Global and Regional Epidemiology of African Swine Fever and Its Risk in Nepal

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Abstract

African swine fever (ASF) is a highly contagious viral infection of domestic and wild pigs with high mortality. First reported in East Africa in early 1900s, ASF was largely controlled in the domestic pigs of many countries. However, in recent years ASF outbreaks have been reported in several countries in Europe and Asia. The occurrence of ASF in China, the largest pork producer in the world, in 2018 and in India, the country that surrounds and shares open borders with Nepal, has increased the risk of ASF transmission to Nepal. Lately, pig farming practices is growing in Nepal overcoming traditional religious and cultural biases against it. However, emergence of viral infections like ASF can severely affect its growth and sustainability. When there are no effective vaccines available to prevent it, the government should focus on preventing entry of the virus through strict quarantine measures in the borders, controlling illegal trades, and by effective management practices including biosecurity measures.

Keywords: African Swine Fever, African Swine Fever Virus, Pig industry, Domestic and wild pigs, Virus transmission, Preventive measures

Introduction

African Swine Fever (ASF) is a devastating and economically important infectious disease of domestic and wild pigs with high mortality rate. Caused by the ASF virus (ASFV), a large double-stranded DNA virus of the Asfarviridae family, ASF is one of the diseases notifiable to the World Organization for Animal Health (Blome et al., 2020). First described in East Africa in the early 1900s, ASFV subsequently spread in the European countries and in the Caribbeans but was largely controlled in the domestic pigs by the end of 20^{th} century (Gaudreault et al., 2020). The 21^{st} century outbreaks of ASF in Georgia (2007), Russian Federation (2007), China (2018), India (2020), and other European and Asian countries indicate its potential emergence as a major health threat to the global pig population (Gaudreault et al., 2020; Patil et al., 2020).

Nepal is an agricultural country where livestock sector alone contributes about 11.5% of the total gross domestic product (GDP) (Poudel et al., 2020). There are about 7.3 million cattle, 5.2 million buffalos, 0.8 million sheep, 11 million goats, and 1.4 million pigs in Nepal (Poudel et al., 2020). Pig farming and pork eating are objected by religious and cultural beliefs in Nepal. However, with declining cultural bigotry, especially in the younger generation, and support and promotion of pig rearing by the Government of Nepal for poverty alleviation, pig farming is increasing in recent years (S. Dhakal et al., 2012). The total population of pig in Nepal is estimated to be around 1.4 million which is 42.30% increase from 2008/9 to 2018/19 (Figure 1) (MoALD, 2020; Poudel et al., 2020). During the same period, pork production in Nepal was increased by 68.19% with the current pork production estimation being 28,579 MT (Figure 1) (MoALD, 2020; Poudel et al., 2020). Pig meat comprises 8% of total meat production in Nepal while pork consumption is less than 1 Kg per capita out of the total national per capita meat consumption of around 11 Kg (MoALD, 2017).

Pig farming is carried out in all 77 districts of Nepal where Jhapa, a district that lies in the lowland plains (Terai) and houses about 81,000 pigs, ranks first and Mustang district, which falls in the trans-Himalayan climatic zone and has less than 100 pigs, ranks last in pig population (Figure 2) (MoALD, 2017). Pig population is higher in Province 1 in the eastern part of Nepal and in Province 5 where the pig farming ethnic communities predominate (Figure 2) (Santosh Dhakal et al., 2014).

While pig farming is growing in Nepal, diseases like ASF can jeopardize this industry which already suffers from challenges in pig breeding, marketing, feed availability, and management of other pig diseases. The recent outbreaks of ASF in Assam, India (Patil et al., 2020), which is around 670 Km away from Nepal, and in China (Ma et al., 2020), the world's largest pig producer and Nepal's another neighboring country, are alarming signs and big threat to Nepalese pig industry. In this scenario, this paper reviews the epidemiology of ASF in Asian countries with special emphasis on the challenges and future perspectives of ASF in Nepal.

