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Qualitative risk assessment for African swine fever virus introduction

Caribbean, South, Central and North Americas

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Executive summary

In Latin America, pork meat has become an increasingly important part of diets during the last few decades. Nowadays, the Americas produce roughly a quarter of global pork and other pig products. Various production systems co-exist, from smallholder low-input low-output systems to industrialized export-oriented pork industries. On 29 July 2021, the Dominican Republic reported the confirmation of an ASF outbreak in domestic pigs, and on 19 September 2021, Haiti followed (OIE, 2021a).

A qualitative risk assessment was conducted to assess the likelihood of African swine fever virus (ASFV) entry from the Dominican Republic and Haiti to unaffected countries and territories of the Americas and the likelihood of exposure of susceptible animal populations should the disease be introduced. The risk assessment used information available up to 5 November 2021 collected from various official sources including questionnaire answers from 35 out of 53 countries and territories in the Americas and considered the time period of December–February. Six key risk pathways were addressed, including formal and informal importations of live pigs, pork products and by-products, pig genetic material (semen, embryos and ova), food waste, fomites and feed of animal origin. Five levels of likelihood and three levels of uncertainty were used to assess each pathway. According to the risk assessment, the main pathways for ASFV introduction from affected to unaffected countries in the Americas are: (1) through informal importation of pork products and by-products including through trade and travellers (e.g. migration, tourism, foreign workers); (2) through food waste; and (3) through fomites.

For the likelihood of ASFV entry through informal importation of pork products and by-products:

- Aruba, Bonaire, Colombia, Cuba, Curaçao, Jamaica, Mexico, Panama, Puerto Rico, the Turks and Caicos Islands, the United States of America, and the Bolivarian Republic of Venezuela were associated with a **moderate likelihood of entry**, with **high uncertainty.** This is due – for each country/territory – to a combination of several of the following factors: low to moderate flow of tourists and/or migrants from ASF affected countries, reports of informal importation of pork products by sea or air from the Dominican Republic, geographic proximity to African swine fever (ASF) affected countries by boat or with short direct flights, acting as transit country/territory for migrants, and/or being a significant Dominican diaspora.
- Argentina, Belize, the Plurinational State of Bolivia, Brazil, Chile, Costa Rica, Dominica, Ecuador, El Salvador, French Guyana, Guadeloupe, Guatemala, Guyana, Honduras, Martinique, Nicaragua, Paraguay, Peru, Saint Lucia, Suriname, Trinidad and Tobago and Uruguay were associated with a **low to moderate likelihood of entry,** with **high uncertainty**. This is due – for each country/territory – to a combination of several of the following factors: likely informal importation of pork products despite appropriate inspection rates at ports of entry, geographic proximity to ASF affected countries by sea or short direct flights, low to moderate flow of tourists or migrants from and to ASF affected countries.

- Other countries or territories in the Americas were associated with a **very low to low likelihood of entry**, with **high uncertainty,** owing to very low to low flows of tourists or migrants from ASF affected countries, and/or highly controlled ports of entry.

For the likelihood of ASFV entry through food waste:

- Aruba, Bonaire, Colombia, Cuba, Curaçao, Jamaica, Mexico, Panama, Puerto Rico, the Turks and Caicos Islands, and the Bolivarian Republic of Venezuela were associated with a **moderate likelihood of entry**, with **high uncertainty**.
- Argentina, Belize, the Plurinational State of Bolivia, Brazil, Chile, Costa Rica, Dominica, Ecuador, El Salvador, French Guyana, Guadeloupe, Guatemala, Guyana, Honduras, Martinique, Nicaragua, Paraguay, Peru, Saint Lucia, Suriname, Trinidad and Tobago, the United States of America and Uruguay were associated with a **low likelihood of entry** with **high uncertainty**.
- Other countries or territories in the Americas were associated with a **very low likelihood of entry**, with **high uncertainty**.

For the likelihood of ASFV entry through fomites:

- Argentina, Aruba, the Plurinational State of Bolivia, Bonaire, Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Ecuador, El Salvador, Guadeloupe, Guatemala, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Turks and Caicos Islands, Uruguay, the United States of America and the Bolivarian Republic of Venezuela were associated with a **moderate likelihood of entry**, with **high uncertainty**.
- Belize, French Guyana, Guyana, Saint Lucia, Suriname, and Trinidad and Tobago were associated with a **low likelihood of entry**, with **high uncertainty**.
- Other countries or territories in the Americas were associated with a **very low likelihood of entry**, with **high uncertainty**.

The likelihood of ASFV entry in the Americas through informal live pig trade was considered **low to moderate for Cuba, Jamaica, and Puerto Rico**, and **negligible to very low for other countries/territories** in the region with an overall **high uncertainty** due to the lack of data regarding informal importations and movements of live pigs in the region.

The likelihood of ASFV entry from affected to unaffected countries/territories in the Americas through live pig trade (formal), pork products trade (formal), pig genetic material importation, and animal-origin feed importation, was assessed as negligible to low. Further details on specific likelihood and uncertainty levels for each pathway and country are provided in the document.

Finally, the likelihood of exposure, i.e. having susceptible hosts exposed to ASFV once the virus entered an unaffected country/territory through one of the pathways previously assessed (particularly pork products, fomites and food waste), is considered: **high with high uncertainty** for countries and territories that demonstrate several of the following risk factors:

- presence of pigs (domestic, feral or wild);
- high proportion (above 50 percent) of domestic pigs kept in low biosecurity holdings (e.g. backyard and smallholder farms);
- low biosecurity practices predominant in the pig sector, particularly linked to the number of backyard holdings and smallholder farms;
- swill feeding as a common practice;

- poor preparedness for ASF prevention and control, including lack of laboratory capacities to test for ASFV; and
- significant presence of poor waste management systems.

The lack of data resulted in high levels of uncertainty for most of the risk pathways, except for those involving formal trade of commodities framed by national and international regulations, under higher biosecurity and strict inspections and controls.

For socio-economic aspects, the impact of pig mortality on pork production, as well as implications for food security, trade, and the labour market were analysed. A scenario was built for disease spread based on the Asian experience, given the similarities in pig production systems in both regions. This scenario was used to monetize the losses due to the reduction of pork production and assess the potential impact of trade bans. FAOSTAT's food balances and the Global Food Security Index (GFSI) were used to identify countries that rely on pork as an important source of protein and that suffer from food insecurity.

Background

THE DISEASE

ASF is one of the most critical viral diseases of pigs, with its high mortality rate and associated trade restrictions causing substantial economic losses to farmers. ASFV is highly resistant and stable in the environment and pork products. There is no effective vaccine or treatment. Therefore, ASF prevention and control, relying on good biosecurity practices, are the only line of defence, posing a challenge in many countries where pig producers struggle to apply appropriate levels of biosecurity.

VIRUS

ASFV is an enveloped, cytoplasmic, double-stranded DNA arbovirus, which is the sole member of the family *Asfarviridae*, divided into 24 known genotypes with numerous subgroups (Gaudreault *et al.*, 2020). ASFV is very resistant in the environment and can survive for long periods of time in some matrices such as carcasses (Beltrán-Alcrudo *et al.*, 2017) (Table 1). The virus can be isolated from sera or blood kept at room temperature for 18 months. In meat products, ASFV may persist for several weeks or months in frozen, uncooked or lightly processed meat (Wilkinson, 1989; EFSA, 2010a).

TABLE 1
Resilience of ASFV across a variety of environmental conditions

Item	ASFV survival time
Meat with and without bone and ground meat	105 days
Salt-cured meats (most sausages, bacon)	182 days
Cooked* pork meat (minimum of 30 minutes at 70ºC) e.g. cooked ham	0 days
Dry-cured meats (salami, prosciutto)	300 days
Smoked and deboned meat	30 days
Frozen meat	1 000 days
Chilled meat	110 days
Offal	105 days
Skin/fat (even dried)	300 days
Blood stored at 4ºC	18 months
Faeces at room temperature	11 days
Putrefied blood	15 weeks
Contaminated pig pens	1 month
Meat with and without bone and ground meat	105 days
Soil (varies by soil type)	3 weeks
Water	At least 60 days at 4ºC
Carcass (organ, bone marrow of wild boar)	3 months at 4ºC
Carcass (skin)	6 months at 4ºC

* In this document, the term 'cooked' refers to heat treatment for a minimum of 30 minutes at 70ºC or equivalent in terms of inactivation of ASFV present in the product.

