Determining the Risks of Introduction of Foot and Mouth Disease from Ethiopia to Europe through the Export of Deboned Beef

Belege Tadesse[1, 2], Askalu Abera, Awraris Ketema[3], Eyasu Demssie[4], Asres Yeneneh[5]

[1]University of Gondar, College of Veterinary medicine and animal sciences, Department of Veterinary Epidemiology and public health, Gondar, Ethiopia. PO. Box. 196.
[2]Amedguya Sheep Breed Improvement and Multiplication Center, North Shoa, Ethiopia.
[3]Menz Geramidir livestock and fishery resource office, North Shoa, Ethiopia
[4]Godar Zuria district livestock and fishery resource office, Gondar, Ethiopia
[5]University of Gondar department of para-clinical studies, Gondar, Ethiopia
tadessebelege@gmail.com

Abstract: Foot and mouth disease is considered as the most important livestock disease in the world in terms of its economic impact. The sero-prevalence in Ethiopia ranges from 5.6% to26.5%. This project was conducted with the objectives of identifying the hazards and assesses the risk of introduction of FMDV to Europe by exporting 1000tone of deboned meat from Ethiopia to Europe. The risk was determined using Monte Carlo stochastic simulation modeling with the @RISK software (@Risk trial version 7.5.1, Palisade Corporation, USA). Probability values for each event in the senario tree were determined from different literatures and opinions of experts. It is computed that foot and mouth disease virus has a risk of introduction from Ethiopia to Europe through deboned meat with a risk ranging from a minimum of $1.05*10^{-7}$(one per ten million animals) to a maximum of $9.92*10^{-6}$(approximately 10 per million animals). To decrease the risk of introduction of the virus the risk reduction procedures should be done properly and also Creation of compartments or zones that are free from FMD virus in the exporting country (i.e. Ethiopia) is also advisable.

[Belege Tadesse, Askalu Abera, Awraris Ketema, Eyasu Demssie, Asres Yeneneh. **Determining the Risks of Introduction of Foot and Mouth Disease from Ethiopia to Europe through the Export of Deboned Beef.** *Rep Opinion* 2018;10(7):11-17]. ISSN 1553-9873 (print); ISSN 2375-7205 (online). http://www.sciencepub.net/report. 3. doi:10.7537/marsroj100718.03.

Key words: FMD, Cattle, Ethiopia Risk

1. Introduction

Foot and mouth disease (FMD) is one of the endemic diseases in Ethiopia that occurs recurrently, causing several outbreaks every year (Ayelet *et al*., 2012). Serological surveys reported a sero-prevalence that ranges from 5% to 27% at the animal level and up to 60% at the herd level in different parts of the country (Rufael *et al*., 2008; Megersa *et al*., 2009; Bayissa *et al*., 2011).

Foot and mouth disease is considered as the most important livestock disease in the world in terms of its economic impact (James and Rushton, 2002). The annual economic impact of FMD in terms of visible production losses and vaccination costs in endemic regions of the world is estimated between US$6.5 and 21 billion, while outbreaks in FMD free countries and zones cause losses of more than US$1.5 billion a year (Knight-Jones and Rushton, 2013). The economic impact of FMD in endemic areas can be separated into two components: direct and indirect losses (Rushton, 2009; Knight-Jones and Rushton, 2013). The direct losses of the disease consist of loss of milk production, loss of draft power, retardation of growth, abortion and delayed breeding, and mortality especially in young animals. The indirect losses are related to market restrictions, use of suboptimal production technologies and costs of control (Rushton, 2009).

Quantitative risk-assessment methods are an extension of standard statistical and epidemiological methods which enable one to evaluate the likelihood and consequences of an adverse event occurring. Miller et al. (1993) outlined a process with key steps for performing a quantitative risk assessment and described a method for quantifying the uncertainty associated with results of risk assessment. Quantitative and qualitative information on the impact of FMD is essential in order to make sound decisions on the trade of animals and animal products. Countries must do a risk analysis to know/ prevent any hazard as a result of importation of that animals and animal product. This project was conducted with the objectives of identifying the hazards and assesses the risk of introduction of FMDV to Europe because of exporting 1000 tone of deboned meat from Ethiopia to Europe.

