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ANIMAL HEALTH **RISK ANALYSIS** ASSESSMENT No. **05**

AFRICAN SWINE FEVER THREATENS PEOPLE'S REPUBLIC OF CHINA

A rapid risk assessment of ASF introduction

SUMMARY

- In March 2017, ASF was reported in Irkutsk, Russian Federation, thousands of kilometres away from previously reported outbreaks and at approximately 1 000 km from the border with China. Entry of ASF into China would have devastating consequences for animal health, food safety, and food security, and raise the possibility of further spread to Southeast Asia including the Korean Peninsula and Japan.
- The FAO rapid risk-assessment framework and methodology was discussed with swine disease experts attending the Second Regional Workshop on Swine Disease Control in Asia (China Workshop, 2017).
- The experts participating in this rapid risk assessment considered transport-associated routes (TARs) as most relevant pathways of ASF introduction into China, followed by illegal imports of food and by Chinese workers working abroad.
- China's northeastern region (Heilongjiang province) is where ASF is most likely to be introduced, followed by Inner Mongolia.
- Wild boar population density is the most relevant factor in the spread of the disease.
- The most likely regions for ASF spread are the northeast (Heilongjiang), followed by the central eastern area (Henan, Shanxi, Ammui, and Hubbei) and the southeast (Hunan). Surveillance for swine diseases in this region should be heightened.
- ASF is most likely to persist and become endemic due to the presence of wild boar populations interacting with susceptible domestic species, and lack of biosecurity in smallholdings. However, due to restrictions on hunting in China, hunters are not likely to affect the spread and persistence of the disease.

BACKGROUND

African swine fever (ASF) is one of the most devastating diseases affecting pigs. Highly contagious, it is associated with a virus from the genus Asfivirus of the Asfaviridae family (Dixon, 2005). The disease can spread through direct or indirect contact and causes high mortality, while the virus can persist for a long time in the environment and in a variety of swine products. Wild boar can harbour the virus and ASF may become endemic with or without an added transmission cycle through the Ornithodoros tick (Plowright, 1994). Currently, there are no vaccines available. Ever since the disease was first described in Kenya in 1921, it was recognized as endemic in most sub-Saharan countries. ASF genotype I entered Europe in 1957, with outbreaks detected in several countries including Portugal, Spain, Malta, France, Belgium, the Netherlands, and Italy. In the Iberian Peninsula, ASF was endemic from 1960 to 1995 (Costard *et al.*, 2009). The disease also occurred in the Caribbean (Cuba, 1971 and 1980; the Dominican Republic, 1978; and Haiti, 1979) and in Brazil (1978). These outbreaks, and those reported later in Eastern Europe, were successfully controlled, resulting in the eradication of ASF from the European continent – although it is considered endemic in some areas of the Italian island of Sardinia. The next ASF incursion (genotype II) into Europe was reported in the Republic of Georgia in 2007, most probably originating from southwest Africa (Rowlands *et al.*, 2008; Costard *et al.*, 2013), From Georgia, the disease spread to neighbouring countries, including Armenia (2007), the Russian Federation (2007), and Azerbaijan (2008). From the southern Caucasus, it continued northward and westward with additional outbreaks to the east of the Russian Federation in domestic pig and wild boar populations. There were reports of a few isolated wild boar cases in Iran in 2008 (Rahimi *et al.*, 2010). In 2012 and 2013, ASF reached Ukraine and Belarus respectively. while in 2014, outbreaks involving wild boar and domestic pigs were reported in Poland, Latvia, Estonia, and Lithuania. In June 2017, further outbreaks occurred in the Czech Republic and Romania. Additional details of ASF incursions into Eurasia are provided in Table 1. In March 2017, ASF was reported in Irkutsk, Russian Federation, thousands of kilometres away from previously reported outbreaks and at approximately 1 000 km from the border with China. This marked the disease's first long jump from central eastern Europe to the eastern side of the Russia Federation, in relative proximity to the Chinese border.

China is home to around half of the global pig population and has the world's highest per capita consumption of pork and pork products (FAOSTAT, 2014). Entry of ASF into China would have devastating consequences for animal health, food safety, and food security, and raise the possibility of further spread to Southeast Asia and the Korean Peninsula. In this preliminary study, a rapid qualitative hazard identification is presented, including an evaluation of the different drivers and activities that could play a role in the potential introduction of ASF into China from infected countries. Also conducted was a qualitative risk assessment to determine the risks of African swine fever virus (ASFV) entering China, as well as to identify risk pathways, the likelihood of exposure of domestic pigs to the virus, its potential further spread, and the likely persistence of the disease.

TABLE 1 *ASFV incursions into Eurasia as of September 2017*

Year	Country	Genotype	Source of introduction	Status
1957	Portugal	I	From West Africa	Eradicated
1960	Portugal	I	After reintroduction into Portugal, ASF spread to seveal countries in Europe	Eradicated in the 1990s, except for the Island of Sardinia (Italy) where it was introduced in 1978 and became endemic
1967	Italy	I		
1969	Spain	I		
1977	France	I		
1978	Malta	I		
1985	Belgium	I		
1986	The Netherlands	I		
2007	Georgia, Armenia, Russian Federation	I	Georgia was likely infected from southeastern Africa while outbreaks in Armenia and the Russian Federation resulted from further incursions from Georgia	Not eradicated; endemicity likely
2008	Azerbaijan, Iran	II		Eraticated
2012	Ukraine	II	Most likely spread from the Caucasus	Not eradicated
2013	Belarus	II		
2014	Lithuania, Poland, Latvia, Estonia	II	Probably introduced from Belarus although the outbreak was not offically reported	Not eradicated
2017	Moldova, Irkutsk (RF), Czech Republic, Romania	II	Progressively spread east and westward	Not eradicated

In response to the geographical expansion of the disease, in 2017 FAO published a manual on ASF detection and diagnosis (Beltran-Alcrudo, 2017) for veterinary professionals, paraprofessionals and diagnosticians.

HAZARD IDENTIFICATION AND DRIVERS

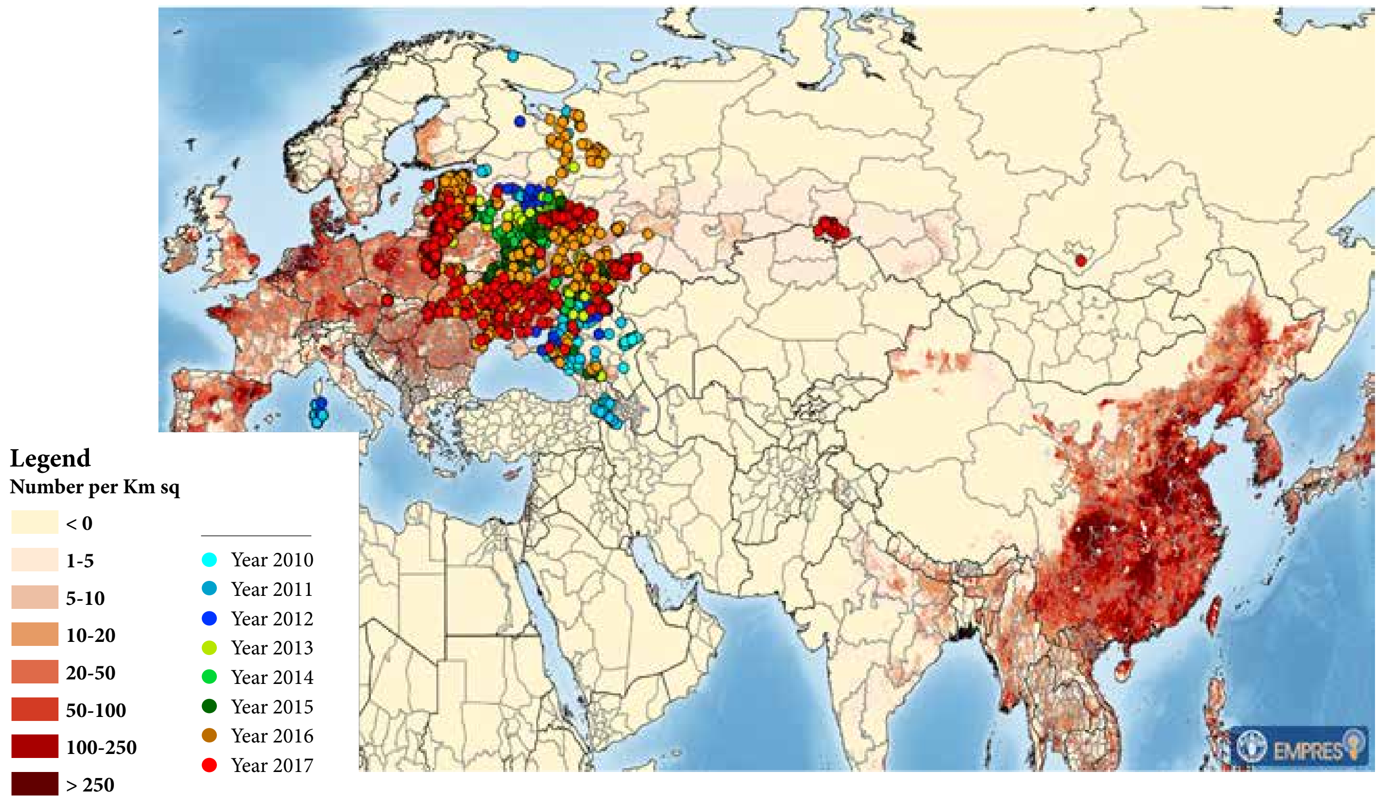
African swine fever epidemiology

ASF is endemic in sub-Saharan African countries, where it persists in a sylvatic cycle between warthogs and Ornithodoros ticks. ASF was first observed and recognized in Kenya in 1921. Soon after, it was reported in Angola and South Africa. It arrived in Portugal, probably from Angola, in 1957 and again in 1959, and from there it spread to Spain. Thereafter, it travelled to a number of countries in the Caribbean (Cuba, Dominican Republic and Haiti) and Brazil, with catastrophic effects on pig farming and production and on the livelihoods of small farmers and rural communities. In the Iberian Peninsula, ASF was eradicated after 30 years. But it remains endemic in some areas of the Italian island of Sardinia and in most sub-Saharan African countries. It was introduced into the Caucasus in 2007 and efforts to control it are ongoing.