Source: Beltrán-Alcrudo *et al.*, 2017; Carlson *et al.*, 2020; EFSA, 2010a; Fischer *et al.*, 2020; Mazur-Panasiuk *et al.*, 2019.

BOX 1
Effective disinfectants

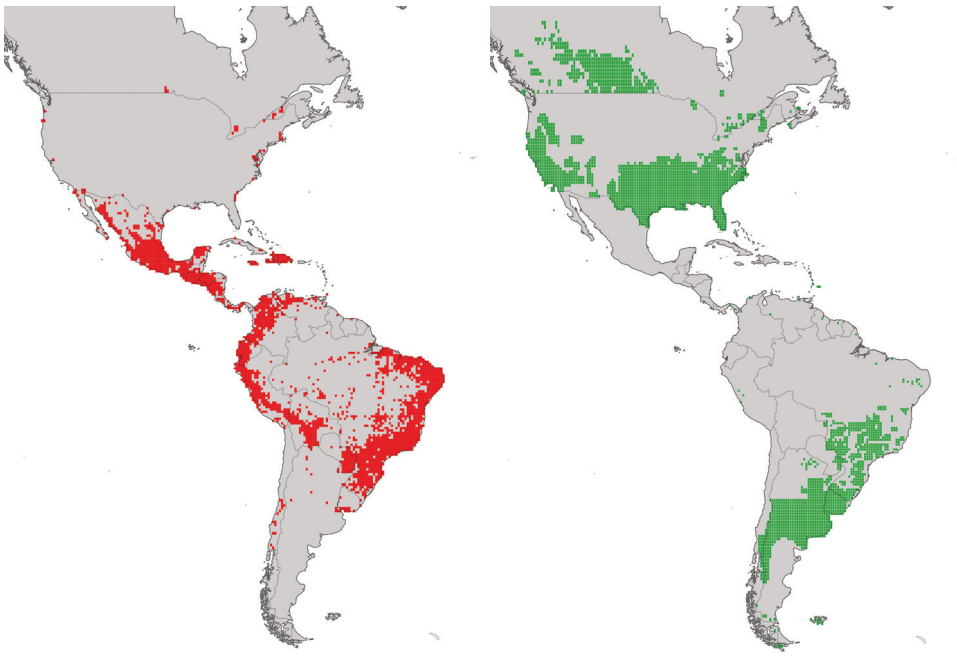
Disinfectant
The ASFV is susceptible to ether and chloroform. Inactivated by 8/1,000 sodium hydroxide (30 minutes), hypochlorites – between 0.03 percent and 0.5 percent chlorine (30 minutes), 3/1,000 formalin (30 minutes), 3 percent ortho-phenylphenol (30 minutes) and iodine compounds. Note: disinfectant activity may vary depending on the pH value, time of storage and organic content (OIE, 2019); Sodium chloride + Potassium peroxymonosulfate, Sodium dichloro-s-triazinetrione (EPA, 2018).

SUSCEPTIBLE SPECIES AND TRANSMISSION OF THE VIRUS

All members of the pig family (*Suidae*) are susceptible to ASFV infection, but clinical disease is only seen in domestic and feral pigs (*Sus scrofa domesticus*), as well as in their ancestor wild boar (*Sus scrofa*). Wild boar are native to Eurasia and North Africa and have been introduced to the Americas and Oceania. Transmission of ASFV to a pig or a wild boar occurs through: 1) direct contact with an infected animal; 2) ingestion of materials containing ASFV; 3) contact with ASFV contaminated environments or items (fomites and iatrogenic transmission); or 4) through a vector capable of transmitting ASFV – soft ticks of the genus *Ornithodoros* (see subchapter on vectors) if such vector species are present. ASFV can be transmitted through pork and pork products (raw/frozen dried/under-cooked) in which the virus can survive for a long time (Table 1). Pigs as well as wild boar are omnivorous. These animals can be infected when: i) pigs are fed kitchen waste containing uncooked pork products from an infected pig; ii) a feral pig scavenges dumped waste containing ASFV contaminated material; or iii) a wild boar gets into contact with the carcass or deathbed (virus contaminated place of death) of another wild boar that died of ASF. Two types of epidemiological cycles are therefore possible in the Americas: "domestic" involving low biosecurity production systems and swill feeding (Figure 1, left) and "wild boar-habitat" involving feral pigs or wild boar and their contaminated carcasses as it happens in Europe (Figure 1, right).

A suitable agro-ecological niche of ASFV in the Americas includes areas occupied by invasive populations of wild boar and/or feral pigs in Canada and the United States of America that are massively expanding their ranges and growing exponentially. Further south, low biosecurity pig production systems (including backyard and semi-intensive sector (based on Gilbert *et al.*, 2018) are distributed continuously in Mesoamerica and Southern America (Figure 1, left). In Brazil and Argentina, both wild boar and feral pigs are also widespread and likely to sustain the transmission cycle of ASFV even without involvement of domestic pigs. Both in the Northern and Southern Americas management of ASFV in wild boar or feral pigs might be even more challenging than currently experienced in Europe.

FIGURE 1
Generalized distribution of low biosecurity pig production.

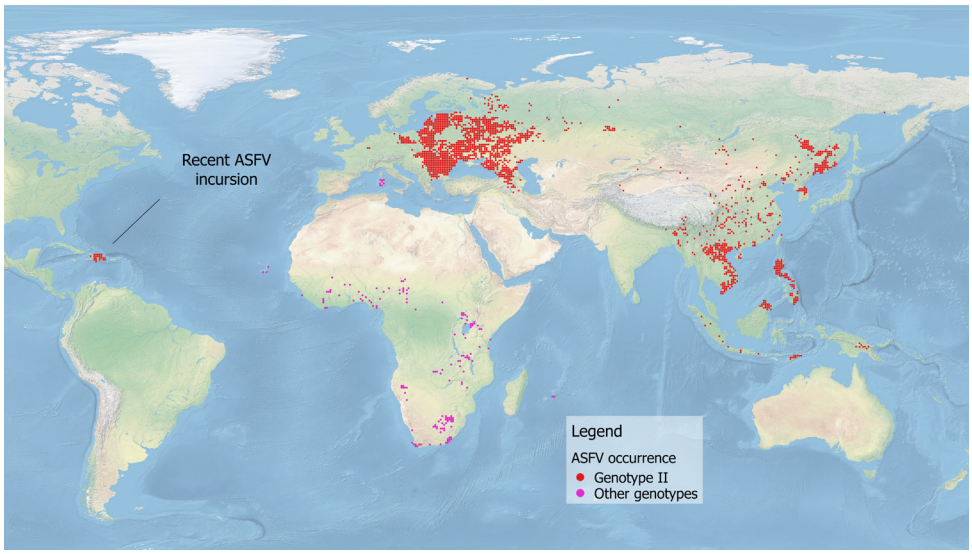


Source: Based on Gilbert *et al.*, 2018; USDA/APIS, 2019; Aschim and Brook, 2019; Salvador and Fernandez, 2017.
Note: (left, over 1 pig per km^2 combined in backyard and semi-extensive sectors), European wild boar and/or feral pigs (right) in the Americas generalized to a 30 arcminute grid.

VECTOR

In Africa, soft-bodied, eyeless *Ornithodoros* ticks play an important role as vectors and natural reservoirs of ASFV, e.g. *O. moubata complex* in sub-saharan Africa. In the 1990s, *O. erraticus* was identified as a natural reservoir in Portugal. Experimentally, some *Ornithodoros* ticks present in the Caribbean islands (*O. puertoricensis*) and in the United States of America (*O. coriaceus or O. turicata*) are found to be capable of replicating ASFV, with trans-ovarial and/or trans-stadial transmission capacity, although the level of their contribution to infection cycles is unknown (Heath, Dixon and Sanchez-Vizcaino, 2020). The establishment of the virus in the tick populations would further hinder control and eradication efforts. On top of biological vectors, certain blood-sucking insects, namely *Stomoxys calcitrans*, have been shown to be able to retain and transmit ASFV for at least 24 hours after feeding on a sick pig (Mellor *et al.*, 1987), which could be particularly relevant for transmission within herds. However, more research is needed to investigate this.

FIGURE 2
Generalized occurrence of ASF in 2007–2021 (as of November 24 2021) in the world represented as centroids of 30 arcminute grid.