African Swine Fever

African swine fever virus (ASFV) belongs to the Asfivirus genus in the Asfarviridae family and is the only known DNA arbovirus (Gaudreault et al., 2020). ASFV is icosahedral, linear double-stranded DNA virus with 170 to 190 kbp genome and an average diameter of 200 nm (Salas & Andrés, 2013). The virus is composed of the outer envelope, capsid, inner envelope, core-shell, and nucleoid (Salas & Andrés, 2013). Replication of the virus takes place in the macrophages initially in the nucleus followed by the cytoplasmic one (García-Beato et al., 1992). Even though various genes are used to characterize the virus, genotyping of ASFV is based on the nucleotide sequence of a 478 bp variable region in the C-terminus of the viral p72 gene (Achenbach et al., 2017; Gaudreault et al., 2020). Based on major capsid protein p72, there are 24 genotypes of ASFV and 8 serotypes based on viral hemagglutinin CD2-like protein (CD2v) and C-type lectin (Gaudreault et al., 2020).

Domestic pigs, wild suids, and soft ticks are the hosts of ASFV where the original vertebrate host is believed to be Warthogs (*Phacochoerus africanus*) and the most important reservoir host in Africa (Costard et al., 2013). It is transmitted through direct contact with an infected animal, indirect contact with contaminated objects, consumption of infected meat, and also by the bites of tampans (*Ornithodoros spp.*) (M. L. Penrith & Vosloo, 2009). Other sources of infection that are unlikely to spread the virus but are suggested to do so are

water, rodents, and birds yet remain unproven and there is still no evidence of transfer of the virus from the sows to the fetus (M. L. Penrith & Vosloo, 2009). Transport of infected animal and infected products is one of the major reasons for the transmission and spread of the virus (Sanchez-Vizcaıno et al., 2015). Airborne transmission has also been identified as a possible route but only for a short distance (M. L. Penrith & Vosloo, 2009; Sánchez-Vizcaino et al., 2019). Stable fly (*Stomoxys calcitrans*) can also act as a mechanical vector up to 48 hrs. after ingesting the virus (Mellor et al., 1987).Though the infected domestic pig can infect the other domestic pigs directly and indirectly (Thomson, 1985), the transmission of the ASFV from infected warthogs to the susceptible host in contact is rare (Golnar et al., 2019; Wilkinson, 1984). Even though the transmission of the virus through sexual contact is not defined, ASFV can be excreted in genital secretion (M. L. Penrith & Vosloo, 2009).

After the infection by the ASFV, the incubation period is 2-7 days although it differs according to the route of infection (Mebus, 1988). Even though the disease was categorized as per acute historically, it can be classified as a per acute, acute, subacute, and chronic disease (Wardley et al., 1983). In the per acute form, the animal can die without the presence of any clinical signs and symptoms, and minimal gross lesions but hemorrhages can be found during the post mortem inspection (Wardley et al., 1983). However, some may show a fever of 41-42degC, rapid respiration, hyperemia of the skin along with 100% mortality and morbidity (Mebus, 1988). Acute and subacute form are the commonly observed forms with highly virulent isolates causing the acute one and moderately virulent strain causing the subacute form (Mebus, 1988). The signs associated with the acute form are elevated body temperature (40-42degC), anorexia, apathy, inactivity, cyanosis in the extremities of legs, ears, and tail, and death with 90-100% mortality within 7-10 days (Sanchez-Vizcaıno et al., 2015; Sánchez-Vizcaino et al., 2019; Wardley et al., 1983). Diarrhea is also found to be associated with the acute form which may result due to the secondary bacterial infection (Mebus, 1988). Early leucopenia, splenomegaly, extensive necrosis, hemorrhage of lymphoid tissue, and rapid labored breathing due to pulmonary edema at the final stage can also be seen in the acute form (Sanchez-Vizcaino et al., 2019). Erythema, epistaxis, vomiting, and abortion can be related to the acute form where abortion can be the first sign of outbreak in many cases (Sanchez-Vizcaıno et al., 2015). The subacute form is indicated with signs shown in the acute form but a less severe form (Wardley et al., 1983). Reduction of feed intake and high body temperature of 40-42°C is present for 10-12 days (Mebus, 1988). But, hemorrhage and edema, the vascular changes associated with the subacute form are more intense than the acute form (Gómez-Villamandos et al., 2013). Mortality can be anywhere between 30-70% and the surviving animals can recover within 2-3 weeks (Sánchez-Vizcaino et al., 2019). Infection with low virulent strain causes a chronic disease that does not show any specific clinical signs and vascular lesions, but lesions can be observed in bacterial coinfection (Sanchez-Vizcaıno et al., 2015). It may persist for a longer duration of time and symptoms like pneumonia, stunting, emaciation, arthritis, and skin ulcers may be seen with hemorrhages during post mortem along with fibrinous pericarditis and pleuritis (Wardley et al., 1983). Poor growth, oscillating fever, skin lesions and soft painless swelling of joints are also associated with chronic form (Mebus, 1988).

