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Sero-prevalence, risk factors and distribution of foot and mouth disease in Ethiopia

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ABSTRACT

Foot and mouth disease (FMD), world's most important highly infectious and contagious trans-boundary animal diseases, is responsible for huge global losses of livestock production as well as severe impacts on international trade. This vesicular disease is caused by foot and mouth disease virus of the genus Aphthovirus, family Picornaviridae. Currently FMD is major global animal health problem and endemic in Africa including Ethiopia. This paper systematically reviewed the sero-prevalence reports, associated risk factors and distribution of FMD in Ethiopia with the main aim of making compressive document on prevalence, risk factor and distribution of the disease thus helping as a basis for designing effective control strategies. FMD is widely distributed in Ethiopia and its prevalence varies from place to place with seropositivity that ranges from 5.6% to 42.7% in cattle and from 4% to 11% in small ruminant and in 30% in ungulate wildlife. In Ethiopia endemic distributions of five of seven serotypes, namely serotypes O, A, C, SAT1 and SAT2 have been documented. The dominant serotype being reported recently is serotype O and serotype C has not been reported in the country since 1983. However, serotype C specific antibody was detected in cattle indicating that circulation of serotype C viruses in the country may have gone unnoticed. The most common risk factor associated with FMD infection in Ethiopia includes production system, geographic location, species, age of animals, contact with wildlife and season of the year, mixed animal species and Breed. Conclusively, this paper revealed as FMD is posing a major threat in different area of the country thereby causing substantial economic losses through morbidity, mortality and restriction of international trade. Thus, demanding for great attention as its occurrence is may affect the export earnings of the country thereby threaten the livelihood of farmers and economy of the country at large.

Contents

1. Introduction

Agriculture represents the backbone of the Ethiopian economy by contributing up to 45% to the total GDP and by employing about 78% of the workforce in the country (Martins, 2014). Ethiopia has

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the largest the largest livestock population in Africa with Cattle being the dominant livestock species accounting for approximately 54 million heads (CSA, 2013). According to Behnke and Metaferia (2011) livestock contribution to the national economy is estimated at 19% of the total GDP, 45% of the agricultural GDP, and about 20% of the country's export earnings. The contribution of livestock to the national economy particularly with regard to foreign currency earnings is through exportation of live animal, meat and skin and hides (Ayele et al., 2003).

Despite having the largest the largest livestock population in Africa, the country is not benefiting from this sector as development of this sector is hampered by different constraints that include wide spread endemic disease caused viral, bacterial, and parasitic infestation, Lack of appropriate disease control policy and lack of appropriate veterinary services and lack of attention from government. Livestock diseases are among the important technical constraints that have hindered the development of the sector by decreasing production and hampering trade in animal and animal products. (Jilo et al., 2016; Abdela, 2016). Among health constrain infectious and contagious trans boundary animal diseases like Foot and mouth disease (FMD) is endemic and has major socio-economic significance in the country as witnessed by (Molla et al., 2010; Bayissa et al., 2011; Jenbere et al., 2011; Mekonen et al., 2011; Mohamoud et al., 2011; Ayelet et al., 2012; Abunna et al., 2013; Yahya et al., 2013; Alemayehu et al., 2014; Desissa et al., 2014; Duguma et al., 2014; Zerabruk et al., 2014; Beyene et al., 2015; Belina et al., 2016; Tesfaye et al., 2016; Mishamo, 2016; Wagari 2016).

Foot and mouth disease (FMD), which is also known as Aphthous fever, is the disease caused by foot and mouth disease virus (FMDV) of the genus Aphthovirus, family Picornaviridae (OIE, 2012a,b; Margo et al., 2013). It is a highly contagious trans-boundary disease that affects all cloven hoofed domestic and wild animals (Andrews et al., 2004; FAO, 2007; Margo et al., 2013). Few, if any, animal diseases have a greater impact than foot-and-mouth disease (FMD).it is one of the world's most important highly infectious animal diseases that is responsible for huge global losses of livestock production, enormous control costs and severe impacts on trade, as well as frequent and highly disruptive large-scale epidemics (Margo et al., 2013; Jemberu et al., 2015; Knight-Jones et al., 2016).