2. Status Of FMD In Ethiopia

2.1. Description Of FMD

FMD is an extremely contagious, acute viral disease of all cloven-hoofed animals, and pigs, characterized by fever, and vesicular eruptions in the mouth and on the feat and teats and sudden death of young animal (Blood *et. al*., 1994). Foot and mouth disease is associated with foot and mouth disease virus (FMDV), is classified within the Aphthovirus genus as a member of the *Picornaviridae* family, being small, a non-enveloped, single stranded RNA virus, icosahedral and is 26 nm in diameter (Alexandersen, 2003).

2.2. Epidemiology of FMD in Ethiopia

In Ethiopia, FMD is endemic and a notifiable disease; the national animal health regulatory directorate sends monthly and annually official reports to OIE (Leforban, 2005; MoLF, 2016). The disease is widely prevalent and previously used to occur frequently in the pastoral herds of the marginal lowland areas of the country. However, this trend has been changed and currently the disease is also frequently noted in the highlands of the country (Tefera, 2010).

2.3. FMD Virus Serotypes Identified in Ethiopia

Research findings indicate that five of the seven FMDV serotypes (O, A, C, Southern African Territories SAT-1 and SAT-2) were identified in Ethiopia and the isolated serotypes were responsible for FMD outbreaks during 1974-2012. These serotypes were identified from bovine, swine, ovine, and caprine samples collected from the outbreak areas of Amhara, Oromia, Beneshangul-gumuz, South Nation Nationalities People, Addis Ababa and Gambella (Gelagay *et al.,* 2009). Cattle were found to be infected with all circulating serotypes of FMDV, whereas swine had only serotype O (Sahle, 2004; Gelaye *et al.,* 2005; Legesse, 2008; Nigussie, 2010; Ayelet *et al.,* 2009).

3. Methodolog

We use a scenario tree models to represent the potential pathways of exposure and spread and subsequently calculate the corresponding probabilities of these occurring. Scenario trees provide an effective way of identifying pathways and information requirements and a framework for a quantitative analysis (MacDiarmid and Pharo, 2003; Martin *et al*., 2007). The risk was determined using Monte Carlo stochastic simulation modeling with the @RISK software (@Risk trial version 7.5.1, Palisade Corporation, USA). The overall expected outcome/ risk of introduction was calculated as a product of all conditional probabilities describing the risks of each specific pathway. Then finally simulation was conducted based on the probability distributions. Each simulation consisted of 10,000 iterations.

3.1. What is the hazard if FMD entered in EU?

Description of the product (i.e. deboned meat):- the product is obtained from cattle population in Ethiopia in which they are extensively managed (extensive production system). Cattles purchased from the farmer, transported by a vehicle to quarantine feedlots and observed for FMD. Later the animals' are transported to the abattoir and observed antemortemly before slaughter. Slaughtering is conducted in properly functioning export abattoir. The meat and other offal were examined at postmortem properly. The deboned meat (lymph nodes are also removed) were kept for some time at room temperature (maturation) and then kept in chilling room until it is transported. The meat is transported with proper transporting facility to the importing country.

Define the Scenario (Context):-We consider that the deboned meat will be marketed/exported by a private company once a week.

Hazard identification:-the hazard is present in Ethiopia and meat can be a potential vehicle for FMD especially if deboning is not supported by lymph node removal and maturation. So the hazard in the importing country is introduction of FMD virus that later result in FMD outbreak in ruminants and pig; trade restriction and loss of production in affected animals.

