One Year of African Swine Fever Outbreak in China

Dapeng Tao

Shenyang Agricultural University

Daipeng Sun

Shenyang Agricultural University

Shu Wei

Liaoning Center for Animal Disease Control and Prevention

Tongqing An

Chinese Academy of Agricultural Sciences Harbin Veterinary Research Institute

Guoshun Shen

Shenyang Agricultural University

Zeliang Chen

Shenyang Agricultural University

Jinling Liu (✉ liujl@syau.edu.cn)

Shenyang Agricultural University <https://orcid.org/0000-0003-1236-0284>

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Abstract

Background: African swine fever (ASF) is a major threat to domestic pigs and wild boars. Since 2018, ASF outbreak has been ongoing in China. As of August 3, 2019, a total of 151 ASF outbreaks reported in China have caused severe economic losses for many pig farmers and pork producers. The present study is to analyze the epidemiologic characteristics of ASF outbreak that occurred in several regions across China during the period August 2018- August 2019. Particularly focusing on the epidemic distribution, main transmission routes, incidence/fatality, impact on pig production capacity, and the main preventive measures adopting to mitigate the risk of ASF spread in pig farming systems by Chinese government.

Results: The data show that the importance of seasonality effect, spatial distribution and the anthropogenic factors on the transmission of ASF, and further suggest that effective ASF risk management in China will require a comprehensive and integrated approach linking science and policy and will need to involve all relevant stakeholders to develop realistic policies.

Conclusions: This provides an improved scientific basis to optimize current interventions as well as develop new tools and strategies to reduce the risk of African swine fever virus (ASFV) transmission to domestic pigs and wild boars.

Background

African swine fever (ASF) is a highly contagious disease that currently has no great economic losses to animal husbandry economy. Since ASF was first identified in Kenya in the 1921, 68 countries have suffered from ASF at present[1, 2]. Especially, more than 3900 ASF epidemics were reported worldwide merely in 2018 with the numbers of cases having increased by 25% compared to that of 2017[3]. Most of concern is that ASF outbreaks have reemerged in some countries such as Hungary, Bulgaria and Belgium 30 years after eradication[4]. More than that ASF outbreaks have occurred in Mongolia and Vietnam along the border of China in 2019[5, 6]. Since the confirmation of the ASF entered China in August 3 2018, a total of 151 ASF outbreaks have been reported in 31 provinces as of August 3, 2019. The experiences in a variety of prevention and surveillance measures against ASF indicate that it is difficult to eradicate ASF in a short period once outbreak[7, 8]. The disease can have great impact on global trade of pigs and pork products which threaten the global food security[9]. This study focuses on the characteristics of ASF outbreak that occurred in the infected regions in China one year on. This work presents ASF risk zones in China and may provide useful information for the development of effective strategies for the prevention and control of ASF outbreak. Furthermore, the data will benefit to assess the potential public health risks posed by ASFV infections.

Results

Geographical distribution of ASF outbreak in China

Outbreak analysis of geographical distribution showed that since August 3, 2018, the first ASF outbreak occurred in Shenyang in China, ASF continued spreading among domestic pigs and wild boars in country. As of August 3, 2019, almost geographical regions total of 31 provinces in China have reported ASF outbreaks except Hong Kong, Macao, and Taiwan (Figure 1A). Outbreak rates of ASF in each province are shown in Figure 1B and Table 1. Apparently, the Liaoning province has the largest cumulative ASF outbreaks, showing 13.9% of cases (21/151), followed by Guizhou with 6.6% (10/151), Anhui and Guangxi both with 5.9%(9/151), subsequently, Hunan, Hubei and Sichuan at 5.2% (8/151), and the other 24 provinces, this ratio is between 4.6-0.6%. Comparison the epidemic tendency among provinces showed that the spread of ASF outbreaks mainly located along the Northeast, Eastern China, and then

reached Southern and Southwest, showing an increasing southward in general. Notably, Xinjiang, Tibet and Hainan, were confirmed ASF for the first time in April 2019. Nine months had elapsed since the first ASF outbreak had occurred in China in August 2018 (Appendix Table 1). In this regard, preliminary speculation is that Xinjiang, Tibet and Hainan, different from Eastern China and other areas, of geographical locations are far away from major economic transport routes and of population densities are at a relatively low level, slowing down the spread of ASF. In addition, Xinjiang and Tibet are the major residential areas of ethnic minorities[10]. The consumptions of beef and mutton occupy the major part of the market because of religious practices[11]. Therefore, the impacts of ASF on these regions are relatively delayed.

