg/kg body weight i/m ly sid. Group D: Control group consisting of 15 animals, and each animal treated by KMnO4, soda, suhaga (sodium borate), honey, etc. no antibiotics were applied. The therapeutic evaluation was assessed on the basis of days required for complete healing of mouth and foot lesions as described by Rahman et al. (1985).

Monitoring the antibiotic treated results

The Chars Livelihoods Programme selected a Livestock Service Provider (LSP) to assist in every respective char to treat the animals. Sometimes they were provided training about the treatment and the management of animals from the project. Whenever any problem or symptom was observed by beneficiaries, they communicated with LSP, and medicine would be given. Especially the efficacy of different antibiotics against FMD was recorded.

Statistical analysis

The data obtained for different characters were statistically analyzed following the one way ANOVA of SPSS version.25. The significant differences among the treatment means were compared by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Results

Epidemiological investigation

The major outbreak of Foot-and-mouth (FMD) was recorded in the month of November-December 2014 at the Fander char and Messerer char and in the month of January 2015 at the char krishnopur.

The affected rate of FMD on the basis of sex and age is presented in Tables 1 and Figure 1, respectively. It is evident from Figure 1 that all age groups of indigenous cattle are susceptible to FMD. More or less similar affected rates were recorded in male (12.68%) and female (12.73%) cattle (Table 1). The affected rate in animals of different age groups ranged from (14.29) % in cattle up to 12 months of age, (13.33) % in 13 to 36 months, (12.57) % in 37 to 55 months, and (11.87) % in 56 to 72 months age groups in cattle. There was no statistically significant difference in the affected rate of FMD in indigenous cattle by age and sex. This study was conducted over a six-month period only due to the availability of clinical cases under these areas, and the month-wise occurrence of FMD in indigenous cattle is presented in Table 2.

It appears from Table 2 that the affected rate of FMD increased gradually from (7.69) % in October to (9.72) % in November to (16.00) % in December with a peak of (18.88) % in January and then gradually decreased to (15.00) % in February to (7.78) in March.

Table 2. Month-wise prevalence of FMD disease in cattle in the chars of Nageshwari upazila.

Month	Number of animals	Animals affected
October	65	5 (7.69 %)
November	72	7 (9.72 %)
December	75	12 (16.00 %)
January	90	17 (18.88 %)
February	80	12 (15.00 %)
March	90	7 (7.78 %)
Total	472	60 (12.71 %)

Table 3. Breed wise prevalence of FMD in Nageshwari upazila.

Breed name	Number of cattle	Animals affected
Indigenous animals examined	325	40 (12.30 %)
Cross breed animals examined	147	20 (13.00 %)
Total	472	60 (12.71 %)

Clinico-pathological investigation

Most of the cattle affected with foot-and-mouth disease showed high rectal temperature (103 to 105) F accompanied by severe dejection and anorexia, followed by painful stomatitis. The affected animals showed abundant salivation and saliva hanging in long, ropey strings(fig.1A). Vesicles appeared on the buccal mucosa on the tongue and gum, which ruptured to form ulcers (fig.1B). Concurrently with the oral lesions, lesions appeared on the feet, particularly on the clefts and the coronet/interdigital space (fig.1C). The clinical sings of FMD were found more severe in young calves than adults.