4. Assessing the Risk

a. Identifying the Population at Risk:-Both the domestic and wild ruminants and pig that will expose by any means to the FMDV will be at risk.

b. Description of the risk pathway/scenario tree: - The scenario tree consists of a sequence of specific events, from the point of origin/source of the deboned meat to its destination. For each point or event in the tree, a specific question related to the risk of FMD virus introduction is asked. The accumulation/product of the answers to those questions determines the final expected risk related to the deboned beef importation.

c. Final Estimation of the Risk:-Probability of FMD virus introduction is determined as a function of: (a) probability of failure in detecting FMD virus in an infected herd; (b) probability of failure in detecting FMD virus during purchasing; (c) probability of failure in detecting FMD virus during serological testing; (d) probability of failure to detect FMD in quarantine feedlots; (e) probability of failure in detecting FMD virus during ante-mortem inspection; (f) probability of failure in detecting FMD virus during post-mortem inspection; (g) probability of FMD virus surviving deboning, lymph node removal, maturation and chilling. The overall expected risk is $p=p1*p2*p3*p4*p5*p6*p7$.

4.1. Estimation of Probability values for each event in the scenario pathway

P1: Probability of the selected exporting herd infected with FMD

The prevalence of FMD in Ethiopia were indicated by different investigators at different time; which includes 26.5% (Shale, 2004) and 21% (Rufael, 2008) for borana pastoral production system, 21.4% (Desissa *et al.,* 2014) in Kellem Wollega zone; 23% (Bayissa *et al*., 2009) from Borana cattles; 5.6% (Jembere, 2008) reported in afar regional state; 12% (Gelaye *et al*, 2009) for bench maji and 24.6 % (113/460) (Habtamu *et al*., 2011) in Borana plateau and Guji highlands of southern Ethiopia. We take the recent prevalence in the areas which provides most of the animals for export (i.e. **24.6** %) (113/460) (Habtamu *et al*., 2011) in Borana plateau and Guji highlands of southern Ethiopia).