There are seven different serotypes of FMD, each with a diversity of topotypes, genetic lineages and strains, namely: O, A, C, South African Territories (SAT) 1, SAT 2, SAT 3, and Asia 1 (OIE, 2012a,b; Brito et al., 2015). Serotypes O and A are widely distributed, whereas serotypes SAT 1, SAT 2, and SAT 3 are normally restricted to Africa, and serotype Asia1 to Asia (Jemberu et al., 2015). FMDVs are endemic in Ethiopia since its first recorded in 1957 (Gulima, 2011) and a large number of outbreaks are reported every year (Ayelet et al., 2012). Endemic distributions of five of seven serotypes of FMDV are maintained in the country and Serotypes O, A, C, SAT1 and SAT2 were responsible for FMD outbreaks during 1974–2007 (Sahle et al., 2004; Gelaye et al., 2005; Ayelet et al., 2008; Legess, 2008; Ayelet et al., 2009; Negusssie et al., 2010). Recently Jemberu et al. (2015) identified as serotypes O, A, SAT 2 and SAT 1 were the causal serotypes of the outbreaks during the year 2007–2012. Serotype is O the most dominant serotype in the country (Jemberu et al., 2015; Ayelet et al., 2009).

The sero-prevalence investigations undertaken so far in the country reported the prevalence that ranges from 5.6% to 42.7% in cattle (Bayissa et al., 2011; Jenbere et al., 2011; Mekonen et al., 2011; Mohamoud et al., 2011; Ayelet et al., 2012; Abunna et al., 2013; Yahya et al., 2013; Desissa et al., 2014; Zerabruk et al., 2014; Duguma et al., 2014; Alemayehu et al., 2014; Beyene et al., 2015; Belina et al., 2016; Tesfaye et al., 2016; Mishamo, 2016; Wagari 2016). The prevalence in small ruminants ranges from 4% to 11% (Sahel, 2004; Beyene et al., 2015) and in 30% in ungulate wildlife (Sahel, 2004).

The studies conducted so far did not cover all corners of the country. However, this vesicular disease is widely distributed in Ethiopia and its prevalence varies from place to place. Recent serological investigation conducted in southern part of Ethiopia (Bayissa et al., 2011; Mekonen et al., 2011; Tesfaye et al., 2016), Western Ethiopia (Desissa et al., 2014; Beyene et al., 2015), central part of Ethiopia (Alemayehu et al., 2014; Wagari, 2016; Belina et al., 2016; Mishamo, 2016), Northern (Zerabruk et al., 2014), Southwest Ethiopia (Gelaye et al., 2009; Molla et al., 2010); Northeast (Shiferaw et al., 2010; Jenbere et al., 2011), Northwest Ethiopia (Mazengia et al., 2010), Eastern Ethiopia (Mohamoud et al., 2011; Abunna et al., 2013; Yahya et al., 2013) and different regions of the country (Ayelet et al., 2008; Ayelet et al., 2009; Negusssie et al., 2010), showed that FMD is posing a major threat in different are of the country thereby causing substantial economic losses through morbidity and mortality. Furthermore, FMD is the most important livestock disease in terms of economic impact on export earnings; about US$ 71026.8 losses is documented by Wagari (2016). According to Alemayehu et al. (2014) in the year 2011 the total annual economic loss due to bulls rejection from international market was estimated to be 3,322,269 USD which is equivalent to 56,345,682.24 ETB (1 USD = 16.96 ETB).

Despite the above situations of FMD in the country there is paucity of comprehensive well documented information that may help in knowing the disease current status at nation level. Therefore, the main objective of this manuscript were to systematically review the sero-prevalence reports from studies undertaken so far with its distributions and risk factors thus, helping as a basis for designing effective control strategies.

2. Sero-prevalence and distribution of FMD in Ethiopia

From historical perspective Foot and mouth disease was first recorded in Ethiopia in 1957 (Gulima, 2011). In Ethiopia reports indicated that during the period of 1957–73, 62 outbreaks of serotype O, 24 of serotype C and 12 of serotype A were recorded (Berson et al., 1972). From record of outbreak investigation in cattle by National Veterinary Institute, between 1982 and 2000, three serotypes: O, A and SAT2 FMDV were identified (Gelaye et al., 2001). Currently FMD is widely prevalent and distributed in all areas of Ethiopia, although the level of the disease prevalence may show significant variations across the different farming systems and agro-ecological zones of the country. Previously the disease 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 frequently noted in the highlands of the country (Tefera, 2010).

Endemic distributions of five of seven serotypes of FMDV are maintained in the country and Serotypes O, A, C, SAT1 and SAT2 were responsible for FMD outbreaks during 1974–2007 (Sahle et al., 2004; Gelaye et al., 2005; Ayelet et al., 2008; Legess, 2008; Ayelet et al., 2009; Negusssie et al., 2010). The most dominant serotype is O, accounting for 72% of the investigated outbreaks occurring in the country, followed by A (19.5%) and Serotype C has not been reported in Ethiopia since 1983 (Ayelet et al., 2009). However, a serotype C specific antibody was detected in cattle (Sahel, 2004; Gelaye et al., 2005; Legess, 2008; Rufael et al., 2008) indicating that circulation of serotype C viruses in the country may have gone unnoticed (Rufael et al., 2008).