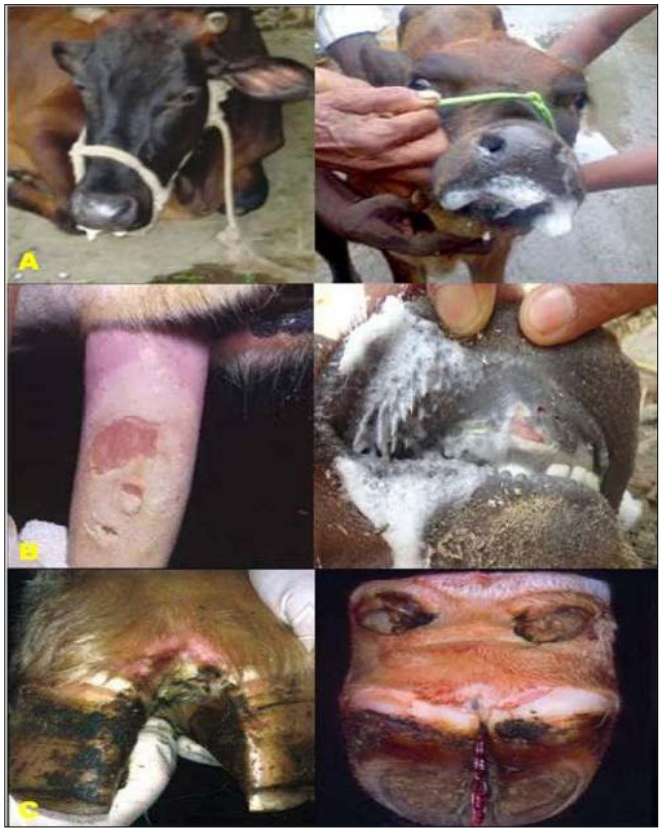

Figure 1. (A) Salivation and saliva hanging, (B) Buccal mucosa, tongue and gum which ruptured to form ulcer, (C) Lesions appeared on the feet (cleft).

Monitoring the therapy result

Some commercial antibacterial drugs available in the Kurigram were used to evaluate their efficacy against secondary bacterial infection in the foot-and-mouth disease affected cattle that is shown in the Table 4.

Group A received amoxicillin per company instructions; Group B received a combination medication such as penicillin + streptomycin per company instructions; Group C received oxytetracycline per company instructions; and Group D received soda, potassium permanganate, suhaga, and honey. Complete recovery from clinical signs and the number of days needed for foot lesions to heal were used to compare the effectiveness outcomes of these antibacterial medications across treatment groups. Antibiotics were shown to be more effective than the group that was treated; foot lesions and clinical symptoms treated with amoxicillin, penicillin + streptomycin, oxytetracycline, and supportive care all recovered in varying amounts of time. Amoxicillin, the antibiotic used to treat foot and mouth illness, produced statistically significant recovery outcomes in group A.

Discussion

Epidemiological investigation

The major outbreaks of FMD were recorded in higher numbers in cattle in the chars of Nageshwari upazila in the month of January 2015 than in any other month of the year. Epidemiological investigation of 472 randomly selected cattle in the outbreak areas revealed that only 60 (12.71%) animals were clinically affected with FMD, of which 2 (3.33%) severely affected calves died. The morbidity, mortality, and case fatality were (12.71%, 0.42%, and 3.33%), respectively. Although the occurrence of FMD outbreaks has been reported to be high in cattle in the district of Tangail (average 8 outbreaks/year), the information on morbidity, mortality, and case fatality rates is lacking in inland literature (Kamaruddin and Pandit, 1988). However, comparatively higher morbidity (48 & 59.5%), mortality (7.2% & 1.8%), and case fatality (12.09%) rates have been reported in Indian cattle due to FMD (Patnaik, 1986; Ray et al., 1989). These variations in morbidity, mortality, and case fatality rates might be due to differences in breed, age, types of virus involved, and annual

Table 4. Grouping of affected animals for therapeutic evaluation of antibacterial drugs against Foot-and-mouth disease in cattle.

Group	Number of animal	Name of antibiotic	Dose and route of administration	Recovery range in days (Mean ± SE)	Level of Significance
A	15	Amoxicillin	8-10mg/kg body wt. i/m ly.	5.2 ± 0.14^{a}	1.01*
B	15	Penicillin+Streptomycin	40,000iu/kg body wt. + 15mg/ kg body wt. i/m ly.	7.1 ± 0.23^{b}	
C	15	Oxytetracycline	5-8 mg /kg body wt. i/m ly.	7.5 ± 0.19^{b}	
D	15	Supportive agents	Soda, suhaga, potassium permanganate and honey	10 ± 0.25^{c}	

One-way ANOVA, Values are expressed as mean ± standard error of means (SEM). NS: Statistically not significant (P>0.05). a b c d means having different superscript in the same row differed significantly (P<0.05), * indicates 5% level of significance.

vaccination programs against FMD. Singh et al. (1981) reported a higher morbidity rate due to FMD in exotic and cross-bred cattle than in indigenous breeds. Blood and Radostits (1989) described only a 2% mortality rate in adult cattle due to FMD and 20% in young stock. It is revealed from the review of literature that types A, O, C, and Asia-1 and subtypes A5 and A22 have been identified in India in association with outbreaks (Jana et al., 2023).