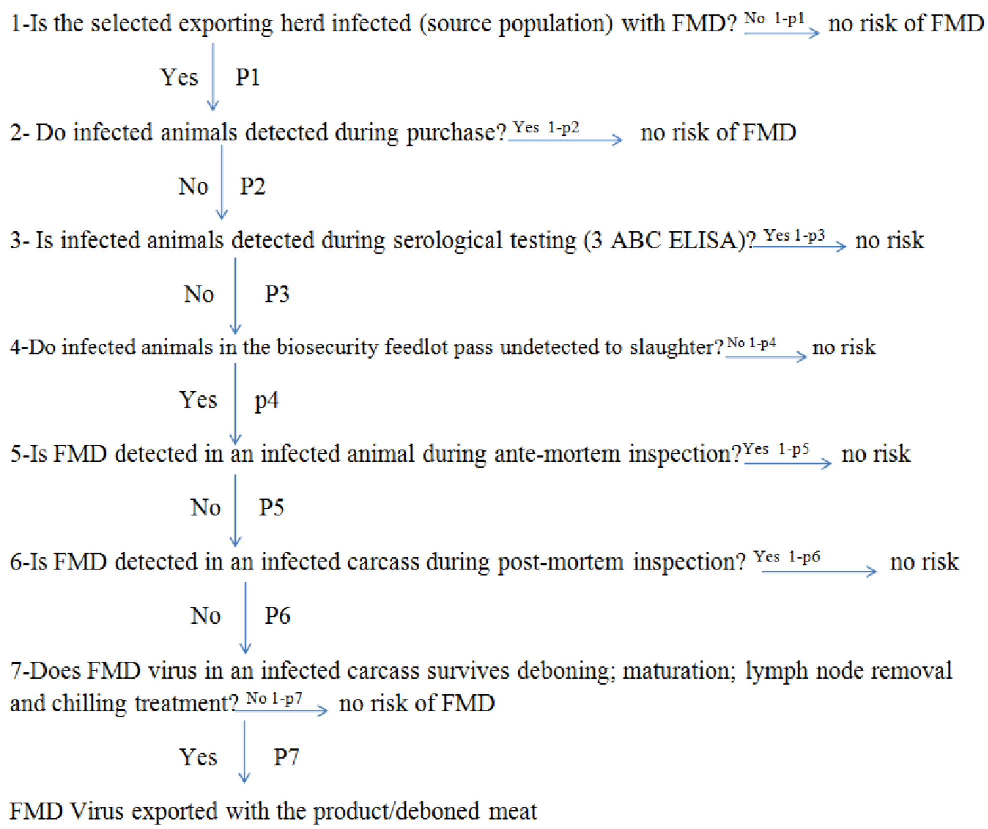


Fig.1. Diagrammatic representation of risk reduction procedures (i.e. the risk pathway)

P2: probability that the purchaser fails to detect foot and mouth disease during purchase

Failure to detect FMD could occur in areas with high vaccination coverage and low morbidity, or if all the source cattle were still within the incubation period. A conservative estimate of the probability that such conditions would occur was assumed to be in a range of 30%-40%, with a most likely and probability value of 35 % (expert opinion).

P3: probability that infected animals are not detected during serological testing (i.e. 3 ABC ELISA)

The 3ABC ELISA had an overall diagnostic sensitivity of 91.5% and diagnostic specificity of 96.4% (Colling *et al*., 2014). P3 is calculated by dividing the success (i.e. product of false negative and total animals needed) to the total population. Which is 200/7143=0.028.

P4: probability that infected animals in the biosecurity feedlot pass undetected to slaughter

Based on expert opinions FMD may pass undetected during quarantine in feedlot in the range of 11.2% and 11.6% with a most likely value of 11.3.

P5: probability that FMD is not detected in an infected animal during ante-mortem inspection

After enter in the abattoir the cattle move into a reception pen for ante-mortem inspection. It would be difficult to miss the feverish, salivating or lame animal and, therefore, the probability that the inspection process fails to detect at least one FMD animal is low. The probability of failing to detect at least one animal with signs of FMD was estimated to be 11%-50%, while the most-likely probability was estimated to be 30%. These values are very conservative and may be too doubtful.

P6: probability that FMD is not detected in an infected carcass during post-mortem inspection.

After at least 24 hours of rest and examination, the animals are moved for slaughter. The tongue, oral mucosa, muzzle and feet of all cattle are inspected individually for acute or recovered vesicular lesions. It would be difficult for an inspector to miss developing vesicles or acute lesions. As in the entire inspection process, any FMD foot lesion or any tongue lesion would cause an immediate interruption of all meat export operations from that abattoir. Based on experts opinions the probability of failing to detect FMD during post-mortem inspection was estimated to be 10%-40%, while the most-likely probability was estimated to be 20%.

P7: Probability of FMD virus in an infected carcass survives deboning; maturation; lymph node removal and chilling treatment