Recently Jemberu et al. (2015) identified as serotypes O, A, SAT 2 and SAT 1 were the causal serotypes of the outbreaks during the year 2007–2012. In the past seven years (2009–2015) on average 93 numbers of FMD outbreaks were reported to MoLF annually. The

outbreaks occurred every year, but most were reported in 2011 and 2012 each 124 and 205 outbreaks, respectively. However, considering the figures provided are definitely underestimated and do not reflect the reality of the epidemiological situation in the country due to endemic nature of the disease and the unreported cases by farmers (MoLF, 2016).

The sero-prevalence investigations undertaken so far in the country reported the prevalence that ranges from 5.6% to 42.7% in cattle (Sahel, 2004; Rufael et al., 2008; Megersa et al., 2009; Molla et al., 2010; Bayissa et al., 2011; Jenbere et al., 2011; Mekonen et al., 2011; Mohamoud et al., 2011; Ayelet et al., 2012; Abunna et al., 2013; Yahya et al., 2013; Desissa et al., 2014; Zerabruk et al., 2014; Duguma et al., 2014; Alemayehu et al., 2014; Beyene et al., 2015; Belina et al., 2016; Tesfaye et al., 2016; Mishamo, 2016; Wagari 2016). The prevalence in small ruminants ranges from 4% to 11% (Sahel, 2004; Beyene et al., 2015) and in 30% in ungulate wildlife Sahel, 2004).

The prevalence of the disease is varying from place to place, and the studies conducted so far did not cover all corners of the country. However, recent serological investigation conducted in southern part of Ethiopia (Rufael et al., 2006; Megersa et al., 2009; Bayissa et al., 2011; Mekonen et al., 2011; Tesfaye et al., 2016), Western Ethiopia (Desissa et al., 2014; Beyene et al., 2015), central part of Ethiopia (Alemayehu et al., 2014; Wagari, 2016; Belina et al., 2016; Mishamo, 2016), Northern (Zerabruk et al., 2014), Southwest Ethiopia (Gelaye et al., 2009; Molla et al., 2010); Northeast (Shiferaw et al., 2010; Jenbere et al., 2011), Northwest Ethiopia (Mazengia et al., 2010), Eastern Ethiopia (Mohamoud et al., 2011; Abunna et al., 2013; Yahya et al., 2013) and different regions of the country (Ayelet et al., 2008; Ayelet et al., 2009; Negusssie et al., 2010), showed that FMD is posing a major threat in many parts of the country thereby causing considerable economic losses through morbidity, mortality and trade restriction.

Rufael (2006) investigated seroprevalence of FMD in three districts of Borana pastoral area of Oromia regional State namely: Yabello, Dire and Moyale. Out of 920 cattle investigated overall of 193 (21%) was found to be positive at individual animal level. On the other hand from 116 herds examined for the presence of antibodies to the 3ABC non-structural protein of FMD virus, 68 (59%) contained, at least, one positive animal. Moreover, significantly higher herd seroprevalence was recorded in Yabello district (61%), followed by Dirre (59%) and Moyale (52) districts. Similarly on animal basis Yabello district recorded the highest FMD seroprevalence (26.1%) followed by Dire (18.8%) and Moyale (16.1%). At Pastoral Associations level the highest herd seroprevalence was found in Dida Tiyara (100%), Romso (100%), Dida Yabello (80%), and Garbi Minch (77%). On individual level, seropositivity was highest at Dida Tiyara (43.3 5%) Garbi Minch (33.3%), Magado (32.4%), and Medhecho (26.9%) Pastoral Associations

The from South-western Ethiopia Gelaye et al. (2009) performed sero-epidemological investigation in two districts (Surma and Semen Bench) of the Bench Maji Zone between November 2007 and February 2008 with the objective of determining the seroprevalence of Foot and Mouth Disease (FMD) in cattle and identifying the potential risk factors associated with the disease. They collected sera samples from a total of 273 cattle in 98 herds and reported an overall sero-prevalence of 12.08% using the 3ABC-ELISA. Regarding the sero-prevalence at district level significantly higher seroprevalence (20%) they found was in the Surma district compared to the Semen Bench district (5.88%). The highest seroprevalence at peasant association level was observed in Kibish 25% (n = 40), followed by Tulgit 20% (n = 40), Koka 15% (n = 40), Aman 8.6% (n = 49), Mizan 5.66% (n = 53) and the lowest was in Temenga yasz 3.92% (n = 51). Furthermore, they evaluated herds for the presence or absence of other species with respect to FMD prevalence and found that herds with different species present had an FMD prevalence rate of 15.52% while those which did not have any other species had a prevalence rate of 6.06%.

In Southern Ethiopia Megersa et al. (2009) investigated FMD in endogenous cattle between October 2007 and March 2008 using 3ABC ELISA. They found seroprevalence of 9.5% and 48.1% at animal and herd levels, respectively. Moreover, they reported significantly higher Seroprevalence in South Omo than Sidama and Gamo Gofa areas.