On March 27, 2017, the Russian Federation reported to the OIE an outbreak located in Irkutsk, Siberia. This report evidenced a jump of about 3 000 km from the previous reported outbreak site on the western side of the Russian Federation (Samarskaya Oblast, Gremyachka, March 6, 2017). This new outbreak likely resulted from the movement of infected swine or pig products. The affected population included 40 fattening pigs with clinical signs compatible with ASF (OIE/WAHIS, 2017). The outbreak was notified by the farm owner, and the samples subsequently tested positive for ASF at the Republican Center for Veterinary Diagnosis, using real-time PCR. Control measures included disinfection, movement controls, traceability, quarantine, stamping out, and control of wildlife reservoirs. The threat posed by the outbreak is significant given the proximity of the Mongolian border (around 300 km), the relatively long distance to other previously reported outbreaks (2007–2017), and the relative proximity of China (1 000 km). In the Russian Federation, ASF was first reported in wild boar in the Chechen Republic in November 2007, and in domestic pigs in the Republic of North Ossetia in June 2008. Thereafter the disease spread widely in the western region of the country. In 2017, in Europe alone, ASF outbreaks have been reported from Belarus, the Czech Republic, Lithuania, Moldova, Poland, Romania, the Russian Federation and Ukraine.

Since ASF's entry into Georgia in 2007, and as of July 20, 2017, at least 5 445 outbreaks of the disease have occurred in continental Europe, with 903 reported in the Russian Federation alone. The

FIGURE 1. *January 2010 to June 2017 ASF outbreaks and backyard pig distribution*



Source: (EMPRESi)

Eurasian distribution of outbreaks since 2010 is shown in Figure 1.

The Irkutsk outbreak of ASF in the Russian Federation raises many concerns due to the proximity of Mongolia and China and the challenges in preventing and controlling the disease in border areas. Also worrisome are the potential consequences on the availablity of, and demand for, pork globally, and the repercussions on the livelihoods of producers, markets, and the pork processing and manufacturing industry.

Surveillance and disease control infrastructure in China

The Ministry of Agriculture (MOA) is the national authority in charge of animal disease control activities in China. Institutes directly affiliated with MOA surveillance activities include the China Animal Disease Control Center (CADC), Beijing, and the China Animal Health and Epidemiology Center (CAHEC), Qindao. CADC is responsible for the analysis and treatment of animal diseases nationwide, the prevention and control of major animal diseases, animal identification administration, safety and quality testing of livestock and poultry products, and guidance on animal health supervision. CAHEC is responsible for epidemiological investigation, diagnosis and surveillance of major animal diseases, assessment of veterinary health, supervision and inspection of health and quality of animals and animal products, and coordination with the sub-centres in Beijing, Harbin, Lanzhou and Shanghai, as well as various veterinary technical institutions for the organization of epidemiological investigations.

Surveillance of swine diseases is conducted by the MOA's Veterinary Bureau, which has a network of more than half a million veterinarians. The work involves 146 animal epidemic surveillance border stations, 304 national-level animal epidemic information stations, and 250 terrestrial animal epidemic surveillance stations (Chinese presentation to FAO, May, 2017). Other agencies apart from CAHEC and CADC are also involved in animal disease surveillance and reporting at national, regional and local levels. Surveillance border stations are show in Figure 2. All the provinces, prefectures and counties have their own animal disease control institutions, which are responsible for surveillance, testing, diagnosis, epidemiological investigation, outbreak reporting, and other technical activities. At the end of 2012, those institutions employed 37 000 staff members (MOA of the People's Republic of China, 2014).

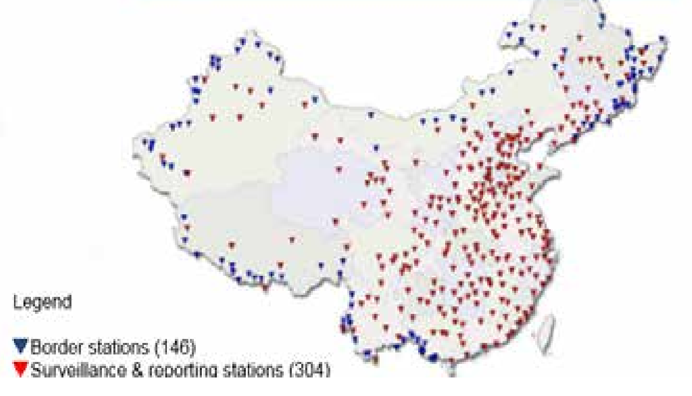
Swine disease control measures in China include: **i)** prevention and control of highly virulent/pathogenic diseases and zoonoses; **ii)** enhancing animal health status; **iii)** compartamentalization and management; and **iv**) prevention and control (workshop on swine disease control in Asia, May 2017).

Samples from animals showing clinical signs compatible with ASF are sent routinely for testing to the national reference laboratory in CAHEC. Active surveillance is in place for commercial farms, while passive surveillance mainly takes place in non-commercial farms. The MOA National Animal Disease Surveillance Plan details the measures required at country level. Provincial veterinary authorities may develop local surveillance plans based on local conditions, in accordance with the national plan, which includes surveillance programmes for classical swine fever (CSF) and ASF. In 2015, almost 564 000 samples were tested for CSF, highly virulent porcine reproductive respiratory syndrome (HV-PRRS), and foot-and-mouth disease (FMD), while the number of tests increased to 622 400 in 2016 (Table 2). The proportion of positive results remained virtually unchanged for CSF and HV-PRRS over the two years, but there was a slight decrease of FMD in pigs tested.

China has developed strict requirements for swine movement, and in 2016 all provinces implemented an "e-quarantine certificate" (Figure 3).

Knowledge of the distribution of the wild boar population in China is required to plan a comprehensive ASF surveillance programme. Any model of ASF spread and persistence should consider estimates of swine density and the geographical range of other susceptible populations (by production system). Models of ASF persistence should also cover porcine reproductive capability, age and sex distribution, and the role of other drivers

FIGURE 2. *Distribution of the national stations and border stations*



Source: adapted from China Workshop, June, 2017

TABLE 2 *CSF samples tested, CSF positive, Swine-origin FMD, and HV-PRRS, China 2015 and 2016*

Disease	2015 Etiological surveillance		2016 Etiological surveillance	
Total	Sample number	Positive number (ratio%)	Sample number	Positive number (ratio%)
CSF	148 000	222 (0.15)	173 600	277 (0.16)
FMD (in swine)	275 200	110 (0.04)	290 800	58 (0.02)
HV-PRRS	140 700	647 (0.46)	158 000	679 (0.43)

Source: ASF Workshop, Beijing, June 2017 in the spread of the disease. Such drivers may include the population dynamics of wild and domestic pigs, seasonality, live pig markets and slaughterhouses, possible transboundary contacts, feeding areas, current control strategies, efficacy of different management methods, and cost.

China's swine production system

China is currently the world's number one producer and consumer of pork (USDA, Foreign Agriculture Services Forecast, 2017). In 2016, China accounted for nearly half of the world's pork production, with 53 990 000 tonnes (USDA, Economic Research Service, January, 2017, USDA, Foreign Agricultura Service Forecast, 2017).

The country is divided into seven geographical regions: Northwest, Southwest, Southern, Central, Eastern, Northern Plain, and Northeast. Four of these regions – Northern Plain, Southwest, Central, and Eastern – are major grain production areas with dense human populations, and they are also home to 70 percent of China's pork production. The Northern Plain accounts for 21 percent of national pork output, while 20 percent and 18 percent are produced in the Southwest and Central regions respectively. The top ten percent of producers are all large production units, and they are concentrated in the eastern part of China from north to south, in roughly a third of the country (Oh and Whitley, 2011).

China is the world's leading pork consumer. Consumption was 57 million tonnes in 2014, amounting to more than half of the global total (109.9 million tonnes) (University of Pennsyvania, Penn Wharton, 2015). The Chinese Statistical Bureau reported per capita pork consumption was 20.1 kg in 2015 – more than double that of poultry (Chinese Annual Report, 2016).

Pork consumption increased 22 percent from the late 1990s and is today almost twice that of the country with the next highest per capita consumption, South Korea (Figure 4). In 2016, China consumed 54.98 million tonnes of pork and had to import 1.62 million tonnes. The amount of pork consumed in China amounts to 50.2 percent of global production (Earth Policy Institute). Pork production in 2016 was in the order of 51.85 million tonnes. By way of comparison, the European Union's output was 23.35 million tonnes and the United States' 11.3 million tonnes. Chinese pig production today is very different from the 1970s, when backyard farming supplied 70 percent of the internal market. Production increased during the 1980s following market-oriented economic reforms. This very active production model showed a positive production and consumption balance in the 1990s. In the decade that followed, production consolidation began, environmental regulations were tightened, and destocking was initiated with the culling of 15 million animals by 2015 (National Hog Farmer Blog, 2016). Swine owners profited greatly from high pork products prices and, given the opportunities for growth, modern, intensive swine farms developed rapidly. Corn quality and supply changes were additional drivers of the consolidation and, as a consequence, medium and small farms were closed due to non-compliance with the new standards or because of non-competitive production levels (USDA, Foreign Agriculture Service, Global Agriculture Information Network, 2016).

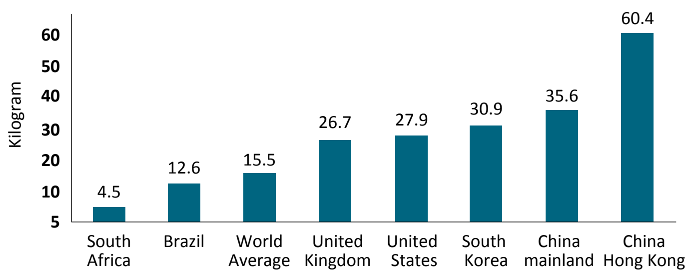
In the current Chinese pig production system, backyard farms contribute about 27 percent of national output. Issues arising from the wide variety of pig farm sizes, coupled with different managements systems, have led to a low level of productivity and a complex structure for the prevention and control of swine diseases, as shown in Figures 5 through 9 (China Workshop presentation, Beijing 2017 and other sources as indicated).

Notwithstanding changes in biosecurity protocols implemented on commercial farms, and despite harmonization and compliance with international partners' requirements, the commercial industry appeared incapable of controlling the spread of swine diseases such as PRRS in 2006. The epidemic started in southern China and northern Viet Nam and affected commercial and backyard producers. China's biosecurity protocols for commercial production were strenghtened as a consequence of PRRS (Lei Zhou, Hanchun Yang, 2010).