Although the O, A, C, and Asia-1 types of FMD virus have been identified from Bangladesh (Kamaruddin and Pandit, 1988; Rahman et al., 1991), recently subtypes A and A have been identified in association with outbreaks (Chowdhury et al., 1994a, b). These subtypes of the FMD virus might spread from India to Bangladesh through migratory cattle. It may be mentioned here that cattle are not usually allowed to be slaughtered for meat purposes in India due to mainly religious causes (Ghosh, 2019). As a result, a large number of slaughterable cattle are being exported from India to the neighboring countries like Bangladesh. This export and import business of cattle from India to Bangladesh is mainly made by the private sector without considering the health and disease of animals. As a result, different diseases and infections are being introduced in Bangladesh through diseased cattle. Islam investigated (2001) 336 imported Indian cattle and found most of the imported cattle had clinical and subclinical infection, of which 44.34% had clinical infection with FMD. This indicates that the affected rate of FMD is higher in imported Indian cattle (44.34%) than in the local cattle (12.71%) in the Nageshwari chars. Therefore, the importation of Indian cattle should be restricted with necessary quarantine and health examination measures. However, Kamaruddin and Pandit (1988) reported that the occurrence of FMD varied from month to month and season to season, with higher frequency due to the movement of infected animals for different purposes. The insignificantly higher affected rate of FMD has been reported in female than male pigs (Shankar, 1992). However, the severity of infection with mortality was recorded in young stock as had been reported by Blood and Radostits (1989), who reported 2% mortality in adults and 20% in young calves due to FMD. The study found that all age groups of cattle are affected by FMD, with mortality rates recorded in young stock. There was no difference in affected rates between male and female animals, but females had a higher rate. The clinical causes of FMD appeared in all months, with the affected rate increasing from October to January and decreasing from February to March. The disease was more prevalent during winter and monsoon and could be spread through cattle fairs, markets, grazing areas, and the movement of infected animals (Jana et al., 2023). Although the occurrence of FMD has been reported in different species of domestic and wild animals elsewhere (Aslam & Alkheraije, 2023.; Hafez et al., 1993), similar reports have not been documented from Bangladesh. Therefore, the epidemiological role of different animal species in the spread of the infection should be explored in this country.

Clinico-pathological investigation

During the study period, the clinical signs were examined carefully in the affected animal, and the symptoms were recorded. The first clinical symptoms in FMD-affected cattle were salivation, vesicles and ulcers in the mouth, tongue, and gums, and also in the interdigital space of the hoof; lameness, pyrexia, and anorexia. In uncomplicated cases, the oral vesicles and ulcers usually healed within 8 to 10 days either by gradual replacement of the epithelium or after scab formation. In complicated cases, the courses of the disease ranged from 12 to 15 days, and most of the cases are complicated with secondary bacterial infection. The clinical pictures resembled very closely those described by Sard (1978) and Blood and Radostits (1989). However, skin lesions (Sen, 1990), eye and udder lesions with mastitis (Singh et al., 1981, Govindaraj et al., 2021), atypical lesions, and allergic reactions (Jana and Mailty, 1997) reported in the literature have not been observed in this study. Necropsy examination of dead calves revealed atypical lesions of myocardial degeneration, necrosis, and non-suppurative myocarditis, which, though not pathognomonic, are believed to be causes of death (Jones and Hunt, 1983). In addition, there were associated lesions of acute abomastitis, enteritis, and pneumonia.

The effect of antibacterial drugs against FMD

Some commercial antibacterial drugs available in Kurigram were used to evaluate their efficacy against secondary bacterial infections in the foot-and-mouth disease-affected cattle. Efficacy results of antibacterial drugs were compared among the treatment groups on the basis of complete recovery from clinical signs and healing of foot lesions in days required. It was observed that the efficacy of the antibiotic-treated group, that the clinical signs and foot lesions treated with amoxicillin, penicillin + streptomycin, oxytetracycline, and supportive treatment recovered within different days. The treating antibiotic amoxicillin in group A showed statistically significant results in recovering the foot and mouth disease compared to the other groups B, C, and D. The healing of untreated control cases generally required 10 to 15 days, with an average of 12 days, and in some cases, it became more complicated. These results could not be compared due to a lack of similar reports in the available literature. The results indicate that the administration of the drug would be required for rapid healing of FMD lesions and to prevent the spread of the disease to other susceptible animals and neighboring villages. However, Kilner (1994) reported that cattle fed with grain treated with caustic soda and Gangopadhya et al. (1990) and Chowdhury et al. (2020) reported that levamisole and zinc salt have some antiviral activity against FMD virus.