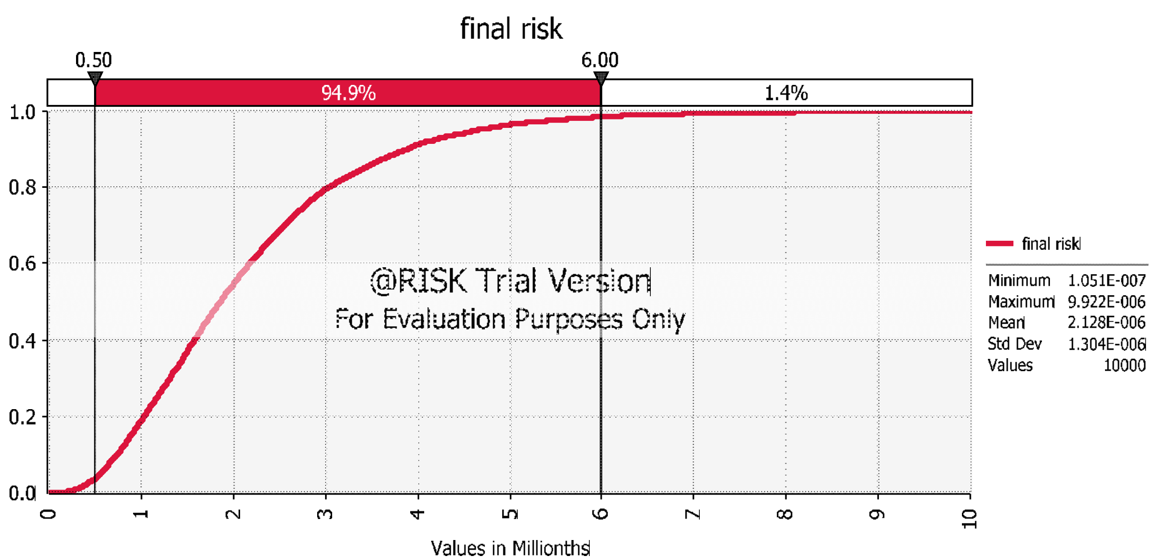
The effectiveness of the maturation depends on the amount of glycogen in the muscle at the time of slaughter, which in turn is influenced by the general health and the resting period of the animal. In addition, the desired pH is not always reached within lymph nodes, bone marrow or the contents of large blood vessels (Cottral G.E., 1969). It is difficult to estimate the amount of FMD virus which might survive in the meat of a matured, deboned carcass from a viraemic animal. For the above-mentioned reasons, we arbitrarily selected 10% as the most-likely probability for carcasses of viraemic cattle to yield contaminated meat. The probability level was assumed unlikely to be less than 1% and not more than 30 %.

5. Result Of Computer Simulation

The above estimated probability values were entered in an Excel (Table 1) for the simulation of the probability that FMD virus might remain in the chain of events. The expected final risk without considering distribution (i.e. using deterministic modelling) is$1.63452*10^{-6}$ calculated by using p1*P2 * P 3 * P 4 * P 5 * P6*p7.

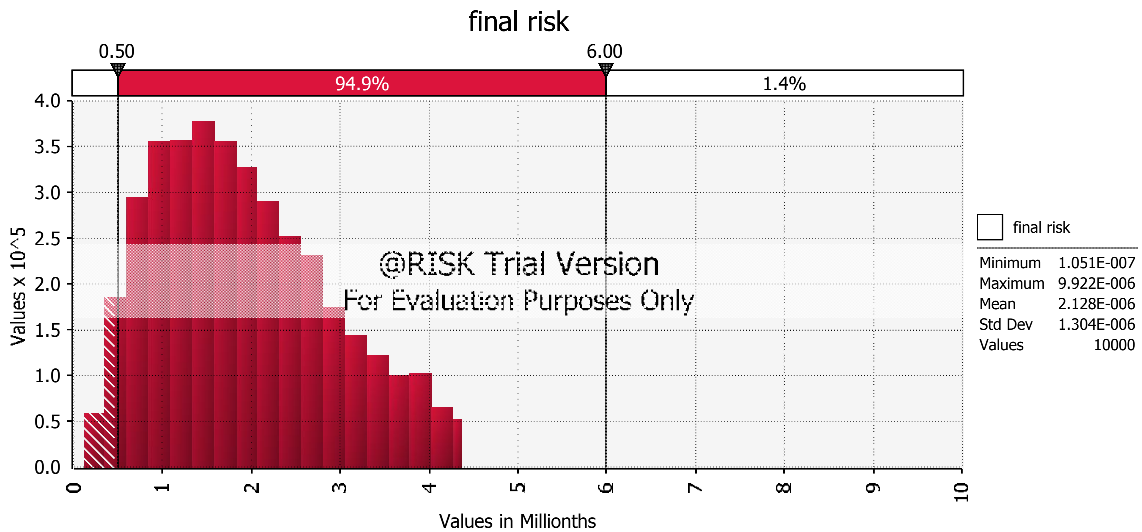
Table1: Excel for estimating effects of risk of foot and mouth disease (FMD) during deboned meat export from Ethiopia to Europe