Source: FAO, 2021d.
Note: In each of the grid cells there was at least one detection of ASF during the reference period. Distribution of ASF Genotype II is shown in red.

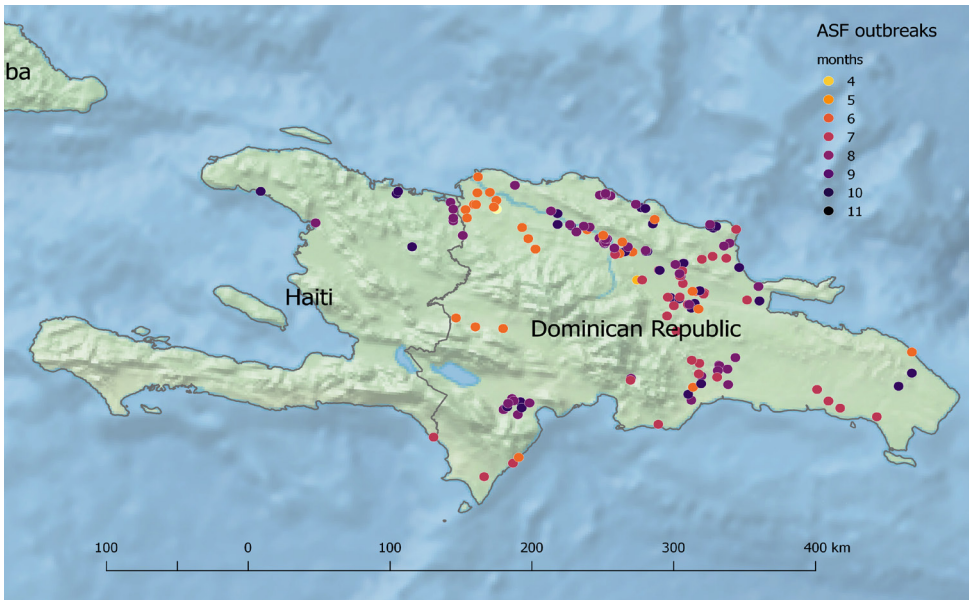
CLINICAL PRESENTATIONS

Wild boar show the same clinical presentation as domestic pigs. The disease is generally characterized by fever, lethargy, loss of appetite and sudden death. All ages and both sexes may be affected. Depending on the virulence of the virus, the clinical forms range from peracute (very acute with sudden death) to asymptomatic (unapparent). The haemorrhagic presentations are seen in its acute and subacute forms. The incubation period in natural infections has been reported to vary from four to 19 days. The acute forms are easily confused with other diseases, especially classical swine fever (Beltrán-Alcrudo *et al.*, 2017). Estonia (Zani *et al.*, 2018), Lithuania (Gallardo *et al.*, 2018), Latvia (Gallardo *et al.*, 2019), and China (Sun *et al.*, 2020) detected ASFV with low virulence.

DISTRIBUTION

After discovery in Kenya in 1909 (Montgomery, 1921), ASFV was limited to sub-Saharan Africa until 1957 when it was detected in Portugal. The infection spread to other countries in Europe and remained endemic for 30 years (Alonso *et al.*, 2018); and from there it spread to Caribbean countries (Cuba in 1971, Dominican Republic and Haiti in 1978) and Brazil in 1978. Most regions and countries in Europe and the Americas eliminated ASFV by the mid-1990s through a stamping out policy (except for Sardinia in Italy) (Danzetta *et al.*, 2020).

FIGURE 3
Outbreaks of ASF in the Dominican Republic and Haiti in 2021 (as of December 1 2021).



Source: FAO, 2021a.

In 2007, ASFV genotype II appeared in Georgia and progressively spread among domestic and wild boar through the Caucasus, multiple European countries and the Russian Federation. In 2018, the infection was confirmed in China and subsequently spread to many countries in Asia and the Pacific. Contaminated food waste from airports/seaports was suspected as the route of introduction in both Portugal (1950s) and Georgia (2000s). The current ASF epidemic has affected many of the major pig production areas in Eurasia over the last 14 years (Figure 2) and the virus has established itself endemically in wild boar populations. In 2021, after nearly 40 years of absence, the disease was also confirmed in 2021 in the Dominican Republic and Haiti in the Caribbean region (Figure 3) (OIE, 2021a).

DISRUPTION

Following the introduction of ASFV, the domestic pig population in an affected country or zone may significantly decrease, either due to the disease itself or as a result of depopulation of pigs as a part of control measures. As breeding stock is often lost, a country may have difficulty repopulating pigs. Even after repopulation, ASF may reoccur multiple times in farms and/or households with low biosecurity or in areas with scavenging pig populations. COVID-19 restrictions may delay ASF reporting, disease detection, confirmatory diagnosis and the implementation of response activities.

Movement control, or other restrictions implemented to stop the disease may cause severe disruptions throughout the value chain. Subsequent trade bans imposed on affected countries place additional economic strains on the swine/pork industry.

An overview of the pig sector in the Americas

The swine sector constitutes a significant part of the livestock market in the Americas. Besides Asia – and particularly China, the leading pork producer worldwide - the Americas are home to countries that are major global producers of pigs and pork products, namely the United States of America, Canada, Brazil, Argentina, Chile and Mexico, among others. Canada is the largest exporter of live pigs in the Americas, while the United States of America accounts for the largest exports in terms of pork products followed by Canada, Brazil, and to a lesser extent Mexico and Chile.

In the Caribbean region, the pig sector is relatively important and five countries/territories account for most of the live pig stock as well as production of pork products, namely Cuba, the Dominican Republic, Haiti, Jamaica and Puerto Rico (Table 2). The majority of countries and territories in the Caribbean region are net importers of pork products. They rely on imports, mainly from other countries in the Americas and Europe, as the ASF epidemic that started in East and Southeast Asia in 2018 led to multiple restrictions with regards to pork product imports from this region to the Americas. Live pig and pork product movements or flows have strong implications on the risk of introduction and spread of transboundary animal diseases, including ASF, being important drivers for disease spread between and within countries.

Informal trade

As per the questionnaire replies received from 35 out of 53 targeted countries/territories, informal importation of live pigs and pork products does exist within the Caribbean region, and between the Caribbean region and beyond, particularly with South America.

Informal importation of live pigs and pork products may take a variety of forms, including international mail/package, air passenger baggage, border crossing (e.g. by foot, truck),

TABLE 2
Total domestic pig population and volume of pork meat production in 2019 in the top five countries/territories in the Caribbean region

Country/territory	Stocks (in heads)	Pork meat production (in tons)
Cuba	2 369 459	234 864
Haiti*	1 016 836	32 016
Dominican Republic*	491 746	79 943
Jamaica	216 135	8 355
Puerto Rico	45 102	8 284

* The more recent data received on domestic pig inventories from the government during the FAO Emergency Management Center for Animal Health (EMC-AH) ASF emergency response mission to the Dominican Republic (2–18 August 2021) and Haiti (19 August–2 September 2021). The total domestic pig population in the Dominican Republic is estimated at 1.4–2 million heads and in Haiti around 700 000 to 1 million heads.

Source: FAOSTAT, 2021.

undeclared cargo imports, and fishing boats, which present a challenge for the customs and border protection authorities to intercept and catalogue. Because of the nature of these importations, limited data is available, although certain data sources, such as pork product confiscations at port of entry of countries/territories, may provide insights on their frequency and volumes. The smuggling of pork products appears to occur more frequently compared to live pigs due to the higher number of possible ways and the convenience to informally import such products. Table 3 describes the different countries or territories that provided responses to the questionnaire and indicated the presence of informal trade (live pigs or pork products) and the country or territory with which the trade occurs.

TABLE 3
Countries and territories that reported the presence of informal importation of live pigs and/or pork meat products

Countries/territories	The informal importation from
Aruba*	Curaçao, Venezuela (Bolivarian Republic of), Colombia, Dominican Republic, Suriname, Haiti
Barbados	N/A
Bonaire	Dominican Republic
Brazil	Argentina, Bolivia (Plurinational State of), Paraguay, Uruguay, Peru
Cayman Islands	N/A
Colombia	Bordering countries
Costa Rica	Nicaragua, Panama
Curaçao*	Dominican Republic, Bonaire
Dominica	Guadeloupe, Marie Galante, Martinique
Ecuador	Colombia, Peru
El Salvador	Guatemala
French Guyana	Suriname, Brazil
Jamaica	Europe, North America
México	Guatemala, Belize
Nicaragua	Honduras, Costa Rica
Panamá	N/A
Peru	Ecuador, Brazil, Colombia, Bolivia (Plurinational State of), Chile
Puerto Rico*	Dominican Republic
Saint Lucia	French territories
Trinidad and Tobago	N/A
Turks and Caicos Islands*	Dominican Republic, Haiti
United States of America	N/A
Uruguay	Neighbouring countries sharing border
Venezuela (Bolivarian Republic of)	Colombia, the United States of America

* Countries or territories that reported informal trade imports of live pigs and/or pork products from either Haiti or the Dominican Republic.