Global Epidemiology of African Swine Fever

ASF was first reported from East Africa in 1921 and is still present in the region (Figure 3) (Lubisi et al., 2005). It was also identified in the southern, central, and West Africa during early 1900s and has been endemic in the African continent by circulating in one of the three different transmission cycles (Lubisi et al., 2005). Portugal had the outbreak of ASF in 1957, the first time outside of Africa (Sanchez-Vizcaıno et al., 2015) and also in 1959 which was believed to be imported from Angola where it was established in the Iberian Peninsula and was only eradicated in 1994 (Mary Louise Penrith, 2009). Several other outbreaks resulted in Western Europe in the 1970s and 1980s, Sardinia in 1987 where ASF persists, Cuba, Hispaniola (Haiti and the Dominican Republic) and Brazil in a similar time frame from where it has been eradicated (Sanchez-Vizcaıno et al., 2015).

The outbreak of ASF in countries of South and North America mainly occurred in 1980s. Since then, ASF outbreak has not been reported in American countries. However, there is still threat of ASF outbreak in both north and south America. Till now, only Australian country, Papua New Guinea, has reported first

outbreak of ASF in 2020 (Mary Louise Penrith, 2020; World Organisation for animal health (OIE) , 2020b).

A resurgence in western Africa occurred in 1994 infecting various nations that were previously unaffected along with the first outbreak in Kenya in 30 years, an outbreak in ASF free region in Mozambique, and first outbreak in Madagascar in 1997 (Mary Louise Penrith, 2009). Countries like Spain, France, Madeira, Italy, and Cuba were infected from 1960 to 1971, Haiti reported the infection in 1979 and reappearance was seen in Cuba in 1980 (Wardley et al., 1983). The spread of the ASF virus can be attributed to three major factors which were: 1) increment in the pig population and production; 2) reservoir non-symptomatic pig population; and 3) globalization (Sanchez-Vizcaıno et al., 2015). Since 2007 ASF is seen in the Caucasian region with the outbreak in Georgia with spread to Armenia, Azerbaijan, and the Russian Federation, Ukraine, and northwest Russia near the Baltic Sea and Barents Sea (Table 1) (Sánchez-Vizcaino et al., 2019). Subsequently, various outbreaks occurred in different European, Asian, and Pacific nations on different years (OIE, 2020b; M. L. Penrith & Vosloo, 2009) (Table 1) (Figure 3). Nepal has not yet reported the case of ASF. But the recent outbreaks in the neighboring countries make it susceptible to the outbreaks in near future mainly due to the open borders with India which could lead into the transfer of infected products and animals into the nation. The first case was detected in India in January with a total of 11 confirmed outbreaks, 9 in Assam and 2 in Arunachal Pradesh, with 10,920 susceptible animals and 4,199 cases (OIE, 2020a). The total death has been reported to be 3,701 with 14,000 pigs culled in Assam alone (OIE, 2020a). To date China reported 165 outbreaks of ASF since the conformation of the first outbreak in Liaoning Province on 3 August 2018 with 1,193,000 pigs being culled (FAO, 2020).