Risk Parameters	Description	min or n	MLE or s	Max or failure	Expected risk
P1	Infection at source	460	113	347	0.246
P2	purchase_undetected	0.3	0.35	0.4	0.35
P3	test_undetected	7143	200	6943	0.028
P4	qur-undetected	0.112	0.113	0.116	0.113
P5	AM_undetected	0.11	0.3	0.5	0.3
P6	PM undetected	0.1	0.2	0.4	0.2
P7	survival in beef	0.01	0.1	0.3	0.1



Probability of risk of survival of FMD virus in meat from infected herd

Fig 1: Cumulative density function ascending graph for the risk of harvesting and processing of beef from a herd infected with foot and mouth disease (FMD)



Probability of risk of survival of FMD virus in meat from infected herd

Fig. 2. The total risk alleviation probability density function for the harvesting and processing of beef from a herd infected with foot and mouth disease virus

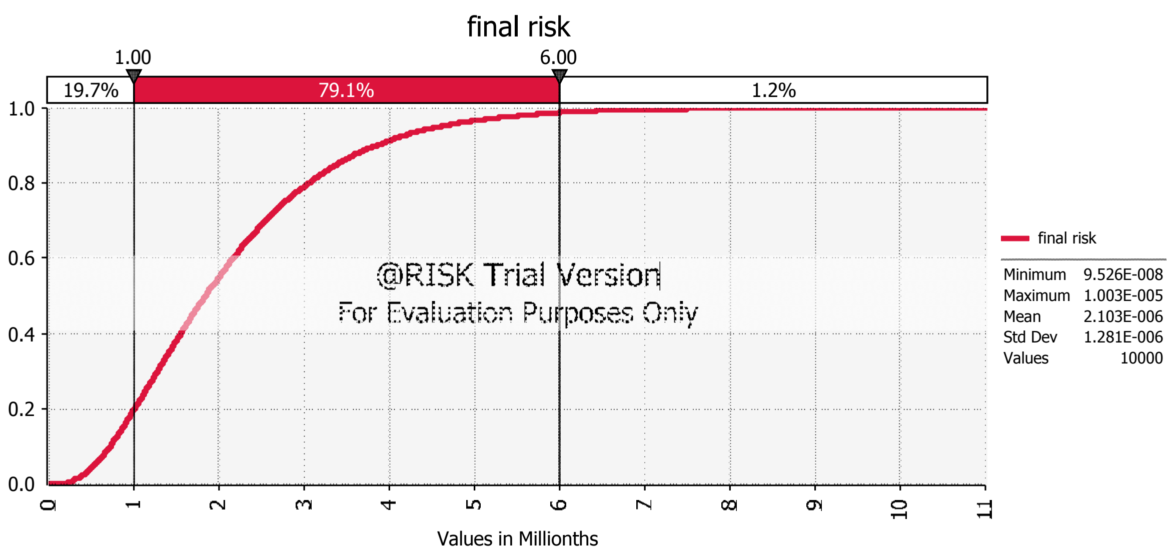


Fig.3. Cumulative density function ascending graph for the risk of harvesting and processing of beef from a herd infected with foot and mouth disease (FMD)

The mean result of the simulation show that meat still contains FMD virus at the end of the chain is $2.128*10^{-6}$ (fig 1 and 2), which means a chance of approximately two in a million animals. From the graph we see that 94.9% of the risk was laid between 0.5 to 6 per million animals (fig 1and 2). From the cumulative density function 98.6% (i.e. 100-1.4) of the risk was not exceed 6per million animals (fig 1 and 2). The result of the simulation also show that the minimum and maximum risk were $1.05*10^{-7}$ and $9.92*10^{-6}$ respectively (fig 1 and 2). This means the minimum risk exceeds one per ten million animals and the maximum risk approaches 10 (i.e. 9.92) per million animals. As we have seen from figure three above up to 19.7% of the risk of importing FMD virus to Europe through infected deboned meat from Ethiopia was not exceed one per million animals. From this graph we have also seen that 79.1% of the risk was laid between 1 to 6 per million animals.