Molla et al. (2010) Conducted sero-epidemiological study between October 2008 and May 2009 in seven districts of the South Omo zone, south-western Ethiopia. A total of 770 cattle sera were investigated using the 3ABC-ELISA and the overall seroprevalence of 8.18% was reported. The highest district-level prevalence was documented in Bennatsemay district (30.2%), and the lowest prevalence was in Malle and Debub Aari districts, each with prevalence of 6.3%

Another serological investigation in more broad area of the country by Negusssie et al. (2010) conducted seroprevalence investigation in three regional states of Ethiopia, namely Amhara, Oromia, and Addis Ababa from August 2008 to April 2009. A total of eight FMD outbreaks three in Oromia, one in Addis Ababa and four outbreaks in Amhara national regional States were investigated. A total of 496 cattle were examined for the presence of antibodies to the 3ABC non-structural protein of FMD virus and 219 (44.2%) were found to be positive. The highest seropositivity was recorded in Haremaya University dairy farm (80.0%), and the lowest was documented in Akaki-kality sub-city (28.3%).

Jenbere et al. (2011) performed sero-prevalence investigation from October 2007 to April 2008 in Afar pastoral area of Ethiopia to determine seroprevalence and associated risk factors for seropositivity of cattle FMD using 3ABC ELISA. four districts of Afar pastoral area from where the study animals were selected were Chifra from zone one, Amibara and Gewane from zone three and Ewa from zone four. At district level seroprevalence was significantly higher in Gewane (11.9%) as compared to Amibara (4.2%), Ewa (2.9%) and Chifra (5.2%). An overall seroprevalence at individual and herds level were found to be 5.6 and 48.4% respectively

The study from Eastern Ethiopia by Mohamoud et al. (2011) also conducted seroprevalence investigation on indigenous cattle from October 2009 to March 2010 in Somalia Regional State in Awbere and Babille Districts of Jijiga zone, A total of 384 sera were tested for antibodies against non-structural protein of FMD virus by using the 3ABC-ELISA and the overall individual animal antibody seroprevalence documented was 14.05%. At district level the prevalence in Awbere District animal was determined as 14.2% (n = 225) while in Babille was 15.1% (n = 159).

Mekonen et al. (2011) performed Seroprevalence investigation from November 2007 to March 2008 on Borana plateau and Guji highlands of southern Ethiopia to determine the prevalence of Foot and Mouth Disease (FMD) in bovine They reported an overall prevalence of 24.6% (113/460) by using 3ABC- ELISA technique. Moreover, they reported significantly higher prevalence in Borana 53.6%(82/153) compared to Guji 10.1%(31/307).

Bayissa et al. (2011) conducted Cross-sectional serological study in Borana pastoral and agro-pastoral area to determine seroprevalence and risk factors associated with foot and mouth disease infection and to assess community perceptions as to importance of the disease. Their investigation was in Borana zone of Oromiya Regional State, Southern Ethiopia in three districts namely, Arero, Teltele, and Yabello. A totally, 768 cattle sera were investigated from 111 herds using 3ABC ELISA test and they reported an overall individual level seroprevalence of 23.0%. From 111 herds examined, 65 (58.6%) found to have at least one positive cattle and The herd level seroprevalence reported was 67.6% in Arero district, 62.5% in Yabello district, and the lowest was found in Teltele district (45.9%). At peasant association level the highest herd level seroprevalence

was observed in Bobela (100%), Surupa (87.5%), Didyabello (70.0%), and Alona and Afura (66.7%). But, the lowest was recorded at Cherri (28.6%), followed by 33.3% at Ebissa, 40.0% at Sabba, and 44.4% at Bulegorma. At individual animal level the lowest (15.7%) seroprevalence was reported in Teltele District, followed by seroprevalence of 24.0% in Yabello and 29.9% Arero District. Furthermore, they concluded that FMD is a highly prevalent and economically important disease in the Borana pastoral and agro-pastoral production systems and suggested the need of effective control strategy.

Ayelet et al. (2012) investigated sero-prevalence FMD from serum sample collected for the serosurveillance of rinderpest between 2003 and 2006.Their study cover broad area of the country which includes 73 villages from Oromia, 33 villages from the State of Southern Nations, Nationalities and Peoples (SNNP), 24 from Amhara, 20 from Tigray, 18 from Addis Ababa, 18 from Afar, 15 from Somali and 8 villages each from Benishangul and Gambella. They tested total of 4465 sera samples and found 10.5% (n = 467) to be test positive by using the 3ABC ELISA. The highest seroprevalence was detected in samples from Oromia (20.7%) and for that time they reported absence of FMDV-specific antibodies in Gambella or Benishangul. From the administrative zones, the highest seroprevalence was detected in samples from the Eastern zone of Tigray with 41.5%; followed by the Guji zone of Oromia and Yeka district of the city of Addis Ababa, with 32.7% and 30%, respectively. A prevalence of 14.8% (n = 325) was obtained from 2241 samples collected from the pastoral areas of the country.