FIGURE 3. *Chinese tagging and mobile phone application for tracing pig movements*

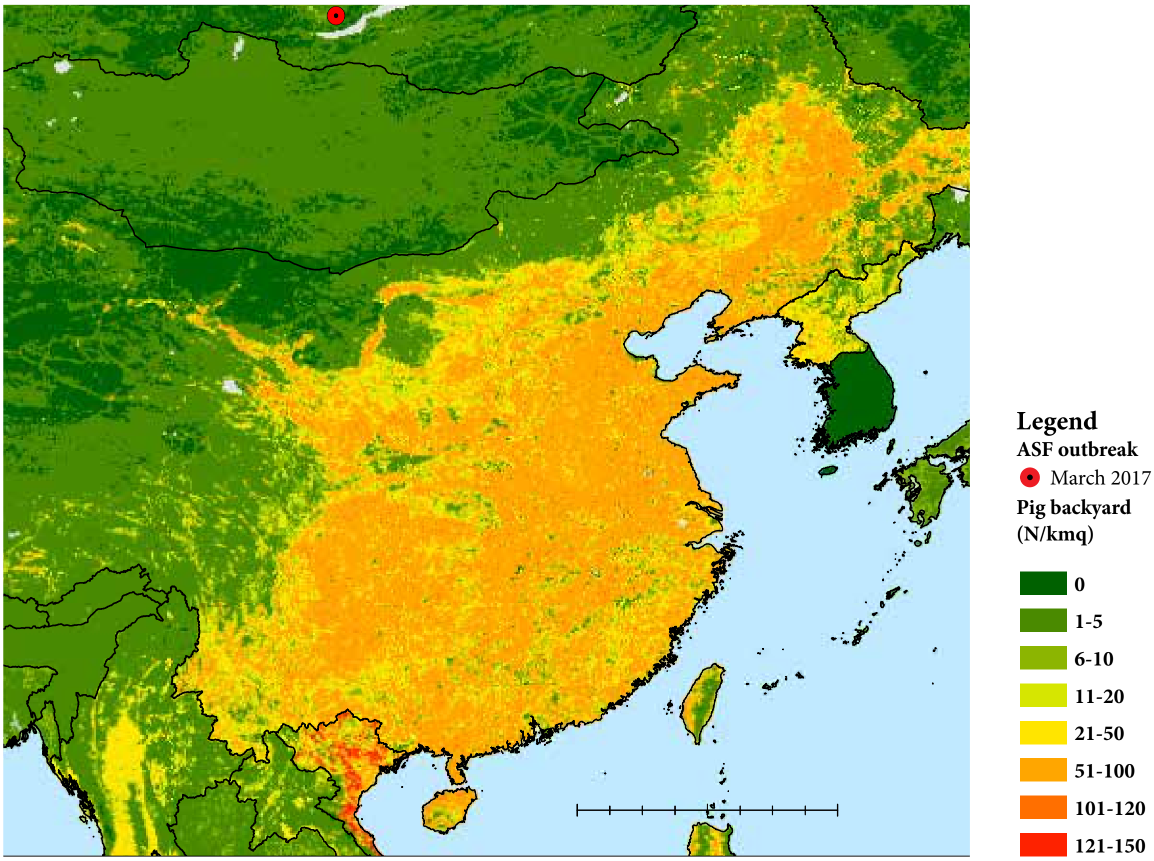
Source: adapted from China Workshop, June, 2017

FIGURE 4. *Pork consumption per capita, 2011*



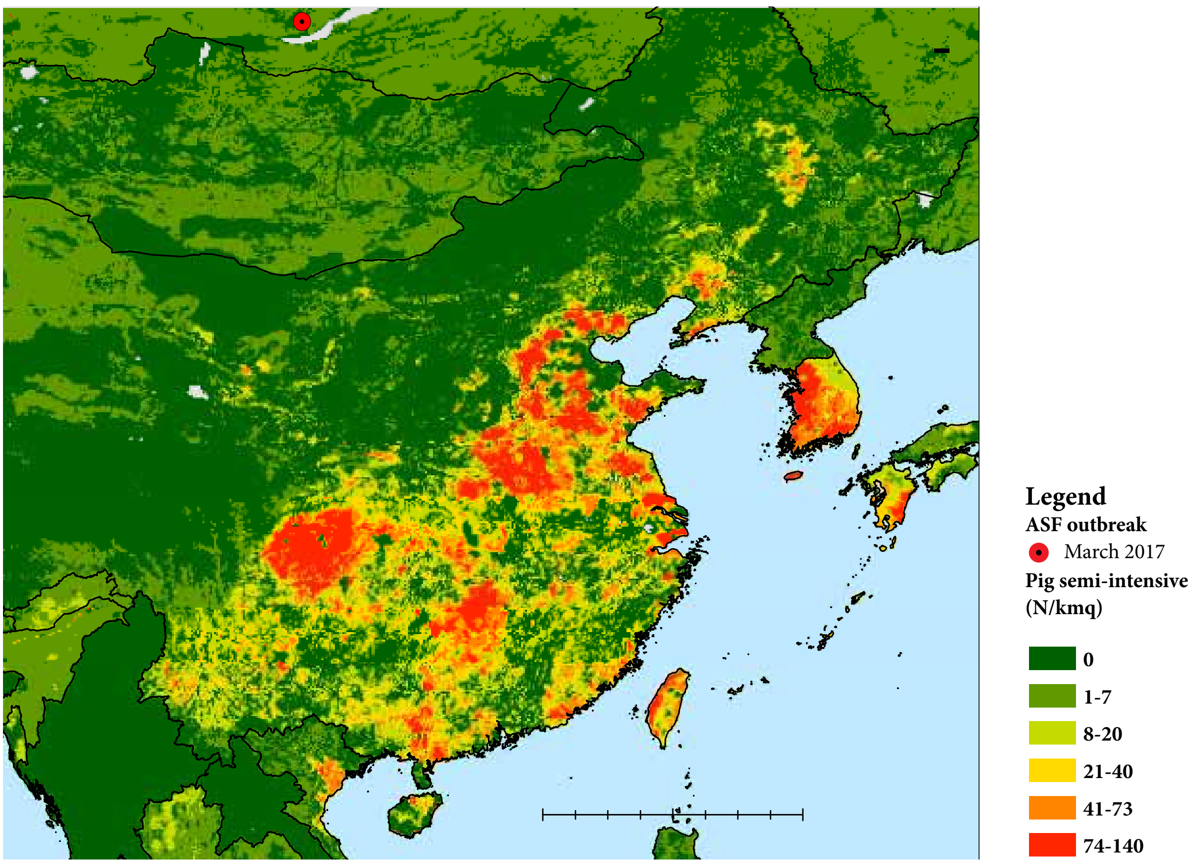
Source: FAOSTAT

FIGURE 5. *Backyard pig production in China*



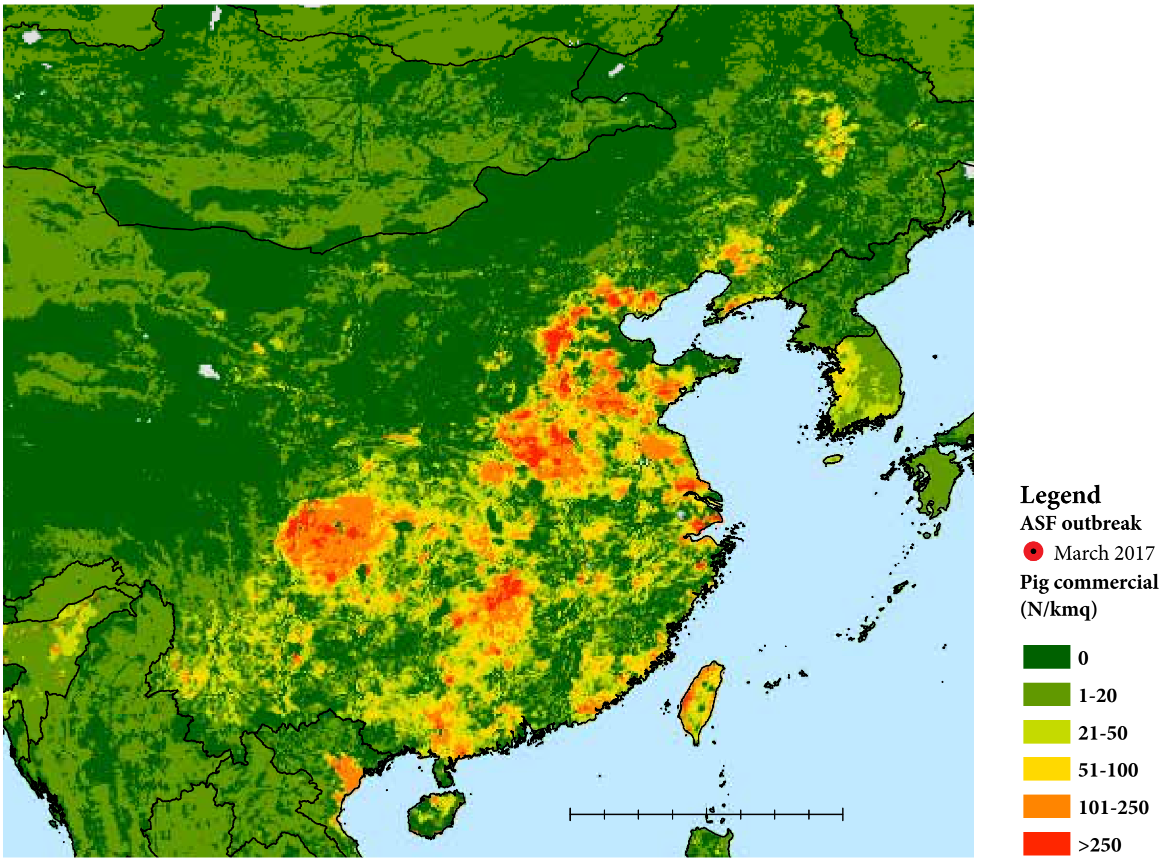
Source: FAO Gridded Livestock of the World 2.0 (2014) adjusted to FAOSTAT 2010

FIGURE 6. *Semi-intensive pig production in China*



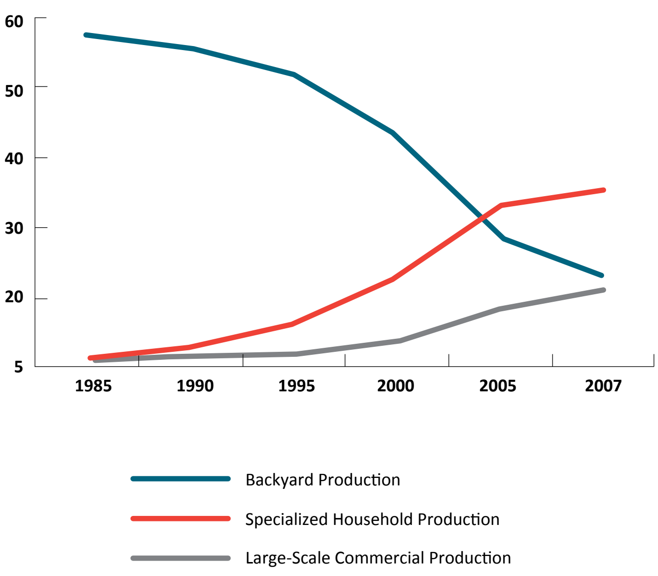
Source: FAO Gridded Livestock of the World 2.0 (2014) adjusted to FAOSTAT 2010