Qualitative risk assessment addressing ASFV introduction into countries and territories of the Americas

RISK PATHWAYS

Based on the epidemiology of ASFV, previous risk assessments conducted by various institutions or committees (DEFRA, 2018; GF-TADs, 2019; USDA APHIS CEAH, 2021) and local knowledge, the key risk pathways considered for ASFV introduction into countries and territories of the Americas are:

1. Importation of live pigs through formal/informal trade;
2. Importation of domestic/wild pork products and by-products:
   a. Through formal/informal trade; and
   b. Through travellers (tourists, foreign workers and illegal migrants) by land, sea or air.
3. Fomites;
4. Food waste;
5. Pig semen importation; and
6. Feed of animal-origin importation.

RISK QUESTIONS

Six risk questions on the likelihood of entry were formulated and addressed based on the key pathways highlighted for ASFV introduction (questions one to six, below) as well as one additional risk question on the likelihood of exposure. The risk questions cover the period from December 2021 to February 2022.

Risk questions on the likelihood of entry:

What is the likelihood of ASFV being introduced from ASF-affected countries to non-affected countries/territories in the Americas,

1. a. through formal trade of live pigs?
1. b. through informal trade of live pigs?
2. a. through formal importation of pork products/by-products?
2. b. through informal importation of pork products/by-products?
3. through formal or informal importation of pig genetic materials (semen, embryos, and ova)?
4. via contaminated food waste?
5. via contaminated fomites?
6. via feed imports of animal origin?

TABLE 4
Levels of likelihood used for the qualitative risk assessment and their respective definitions

Likelihood estimate	Definition
High	The event is highly likely to occur
Moderate	The event is potentially occurring
Low	The event is unlikely to occur
Very Low	The event is very unlikely to occur
Negligible	The event is extremely unlikely to occur/almost never occurring

TABLE 5
Levels of uncertainty used for the qualitative risk assessment and their respective definitions

Level of uncertainty	Definition
High uncertainty	Lack of data, limited data, or lack of conclusive data; weak correlation or crude speculation
Medium uncertainty	Small sample data set(s), fair correlation/good fit; reliable method
Low uncertainty	Large sample data set(s); known fact, event known to occur, or exact measure

Risk question on the likelihood of exposure:
Given that ASFV has been introduced to a previously unaffected country or territory in the Americas, how likely is it that susceptible host species will be exposed to ASFV?

METHODOLOGY

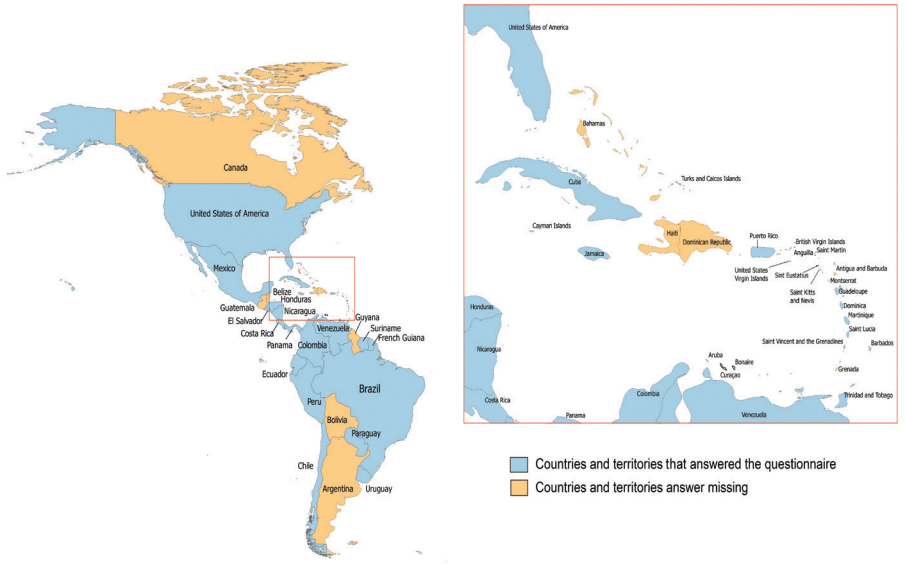
A qualitative risk assessment was conducted to assess the likelihood of introduction of ASFV into countries/territories of the Americas that at the time of writing were free of ASF. The assessment did not cover countries already affected by ASF in the region, namely Haiti and the Dominican Republic. The risk assessment covers the period from December 2021 to February 2022 and might be updated further as new information arises. The risk assessment considers information available up to 5 November 2021 and was based on the major risk pathways outlined previously.

Five levels were used to qualitatively determine the likelihood of introduction (Table 4).

In addition, the assessment considered three levels of uncertainty when interpreting the available data based on data quality and quantity. Definitions used for uncertainty levels were as follows (Table 5):

A questionnaire addressing ASF risk factors was distributed in early September 2021 to animal health services in 35 recipient countries and 18 territories in the Americas. The questionnaire was made available in English, French, Portuguese and Spanish and included questions on domestic/wild pig inventory, formal and informal trade volumes, and trade routes for live pigs and their products, vector presence, traveller flows, ports of entry inspections, emergency response plans, veterinary services and laboratory capacity, animal control and quarantine at borders, pig production systems and biosecurity practices.

FIGURE 4
Countries and territories of the Americas targeted by the questionnaire.



In light blue, countries and territories for which responses were received;
in orange, countries, and territories for which no responses were received.

Note: Countries and territories with missing responses included Anguilla, Antigua and Barbuda, Argentina, Bahamas, Belize, Bolivia (Plurinational State of), Canada, Dominican Republic, Grenada, Guatemala, Guyana, Haiti, Montserrat, Saba, Saint Barthelemy, Saint Kitts and Nevis, Sint Maarten, and the United States Virgin Islands.

The **35 countries** targeted included: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, the Plurinational State of Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, the United States of America and the Bolivarian Republic of Venezuela.

The **18 territories** targeted included: Anguilla, Aruba, Bonaire, British Virgin Islands, Cayman Islands, Curaçao, French Guyana, Guadeloupe, Martinique, Montserrat, Puerto Rico, Saba, Saint Barthelemy, Saint Martin, Sint Eustatius, Sint Maarten, the Turks and Caicos Islands, and the United States Virgin Islands.

Out of the 53 recipients, 35 responses to the questionnaire were received and compiled for analysis in a spreadsheet database (see Figure 4).

In order to supplement the questionnaire data, additional information on countries and territories, and risk factors for ASF introduction was retrieved from various secondary sources, including the databases and reports of United Nations organizations (FAOSTAT, United Nations Statistics Division, UNWTO, UNHCR, OIRSA, IOM), national government reports, scientific publications, and other official websites that allowed for compilation of a more comprehensive data set.

Annex 4 compiles the risk assessment outcomes for each country/territory and key risk pathways addressed.

ASSESSMENT

This section considers evidence of hazard identification and drivers described in the background section as well as additional data from questionnaires and literature searches.

LIKELIHOOD OF ENTRY

Risk question 1. What is the likelihood of ASFV entering non-affected countries/territories from affected countries in the Americas through:

a. formal trade of live pigs?

Considering:

- All countries/territories of the Americas import live pigs from ASF-free countries including but not limited to: Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Denmark, France, Portugal, Spain and the United States of America.
- No country/territory in the Americas officially imports live pigs from Haiti or from the Dominican Republic.
- Importing countries and territories in the Americas generally quarantine live pigs upon arrival with a quarantine procedure longer or equal to seven days and/or a test for ASFV by laboratory means.
- All countries and territories in the Americas importing live pigs require farms of exporting partner countries to be ASFV-free with a required pre-approval certification before importation.
- Regulatory officials in countries/territories of the Americas are aware of ASF and strict regulatory frameworks are in place at borders, including inspection of live pigs and pork products at ports of entry, banning imports of live pigs and pork products and/or strictly regulating movements for countries affected by the disease. Most national borders of countries and territories in the Americas importing live pigs include qualified customs and animal health officials such as veterinarians.