Abunna et al. (2013) investigated Sero-prevalence of cattle Foot and Mouth Disease in Dire Dawa and its Surrounding area using non structural protein 3ABC ELISA kit from November 2010 to March 2011. A total of 986 local (Zebu) cattle were included and overall prevalence they found was 8.01% (79/986). Furthermore, they found higher prevalence of FMD at Dire Dawa area 8.91% followed by 5.13% in Eastern Harerghe Zone.

Yahya et al. (2013) conducted seroprevelence study between November 2008 and March 2009 in traditionally managed cattle in 21 districts of East and West Hararghe zones in Oromia reginal State, Ethiopia. A total of 504 cattle were investigated and an overall prevalence rate of 11.6% was found. Furthermore, they found significantly ($p < 0.05$) higher (25.7%) seroprevalence in West Hararghe was than in East Hararghe (1.4%). From West Hararghe highest (46.1%) prevalence was documented in Meisso woreda, followed by Chiro and Darolebu woredas (28.7% each), while from East Hararghe, Girawa woreda had the highest seroprevalence (10.1%), followed by Babile and Gola-Oda woredas (6.4% each).

The from West Ethiopia Desissa et al. (2014) Performed serological study between November 2011–March 2012 in three districts of Kellem Wollega Zone of Oromia Regional State, to determine the seroprevalence of foot and mouth disease (FMD) in cattle and assessing the potential risk factors associated with the disease. From the total 384 sera tested, the overall seroprevalence of FMD in Kellem Wollega Zone was found to be 21.4%. The highest seroprevalence was observed at Sayo 31.53% followed by Lalo Kile district 19.01% and Dale Sadi district 15.26%

Zerabruk et al. (2014) performed Seroepidemiological investigation of FMD in Cattle managed under extensive husbandry system in Tigray, Northern Ethiopia from October 2008 to June 2009. They reported an overall seroprevalence of 15.4% (60) out of 390 cattle investigated

Duguma et al. (2014) conducted seroprevalence study from November 2007 to April 2008 in three districts of Bale Zone, Oromiya regional state. They collected serum samples from two districts and one dairy farm (Sinana 172, Goba 109 and Agarfa dairy farm 20). Out of 301 samples 65 (21.59%) were found to be positive for FMD by 3ABC ELISA. The highest prevalence they reported was from Sinana (24.41%) followed by Goba (20.18%) and Agarfa dairy Farm (5%).

Another sero-prevalence study from export quarantine centers by Birhanu (2014) investigated FMD at Adama-Modjo Livestock Export Industry in five Private beef animals' Exporter Enterprises located in and around Adama namely, Jordan, Moges, Seyoum, Jacranda and Israel Feedlot. This investigation included a total of 4321 apparently healthy bulls for the prevalence of antibody against FMD by using 3ABC ELISA from November 2013 to May 2014 and reported an overall prevalence of 556 (12.9%). Those bulls included in this sero-prevalence investigation were come from Borena, Arsi and Bale areas. The highest sero-positivity 276(19.3%) was found in bull originated from Bale followed by 89 (15.2%) from Borana and (9.50%) from Arsi.

Alemayehu et al. (2014) conducted sero-prevalence on 31 cattle feedlots found in central part of Ethiopia in 2011 for one year. Among total of 38,187 bulls examined for foot and mouth disease antibody, 5536 (14.5%) was found positive. Moreover, the seropositivity of FMD in their study varied from site to site with the highest being in Meki (37.4%) and the lowest in Nahmaled site (3.1%).

The study conducted in western Ethiopia by Beyene et al. (2015) investigated FMD seroprevalence from November 2011 to April 2012 in two districts of Oromia regional state and four districts of Beneshangul Gumuz regional state. A total of 1144 animals (589 cattle, 309 goats, and 246 sheep) and 181 herds were included in their investigation. The overall seroprevalence at animal level and herd level they found was 9% and 38.1%, respectively. Moreover, they indicated individual-animal seroprevalences of 15%, 11%, 10% and 6% in Tongo special district, Western Wollega zone, Kelem Wollega zone and Asosa zone, respectively. At animal level the lowest seroprevalence was recorded in Mange district followed by Asosa district, while the lowest herd seroprevalence was recorded in Asosa district followed by Mange district. Furthermore, they found statistically significant differences ($p < 0.05$) among different species, the highest level of seropositivity was seen in cattle 14% followed by 4% in small ruminants (sheep 5% and goats 3%).