FIGURE 7. *Commercial pig production in China*



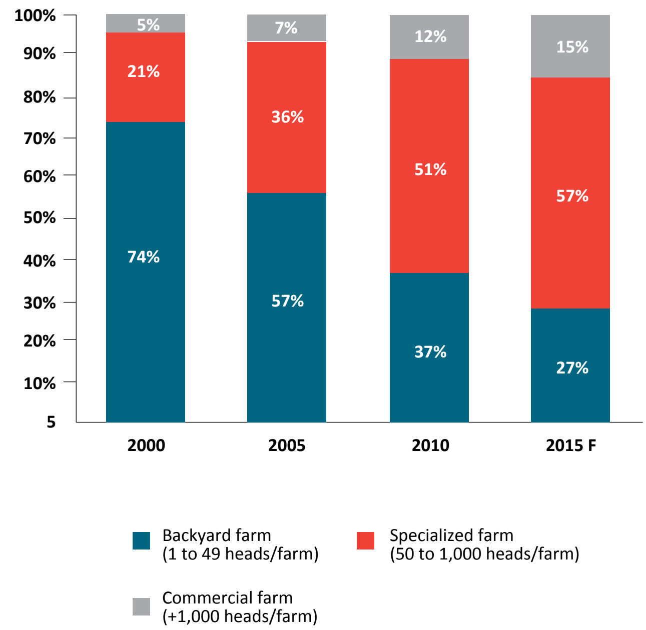
Source: FAO Gridded Livestock of the World 2.0 (2014) adjusted to FAOSTAT 2010

FIGURE 8. *Share of total pig production by farm type between 1985 and 2007*



Source: Informa Economics and National Grain and Oil Information Center, 2009

FIGURE 9. *China's hog farming structure, 2001-2015*



Source: MOA, Rabobank estimates, 2011

Trade

China protocols for bilateral agreements fall under the jurisdiction of the General Administration of Quality Supervision for Inspection and Quarantine (AQSIQ) – equivalent to the Food Safety and Animal Health Department in other countries. AQSIQ determines the veterinary and health requirements for imports of live swine and swine commodities into China.

In the AQSIQ protocols, the responsibility for inspection and quarantine is assigned to the exporting country. The necessary export health certificates include compliance with Chinese requirements. Exporting authorities are required to: **i)** report management regulations and procedures associated with processing plans and disease control systems; **ii)** officially confirm animal disease status; **iii)** ensure specific traceability requirements; **iv)** confirm registration of facilities by the Chinese Certification and Accreditation Administration; and, **v)** confirm compliance with requirements for slaughter (China Inspection and Quarantine Services, 2017). Although China relies on the exporting country complying with export requirements, many live animals are imported from non-ASF affected countries, as shown in Figure 10.

Fresh meat and other pork products

Figures 11 and 12 show the direction of trade in terms of net weight of meat products imported into China, with a description of the import volume of swine meat (fresh and frozen) in 2016. China is a net importer of pork and pork products despite the industry's growth. Processed pork products imported into China include salted, dried and smoked meat, edible flours and meals of meat or offal.

According to a report by the Institute for Agriculture and Trade Policy (Schneider *et al.*, 2014), from 2000 to 2006, China and Hong Kong together imported between 500 000 and 600 000 tonnes of pork per annum. This was less than one percent of overall consumption.

Largely driving China's pork sourcing decisions are food safety issues. Since 2007, China has been the primary export destination for the US pork industry. During the country's peak pork import year in 2008, US sales to China–Hong Kong accounted for 18 percent of US pork exports – double the share in 2000–2006. But in the first half of 2013, Germany overtook the United States as China's top pork supplier, with the US market share dropping from 48 to 18 percent and Germany's rising to 23 percent. From 2007 to 2014, China's pork imports have increased at an annual average rate of 150 percent (University of Pennsyvania, Penn Wharton, 2015).

The volatility of China's pork market allowed exporters to gain a growing share of that market, as in the aftermath of the PRRS outbreak in 2006, when pork supplies and prices became unstable, prompting increased imports the following year.

Smuggling of pigs into China is a source of concern. There have been media reports of the informal introduction of live pigs from Viet Nam (Best China News, 2016) on China's southern border. It is unknow if smuggling occurs in the northern part of the country, but due to the price difference for pork and live pigs between Russia and China, smuggling of commodities cannot be ruled out (China Workshop discussion, 2017). For instance, in 2015, pigmeat was estimated to be 15 percent cheaper (live weight) in the Russian Federation than in China, which could have contributed to the smuggling of potentially infected pork into the Chinese market.

Because of this price difference, informal imports of pig feed and fodder also increased (China Workshop discussion, 2017), which may have led to the introduction of ASF into China through contaminated vehicles and feed. Feeding pigs with fresh fodder harvested in areas at risk of ASFV exposure risks introducing the virus into backyard holdings (Bellini *et al*. 2016). In 2016, the average price for pig feed in the Russian Federation was USD 0.22 per kg (GENESUS, 2017) compared with USD 1.94 per kg in China (Gale 2017).

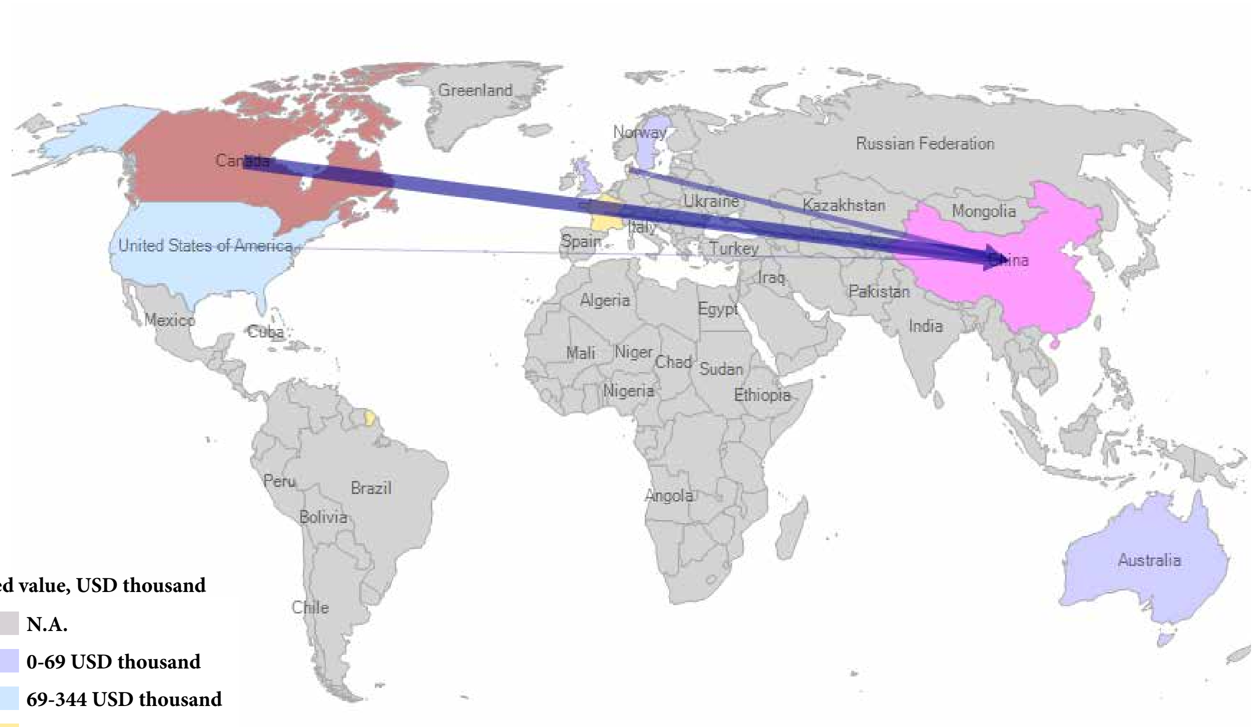
Wild boar population in China

The wild boar (Sus scrofa ferus) is an omnivorous, generalist, and opportunistic species able to thrive in a variety of environmental conditions and habitats, and with a one of the widest geographic distributions of all mammals. Due to a combination of biological, environmental and anthropogenic factors, the abundance of wild boar has continuously increased over the last decades and its distribution has expanded globally (Morelle *et al.*, 2014). Wild boar are significant crop raiders as well as a reservoir and agents of several swine diseases. In China, wild boar density is estimated at between two and five head/km2, with densities put at 2.24 head/km2 in some forests in northeastern China, and even higher in the southeastern coastal areas. In Guangdong Province Nature Reserve, wild boar density was estimated at between 4.87 and 5.15 head/km2 (Vergne, 2017).

The species is widely distributed thoroughout China, except for some dry and unsuitable regions in the west (Xinjiang province) and north of the country, including the Tibetan plateau, and the region bordering Mongolia (Figure 13). However, little precise information is available about the ecology, population structure and dynamics, as well as the actual distribution and density, of wild boar in China (Guo *et al.*, 2017).