The current ASF epidemiological situation shows that Europe holds maximum outbreak of ASF (66.87%), Asia (32.72%) and Africa (0.41%) respectively (Table 2) (OIE, 2020b). Asian pig industry is highly affected by ASF with more than 80% losses compared to that in Europe (16.86%) and Africa (1.04%). Asian and African countries mainly report cases of domestic pigs while the European countries also reported a larger number of the cases of wild boar (Table 2). The increasing trend in spread of ASF brought a serious threat to animal health, pig production, and swine population globally and therefore, affect economies and trade. ASFV remains endemic in many sub-Saharan countries on the African continent.

Factors Contributing to the Spread of ASF in Asia

Four of the top 10 pork producing countries in the world, namely China, Vietnam, Philippines, and South Korea produce 34,000; 2,250; 1,450 and 1,350 thousand Metric Ton respectively, are in Asia (Statista, 2020). Historically Asian countries were less affected with ASF which may be attributed to the effective sanitary regulation and strict rules for import of animals and animal products (Costard et al., 2013). Periodic outbreak of various viral and prion diseases including BSE, Avian influenza, Classical swine fever has further alerted various Asian countries to strengthen veterinary services (Ozawa et al., 2006).

Recently, outbreaks of ASF are reported in Asian countries including China, Laos, Vietnam, India and is rapidly spreading all over Asia (Table 3) (OIE, 2021). China is the key Asian country for the production and supply of pork globally. There is high risk for the entry of ASF into various other Asian countries through China as it has international trade with various countries of Africa where ASF outbreak have been recently reported (Costard et al., 2013). Furthermore, various cultural events in Asia demand more pork supply that increases the risk of ASFV transmission and ASF outbreaks. Illegal import of pig products also favors the entry and outbreak of disease vigorously (Shih et al., 2005). Movement of live animal and pig products support the condition for spread of the virus at the regional level. Most of the Asian countries practice free ranging pig husbandry system that causes endemic outbreak of ASF. Beside this, existence of wild pigs also favors the potential outbreak of disease since the virus is maintained in wild suid reservoirs. Study of soft tick including *Ornithodoros* (*Alectorobius*) spp. is also due essential to better understand the dynamic of spread of disease by these vectors in Asian territories (Ahmed et al., 2007).

Prevention and Control of ASF

No vaccine is available for the effective control of the ASF virus (Sanchez-Vizcaıno et al., 2015). Once the disease is established in an area, it is extremely difficult to eradicate since ASFV can survive in meat and meat products, feeds, and various reservoirs including wild boars and ticks (Wardley et al., 1983). Stamping out and killing a large number of pigs to control the spread is another measure that has been successful to an extent but faces challenges due to ethical and environmental reasons along with the finances involved in it (Mary Louise Penrith, 2009). Prevention remains the most effective method with the major focus on biosecurity. Limiting the access of people and vehicles into the farm, the use of separate clothing and boots inside the farm, and the use of disinfectants and footbaths can reduce the transmission of the virus (M. L. Penrith & Vosloo, 2009). The movement of pigs from the infected areas should be restricted. Contact between the wild boars and domesticated pigs should be prevented. Contaminated garbage from international airports and docks that are an important source of the virus should be incinerated instead of feeding to the pigs (Sánchez-Vizcaino et al., 2019). Awareness among all the involved parties, effective communication among them, user-friendly practical courses on biosecurity linked with incentives such as compensation and insurance fees can be effective measure in the prevention (Gortazar et al., 2015). Contingency plans should be designed and made ready to implement when necessary considering the geographical location, economy, various epidemiological situation and the status of ASF in the neighboring countries (Sanchez-Vizcaino et al., 2019).

Risk of ASF in Nepal

ASF is accountable for creating havoc in the pig industry across the world resulting in deaths of domestic and wild pigs. Even though there have been historical reports of the existence of this disease across Africa, America, Europe and Caribbean (Dei Giudici et al., 2019), its recent introduction was in 2007 in Caucasus, Georgia and is now present and rapidly spreading across Europe, Asia, and Africa (Karger et al., 2019). Being a transboundary animal disease (TAD), the easy spread of the virus through the pigs and pork, contaminated feed, and equipment present a great threat of disease transmission to the pig importing countries lacking proper surveillance and quarantine (Niederwerder et al., 2019).