Considering the evidence above, the likelihood of ASFV entering non-affected countries/territories from ASF-affected countries in the Americas through formal importation of live pigs is considered **negligible to very low** with **low uncertainty**.

b. informal trade of live pig?

Considering:

- Evidence presented under 1a.
- Informal trade of live pigs in the Americas is not well documented. Information available does not suggest significant volumes of informal trade among countries/territories, particularly in the Caribbean region. However, smuggling live pigs via private or commercial boats remains a possibility for disease introduction from affected countries to non-affected countries/territories, especially between islands of the Caribbean region. In this regard, French Guyana reported evidence of live pigs and pork products crossing river borders by boat from Suriname and Brazil (Préfet de la Région Guyane, 2021). The countries/territories in closest proximity by boat to Haiti

and the Dominican Republic, such as Cuba, Jamaica, and Puerto Rico, possess major pig stocks in the Caribbean region (see Table 2).

Based on the evidence above, the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through informal importation of live pigs is:

Low to moderate for Cuba, Jamaica, and Puerto Rico, and **negligible to very low for other countries/territories** in the region with an overall **high uncertainty** due to the lack of data regarding informal importations and movements of live pigs in the region.

Risk question 2. What is the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through:

a. formal importation of pork products/by-products?

Considering:

- ASFV can have long survival times depending on the food processing procedures involved for a given pork product (see Table 1 in epidemiology section). This has implications for the possible introduction and spread of the virus across the Americas through importation of infected pork products.
- None of the responding countries and territories reported formal imports of pork products in the last three years from either Haiti or the Dominican Republic, except for Sint Eustatius reporting imports from the Dominican Republic (although no exact volumes were reported). Nonetheless, Sint Eustatius is a small island with an approximate population of 3 100 inhabitants and a small pig population. Sint Eustatius imported less than five live pigs in the last three years, from Saint Kitts and Nevis, suggesting the volume of pork products imported via official trade is also low.
- The Dominican Republic officially exported pork products in the last three years. However, only records from 2018, and to a lesser extent from 2019, were available. In 2018, all pork products and pork by-products combined, the main importers from the Dominican Republic were Haiti, French Overseas Departments, and Cuba, accounting for 98 percent of that country's total reported exports (Table 6).
- No official exports of pork products from Haiti were recorded since 2017.
- The United States of America banned pork product imports from the Dominican Republic due to the presence of classical swine fever (National Achieve, 2021; USDA/APHIS, 2021a) several decades ago, and that ban is still in place. In addition, Canada does not currently import live pig or pork products from the Dominican Republic (CFIA, 2021).
- The introduction of ASFV into the Caribbean region has led most countries/territories of the Americas to increase surveillance at the borders and ports of entry, strengthen restrictions on all pork product imports from countries or territories affected by ASF, and raise awareness among veterinarians and related professionals playing a key role in the mitigation of disease introduction. As an example, the government of Mexico implemented an emergency biosecurity plan to mitigate the risk of ASFV introduction including health intelligence work, review of animal health requirements and biocontainment measures, and strengthening inspection at ports, airports and borders (Government of Mexico, 2021). In addition, other countries in South and Central America, including members of the International Regional Organisation for Plant and

TABLE 6
Overview of pork product and by-product exports from the Dominican Republic to trade partners worldwide in 2018

Importing country/territory	Quantity (kg)	Importing country/territory	Quantity (kg)
Haiti	5 926 343	**Germany**	1 217
France	165 894	**Jamaica**	1 150
Cuba	13 3384	**Mexico**	708
United States of America	42 461	**United Kingdom of Great Britain and Northern Ireland**	658
Spain	18 229	**Finland**	549
Turks and Caicos Islands	14 064	**Denmark**	516
British Virgin Islands	7 382	**Barbados**	400
Venezuela (Bolivarian Republic of)	4 352	**Antigua and Barbuda**	297
Curaçao	2 639	**Malta**	181
Chile	2 000	**Argentina**	88
Panama	1 631	**Sweden**	52
Peru	1 418	**Portugal**	6
Russian Federation	1 408	**Poland**	3
Netherlands	1 373	**Anguilla**	1

Source: United Nations Statistics Division.
Note: UN Comtrade database search included the following commodities (code): edible offal of swine, (other than liver), frozen (020630; 020641; and 020649); meat or carcass cuts of swine chilled, fresh, frozen (203; 20312; and 20322); swine pork, salted, in brine, dried or smoked, hams, shoulders and cuts thereof, with bone (021011; 021012; 021019); and of meat preparations of swine meat, offal, or blood (160210; 160241; and 160249).

Animal Health (OIRSA), have been on alert over the last months and implemented strict measures with regards to importations of pork products (Porcicultura, 2021; Gobierno de Guatemala, 2021).

Considering the evidence above, the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through formal importation of pork products/by-products is considered **negligible to very low, with low uncertainty** given the increased restrictions or bans in place in other countries/territories of the Americas to prevent ASF introduction, and the absence of official trade of pork products and by-products records from Haiti or Dominican Republic in the last three years.

b. Informal importation of pork products/by-products?

Considering:

- Evidence presented under 1., and 2.a.
- The Dominican Republic and Haiti are located on the same island, the two potential trade routes for informal importations from these two countries are sea and air routes. The informal importation of pork products via air routes concerns mainly the smuggling of those products by travellers visiting or leaving Haiti or the Dominican Republic. In addition, trade in goods between these two countries and the Caribbean region occurs by sea, which may involve informal trade or smuggling on the boats of professionals (fishing boats, cargo, etc.), travellers, or migrants, or tourists hopping on cruises or ferries between islands within the Caribbean region or beyond.

- Recently, the United States of America also increased inspection of travellers from the Caribbean region and increased surveillance in Puerto Rico and the United States Virgin Islands (USDA APHIS, 2021b).
- Very limited data is available on the number or percentage of travellers leaving or entering countries or territories while carrying uncooked pork or wild boar products (raw, dry-cured, salt cured, or smoked pork products) in their luggage. Depending on responding countries/territories of the Americas, it was estimated that between zero and five percent of travellers (mostly air route considered here) are carrying such products when leaving or coming into a country. In Asia, a survey conducted by Lei *et al.* (2020) found that 2.8 percent of 248 air travellers from China to Japan illegally imported pork products.
- Since 2020, a downward trend in the number of confiscations was observed, which is likely correlated with the COVID-19 pandemic affecting the flow of travellers between countries/territories (as reported in questionnaire answers and retrieved from the OIRSA report, 2020). However, an increase of traveller flows may be expected as COVID-19 vaccination campaigns progressively roll out and entry requirements for tourist/leisure purposes become less restrictive.
- Number of pork product confiscations at points of entry (e.g. ports, airports, land border) varied significantly among countries/territories, however information on the origin of such products was not always retrievable. In countries/territories where the origin of confiscated pork products was available, none of them reported Haiti nor the Dominican Republic. Table 7 presents answers received from countries and territories regarding the estimated quantity of pork products confiscated per year. Nonetheless, these figures should be interpreted with caution as they do not reflect the actual effort made by a country/territory towards inspection and control of travellers at ports of entry, i.e. one country/territory with few confiscations could either have low volumes of illegal importations and/or have inefficient inspection and control mitigation measures.
- Data on volumes of pork products confiscated by the authorities of customs and border protection from departing travellers at ports of entry of the Dominican Republic or Haiti were not available. Overall, little data was available on pork products confiscation at ports of entry of countries and territories in the Americas. However, given the intense flow of travellers, and the impossibility to thoroughly inspect all passengers' luggage, it is acknowledged that smuggling of pork products may occur.
- Control of travellers' luggage at ports of entry is occurring in 31 out of 35 responding countries and territories. Most of the responding countries and territories mentioned the existence of either systematic or random controls for traveller luggage, with ten countries/territories specifying the use of X-ray scanners. The use of sniffer dogs to detect specific products at international airports is variable within the region and while their frequent use has been reported in the United States of America, Canada, and several countries in Central and South America, their use in the Caribbean region appears uncommon. Sniffer dogs may not be trained to detect pork products and their use might be more oriented toward drug detection as a priority. In addition, several countries/territories conduct targeted physical inspections of traveller luggage based on country or territory of origin, or upon suspicion after first control (e.g. suspicion after X-ray scan) (Figure 5). Overall, most countries and territories have