Wild boar tend to thrive in agricultural areas and can decimate crops by uprooting them and destroying vegetation. They damage forests, posing a threat to native wildlife competing for similar sources of food. East Asian wild boar show genetic diversity and adaptation, and are distinct from European wild boar populations (Sung Kyoung Choi, 2014; Hendrik-Jan Megens, 2007), which could have an impact on viral ecology, disease susceptibility and epidemiological traits. Wild boar and backyard pigs may have access to untreated or uncooked food waste and swill given the

FIGURE 10. *Country of origin and flow of trade in live swine*

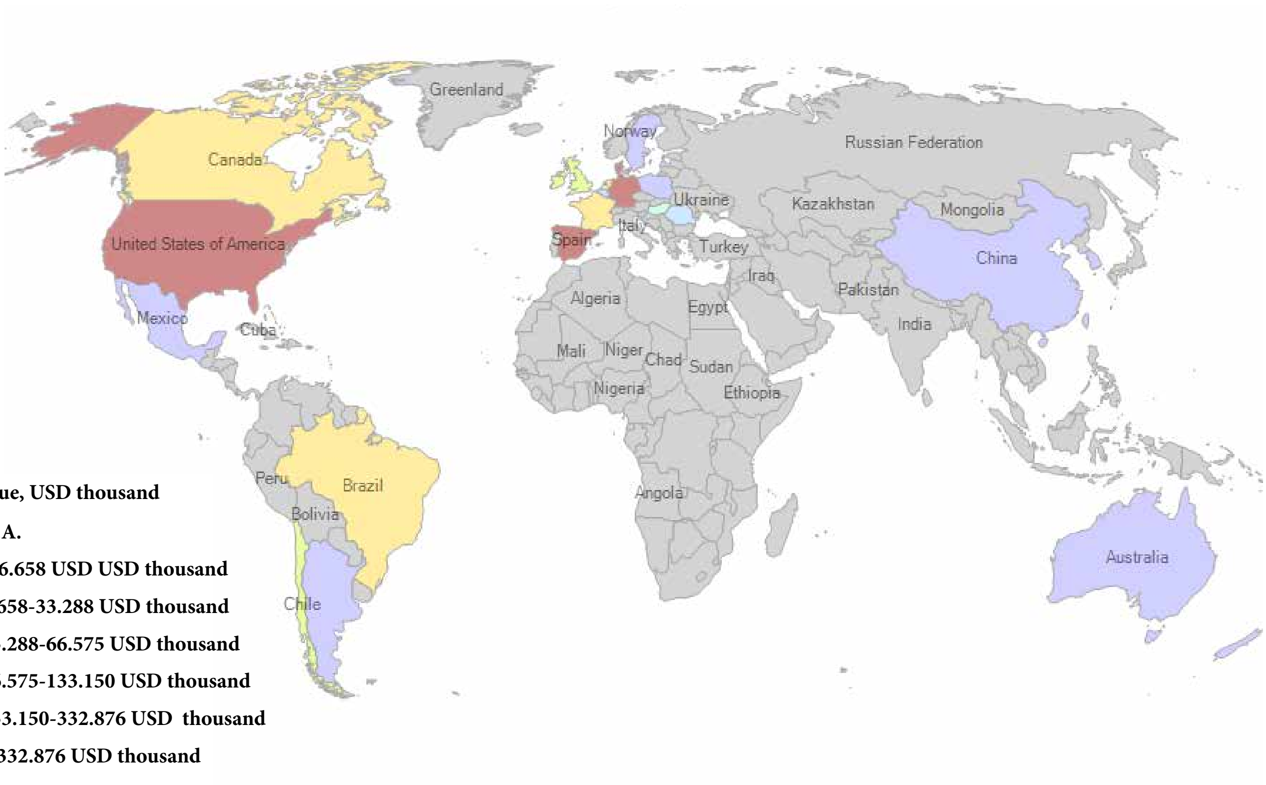


Imported value, USD thousand

- **N.A.**
- **0-69 USD thousand**
- **69-344 USD thousand**
- **1.578-3.445 USD thousand**
- **> 3.445 USD thousand**

Source: http://www.trademap.org/tradestat, 2017

FIGURE 11. *Country of origin of trade in fresh and frozen pigmeat*

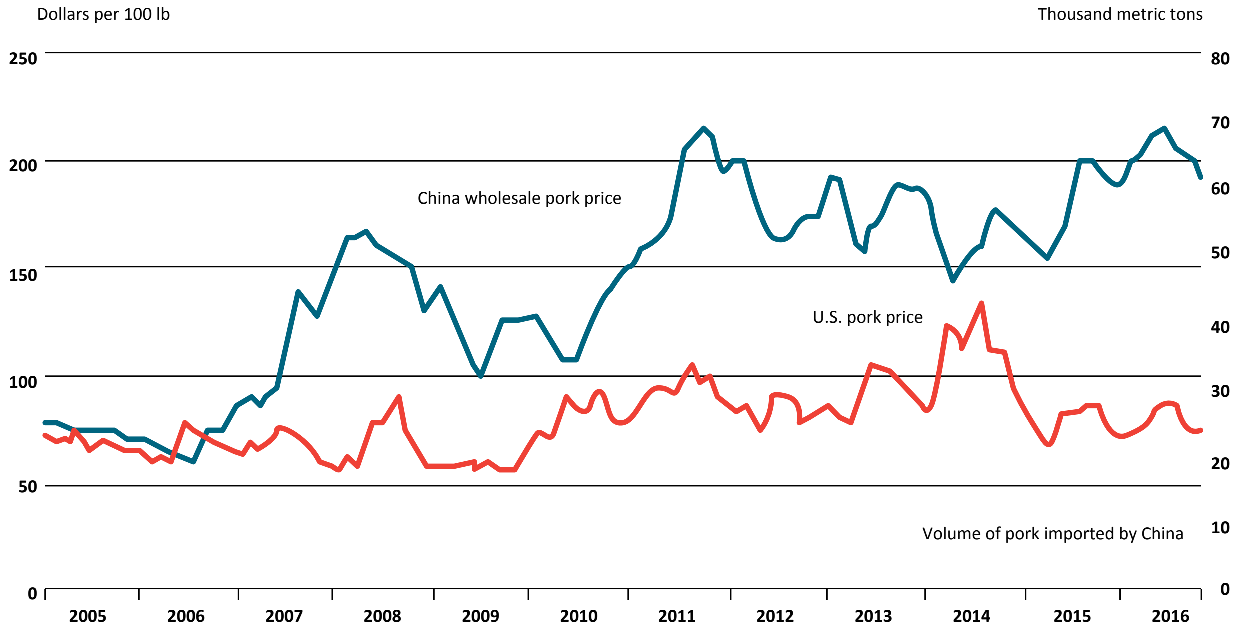


Imported value, USD thousand

- **N.A.**
- **0-6.658 USD USD thousand**
- **6.658-33.288 USD thousand**
- **33.288-66.575 USD thousand**
- **66.575-133.150 USD thousand**
- **133.150-332.876 USD thousand**
- **> 332.876 USD thousand**

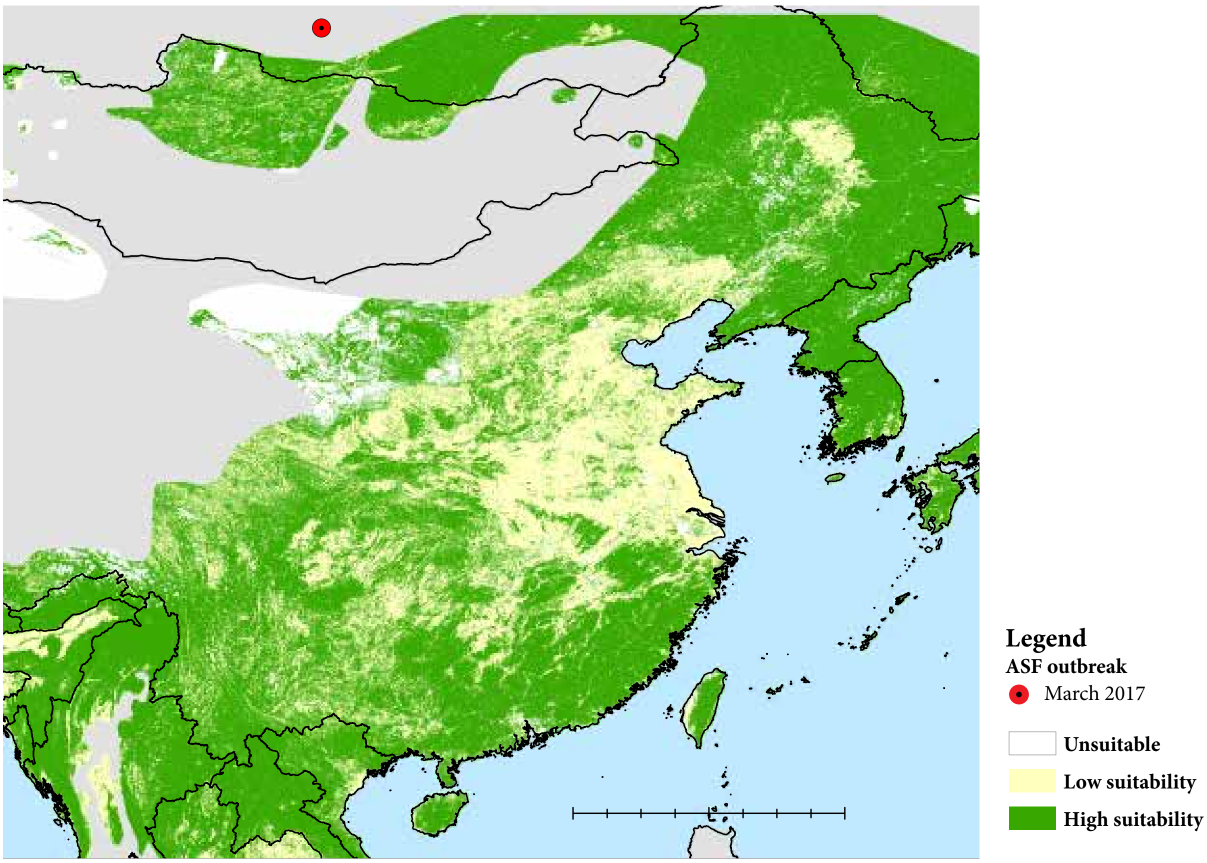
Source: http://www.trademap.org/tradestat, 2017

FIGURE 12. *China and US monthly pork prices and imports, 2005-2016*



Source: USDA, Economic Research Service analysis of data from China Ministry of Agriculture and China customs statistics
Note: China hog prices not adjusted for inflation

FIGURE 13. *Wild boar suitability in the Central and South East Asia Region*



Source: Rondini *et al.*, 2011. Global suitability models of terrestrial mammals.
Legend: Unsuitable – the species cannot survive in this habitat; Low suitability – the species can use this habitat but not all the resources necessary for survival are present; High suitability – the species can survive.

lack of local regulations or compliance with any existing ones. Food waste is distributed through local networks to small-scale production pig units or farmers. According to recent reports (The Telegraph, September 2010) the number of wild boar in Zhejiang Province has risen to an estimated 150 000, compared with about 29 000 a decade ago. Wild boar populations have flourished as environmental fragmentation, urbanization and public works caused a decline in China of traditional predators such as tigers and wolves. Chinese law has prohibited the hunting of wild boar since 1994 unless the farmers are able to demonstrate through pictures or other documentation that they are responsible for crop damage. Compensation for wild boar crop damage is available in China, as reported by Chinese resource specialists who attended the 2017 FAO workshop. Authorities are trying to encourage licensed "farming" of wild boar and other wild ungulates (Meng, 2009), as well as traditional breeding practices between wild boar and backyard pigs, which can be reared outdoors in open/extensive areas (Wu, personal communication, 2017). These practices increase the interface or contact rate between wild boar and domestic pigs, and represent an important risk factor for the introduction and spread of swine diseases in both directions.