The cumulative number of susceptible pigs in different provinces in China

Subsequently, further analysis of total cases among the 31 provinces in China displayed that Jiangsu province has the maximum cumulative number of susceptible pigs, in which there are 83 752 heads, followed by Heilongjiang province with 74 649 heads and Liaoning province with 52 981 heads. Generally, Jiangsu, Heilongjiang and Liaoning are the main livestock production provinces and important supply bases of animal products for the whole country. The stock of live pigs occupying the top spot increases the number of susceptible pigs. Meanwhile, Ningxia, Tibet and Qinghai have the minimum number of susceptible pigs, showing 179, 129 and 101 respectively (Figure 2A, Table 2). Which of them are also the main residential areas of Hui nationals in China[10]. Thus, live pig stocks and pork consumption are keeping at relatively lower level because of religious practice, and then reducing the number of susceptible pigs[11]. In brief, the spread of the ASF epidemics are associated with anthropogenic factors, such as trade of animals, processed meat products and ethnic culture.

The incidence and fatality in different regions of China

This comprehensive analysis has highlighted that in one year period, Shandong province reported 17 infected pigs, substantially fewer than the 5123 infected cases reported in Heilongjiang province, followed by Jiangsu with 3079 cases and Liaoning with 2378 cases. Similarly, the provinces with the highest number of dead pigs are Heilongjiang (4158). Liaoning (2087) and Jiangsu (1466). The lowest number of dead pigs is only 3 in Shandong (Figure 1 A, Figure 2B, Table 2). However, it is worth noting that the highest fatality rate of 97.6%(204/209) is in Jilin province, followed by Tibet with 91.7%(55/60). The previous provinces of Heilongjiang, Jiangsu and Liaoning, in which there are the maximum cumulative cases of infected and dead pigs, conversely, showing fatality rates with 81.2%(4128/5123), 47.6%(1466/3079), and 87.8%(2087/2378) respectively (Figure 2B, Table 2). Meanwhile, as for incidence, Gansu province has the highest pig incidence rate of 62.5%(187/299), followed by Tibet and Qinghai with the incidence values are 46.5%(60/129) and 45.5%(46/101) respectively. These indicate that there is no consistent tendency between the incidence and fatality (Figure 2B, Table 2). For this, it seems that the appropriate prevention and control measures applied in time are fully effective in protecting against ASFV incursion and decreasing the fatality rate.

Characteristics of ASF epidemic in suburban and rural areas

As shown in Figure 3A-3B, the pig numbers of susceptibility, incidence and death in rural areas exceed that of in suburban areas. This can partly be explained that most of commercial pig farms are mainly located in the urban suburbs, they can effectively control the ASF epidemics together with higher level biosecurity and various management measures[12, 13]. Meanwhile, the majority of backyard pig farms with either a low or very low

biosecurity level are scattered, correspondingly, the management measures of various norms are relatively primitive resulting in a delayed response to the epidemic, which increases the pig numbers of susceptibility, incidence and death.

It is generally assumed that low level biosecurity farms are at higher risk of introduction the infections. Also, we note that the pig numbers of susceptibility, incidence and death showed an “explosive” increase during the December 2018-February 2019, reaching the peak in January 2019. Despite a small increase during September 2018-November 2018(Figure 3A-3B, Table3). This is likely the result to coincide with the Chinese New Year, which stimulated the nationwide trades of animals and processed meat products due to an increased demand for various pork products across the country, accelerating the incursion of ASFV and the frequency of ASF outbreaks. And subsequently, the pig numbers of susceptibility, incidence and death varied between different month together with a decreasing trend in general during the period March 2019-August 2019 (Figure 3A-3B, Table3), although there were marginal fluctuations within some months.