TABLE 7
Quantity of informal pork products confiscated at ports of entry per year by country/territory as reported in questionnaire answers and retrieved from the OIRSA report (2020)

Country/territory	Quantity of pork products confiscated every year in kilograms (kg)
Belize	108.96 kg (2016); 350.6 kg (2017); 87.9 kg (2018)
Chile	6 041 kg (2019); 489 kg (2020); 397 kg (2021)
Costa Rica	313 kg (2018); 264.6 kg (2019); 129.62 kg (2020)
Cuba	1 200 kg
Curaçao	470 kg
Ecuador	24 600 kg (2019); 1 930 kg (2020); 230 kg (2021)
French Guyana	1 000 kg < and <4,000 kg
Guadeloupe	85 kg (since August 2021)
Guatemala	1 059 kg (2018); 37 864 kg (2019)
Honduras	487 kg (2019-2020)
Jamaica	100 kg
México	477 kg (2017-2020)
Nicaragua	Small volumes
Panamá	372.5 kg (2019); 207.7 kg (2020); 309.7 kg (June 2021)
Paraguay	425 kg
Peru	1 338 kg (2019; 521 kg (2020); 394 kg (2021)
Turks and Caicos Islands	<500 kg
United States of America	Cargo, express mail, and express courier pathways: 300 kg in 2020. International mail pathway: 16 900 kg in 2020. Air passengers: 57 250 swine products in 2020.
Uruguay	3 000 kg
Venezuela (Bolivarian Republic of)	900 kg

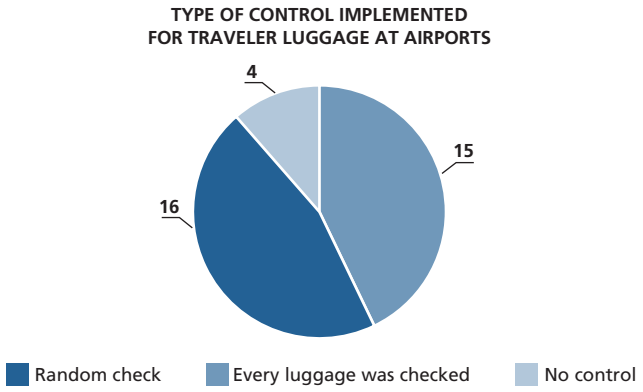
Note: Reporting year was sometimes not specified by respondents.

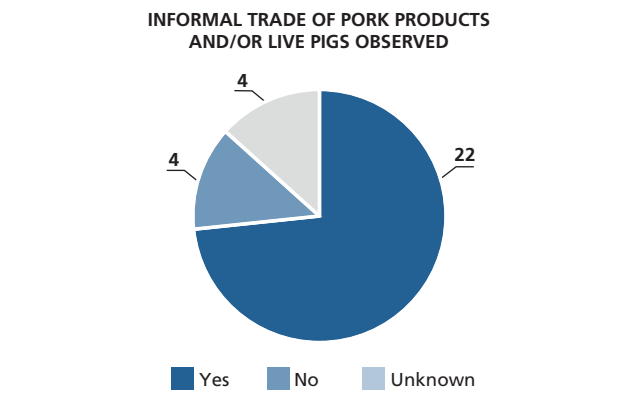
official policies and awareness materials to discourage smuggling of pork products by travellers and discourage taking such products onto pig farms.

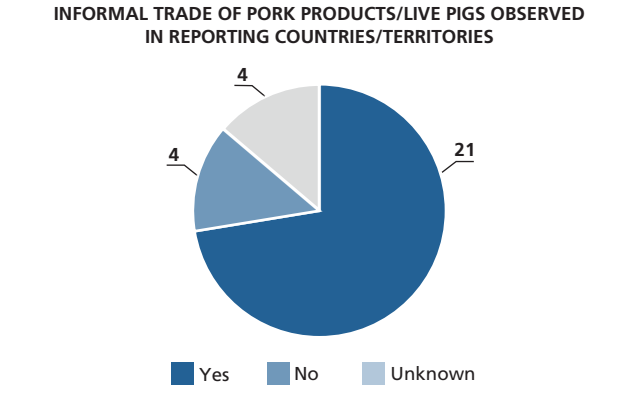
- Shipment of pork products by express mail, courier, or mailed packages is a common and convenient practice to informally send products from one location to another with lower odds of being noticed. Data from the questionnaire indicates that the United States of America confiscated 1.93 tonnes of actionable swine products in 2018, 4.63 tonnes in 2019, and 0.30 tonnes in 2020 through cargo, express mail, and express courier from worldwide origin. These shipping practices are likely to concern most of the countries and territories in the region and may play a role in disease introduction in unaffected countries/territories.
- Informal importations or trade of live pigs and/or pork products is known to occur in the Americas as per answers from countries and territories (Figure 5 and Table 3). However, only few countries or territories mentioned informal trade with Haiti or the Dominican Republic including Aruba, Bonaire, Curaçao, Puerto Rico, and the Turks and Caicos Islands.

FIGURE 5

Answers retrieved from countries and territories of the Americas with regard to control of traveller luggage at airports, inspection of luggage at ports of entry, and the existence of informal trade of pork products and/or live pigs

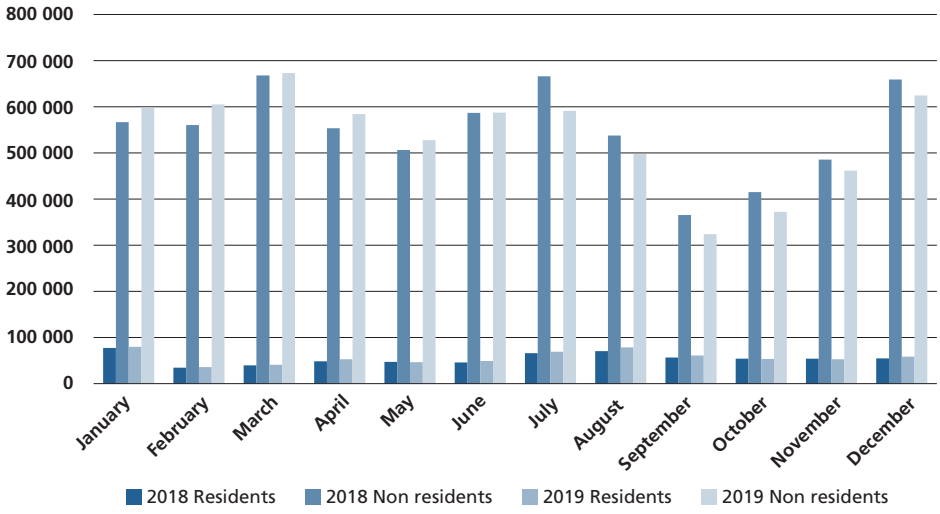






Source: FAO, based on questionnaire data.

FIGURE 6
Number of air passengers arriving to the Dominican Republic by residence type and by month for 2018 and 2019



Source: Banco Central Republica Dominicana, 2021.

- During informal trade/importation of pork products or by-products, biosecurity measures are likely to be lacking (e.g. absence of truck or materials cleaning and disinfection) to effectively mitigate the risks of ASF introduction and spread.

Migration/tourism:

- The Dominican Republic is the most visited island in the Caribbean region and thrives on tourism, its number one economic activity. The total number of passenger arrivals to the Dominican Republic through international airports in 2020 was 2 707 423, (versus 7 126 857 in 2019) of which 2 405 315 were non-resident passengers, including 706 121 Dominicans and 1 699 194 foreigners. As per numbers from 2018 and 2019 (Figure 6), the number of passenger arrivals at international airports of the Dominican Republic appear lower during September–October, then reaching one of the highest flows in December (Banco Central Republica Dominicana, 2021). This is likely correlated with the Hurricane season for the former and the festivities and holidays for the latter.
- The COVID-19 pandemic has affected traveller flows to the Dominican Republic with some countries being underrepresented in recent flows as compared to the period before 2020 (e.g. Canada). However, in 2021, an increase in traveller flows has been observed.
- So far, in 2021, around 60 percent of travellers to the Dominican Republic were foreigners, and 57 percent of those travellers originated from the United States of America (see Table 8). In general, non-resident Dominican travellers were significant and represented around 17 percent of the non-resident traveller flow in 2018 and 2019.