Wagari (2016) conducted Serological investigation on apparently healthy bulls which were quarantined for export in Adama from December 2011 to May 2012 using 3ABC ELISA kit. A total of 1071 blood sample were included in the study and the over-all prevalence of FMD infection documented was 10.8% (116/1071).

Recently Belina et al. (2016) conducted sero-prevalence investigation from September 2014 to July 2015 with the aim of determining sero-prevalence of Foot and Mouth Disease (FMD) in selected Abattoirs and Veterinary Clinics in and around Bishoftu and Bull screening quarantine station (for feedlot) in Adama of East Showa zone. Out of 634 sera tested using 3ABC ELISA 69 (10.88%) animals were sero-positive for bovine FMDV. The highest prevalence was recorded in animals from export abattoirs (15.5%) whereas the lowest sero-prevalence was recorded in animals from Clinics. Animals from abattoir were found to be more affected than feedlot.

Recent study from Borena zone by Tesfaye et al. (2016) investigated the sero-prevalence of foot-and-mouth disease (FMD) in cattle using 3ABC-Enzyme Linked Immuno Sorbent Assay (ELISA) between April and November 2015. They collected a total of 363 sera samples from nine peasant associations found in three different districts namely Yabello, Dubuluk and Moyale districts of Borena zone romiya Regional State and reported an overall seroprevalence of 42.7%. At district level the highest prevalence was found in Dire district which is 52.8% followed by Yabello and Moyale. At peasant association level the highest sero-prevalence was documented in Soda peasant association of Dire district and Surupa peasant association of Yabello district which accounted for 65.5% and 65.0%, respectively, while the lowest seroprevalence was found in Bokela and Legsure peasant associations of Moyalle district which was estimated to be 25.6% and 34.5% respectively. Moreover, they concluded that foot-and-mouth disease is an endemic

and trans-boundary animal disease in Borena zone that calls for an effective control strategies to be in place.

In Central Ethiopia most recently Mishamo (2016) conducted sero-prevalence investigation of FMD in dairy cattle from September 2015 to May 2016. This study considered dairy farm animals in and around Adama and Assela town. A total of 574 dairy cattle were investigated and overall sero-prevalence of 24.22% (139/574) was reported. The higher prevalence was observed in and around Adama town 26.84 compared to Asella (22.91).

In general at the country level FMD sero-prevalence studies have been conducted in different localities of the country. However there is a great variation of reports from different area Sero-prevalence reports of FMD from different locations in Ethiopia is summarized in Table 1.

3. Risk factors associated with foot and mouth disease

Several risk factors were identified for spread of FMD in Ethiopia which include, production system, geographic location, age of animals, contact with wildlife and season of the year (Megersa et al., 2009). Jenbere et al. (2011) indicated that the association of herd size, difference in geographical location (district) and age of the animals with seropositivity of FMD. Beyene et al. (2015) also showed a statistically significant ($p < 0.05$) association of FMD seropositivity and contact between livestock and ungulate wildlife. Similarly, in South Omo zone in the SNNPR, there was a higher seroprevalence in herds which regularly had contact with ungulate wildlife than in herds which rarely had contact with wildlife (Molla et al., 2010). Beyene et al. (2015) found statistically significant differences ($p < 0.05$) among different species, the highest level of seropositivity was seen in cattle 14% followed by 4% in small ruminants (sheep 5% and goats 3%). Furthermore, they indicated cattle to be five times more likely to be infected with FMDV than goats. In recent study by Mishamo (2016) significant prevalence variation was observed in keeping cattle and small ruminants together. Similarly the study conducted in 4 selected Districts of Gambella Regional State reported a similar effect (Tefera, 2010).

The several investigations conducted in Ethiopia revealed age as the most important risk factor that significantly associated with sero-positivity of animal (Rufael et al., 2006; Megersa et al., 2009; Gelaye et al., 2009; Negusssie et al., 2010; Mohamoud et al., 2011; Mekonen et al., 2011; Bayissa et al., 2011; Abunna et al., 2013; Yahya et al., 2013; Desissa et al., 2014; Zerabruk et al., 2014; Beyene et al., 2015; Mishamo, 2016).