Discussion

Due to the ASF epidemic, ever since the second half of 2018, the swine industry in China, especially the basic production capacity has been declining[14]. Moreover, as seen in January 2019, compared with the same period last year, the stocks of both live pigs and sows have significantly reduced reaching the lowest level in the decade. This to the same extent will affect the supply of pork in the market mostly during the second half of the year. It is expected that there will be a large increase in the price of pigs after the third quarter, particularly in the fourth quarter[14]. Additionally, several other factors influence domestic pig production. Firstly, the uncertainty about the epidemic situation results in farmers and breeding enterprises giving up increasing the number of live pigs in stock, where epidemics have occurred. Secondly, because of the influence of economic factors, pig farmers experience financial difficulties, consequently, they have to adjust or reduce their production capacity in some areas. Finally, the Chinese swine industries are being transformed and upgraded, some free-range farmers have gradually withdrawn from the industry during the outbreak of ASF[13]. To sum up, these factors are also accountable for the current decline in the pig production capacity.

After the outbreak of ASF, the MARA of China has issued several policies and regulations to prevent and control ASF outbreak. Firstly, more stringent surveillances, monitoring programs and enhancing the fulfillment of legal requirements on biosecurity have been established for early detection and eradication of ASF. Currently, all 151 cases have been effectively dealt in time and no secondary spread occurred, with 90% of the affected areas have been identified to lift the blockade according to relevant regulation[15]. Additionally, the off-site transportation of live pigs is an important factor contributing to the spread of ASF. Therefore, the MARA of China has strengthened the supervision and regulation of live pigs transports and their products. Based on the epidemiological information, the proportion of outbreaks has declined around 35–15% at a national level compared to the previous period of ASF outbreaks[15].

Furthermore, among the 151 reports of ASF, 148 of which had been confirmed in domestic pigs and 3 ASF outbreaks were from wild boars (Appendix Table 1). Interestingly, there is no obvious evidence that direct association between domestic herds and wild herds. For this reason, contact between hunters and pig producers may be a major factor causing ASF transmission among them. Besides, another explanation for this might be tick-to-pig transmission. Soft ticks of the genus *Ornithodoros* have been identified as competent vectors of ASFV to domestic pigs[16, 17].

Additionally, feeding of contaminated swill has been generally considered one of the main risk factors for indirect transmission of ASFV. Some pig farms especially on backyard farms, the feeding of kitchens leftovers could not be

excluded[4, 18, 19]. Thus, most likely, the virus has entered and affected herds by means of contaminated fomites, clothing, vehicles, feed and bedding material due to inadequate biosecurity measures or errors in the implementation of these measures. Accordingly, the MARA of China has banned feeding food scraps to pigs. By comparison, the proportion of nationwide ASF outbreaks caused by feeding pigs with kitchen scraps has dropped around 50–44%[19, 20]. In addition to these measures, the registration of pig transport vehicles, inspection of transportation and regulations for slaughtering pigs have been implemented to combat illegal cross-border movement of pigs or meat.

Conclusion

In summary, the ASF epidemic situation in China can be controlled with the gradual improvement in the prevention and control programs. However, the risk of ASF outbreak and transmission in China is still high. Further strengthened active surveillance is needed to control the transmission and evolution of ASFV. Also, the study is useful to detect trends and to evaluate the impact on the already implemented measures at regional or even at a national level. The control of ASF in China is a challenging and long-lasting battle that needs the participation and coordination of all national and international stakeholders. Particularly on developing models to forecast the epidemiological dynamics of ASF. More broadly, the international community should support research and policy in ASF-free countries that are at risk of exposure to the virus.

Methods

The regional distribution of ASF nationwide

The disease reporting database collated from China Ministry of Agriculture and Rural Affairs(MAFA) (http://www.moa.gov.cn/gk/yjgl_1/yqfb/) presented in Appendix Table 1. The cartographical analysis of the ASF outbreak in China was performed using the geographic information system ArcGIS ArcMap 10.6.3 (ESRI, Redlands, CA, USA) and Statistical Product and Service Solutions 22 (SPSS 22, SPSS Inc., Chicago, IL, USA) based on Appendix Table 1.

ASF incidence and fatality

Thereafter, the rates of case fatality and incidence for ASF in different provinces were calculated with SPSS 22 by using epidemically and population data sourced from the China MAFA database presented in Appendix Table 1. Incidence was defined as numbers of new ASF cases/numbers of susceptible animals/K, and generally fatality rate = numbers of deaths/numbers of animals suffering from ASF infection/K, K = 100%.

Numbers of dead, infected and susceptible pigs in the suburban and rural areas

Similarly, the numbers of dead, infected and susceptible pigs in suburban and rural areas in China were calculated with SPSS 22, respectively. The time range was from August 2018 to August 2019; the retrospective analysis metrics was space-time; and the maximum temporal cluster size was one month.