TABLE 8
Origin of travellers to Haiti and Dominican Republic
Foreigner arrivals (excluding non-resident Haitian or Dominicans) at the national borders of Haiti in 2019 and of the Dominican Republic during January-August 2021.

Country/territory of origin	Arrivals (# of people) to Haiti	Country/territories of origin	Arrivals (# of people) to the Dominican Republic
United States of America	224 299	**United States of America**	1 174 616
Canada	20 923	**Colombia**	78 224
Cuba	15 148	**Spain**	69 823
Dominican Republic	1 130	**Venezuela (Bolivarian Republic of)**	67 408
Guadeloupe	923	**Puerto Rico**	65 791
Mexico	549	**Cuba**	60 446
Bahamas	537	**Ukraine**	50 998
Brazil	397	**France**	47 476

Source: UNWTO, 2021; Banco Central República Dominicana, 2021.

TABLE 9
Top travel destinations from the Dominican Republic and Haiti in 2018
In blue, countries that appear in both the Dominican Republic and Haiti top travel destinations.

From Dominican Republic to […]	Departures (# of people)	From Haiti to […]	Departures (# of people)
United States of America	451 058	**United States of America**	131 003
Colombia	25 631	**Canada**	9 617
Mexico	15 837	**Guyana**	5 799
Canada	10 684	**Argentina**	3 969
Peru	8 882	**Dominica**	2 983
Argentina	6 177	**Curaçao**	1 776
Brazil	4 054	**Bahamas**	1 518
Curaçao	2 288	**Brazil**	1 507
Jamaica	2 213	**Mexico**	1 389

Source: FAOSTAT, 2021.

Non-resident Dominicans may have more incentives compared to other tourists to bring "food from home", including pork products back to their country of residence.

- Most travellers to Haiti are from the United States of America. However, a significant flow of travellers originate from Cuba in the Caribbean region (see Table 8). From 2018 to 2019, a decrease of 35.15 percent was observed in the number of arrivals to Haiti. However, no figures were available since the onset of the COVID-19 pandemic (UNWTO, 2021).
- Significant migration of Haitians to other countries/territories in the Americas takes place daily due to the socio-political and economic contexts, especially since the devastating earthquake of 2010. Starting in 2010, many Haitians migrated to South

America (mainly to Chile and Brazil), however a trend reversal has been observed since the onset of the COVID-19 pandemic with Haitian migrants moving northwards to Colombia and Panama, aiming eventually to reach North America, in particular the United States of America (IMO, 2019). On 14 August 2021, another violent earthquake hit Haiti, affecting an estimated population of 800 000 people. This forced about 14 000 Haitians to leave the country and head to the border of the United States of America, settling in large camps under poor hygiene conditions (UNICEF, 2021). In addition, the Dominican Republic reports significant migrations of Haitian residents annually (UNHCR, 2021).

- Main destination countries/territories for emigrations from the Dominican Republic include the United States of America, Puerto Rico, Spain and Italy. The United States of America accounted for 78.12 percent of the emigration flow from the Dominican Republic in 2015 versus 72.13 percent in 2000 (IOM and INM RD, 2017). In addition, part of this migration flow is not conducted in official ways. Boats leaving the Dominican Republic to Puerto Rico are frequently sighted, as evident by coast guard reports in the media (Minority Rights, 2021; Associated Press, 2021).
- Migration in the Caribbean regions is often exacerbated by recurring natural disasters such as hurricanes, which particularly affect Cuba, Haiti, and the Dominican Republic (IOM, 2021). However, hurricane season generally takes place between June and November, which is not the period covered by the assessment (NOAA, 2021).
- Due to the currently enforced visa regulations, most Haitian migrants do not head directly to Mexico or the United States of America, but instead make a detour through South America and move northwards via land transportation (e.g. bus) (IOM, 2019).
- As per International Air Transport Association (IATA) criteria for COVID-19 entry restrictions, Colombia and Mexico are not considered restrictive, while most countries in the Americas are considered partially restrictive. Nonetheless, while traveller flows might be partially affected, citizens or residents of Haiti and the Dominican Republic are still able to travel to most countries in the Americas if complying with COVID-19 related travel requirements (IATA, 2021).

Considering the evidence presented under 1., and 2. including the implementation and strengthening of mitigation measures to prevent ASF introduction, the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through informal importation of pork products is assessed as:

Moderate, with **high uncertainty** for: Aruba, Bonaire, Colombia, Cuba, Curaçao, Jamaica, Mexico, Panama, Puerto Rico, the Turks and Caicos Islands, the United States of America and the Bolivarian Republic of Venezuela. For each country/territory this is due to a combination of several of the following factors: low to moderate flow of tourist and/or migrants from ASF affected countries, reports of informal importation of pork products by sea or air from the Dominican Republic, or geographic proximity with ASF affected countries by boat or with short direct flights, act as a transit country/territory for migrants, and/or significant Dominican diaspora.

Low to moderate, with **high uncertainty** for Argentina, Belize, the Plurinational State of Bolivia, Brazil, Chile, Costa Rica, Dominica, Ecuador, El Salvador, French Guyana, Guadeloupe, Guatemala, Guyana, Honduras, Martinique, Nicaragua, Paraguay, Peru, Saint Lucia,

Suriname, Trinidad and Tobago, and Uruguay. For each country/territory this is due to a combination of several of the following factors: likely informal importation of pork products despite appropriate inspection rates at ports of entry, geographic proximity with ASF affected countries by sea or short direct flights, low to moderate flow of tourists or migrants from and to ASF affected countries.

Very low to low, with **high uncertainty** for other countries or territories in the Americas due to very low to low flow of tourists or migrants from and/or to ASF affected countries, and/or highly controlled ports of entry.

Risk question 3. What is the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through formal or informal importation of pig genetic materials (semen, embryos and ova)?

Considering:

- All semen imports taking place in the targeted countries/territories of the Americas are originating from currently ASF-free countries. Canada and the United States of America are important pig semen exporters, followed by European countries including Denmark, France, the Netherlands and Spain.
- The import requirements and additional animal health controls in place in countries/territories of the region for such products.
- Pig semen for import to the countries/territories of the region generally comes from higher genetic value animals that are kept in premises with higher biosecurity level.
- Data on production and trade of pig embryos and ova was not available, but It is expected to be to a smaller extent compared to pig semen, and undertaken under similar – if not higher – biosecurity practices.
- A small number of studies indicate that ASFV can be found in the semen of boars after experimental infection, and even be transmitted to recipient sows. However, there is little published evidence on virus survival in semen (Thacker *et al*., 1984; Maes *et al*., 2008).
- The absence of information on informal trade of semen does not rule out its actual occurrence. However, it is not expected to be in significant volumes, nor coming from ASF-affected countries or territories of the region.

Considering the evidence above, the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through formal or informal importation of pig semen is considered:

Negligible, with **low** and **high uncertainty** for **formal** and **informal trade**, respectively.

Risk question 4. What is the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through food waste?

Considering:

- Evidence presented under 1. and 2.
- Food waste considered here includes any pork-based food waste generated by airlines, ships and cruise ships. Haiti and the Dominican Republic are surrounded by sea,

hence ASFV introduction to other countries or territories through contaminated food waste and fomites will only be possible via air and sea routes.

- Food waste containing pork or pork products carried or generated by boats, cruise ships, passenger aircrafts, or airports may not be properly discarded. According to questionnaire answers available (n=24) on the management of waste from airports, cargo boats and other sea transportations, at least 18 countries and territories conduct inactivation, destruction or incineration of food waste while having additional specific regulations for other sea transportation means (e.g. leisure boats, cruise ships, etc.). The inactivation, incineration or destruction of potentially contaminated solid waste from airlines and ships is key to mitigate the risk of introduction of ASFV through this pathway. The disposal of such waste directly in open landfills without processing constitutes a risky practice.
- Waste management is a significant challenge for most countries and territories in the Caribbean due to multiple factors including but not limited to: lack of financial resources, insufficient disposal systems, inconsistent management approaches, lack of space for waste management and inappropriate waste disposal practices. Multiple open landfill sites can be found in the Dominican Republic and in Haiti, accessible to people as well as roaming domestic, or wild and stray animals (e.g. pigs, dogs, cats, etc.). (Haney and Bodenman, 2017; Edelman, 2019).
- It is common among countries and territories in the region to only stack food waste in open landfills, instead of appropriately burying it, and to not follow the good practice of separating it from other solid waste.