In study by Megersa et al. (2009) the odds of seropositivity were 2.8 and 2.3 times higher in the adult (>4 years) and maturing animals (3–4 years) compared to young age category (<3 years). Mohamoud et al. (2011) also indicated as prevalence of FMD was highest in adult cattle and lowest calves with Seroposetivity for calves being (Zero), young (13.2%) and adult (18.9%). Mekonen et al. (2011) revealed difference in age status to be statistically significant and higher prevalence being in adult 27.6% (94/341) followed by heifer 16.8% (17/101) and bull 0.1% (2/18). Bayissa et al. (2011) also found the highest seroprevalence of 32.6% in animals aged at least 4 years old, followed by 18.2% and 8.5% in animals aged between 2 and 4 years old, and less than 2 years old, respectively. Abunna et al. (2013) indicated as there is a tendency of progressively increased prevalence with increasing age and the odds of animals in age band of 3–4 years and above 4 years of age was 3.46 and 2.43 times at more risk of infection than young animals (age group less than 3 years). In eastern Ethiopia Yahya et al. (2013) also found statistically significant differences ($p < 0.05$) in seropositivity between the three age groups, with adults recording the highest seroprevalence rates (16.3%) and young cattle the lowest (4.7%). Similarly in study by Desissa et al. (2014) the highest seroprevalence was observed in cattle aged greater than 4 years 24.22% (56/227) followed by in group of animals aged less than 2 years 18.75% (9/48) and between 2–4 years 16.51% (17/109). Recently Beyene et al. (2015) also indicated that the risk cattle of seropositivity increases every year as the animal gets older: for the adult age group (3.5–5.5 years old) the risk increases 2.7 times with every advancing year, while in the old age group (>5.5 years old) the risk increases 3.4 times. Most recently, Mishamo (2016) indicated Animals greater than 3 years old to be 8.14 times more FMD sero-positive than young animals (those found below 2 years old).

Studies in different regions of Ethiopia have also reported a direct association between FMDV infection and herd size (Rufael, 2006; Gelaye et al., 2009; Bayissa et al., 2011; Beyene et al., 2015). Jenbere et al. (2011) indicated that the seroprevalence of FMD increase as the herd size increase. In recent study by Beyene et al. (2015) there is positive relationship between FMD seroprevalence and herd size: as herd size increase, the risk of there being seropositive animals in the herd increase. Furthermore they showed that herds in communal grazing areas to be 3.2 times more likely to become infected with FMDV than herds that grazed separately.

Difference in season is also observed by Rufael (2006) who indicated the seasonal incidence of FMD to be high during long dry season, (December to February) compared to cold dry season (June to July), the lowest incidence being during rainy season. Similarly Alemayehu et al. (2014) indicated statistically significant difference of seroprevalence between months of the year, with highest seropositivity on July (36.3%) and lowest was recorded on April (3.8%). Molla et al. (2013) also indicated the incidence of FMD to be high during the dry season than cold dry season and reported the lowest incidence during the rainy season. Another risk factor is Breed as confirmed by Negusssie et al. (2010) who indicated as introduced breeds are more susceptible to the FMD viruses endemic to Ethiopia. Similarly Mishamo (2016) indicated Breed specific prevalence of 12.69% for local and 27.73% for cross. Geographical Location is also reported as witnessed by Yahya et al. (2013) who found Location and altitude, to be significant infection risk factors in their result cattle sampled in the lowlands had a significantly ($p < 0.05$) higher FMDV seroprevalence (36.2%) than those in the highlands (3.4%). Moreover, Zerabruk et al. (2014) also found location ($x = 10.9$, $P = 0.012$) to be significantly associated with prevalence of FMD. Similarly Tesfaye et al. (2016) found significant difference between areas of different altitude with a prevalence of 53.6% and 10.1% at low and high altitude, respectively.

4. Conclusion

FMD is one of the major endemic trans-boundary livestock diseases of socio-economic importance in Ethiopia and in other parts of the world. The presence of foot-and-mouth disease in the Ethiopia is a major obstacle to the development to the livestock sector because of its adverse effects on livestock production and export earing of the country. Among five FMDV serotypes documented in Ethiopia (O, A, C, SAT1 and SAT2), the most dominant serotype is Serotype O and Serotype C has not been reported since 1983; except that a serotype C specific antibody was detected in cattle. The seroprevalence report of FMD in Ethiopia ranges from 5.6% to 42.7% in cattle and 4% to 11% in small ruminant and in 30% in ungulate wildlife. Among most common risk factor herd size is one which has direct association to FMDV infections. Herds with large number of animals were found more at risk of contracting FMD as compared to small and medium herd sizes. Significance variation between age groups of animals is also found being highest in adult. Moreover, the incidence of FMD is also found to be high during the dry season compared to cold dry season. Furthermore significantly higher infection rate was observed in lowlands than

Table 1
Sero-prevalence reports of FMD from different locations in Ethiopia.