Nepal is a small landlocked country bordering China in the north and India in the remaining directions. Therefore, the emergence and prevalence of new diseases in either of these neighboring countries exhibit the high risk of transmission threat in Nepal owing to the leaky border, ineffective surveillance and illegal importing of the products from the neighbors. Nepal has both conventional and modern pig farms. The majority of pig farms in Nepal are conventional which represent small household farms with 1-2 pigs. They are raised on kitchen waste, grain by-products, and food industry by-products (Gurung et al., 2014). Open border with India and illegal trading are the major challenges for Nepal to stop the entry of ASF in Nepal (Acharya & Wilson, 2020; Lim et al., 2019). Lack of vaccination of ASF (Sanchez-Vizcaıno et al., 2015) and the traditional way of pig rearing in Nepal could lead to a massive economic loss if the ASF outbreak occurs in the coming future.

Since the introduction of the first case of ASF in early August of 2018 to late November 2019, China culled around 12 million pigs from 160 outbreaks losing billon of Yuan (Ding & Wang, 2020). A bilateral agreement between Nepal and China regarding the exchange of pig products and pig farmers may act as a peril (RSS, 2019). Similarly, India confirmed its first ASF cases in mid-May in Assam and Arunachal state that have already killed around 15,000 pigs in the states (Bhattacharyya, 2020). Besides China and India, there are several Asian countries like South Korea, Philippines, Vietnam, Cambodia, Hongkong, Tibet, and Vietnam that impose constant menace to the Nepalese pig industry directly or indirectly through several international boundaries (Normile, 2019). With the initial understanding of the infection in Arunachal Pradesh and Assam through Tibetan borders, the transmission in Laos and Myanmar, and a high number of deaths in China, the possibility of entry and existence of the virus in Nepal through the chain of international borders cannot be overlooked (Agarwala & Gill, 2020; Normile, 2019).

Challenges for ASF control in Nepal

Nepal has not reported the disease as of 25 June 2020 (Acharya & Wilson, 2020) but the increasing trend

of pork imports in the past several years suggest for the increased odds of virus entry risk in the country (Knoema, 2019). Apart from annual official import of 8000-10000 pig heads via India and 130 tons of pig products through China, Thailand, and Denmark, Nepal faces illegal imports of the pig through the open border coupled with ineffective quarantine (Acharya & Wilson, 2020; Lim et al., 2019). Moreover, Nepal and India share transboundary wildlife habitats like Chitwan National park and Valmiki Tiger reserve, Shuklaphanta National park, and Dudhwa Tiger Reserve providing easy access in the movement of wild boars and increasing the transmission threat through sylvan routes (Aggarwal, 2019). The ability of the virus to resist the harsh environmental condition twinned with the traditional swill feeding system (Sah et al., 2018) to raise pigs can trigger the havoc impending severe loss in Nepalese pig industry. Besides, the lack of effective vaccination against ASF, ineffective disease surveillance, and minimal awareness about the dynamics of the disease transmission among traditional pig farmers may create complications in disease control once the virus is introduced (Teklue et al., 2020).

Future Prospective

Nepal Government and related stakeholders may find it extremely difficult to control the epidemics of ASF after its introduction looking at the previous disease outbreak scenarios (Acharya et al., 2020). Amid the fear of ASF outbreaks, ban on the import of pig products by Government (HNS, 2019) is certainly an initiation of the efforts, but as long as illegal drift continues in the system (Panta, 2018), the imposed ban may not have any significance. Strict quarantine measures at the borders; strong coordination among national, federal and local governments for disease surveillance and reporting; restriction of illegal transport of the pigs and pig products; and awareness about the transmission dynamics of the disease among the traditional and modern pig farmers; and adaptation of strict biosecurity measures in pig farms are essential to containing the possible hazard due to the virus. The travel restrictions amidst the coronavirus pandemic may have reduced the transmission probability for the time-being but the entry of the virus through any of the borders is likely to have substantial effects in pig industry of Nepal that may result in pig losses due to deaths or culling; decreased production; reduced export of the pig products; and lowered income for a very long time (Acharya & Wilson, 2020).