6. Conclusion And Recommendations

Generally FMD is endemic in Ethiopia and meat can be serving as a vehicle for the FMD virus. Even if there are a series of disease mitigation procedures, this project shows that FMD virus has a risk of introduction from Ethiopia to Europe via deboned meat. Based on these findings we recommend that the risk reduction procedures should be done properly from the selection of the source population to the end of the process to reduce failure of detection. Creation of compartments or zones that are free from FMD virus in the exporting country (i.e. Ethiopia) is also advisable.

Corresponding Author:
Dr. Belege Tadesse;
University of Gondar, College of Veterinary Medicine and Animal Science, P.O. Box: 196, Gondar, Ethiopia or Amedguya Sheep breed improvement and multiplication center.
Telephone +251931201843;
Email. tadessebelege@gmail.com

References

1. Colling, A., Morrissy, C., Barr, J., Meehan, G., Wright, L., Goff, W., Gleeson, LJ., van der Heide, B., Riddell, S., Yu, M., Eagles, D., Lunt, R., Khounsy, S., Than Long, N., Phong Vu, P., Than Phuong, N., Tung, N., Linchongsu-bongkoch, W., Hammond, J., Johnson, M., Johnson, W., Unger, H., P Danielsa, P. and Crowther, JR. (2014): Development and validation of a 3ABC antibody ELISA in Australia for foot and mouth disease. *Aus. Vet. J.* 92, No 6, June 2014.
2. Alexandersen, S., Zhang, Z., Donaldson, A. I. and Garland, A. J. (2003): The Pathogenesis and Diagnosis of Foot and mouth disease*. Inst. Ani. Heal.*, 129: 1-36.
3. Ayelet, G., Gelaye, E., Negussie, H., Asmare, K. (2012): Study on the epidemiology of foot and mouth disease in Ethiopia. *Rev. Sci. Tech. 31*, 789–798.
4. Ayelet, G., Mahapatra, M., Gelaye, E., Egziabher, G. B., Rufeal, T., Sahle, M., Ferris, N. P., Wadsworth, J., Hutchings, H. G. and Knowles, J. N. (2009): Genetic characterization of foot and mouth disease viruses, Ethiopia, 1981-2007. *J. Emer. Infec. Dis.,* 15(9): 1-40.
5. Bayissa, B., Ayelet, G., Kyule, M., Jibril, Y., Gelaye, E. (2011: Study on seroprevalence, risk factors, and economic impact of foot-andmouth disease in Borena pastoral and agro-pastoral system, southern Ethiopia. *Trop. Anim. Health Prod*. 43, 759–766.
6. Blood, D. C., Radostits, O. M., and Henderson, J. A. (1994): Veterinary Medicine, a textbook of disease of cattle, sheep, goats, pigs and horses, 6th edition. The English Language Book Society and Bailliere Tindall. Pp: 730-746.
7. Cottral G.E. (1969): Persistence of foot-and-mouth disease virus in animals, their products and the environment. *Bull. Off. int. Epizoot*, 7 1, (3-4), 549-568.
8. Desissa, F., Tura, T., Mamo, B., and Rufael, T. (2014): Epidemiological study on foot and mouth disease in cattle: Sero-prevalence and risk factor assessment in Kellem Wollega Zone, West Ethiopia*. Acad. J.* 9(18): 1391-1395.
9. Gelagay, A., Mahapatra, M., Essayas, G., Berhe, G. E., Tesfaye, R., Mesfin, S., Ferris, N. P., Wadsworth, J., Hutchings, G. H. and Knowles, N. J. (2009): Genetic characterization of footand mouth disease viruses, Ethiopia, 1981-2007. Emerging Infectious Diseases, 15 (9): 1409 - 1471.
10. Gelaye, E., Beyene, B. and Ayelet, G. (2005): Foot and mouth disease virus serotype identified in Ethiopia. *Eth. Vet. J.*, 9:75-79.
11. Habtamu, M, Beyene, D and Tesfaye, R, Ashenafi, F. and Abunna, F. (2011): Study on the prevalence of foot and mouth disease in the Borana and Guji zones, Southern Ethiopia. *Vet. World* 4(7): 293-296.
12. James, A., Rushton, J. (2002): The economics of foot and mouth disease. *Rev. Sci. Tech*. 21, 637–644.
13. Jembere, S. (2008): Participatory epidemiology and sero-prevalence of foot and mouth Disease in Afar pastoral region, Ethiopia. MSc Thesis, Addis Ababa University, Faculty of Veterinary Medicine, DebreZeit, Ethiopia.
14. Knight-Jones, T.D.J., Rushton, J. (2013): The economic impacts of foot and mouth disease – what are they, how big are they and where do they occur? *Prev. Vet. Med. 112*, 161–173.
15. Leforban, Y. (2005): Report of a Mission on FMD in Ethiopia, Proposals for Strategic Plan for a Control Program oriented to exports. Addis Ababa, Ethiopia. Pp 1-43.
16. Legesse, Y. (2008): Foot and mouth disease outbreak investigation in selected parts of Etihiopia. MSc Thesis, Addis Ababa University, Faculty of Veterinary Medicine, DebreZeit, Ethiopia.
17. MacDiarmid, SC. and Pharo, HJ. (2003): Risk analysis: assessment, management and communication. *Rev Sci Tech* 22(2):397–408.
18. Martin RAJ, Cameron AR and Greiner M. (2007): Demonstrating freedom from disease using multiple complex data sources 1: a new methodology based on scenario trees. *Prev Vet Med* 79(2–4):71–97.10.1016/j.prevetmed.2006.09.008.
19. Megersa, B., Beyene, B., Abunna, F., Regassa, A., Amenu, K., Rufael, T. (2009): Risk factors