Abbreviations

ASF: African swine fever; ASFV: African swine fever virus; MAFA: Ministry of Agriculture and Rural Affairs; SPSS 22:Statistical Product and Service Solutions 22

Declarations

Acknowledgments

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The authors of this article have no competing interests to disclose.

Authors' contributions

Dapeng Tao and Daipeng Sun analyzed the data and wrote the manuscript. Shu Wei and Tongqing An revised the manuscript. Guoshun Shen, Zeliang Chen and Jinling Liu designed the research. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated and/or analyzed during this study are included in this manuscript.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

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.

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Tables

**Table 1 The Percentage of African Swine Fever Outbreaks
in Different Provinces in China**

Provinces	ASF Cases	No.case-ASF (%)	Provinces	ASF Cases	No.case-ASF (%)
Anhui	9	5.9%(9/151)	Liaoning	21	13.9%(21/151)
Beijing	4	2.6%(4/151)	Inner Mongolia	6	3.9%(6/151)
Fujian	3	1.9%(3/151)	Ningxia	4	2.6%(4/151)
Gansu	2	1.3%(2/151)	Qinghai	2	1.3%(2/151)
Guangdong	3	1.9%(3/151)	Shandong	1	0.6%(1/151)
Guangxi	7	4.6%(7/151)	Shanxi	5	3.3%(5/151)
Guizhou	10	6.6%(10/151)	Shaanxi	4	2.4%(4/151)
Hainan	6	3.9%(6/151)	Shanghai	1	0.6%(1/151)
Hebei	1	0.6%(1/151)	Sichuan	8	5.2%(8/151)
Henan	2	1.3%(2/151)	Tianjin	2	1.3%(2/151)
Heilongjiang	6	3.9%(6/151)	Tibet	1	0.6%(1/151)
Hubei	8	5.2%(8/151)	Xinjiang	3	1.9%(3/151)
Hunan	8	5.2%(8/151)	Yunnan	9	5.9%(9/151)
Jilin	4	2.6%(4/151)	Zhejiang	2	1.3%(2/151)
Jiangsu	3	1.9%(3/151)	Chongqing	3	1.9%(3/151)
Jiangxi	3	1.9%(3/151)			

Data acquired from China Ministry of Agriculture and Rural Affairs database (<http://www.moa.gov.cn>) presented in Appendix Table 1. --: Representing no relevant information.

Data acquired from China Ministry of Agriculture and Rural Affairs database (<http://www.moa.gov.cn>) presented in Appendix Table 1. --: Representing no relevant information.

Affairs database (<http://www.moa.gov.cn>)

presented in Appendix Table 1. --: Representing no relevant information.

Table 3 The Characteristics of ASF outbreak in Suburban and Rural Areas
in China During August 2018-August 2019

Table 2 The Incidence and Fatality of ASF in 31 Provinces in China,
August 2018-August 2019