Conclusion

Nepal has not reported any cases of ASF yet. However, ASFV is circulating in China for few years now and has recently been reported in various states of India. Occurrence of ASF in two neighboring countries with whom Nepal does import and export of animals, feeds, and animal products raises concern over the potential of cross-country transmission of ASFV. Moreover, the risk is compounded as Nepal shares open border with India and illegal trades of animal and animal products through the open border is possible. In these circumstances, Nepal government needs to be more vigilant to prevent the entry of ASF in Nepal. Strict quarantine measures should be employed in the borders and illegal trades of animals and animal products must be controlled. In addition, preparedness is necessary for early detection of ASFV and management of ASF through epidemiological tracing and tracking; culling of infected animals; disinfection of contaminated farms; and financial support to the farmers to avoid tremendous socioeconomic losses which may jeopardize the slowly but steadily growing pig industry in Nepal.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

DS perceived the initial idea, DS, SB, SP, UP, MK wrote initial draft, DS, SK, SD extensively revised the manuscript and all authors approved the final version of the manuscript.

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Tables

Table 1. Outbreaks of ASF in European, African, Asian and Pacific countries in recent years in 21st century.

Year	Europe and Transcaucasus	African	Asia and Pacific countries
2000		Gambia (The)	
2002		Burkina Faso, Ghana	
2007	Armenia, Georgia	Mauritius	Russia
2008	Azerbaijan		Iran
2010		Central African Republic, Chad	
2011		Ethiopia, Liberia	
2012	Ukraine		
2013	Belarus		
2014	Estonia, Latvia, Lithuania, Poland	Cote d'Ivoire	
2016	Moldova	Mali	
2017	Czech Republic, Romania		
2018	Bulgaria, Belgium, Hungary		China
2019	Slovakia	Sierra Leone	Mongolia, Vietnam, Cambodia, Hong Kong,
2020	Serbia, Greece		Papua New Guinea, India

Table 2. Cases of ASF reported from different Continents from 2016 to June 18th, 2020. (Losses include dead and culled animals)

Region	**Swine Outbreak**	**Swine Susceptible**	**Swine Cases**	**Swine Losses**	**Wild Boar Outbreak**	**Wild Boar Cases**	**Total Out-break**	**Total Cases**
Asia	9928 (69.28%)	8 107 951 (79.63%)	115 309 (14.37%)	6 733 791 (82.08%)	631 (3.51%)	1 121 (3.65%)	10 559 (32.72%)	116 430 (13.97%
Europe	4271 (29.80%)	1 859 480 (18.26%)	625 269 (77.90%)	1 383 372 (16.86%)	17 307 (96.48%)	29 513 (96.35%)	21 578 (66.87%)	654 809 (78.59%
Africa	128 (0.89%)	213 795 (2.09%)	61 459 (7.66%)	85 539 (1.04%)	0	0	128 (0.39%)	61 459 (7.38%)

Region	Swine	Swine	Swine	Swine	Wild Boar	Wild Boar	Total Out-break	Total Cases
America (South and North)	0	0	0	0	0	0	0	0
Australia and Oceania (Papua New Guinea only)	4 (0.03%)	700 (0.02%)	500 (0.07%)	396 (0.02%)	0	0	4 (0.02%)	500 (0.06%)
Total	**14 331 (100%)**	**10 181 926 (100%)**	**802 564 (100%)**	**8 203 098 (100%)**	**17 938 (100%)**	**30 634 (100%)**	**32 269 (100%)**	**833 198 (100%)**

Table 3. Outbreak of ASF in Asian and Pacific region. (2018- 7th January, 2021)

Country	Total Outbreaks	Ongoing Outbreaks	Total Animal Losses
Vietnam	8979	1336	5971717
Korea (Rep. of)	873	873	28740
Indonesia	521	521	38123
Russia	205	7	7753
China (People's Rep. of)	186	20	391523
Laos	151	10	39944
Timor-Leste	126	126	405
Cambodia	13	0	3673
India	11	11	3701
Mongolia	11	0	2855
Myanmar	10	2	232
Papua New Guinea	4	4	397
Hongkong	3	0	4163
Korea (Dem. People's of)	1	1	99
Total Asia	11545	3214	6835482

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`Figure 1.docx` available at https://authorea.com/users/401885/articles/513850-global-and-regional-epidemiology-of-african-swine-fever-and-its-risk-in-nepal

Figure 1: Pig population and pork production from the year 2008/09 to 2018/19 in Nepal.