In order to determine the possible introduction or ASF into China through the wild boar population, and to elaborate relevant qualitative and quantitative models, several variables need to be considered. These include the identification of the types of data to be gathered from public and private enterprises involved in pig production and pork product manufacture at local level. Furthermore, the objectives, resources, communication of disease occurrence and interpretation, and findings and decision-making processes, need to be evaluated and incorporated into a database to elaborate models for the introduction of ASF in the wild boar population.

POSSIBLE PATHWAYS OF ASF INTRODUCTION

Possible pathways of ASF introduction into China are:

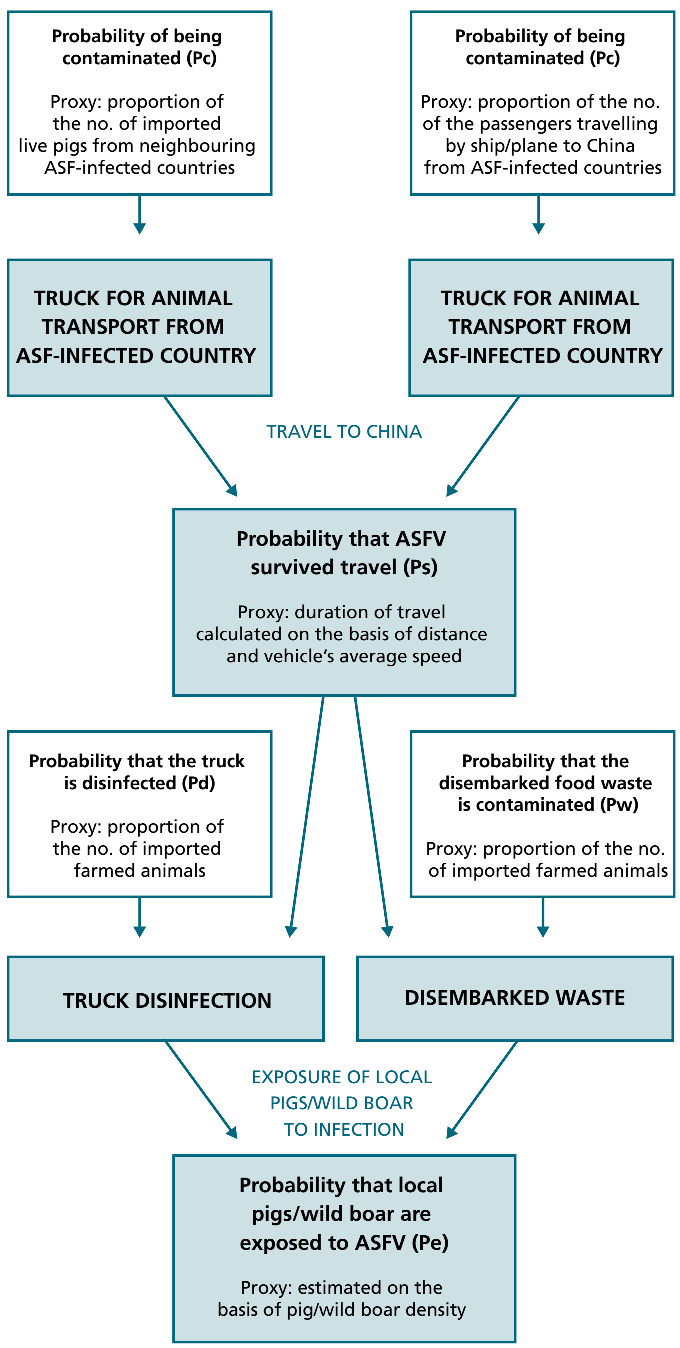
- transport-associated routes (TARs), including trucks, airplanes and ships carrying food contaminated with ASFV;
- legal or illegal introduction of infected animals (pigs or wild boar);
- contaminated foodstuffs and other legally imported goods;
- illegal imports of food products for private consumption or small-scale trade.

As regards TARs, ASFV introduction could occur through i) vehicles (e.g trucks) contaminated on coming into contact with infected animals or premises in neighbouring ASF-infected countries, and not being disinfected before returning to China; and, ii) pork waste and contaminated products, or fomites from international shipping or flights entering China, including for personal consumption (Figure 14).

Each of these TAR issues is characterized by different factors.

Concerning the trucks moving animals or pig-derived products, consideration should be given to a) the number of trucks entering the country from ASF-positive areas; b) the proportion of such shipments being contaminated (could be expressed as proportion of the volume of exported pigs); c) the distance between point of origin and destination as a measure for estimating viral survival during transportation; and, d) truck disinfection procedures. The

FIGURE 14. *ASFV introduction pathways into China through Transport-Associated Routes*



survival of ASFV in various environmental conditions is given in Table 3.

Three main risk pathways can be considered for ASFV introduction through infected animals: a) legal imports of infected pigs; b) illegal introduction; c) cross-border movements of wild boar. Account should also be taken of the tick population/distribution in China and of ticks' potential contribution to the introduction of diseases (Figure 15).

In addition, other potential routes of ASF entry into China are: people travelling in contaminated vehicles and carrying infected food for personal consumption; and food waste from ships/trains/airplanes (Figure 16). Also to be considered is the number of passengers entering the country; the frequency and place of origin of those passengers; and the distance travelled by goods and people from their country of origin, as well as the ASF status there.

TABLE 3 *Resilience of ASFV in various environmental conditions*

Item	ASFV survival time
Meat with and without bone and ground meat	105 days
Salted meat	182 days
Cooked meat (minimum of 30 minutes at 70 °C)	0
Dried meat	300 days
Smoked and deboned meat	**30 days**
Frozen meat	**1 000 days**
Chilled meat	**110 days**
Offal	**105 days**
Skin/Fat (also dried)	**300 days**
Blood stored at 4 °C	**18 months**
Faeces at room temperature	**11 days**
Putrefied blood	**15 weeks**
Contaminated pig pens	**1 month**

Source: Beltran-Alcrudo et al., 2017

FIGURE 15. *ASFV introduction pathways into China through live animals*

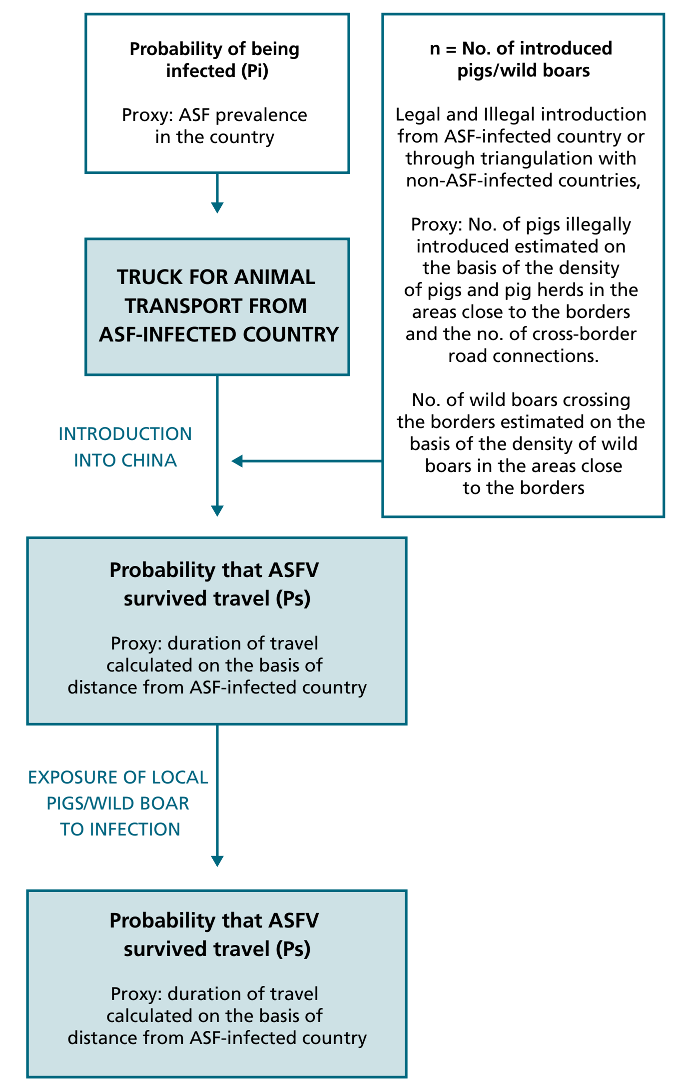
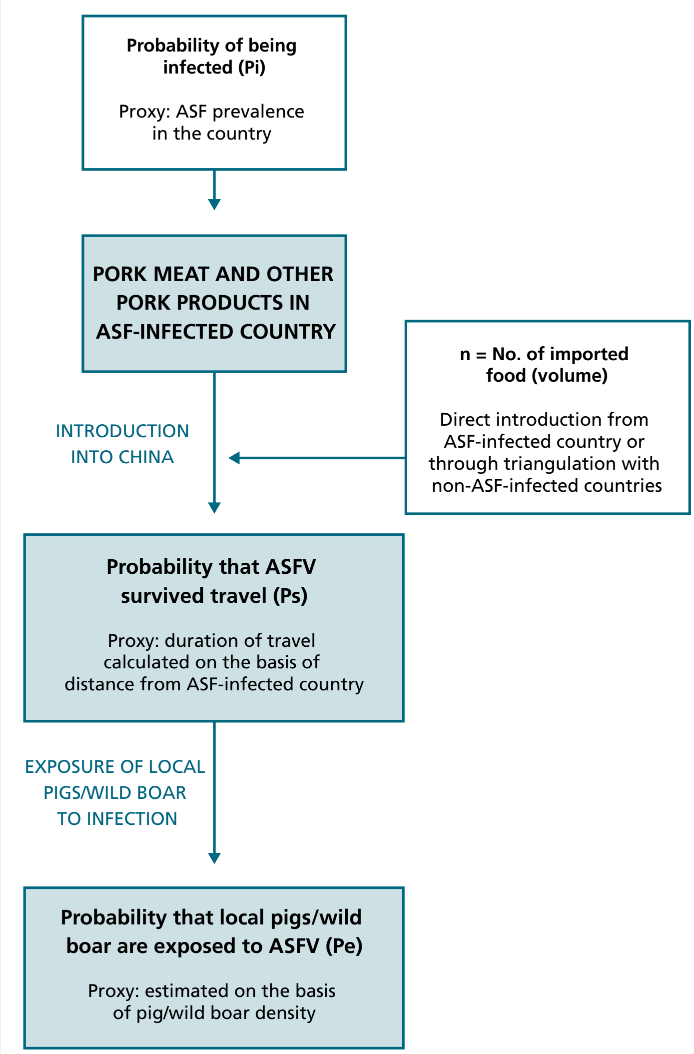