Provinces	Susceptible Numbers	Incidence Numbers	Death Numbers	Incidence	Fatality
Anhui	11019	802	408	7.3%(802/11019)	50.9%(408/802)
Beijing	14050	235	129	1.7%(235/14050)	54.9%(129/235)
Fujian	22247	147	123	0.7%(147/22247)	83.7%(123/147)
Gansu	299	187	46	62.5%(187/299)	24.6%(46/187)
Guangdong	6167	52	31	0.8%(52/6167)	59.6%(31/52)
Guangxi	27619	1705	954	6.2%(1705/27619)	56.0%(954/1705)
Guizhou	1763	259	215	14.7%(259/1763)	83.0%(215/259)
Hainan	1238	432	223	34.9%(432/1238)	51.6%(223/432)
Hebei	5600	320	240	5.7%(320/5600)	75.0%(240/320)
Henan	2347	178	94	7.6%(178/2347)	52.8%(94/178)
Heilongjiang	74649	5123	4158	6.9%(5123/74649)	81.2%(4158/5123)
Hubei	2026	167	114	8.2%(167/2026)	68.3%(114/167)
Hunan	13443	729	400	5.4%(729/13443)	54.9%(400/729)
Jilin	1459	209	204	14.3%(209/1459)	97.6%(204/209)
Jiangsu	83752	3079	1466	3.7%(3079/83752)	47.6%(1466/3079)
Jiangxi	463	75	63	16.2%(75/463)	84.0%(63/75)
Liaoning	52981	2378	2087	4.5%(2378/52981)	87.8%(2087/2378)
Inner Mongolia	1232	348	311	28.2%(348/1232)	89.4%(311/348)
Ningxia	179	60	46	33.5%(60/179)	76.7%(46/60)
Qinghai	101	46	31	45.5%(46/101)	67.4%(31/46)
Shandong	4504	17	3	0.4%(17/4504)	17.6%(3/17)
Shanxi	8379	176	100	2.1%(176/8379)	56.8%(100/176)
Shaanxi	11857	459	224	3.9%(459/11857)	48.8%(224/459)
Shanghai	314	50	11	15.9%(50/314)	22.0%(11/50)
Sichuan	1323	344	244	26%(344/1323)	71.0%(244/344)
Tianjin	1000	361	256	36.1%(361/1000)	70.9%(256/361)
Tibet	129	60	55	46.5%(60/129)	91.7%(55/60)
Xinjiang	1124	204	146	18.1%(204/1124)	71.6%(146/204)
Yunnan	2327	860	731	37.0%(860/2327)	85.0%(731/860)
Zhejiang	4144	486	396	11.7%(486/4144)	81.5%(396/486)
Chongqing	423	20	12	4.7%(20/423)	60.0%(12/20)

Data for this study was acquired from the Ministry of Agriculture and Rural Affairs (MAFA) database (<http://www.moa.gov.cn>) for Appendix Table 1. --: Representing missing information.

Supplementary Information

Appendix Table 1 Summary of African Swine Fever Outbreaks in China, August 2018-August 2019. The data for this study was available from China Ministry of Agriculture and Rural Affairs (MAFA) database (<http://www.moa.gov.cn>).

Figures

Months	Death Numbers in Suburban Areas	Death Numbers in Rural Areas	Incidence Numbers in Suburban Areas	Incidence Numbers in Rural Areas	Susceptible Numbers in Suburban Areas	Susceptible Numbers in Rural Areas
Aug-2018	505	80	1122	185	543	459
Sep-2018	244	341	272	379	1645	2553
Oct-2018	278	2682	302	3323	24599	30036
Nov-2018	696	252	703	296	7851	12543
Dec-2018	399	195	656	211	25488	20566
Jan-2019	37	5157	143	7208	190	142135
Feb-2019	1310	62	2144	150	38781	11334
Mar-2019	98	15	115	9	3397	241
Apr-2019	43	486	252	580	252	2411
May-2019	4	144	5	204	72	689
Jun-2019	10	135	15	189	331	1258
Jul-2019	0	58	0	77	0	1165
Aug-2019	0	3	0	9	0	32

Figure 1

The distribution characteristics of ASF outbreak in China in one year. (A)The cartographical analysis of the ASF outbreaks was performed using the geographic information system ArcGIS ArcMap 10.6.3 based on Appendix Table 1. The yellow color represents the cumulative number of death cases in each province. The shades of red color on the map vary with the number of infected cases. (B)The percentage of ASF outbreaks in different provinces in China. Different color represents the percentage of ASF outbreaks for each province.

Figure 2

The characteristics of incidence, fatality and the number of susceptible pigs for ASF in China in one year. (A)The cumulative numbers of susceptible pigs in different provinces by using epidemiology and population data sourced from the China MAFA database presented in Appendix Table 1 and Table 2 using IBM SPSS statistics 22. (B)The incidence and fatality of ASF in different regions of China. Blue bars show incidence; yellow bars show fatality.

Figure 3

The characteristic analysis of ASF outbreak in suburban and rural areas in China during August 2018-August 2019. (A)The cumulative numbers of susceptible pigs in suburban and rural areas by using epidemiology and population data sourced from the China MAFA database presented in Appendix Table 1 and Table 3 using IBM SPSS statistics 22. Purple and blue lines show cumulative number changes of susceptible pigs with different months in suburban and rural areas, respectively. (B)The infected and dead pigs of ASF in suburban and rural areas in China. Different color lines show cumulative number changes of infected and dead pigs with different months in suburban and rural areas based on the online Appendix Table 1, respectively.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AppendixTable1SummaryofAfricanswinefever.pdf](#)