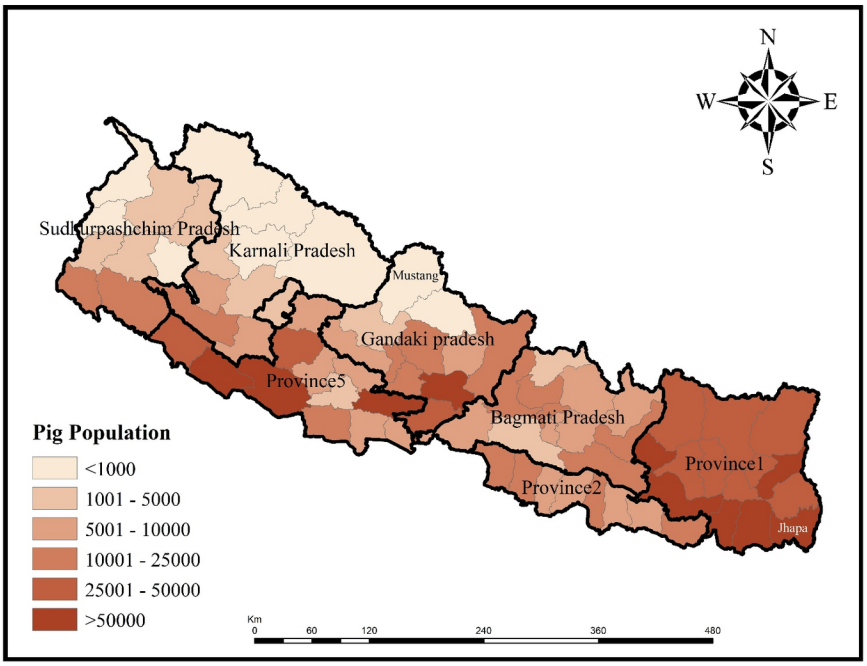

Figure 2: Map of Nepal showing Pig distribution in Nepal.

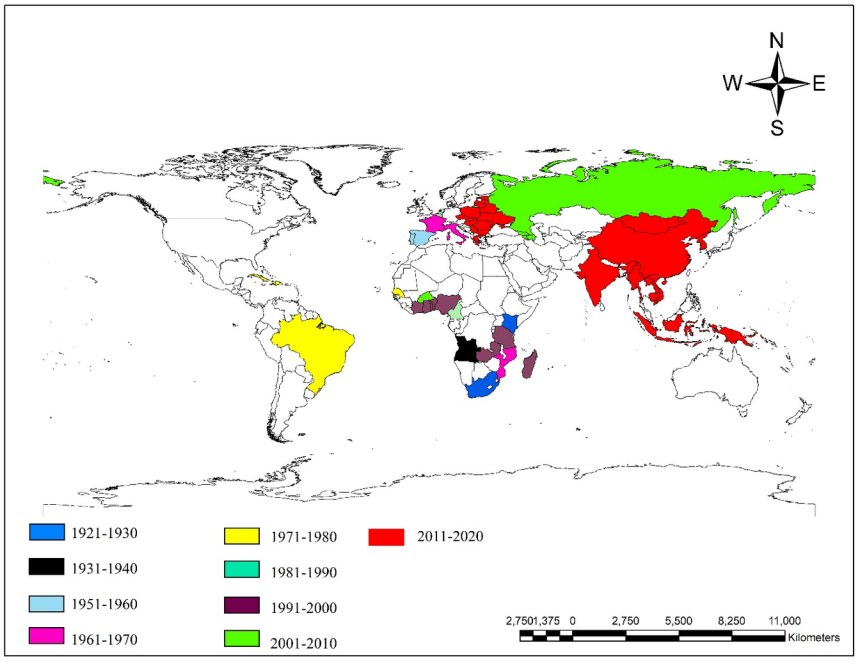

Figure 3: Map of world showing outbreaks of ASF in different decades.