FIGURE 16. *ASFV introduction pathways into China through contaminated foodstuffs*

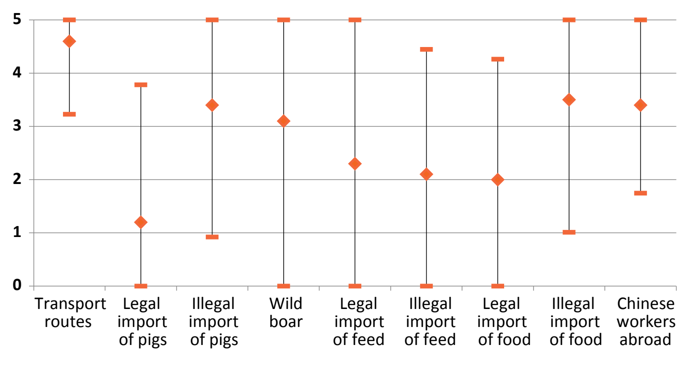


FAO EXTERNAL EXPERT CONSULTATION

The FAO rapid risk-assessment framework and questionnaire was discussed with swine disease experts attending the Second Regional Workshop on Swine Disease Control in Asia (China Workshop, 2017). Under the title "Assessment of the Risk of African swine fever introduction, spread, and presistence in China", information was obtained from five Chinese veterinary and laboratory experts from CAHEC and the China Agricultural University (CAU), as well as one FAO regional veterinary officer (total, six). In addition, the questionnaire was submitted by email to 12 experts in July, 2017. Responses were received from four of the additional 11 experts contacted. The questions, responses, and results of 11 respondents are below (11 responses unless otherwise indicated). This paper reports responses from the following experts:

- Guo Fusheng, FAO, Thailand
- Shengqiang Ge, CAHEC
- Xianodong Wu, CAHEC
- Xiaoxu Fan, CAHEC
- Changchun Tu, Academy of Military Medical Science
- Hanchun Yang, College of Veterinary Medicine, China Agricultural University
- Klaus Depner, Friedrich-Loeffler-Institut, Germany
- Huaji Qiu, Habrin Veterinary Research Institute
- Domenico Rutili, Instituto Zooprofilattico, Teramo, Italy
- Young S. Lyoo, Konkuk University
- Daniel Beltran-Alcrudo, FAO, Hungary

FIGURE 17. *Most likely way of ASF introduction*



Results

1. Introduction of ASF in China

Question 1. What is the most likely way for the disease to be introduced?

Reponses were ranked from the most (5) to the least (0) relevant risk factors for the introduction of ASF into China. Experts widely agreed that the most likely way of ASF introduction into China were transports routes, followed by illegal imports of food and Chinese migrant workers. Legal imports of pigs were considered unlikely to introduce the disease into the country.

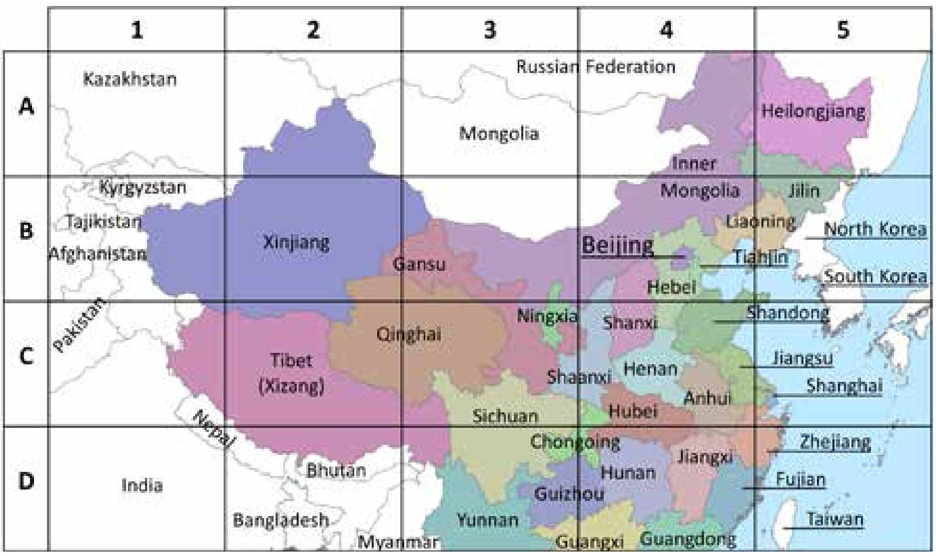
Question 2. What is the Chinese region where the disease is most likely to be introduced?

Respondents were asked to select the quadrats were the disease was considered likely to be introduced. Experts considered that Quadrat A5, representing the northeast of China (largely Heilongjiang Province) represents the most likely region for ASF introduction, followed by A4 (Inner Mongolia). Number of respondents: seven.

Question 3. What are the risks of introduction through Transport-Associated Routes? Please rank from least to most relevant.

Regarding the pathway of ASF introduction into China through TARs, the experts considered that contaminated trucks and cars, and wastes from ships, planes and trains can contribute to the introduction of the disease.

FIGURE 18. *Chinese region where the disease is most likely to be introduced*



Quadrats	No. of times selected
A5	4
A4	3
B4	2
C5	1
D4	1

Source: FAO Global administrative unit layers (GAUL), 2015

Question 4. What are the relevant risk factors for introduction of ASF into China?
Please rank from most to least relevant.
There was agreement that legal imports of pigs represented the least important pathway for the introduction of ASF into China.

Question 5. Which ASF-infected countries (based on notification of the disease in the past two years) receive more farm workers living/ travelling and returning to major Chinese pork-producing areas? Please rank from the most (14) to the least (0) affected. Number of respondents: 6.
The experts considered that Chinese workers abroad are a potential pathway of ASF introduction. Specifically, the experts agreed that workers living/travelling in the Russian Federation, South Africa, Zimbabwe, and Kenya are the most likely to introduce the disease into China.

Spread of ASF in China

Question 6. What is the risk of further spread of ASF once introduced by wild boar into China?
Question 7. What is the potential role of ticks in the spread of ASF in China?
Number of respondents for each question: nine.
Regarding spread of ASF in China, wild boar were considered the most relevant factor.
Most respondents considered ticks as unlikely to be relevant in spreading ASF in China.

Question 8. What is the region in China where the disease is most likely to spread?
Number of respondents: seven.
Experts agreed that the most likely area for ASF spread is the northeast region of China (Heilongjiang) followed by the central eastern region (Henan, Shanxi, Ammui, and Hubbei) and the southeast of the country (Hunan).

Question 9. What production system would be most economically affected in China? Rank from the most to the least relevant.
Respondents considered that the backyard systems are the most likely to be affected if ASF is introduced. Impacts on trade, and interruption of business and markets, are likely to be higher in this category. In backyard systems, the impact of ASF would be on food security and livelihoods.

DISCUSSION AND NEXT STEPS

The aim of this study was to develop a rapid risk assessment of the introduction of, spread to, and persistence of, ASF in China, and of the different factors or drivers facilitating this process. A qualitative risk assessment was proposed to address various