for foot and mouth disease seroprevalence in indigenous cattle in Southern Ethiopia: the effect of production system. *Trop. Anim. Health Prod*. 41, 891–898.
20. MoLF. (2016): Ministry of Livestock and Fishery and Epidemiology Directorate. Foot and mouth disease outbreaks annual report recording data summary from the years 2009-2015.
21. Nigussie, H. (2010): Study on molecular epidemiology of foot and mouth disease in Ethiopia. MSc Thesis, Addis Ababa University, Faculty of Veterinary Medicine, DebreZeit, Ethiopia.
22. Miller, L., McElvaine, M.D., McDowell, R.M. and Ahl, A.S. (1993): Developing a quantitative risk assessment process. *Rev. Sci. Tech. Off. int. Epiz*., 12: 1153-l 169.
23. Rufael, T., Catley, A., Bogale, A., Sahle, M., Shiferaw, A. (2008): Foot and mouth disease in the Borana pastoral system in southern Ethiopia and implications for livelihoods and international trade. *Trop. Anim. Health Prod*. 40, 29–38.
24. Rushton, J. (2009): The Economics of Animal Health and Production. CABI, Nosworthy Way, Wallingford, Oxfordshire, UK, pp. 193–200.
25. Rushton, J. (2009): The Economics of Animal Health and Production. CABI, Nosworthy Way, Wallingford, Oxfordshire, UK, pp. 193–200.
26. Sahel, M. (2004): An epidemiological study on the genetic relationship on FMDV in East Africa. A thesis submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the department of veterinary tropical diseases, Faculty of Veterinary Science University of Pretoria, South Africa.
27. Tefera (2010): Sero-prevalence, involvement of small ruminants in the epidemiology of FMD, and characterization of FMD virus circulating in the study area and assess epidemiological risk factors associated with FMD in cattle in selected districts of Gambella region, Ethiopia. MSc Thesis, Addis Ababa University, Faculty of Veterinary Medicine, DebreZeit, Ethiopia.

7/21/2018