Conclusion

A total of 472 cattle, regardless of sex, different age groups, month, and breed, were investigated carefully, and outbreaks of FMD in those chars' areas revealed that 60 (12.71%) animals were clinically affected with FMD, and the 412 animals were found apparently normal or healthy. The affected rate was also recorded sex-wise, but there was no significant difference in the affected rate between male (12.68%) and female (12.73%) animals. The affected rate was recorded monthwise, and the affected rate was (7.69%)

in October, (9.72%) in November, (16.00%) in December, (18.88%) in January, (15.00%) in February, and (7.78%) in March, respectively. In Bangladesh, November to February is winter season, and peak cold weather is in December-January, and animals are moved to high ground and close herding, so the affected rate is high. The affected rate in Indigenous animals and crossbreed animals was, respectively, 12.30% and 13.00%, which were non-significant. It was observed that the efficacy of antibiotics among the four treated groups with amoxicillin, penicillin + streptomycin, oxytetracycline, and supportive treatment recovered within different days. The treating antibiotic amoxicillin in group A showed statistically significant results in recovering from foot and mouth disease compared to the other groups B, C, and D. So, this study recommends that amoxicillin is better than the combined effect of penicillin and streptomycin for foot and mouth disease. But further research is needed for better recommendations.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

References

Aslam, M., & Alkheraije, K. A. (2023). The prevalence of foot-and-mouth disease in Asia. *Frontiers in Veterinary Science, 10*, 1201578.

Barman, N. N., Sharma, D. K., Das, S. K., & Boro, B. R. (1990). Foot and mouth disease outbreaks due to FMD virus type O in the NE States of India during 1985-1988. *Indian Journal of Animal Health, 29*(2), 167-169

Blood, D. C., Radostits, O. M., & Henderson, J. (1989). *Veterinary Medicine (7th edn.)* Baillière Tindall. London, UK, 1158.

Chowdhury, M. S. R., Ahsan, M. I., Khan, M. J., Rahman, M. M., Hossain, M. M., Harun-Al-Rashid, A., ... & Uddin, M. B. (2020). Data on prevalence, distribution and risk factors for foot and mouth disease in grazing cattle in haor areas of Bangladesh. *Data in Brief, 28*, 104843.

Chowdhury, S. M. Z. H., Rahman, M. F., Rahman, M. B., & Rahman, M. M. (1996). Strains of foot-and-mouth diseas virus in different districts of Bangladesh. *Asian-Australasian Journal of Animal Sciences, 9*(3), 315-317.

Cleland, P. C., Baldock, F. C., Chamnanpood, P., & Gleeson, L. J. (1996). Village level risk factors for foot-and-mouth disease in northern Thailand. Preventive Veterinary Medicine, 26(3-4), 253-261.Dubie, T., & Amare, T. (2020). Isolation, serotyping, and molecular detection of bovine FMD virus from outbreak cases in Aba'ala district of Afar region, Ethiopia. *Veterinary Medicine International*, 2020 (1), 8847728.

Elnekave, E., van Maanen, K., Shilo, H., Gelman, B., Storm, N., El Khaliq, M. A., ... & Klement, E. (2016). Prevalence and risk factors for foot and mouth disease infection in cattle in Israel. *Preventive Veterinary Medicine, 130*, 51-59.

Gangopadhyay, N. N., Sharma, S. K., & Pathak, R. C. (1990). Antiviral activity of levamisole and zinc salt on experimental foot-and-mouth disease (FMD) virus infection in baby mice and guinea pigs. *Indian Journal of Virology,* 6 (1/2) 17-22.

Ghosh, S. (2019). Chor, police and cattle: The political economies of bovine value in the India–Bangladesh borderlands. *South Asia: Journal of South Asian Studies, 42*(6), 1108-1124.

Gurkirpal Singh, G. S., & Sandha, H. S. (1996). Epidemiological observations on five outbreaks of foot-and-mouth disease in exotic pigs. *Indian Journal of Comparative Microbiology, Immunology and Infectious Diseases, 17(*1), 73.

Govindaraj, G., Krishnamohan, A., Hegde, R., Kumar, N., Prabhakaran, K., Wadhwan, V. M., ... & Habibur, R. (2021). Foot and Mouth Disease (FMD) incidence in cattle and buffaloes and its associated farm-level economic costs in endemic India. *Preventive Veterinary Medicine, 190*, 105318.

Islam, M. A., Rahman, M. M., Adam, K. H., & Marquardt, O. (2001). Epidemiological implications of the molecular characterizationof foot-and-mouth disease virus isolated between 1996 and 2000in Bangladesh. *Virus Genes,* 23, 203-210.