References	Study duration	Location	Sample size	Sero-prevalence%
Sahel (2004)	2004	Borena zone.		26.5
Rufael (2006)	2006	Yabello	341	26.1
		Dire	405	18.8
		Moyale	174	16.1
Misgana (2008)	2008	Bale zone		21.4
Lemma (2009)	2009	feedlots of Adama area		27.7
Megersa et al. (2009)	October 2007–March 2008	South Omo zone Bena Tsemay district	60	23.3
		South Omo Dhasanech district	30	30
		South Omo zone Hamar district	60	23.3
		South Omo zone South Arri district	30	20
		Gamo Gofa zone Arbaminch Zuria district	90	7.3
		Gamo Gofa zone Kucha district	75	5.3
		Gamo Gofa zone Sawla district	75	20
		Sidama zone Aleta wando district	60	3.3
		Sidama zone Awassa Zurya district	45	22.2
		Sidama zone Dalle district	60	8.5
		Sidama zone Darra district	45	2.2
		Sidama zone Wondogenet district	45	8.9
Molla et al. (2010)	between October 2008 and May 2009	Jinka	162	4.9
		Hammer	104	13.5
		Malle	123	3.3
		Benna tsemay	94	20
		Dasenech	84	7.1
		Semen Aari	142	2.8
Negusssie et al. (2010)	August 2008–April 2009	South Achefer	101	52.5
		Yilmana Densa	98	37.8
		Bahirdar Zuria	112	38.4
		Habru	218	38.7
		Haremaya	35	80.0
		Dangela	104	43.3
Mazengia et al. (2010)	2010	Andassa dairy farm		14.6
Mohamoud et al. (2011)	October 2009–March 2010	Awbere	225	14.2
		Babille	159	15.1
Mekonen et al. (2011)	November 2007–March 2008	Borena zone	82	53.6
		Guji zone	31	10.1
Jenbere et al. (2011)	October 2007–April 2008	Amibara	120	4.25
		Gewane	134	11.9
		Ewa	204	2.9
		Chifra	307	5.2
Bayissa et al. (2011)		Teletele	248	15.7
		Yabelo	296	24
		Arero	224	2.9
Gelaye et al. (2009)	November 2007 and February 2008	BenchMaji zone Semen bench district	153	5.8
		Bench Maji zone Surma district	120	20
Ayelet et al. (2012)	Between 2003 and 2006	Yeka district of Addis Ababa	40	30
		Afar Zone 4	299	4.7
		South Wollo	93	4.3
		Borena	585	26.8
		Guji	349	32.7
		South Omo	200	12
		Tigray Central zone	139	26.6
		Tigray Eastern zone	41	41.5
		East Harerge	45	8.9
		Bole of district of Addis Ababa	40	12.5
Abunna et al. (2013)	November 2010–March 2011	Dire Dawa	752	8.91
		Estern Harerghe Zone	234	5.13
Yahya et al. (2013)	From November 2008–March 2009.	East Hararghe	294	1.4
		West Hararghe	210	25.7
Birhanu (2014)	November 2013–May 2014	Adama-Modjo Livestock Export Industry	4321	12.9
Zerabruk et al. (2014)	from October 2008–June 2009	Tigray Central zone	60	5
		Tigray Western zone	195	16.9
		Tigray Southern zone	75	24
		Tigray Eastern zone	60	10
Duguma et al. (2014)	November 2007–April 2008	Sinana	172	24.41
		Goba	109	20.18
		Agarfa dairy farm	20	5
Desissa et al., (2014	November 2011–March 2012	Sayo	111	31.53
		Dale Sadi	131	15.26
		Lalo Kile	142	19.01
Alemayehu et al. (2014)	2011	Feedlots in central part of Ethiopia	38,187	14.5
Beyene et al. (2015)	November 2011–April 2012	Asosa	27	6
		Kelem Wollega	197	10
		Western Wollega	47 2	11
		Tongo	73 2	15
Tesfaye et al. (2016)	between April and November 2015	Dire	125	52.8

Table 1 (*Continued*)

References	Study duration	Location	Sample size	Sero-prevalence%
		Moyale	68	29.4
		Yabello	170	40.58
Belina et al. (2016)	September 2014–July 2015	quarantine station (for feedlot) in Adama	250	6.8
		Abattoirs in and around Bishoftu	303	15.5
		Veterinary Clinics in and around Bishoftu	81	6.17
Wagari (2016)	December 2011–May 2012	Quarantine in Adama	1071	10.8
Mishamo (2016)	September 2015–May 2016	dairy cattle in Adama	190	26.84
		dairy cattle in Asella,	384	22.91

in highlands. Significant differences among different species of animal were also reported and, the highest level of seropositivity was seen in cattle and introduced breeds are found to be more susceptible. Control strategy against this economically important emerging pathogen should be based on the application of FMD vaccination programme and vaccine must be formulated taking into account the virus type and subtypes prevalent in the area. Furthermore, great attention should be given for this economically important disease as its occurrence is may affect the export earnings of the country thereby threaten the livelihood of farmers and economy of the country at large.

Consent for publication

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Availability of data and materials

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Competing interests

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