FIGURE 19. *Risk of introduction through TARs*

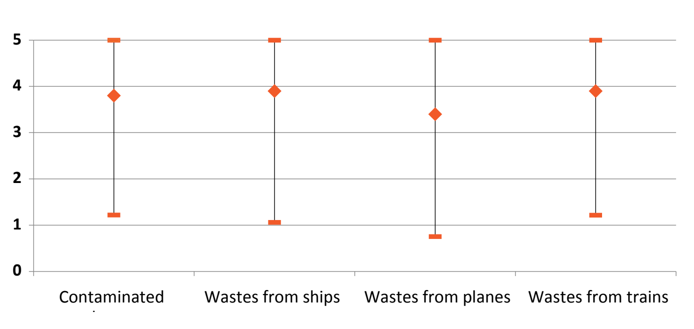


FIGURE 20. *Introduction risk factors*

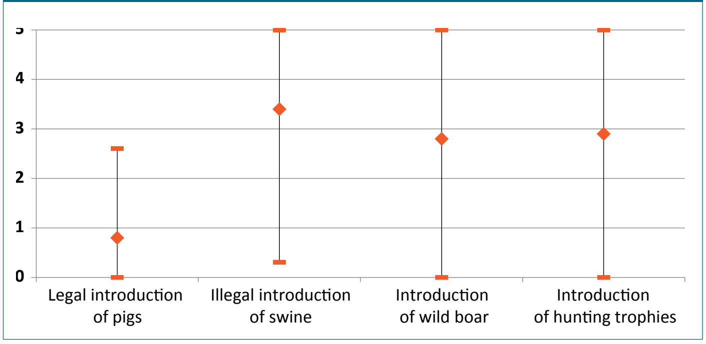


FIGURE 21. *ASF-infected countries as potential sources via Chinese workers*

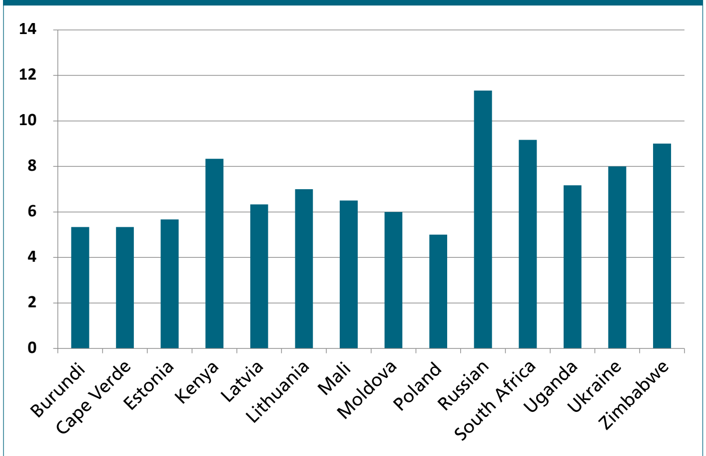


FIGURE 22. *Relevance to ASF spread within China*

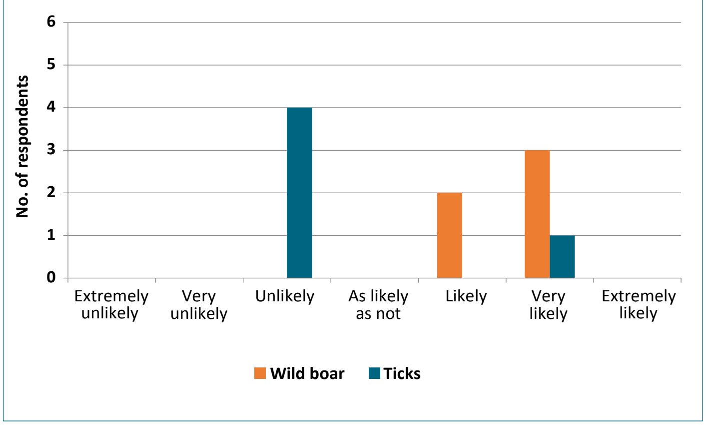
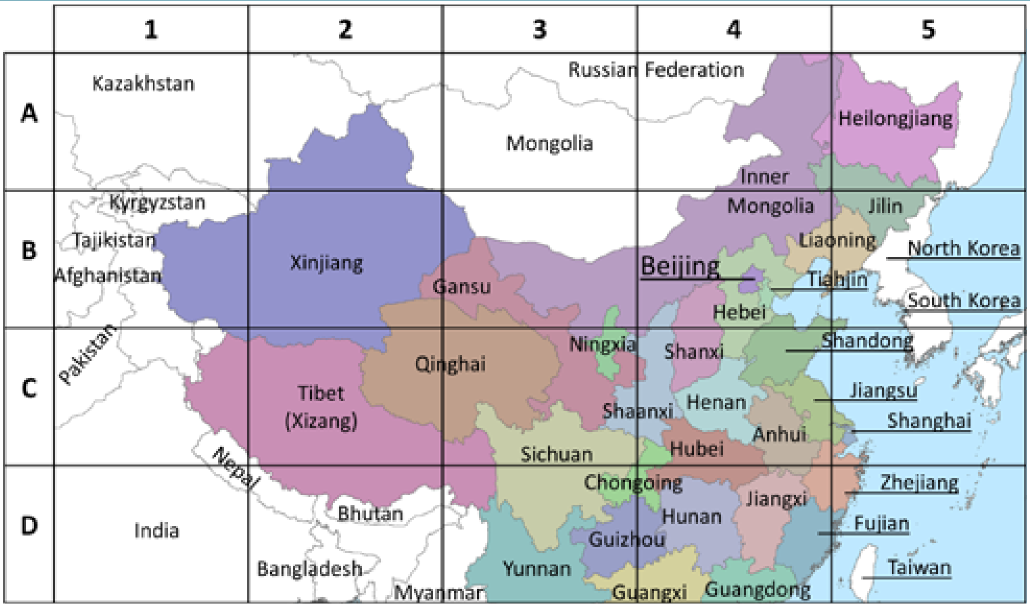


FIGURE 23. *Region of China where the disease is most likely to spread*



Quadrats	No. of times selected
A5	5
C4	3
D4	3
A4	2

Source: FAO Global administrative unit layers (GAUL), 2015

risk questions involving the potential entry of ASFV, the likelihood of domestic pigs being exposed to the virus, and the potential further spread and persistence of the disease.
As described, the introduction of ASFV into China could follow different pathways: (1) transport- associated routes, (2) legal and informal swine imports, and (3) legal and informal imports of swine and swine commodities.

There are many gaps in the data collected for this assessment. For instance, information on the number of trucks entering China from neighbouring countries was not available. However, the number of pigs entering the country and the mode of transport can be used as a proxy. For example, live pig imports in 2015 from Mongolia amounted to 30 000 tonnes, with somewhat less from other countries/regions (e.g. Croatia, Indonesia and Nepal). These values can be used as proxies to estimate the entry of products via maritime routes and subsequent truck transport within China. The distance from the point of origin to destination can also be used as a proxy for virus survival. Return trips that can be made in a day from the point of origin could be associated with possible survival of the virus. The half-life of ASF virus in faeces is a little over half a day when stored at 4 °C and a fifth of a day at 37 °C. In urine, the virus can last two days at 4 °C, and less than half a day at 37 °C (see Table 3). Depending on transport conditions and the viral dose in a cargo, the virus could survive for longer periods at variable temperatures and in different seasons. The half-life of ASFV DNA has been estimated at between eight and nine days in faeces and two to three days in oral fluid at various temperatures. In urine, the half-life of ASFV DNA is 33 days at 4 °C, decreasing to 19 days at 37 °C. This is an important point to consider when shipping products. The survival of the virus can also depend on cleaning and disinfection procedures and the products used for vehicle disinfection.

Estimates based on the experience of local authorities are needed to determine the occurrence and volume of illegal entry of pigs, the types of herds involved, the porosity of borders, and pig/boar population density on both sides of borders. Road access and types of inspection and control measures should also be clarified.

International waste originating from ships has been recognized as an important pathway of ASF introduction (Costard *et al.*, 2009). In order to determine the risk arising from international shipping, the volume of swine-related comodities and number of persons transported by different types of ships could serve as an indicator of the volume of potentially contaminated products arriving in China by ship. At the very least, ships departing from countries that have experienced cases of ASF in the last two years (14 countries reported ASF between 01/04/2015 and 25/04/2017) should be taken into account.

ASF could be introduced into China not only through imports of infected live swine but also from contaminated/infected foodstuff. Imports of pigs and pork commodities fall under the jurisdiction of the General Administration of Quality Supervision for Inspection and Quarantine, which determines the veterinary and health requirements required. Chinese regulations comply with international animal health standards, including OIE and CODEX, for the safe trade of animal and animal products. The likelihood of legally imported pigs being infected with ASF should therefore be very low. Further, the vast majority of imports are from countries that have not reported cases of ASF (Canada, Germany and the United States).

FIGURE 24. *Production system most affected*

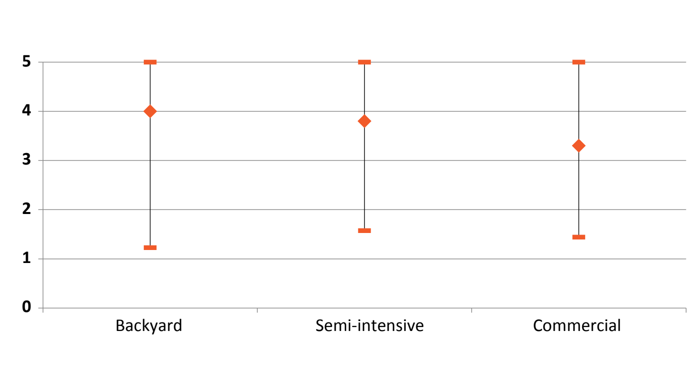
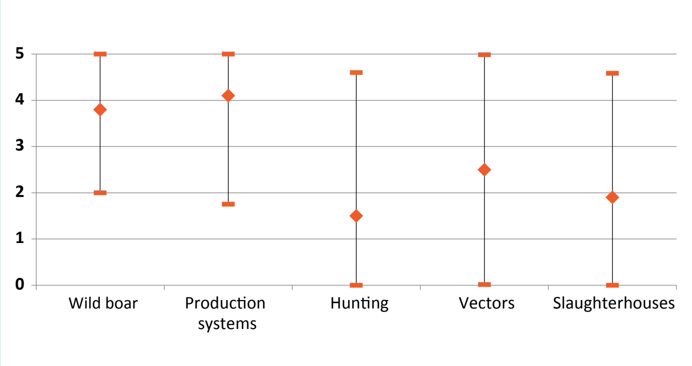


FIGURE 25. *Persistence factors*



The experts involved in this risk assessment concluded as follows:

- TARs are the most relevant pathway of ASF introduction into China, followed by illegal imports of food and by Chinese workers working abroad. Legal imports of pigs were unlikely to introduce the disease into the country.
- Contaminated trucks and cars, and wastes from ships, planes and trains can contribute to the introduction of the disease.
- China's northeastern region (Heilongjiang province) is where ASF is most likely to be introduced, followed by Inner Mongolia.
- Chinese workers abroad are a potential pathway of ASF introduction. Workers living/travelling in the Russian Federation and in African countries that reported ASF between 01/04/2015 and 25/04/2017 are the most likely to introduce the disease into China.
- Legal imports of pigs are the least likely pathway of introduction of ASF into China.
- Wild boar are the most relevant factor in the spread of the disease.
- The most likely regions for ASF spread are the northeast (Heilongjiang), followed by the central eastern area (Henan, Shanxi, Ammui, and Hubbei) and the southeast (Hunan). Surveillance for swine diseases in these regions should be heightened.
- ASF is most likely to persist and become endemic due to the presence of wild boar interacting with susceptible domestic species, and lack of biosecurity in smallholdings. However, due to restrictions on hunting in China, hunters are not likely to affect the persistence of the disease.

After this preliminary assessment, FAO will refine its findings with a follow-up qualitative risk assessment of specific ASF pathways and the development of a spatial, multi-criteria decision analysis (MCDA) to predict suitability for the introduction of ASF into the pig and wild boar population of China. This approach will also provide estimates of the distribution of suitability for ASF transmission between domestic pigs and wild boar in Asia.

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NOTES

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RISK ANALYSIS IN ANIMAL HEALTH

Risk analysis is a procedure, which we all do intuitively in our everyday life as we also do in our professional work to assess the risk of any hazard or threat. In animal health, risk analysis has been most widely used as a decision tool about the most appropriate health interventions to support disease control strategies, guide disease surveillance and support of disease control or eradication strategies.

It should be remembered that risk is not equal to zero and never stays static. Risks changes as drivers or factors of disease emergence, spread or persistence change such as intensification of livestock production, climate change, civil unrest and changes in international trading patterns. Risk analysis should therefore not be seen as a "one off" activity and it should be seen as a good practice of animal health systems to conduct their regular activities. Therefore, risk analysis process should be repeated and updated regularly.

Risk analysis comprises the following components:

H **Hazard identification:** the main threats are identified and described.

A **Risk Assessment:** risks of an event occurring and developing in particular ways are first identified and described. The likelihood of those risks occurring is then estimated. The potential consequences or impact of the risks if they occur are also evaluated and are used to complete the assessment of the risk.

M **Risk Management:** involves identifying and implementing measures to reduce identified risks and their consequences. Risk never can be completely eliminated but can be effectively mitigated. The aim is to adopt procedures that will reduce the level of risk to what is deemed to be an acceptable level.

C **Risk Communication:** an integrated processes that involves and informs all stakeholders within the risk analysis process and allows for interactive exchange of information and opinions concerning risk. It assists in the development of a transparent and credible decision-making processes and can instil confidence in risk management decisions.

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