Jana, C., Sagar, A. K., Mohapatra, J. K., Dubey, P., Sharma, D., & Singh, R. P. (2023). Clinical investigation and risk factor analysis for foot and mouth disease outbreak in farm ruminants at Uttarakhand. *Indian Journal of Veterinary Pathology, 47*(2), 111-116.

Jana, D., & Maity, B. (1997). Foot and mouth disease outbreak in vaccinated herds of cattle with atypical lesions and allergic reaction. *Indian Veterinary Journal, 74* (1), 77-79.

Jones, T.C. and Hunt, R.D. (1983). *Veterinary Pathology. 5th edn*. Lea and Febiger, Philadelphia, 385-388.

Kamaruddin, K. M., & Pandit, K. K. (1988). Pattern of foot-and-mouth disease virus infection in cattle of Bangladesh. *Bangladesh Veterinary Journal, 5*, 54-58.

Kilner, C. G. (1994). Foot-and-mouth disease and treatment of cattle feed with caustic soda. *Veterinary Record, 134*(9), 222.

Nandi, S. P., Rahman, M. Z., Momtaz, S., Sultana, M., & Hossain, M. A. (2015). Emergence and distribution of foot-and-mouth disease virus serotype A and O in Bangladesh. *Transboundary and Emerging Diseases, 62*(3), 328-331.

Prasad, S., Ahuja, K. L., Dogra, S. C., & Kumar, A. (1981). Epidemiology of foot-and-mouth disease in north-west region of India. A review. *Haryana Veterinarian, 20*, 79-87.

Radostits, O. M., Blood, D. C. and Gay, C. C. (1989). *Veterinary Medicine, 8th edition*. London: Bailliere Tindall. pp. 345-372.

Rahman, A. A., Islam, S. S., Sufian, M. A., Talukder, M. H., Ward, M. P., & Martínez-López, B. (2020). Foot-and-mouth disease space-time clusters and risk factors in cattle and buffalo in Bangladesh. *Pathogens, 9*(6), 423.

Rahman, A., Ahmed, J. U., & Islam, A. (1985). Quantification of losses among draught cattle due to foot-and-mouth disease. A case study in Mymensing District, Bangladesh. *Indian journal of animal sciences, 55*.

Rahman, M. F., Chowdhury, S. M. J. H., Rahman, B. M., Jahan, S., Mian, M. F., & Howlader, M. M. R. (1989). Prevalence of different types of foot and mouth disease virus in Bangladesh. *Bangladesh Veterinary Journal*, *23*, 49-53.

Rahman, M. B., Chowdhury, S. M. Z. H., Rahman, M. F., & Rahman, M. M. (1991). Application of an enzyme-linked immunosorbent assay for typing and subtyping of foot and mouth disease virus in Bangladesh. *Bangladesh Veterinarian*, 8(1/2), 8-10.

Ray, D. K., Bhattacharyya, U. K., Chowdhury, B., Dasgupta, P., & Bhattacharyya, A. K. (1989). Studies on a severe outbreak of foot and mouth disease in regularly vaccinated cross-exotic dairy cattle in West Bengal (India). I. Isolation of virus from typical and atypical lesions and also from milk. *Indian Journal of Animal Health, 28*(1), 51-55.

Ray, D. K., Dasgupta, P., Bhattacharyya, U. K., Choudhury, B., & Bhattacharyya, A. K. (1989). Studies on a severe outbreak of foot and mouth disease in regularly vaccinated cross-exotic dairy cattle in West Bengal (India). *Journal of Animal Health and Production, 28,* 155-158.

Sard, D. M. (1978). Clinical aspects of foot-and-mouth disease. *Veterinary Record, 102*, 186-187.

Sarma, D. K., & Hazarika, A. K. (1996). FMD [foot and mouth disease] in organised cattle farms of the NE States of India. *Journal of the Assam Veterinary Council,* 6, 51-52.

Singh, K. C. P., Prasad, C. B., & Singh, R. B. (1981). Some epidemiological features of foot and mouth disease outbreaks in cattle in Bihar. *Indian Journal of Animal Research*, 15, 98-102.

Valdazo-González, B., Timina, A., Scherbakov, A., Abdul-Hamid, N. F., Knowles, N. J., & King, D. P. (2013). Multiple introductions of serotype O foot-and-mouth disease viruses into East Asia in 2010–2011. *Veterinary Research, 44*, 1-12.