Considering the evidence presented under 2.a, 2.b and 4, the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through food waste is considered:

Moderate, with **high uncertainty** for: Aruba, Bonaire, Colombia, Cuba, Curaçao, Jamaica, Mexico, Panama, Puerto Rico, the Turks and Caicos Islands, and the Bolivarian Republic of Venezuela.

Low with high uncertainty for Argentina, Belize, the Plurinational State of Bolivia, Brazil, Chile, Costa Rica, Dominica, Ecuador, El Salvador, French Guyana, Guadeloupe, Guatemala, Guyana, Honduras, Martinique, Nicaragua, Paraguay, Peru, Saint Lucia, Suriname, Trinidad and Tobago, the United States of America and Uruguay.

Very low, with **high uncertainty** for other countries or territories in the Americas.

Risk question 5. What is the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through fomites?

Considering:

- Evidence presented under 1., 2. and 4.
- Fomites include various materials, equipment, or clothing, for example farming equipment, crates, clothes, shoes, hunting equipment, etc.
- ASFV can survive up to several weeks in the environment and on fomites (e.g. clothes, footwear, farm equipment, bedding) under suitable conditions, such as low humidity, cool temperatures, and in the presence of organic matter (EFSA, 2014; Mazur-Pana-

siuk *et al*., 2019). ASFV may survive long enough on shoes or clothes to be carried by air or sea travellers from affected to unaffected countries/territories, particularly if travellers have recently visited a pig farm or backyard. Contaminated equipment or materials transported by boats could also contribute to the spread of the virus. Proper cleaning and disinfection can drastically reduce the viral load on any material.

- None to negligible volumes of live pigs and pork products are traded formally between Haiti and the Dominican Republic and the rest of the Americas. This is what directly affects the likelihood of ASF contaminated fomites being introduced to unaffected countries/territories through this pathway.
- Backyard smallholdings counting only a few pig heads are common in the Americas, with the exception of North America. At least 17 countries and territories reported in the questionnaire that backyard and smallholder farms account for at least 50 percent of the pig production sector. Generally, biosecurity practices on such production sites are low if not absent, which favours disease introduction.

Considering the evidence presented under 1., 2., 4. and 5., the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through fomites is considered:

Moderate, with **high uncertainty** for: Argentina, Aruba, the Plurinational State of Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Ecuador, El Salvador, Guadeloupe, Guatemala, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Turks and Caicos Islands, Uruguay, the United States of America and the Bolivarian Republic of Venezuela.

Low with high uncertainty for Belize, French Guyana, Guyana, Saint Lucia, Suriname, and Trinidad and Tobago.

Very low, with **high uncertainty** for other countries or territories in the Americas.

Risk question 6. What is the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through animal-origin feed importation?

Considering:

- Evidence presented under questions 1., 2., 4. and 5.
- Since 2019, no official exports of animal-origin feed from Haiti nor the Dominican Republic to other countries/territories in the Americas have been recorded (UNSD, 2021).
- It is not known whether informal trade of animal-origin feed occurs in the Americas. Animal-origin feed may be imported informally from affected to unaffected countries/territories through similar networks to informal trade involving pork products.
- For the majority (>90 percent) of the countries and territories, pig blood, offal, or by-products obtained after slaughtering are used for further purposes including the production of sausages, *chicharrones*, animal meals, or gelatines (for cosmetics or medicaments). Otherwise, these by-products are mainly discarded or destroyed using officially approved methods.
- Processes involved (e.g. heat treatment, pelletization) for the preparation of animal-origin feed may inactivate any ASFV present, however there is lack of evidence.

Nonetheless it is believed that such processes would at least reduce - if not eliminate - the contamination of feed. (EFSA, 2021)

Considering the evidence presented above, the likelihood of ASFV entering non-affected countries/territories from ASF affected countries in the Americas through animal-origin feed importation is considered:

- **Low with high uncertainty** for Aruba, Bonaire, Cuba, Curacao, Jamaica, Puerto Rico, and the Turks and Caicos Islands due to **either** reported informal trade of pork products with the Dominican Republic **or** the close geographic proximity with ASF affected countries, which favours trade, although no evidence is yet available for the potential involvement of animal-origin feed in informal or formal trade.
- **Negligible to low with high uncertainty** for other countries and territories given the absence of documented formal or informal trade of feed from animal-origin with ASF-affected countries, and that most countries/territories in the Americas would likely import through formal trade pig feed from plant origin (e.g. feed made from corn and soybeans) from the biggest producers, including for example Thailand, China, the United States of America, Brazil or the Netherlands.

LIKELIHOOD OF EXPOSURE

Risk question: Should ASFV enter an unaffected country or territory in the Americas, how likely are susceptible hosts to be exposed to the virus?

Considering:

- Evidence presented in the background and likelihood of entry sections.
- National estimates of the susceptible domestic pig population in the targeted countries and territories (Annex 1).
- ASFV has spread across the island of Hispaniola (Dominican Republic and Haiti), with 199 outbreaks in the Dominican Republic and 26 outbreaks in Haiti to date, respectively (FAO, 2021a). Most of the outbreaks were observed in small holdings. Backyard farms account for an important part of the pig production system in both countries. This, together with the existence of scavenging pigs that feed on garbage dumps, favours exposure to ASFV and further spread of the disease.
- Backyard smallholdings account for at least 50 percent of the pig production sector in at least 17 countries/territories of the Americas. This generally comes with low levels of biosecurity. Conversely, the United States of America reported that farms with less than a hundred pigs accounted for only 1.3 percent of the total pig sector.
- Swill/food waste feeding is a common practice in several countries and territories of the region, whereby untreated food scraps are given to pigs. This practice is reported in some countries/territories despite regulations prohibiting swill/food waste feeding. As per questionnaire answers, 19 out of 35 countries and territories reported swill feeding as a common practice, while three did not know and 13 said it was not occurring.
- In some countries/territories, pigsaer are allowed to scavenge freely for food, including in unprotected dump sites. Out of the 35 responding countries/territories, 18 mentioned that scavenging pigs are present but rare, while Mexico and Puerto Rico reported them as common.

- Wild boar and feral pigs also susceptible to ASFV. They are commonly found in the Americas, and often coexist with domestic pigs (roaming around farms, or in small villages). In addition, Cuba, Paraguay, the United States of America and Uruguay reported that disease surveillance in feral pigs was conducted.
- It is common in the Americas to have open landfills gathering solid waste from various origins and accessible by roaming, and stray, domestic or wild animals, including pigs or other *Suidae*.
- Annex 3 provides self-evaluation scores of responding countries/territories on ASF preparedness in terms of provisions for laboratory diagnosis, quarantine and movement control, stamping out, carcasses disposal, affected premises cleaning and disinfection. All categories sum up for a score of 15 points, with three points for each of the five categories. Countries/territories with a total score below ten out of 15 are mainly located in the Caribbean region, in addition to Ecuador, Honduras, Nicaragua and Uruguay.
- In addition, 15 out of the 35 responding countries and territories stated they did not have appropriate laboratory capacity to test suspected domestic and feral pigs for ASFV. The majority were small islands from the Caribbean region with a maximum of 15 000 live pig stock, as well as El Salvador, Suriname, Uruguay, and the Bolivarian Republic of Venezuela.

The likelihood of having susceptible animals exposed to ASFV and becoming infected once it entered an unaffected country/territory through one of the pathways previously assessed (particularly pork products, fomites and food waste) is considered:

High with high uncertainty for countries and territories that demonstrate several of the following risk factors:

- presence of pigs (domestic, feral or wild);
- high proportion (above 50 percent) of domestic pigs kept in low biosecurity holdings (e.g. backyard and smallholder farms);
- low biosecurity practices predominant in the pig sector, particularly linked to the number of backyard holdings and smallholder farms;
- swill feeding as a common practice;
- poor preparedness for ASF prevention and control, including lack of laboratory capacities to test for ASFV; and
- significant presence of poor waste management systems.

Moderate with high uncertainty for countries and territories that demonstrate several of the following risk factors:

- presence of pigs (domestic, feral or wild);
- moderate proportion (between 20 and 50 percent) of domestic pigs kept in low biosecurity holdings (e.g. backyard and smallholder farms); and
- low biosecurity practices significant in the pig sector, particularly linked to the number of backyard holdings and smallholder farms;

Low with high uncertainty for other countries and territories in the Americas due to **either** very low to low densities/numbers of domestic pigs **or** moderate to high density of domestic pigs but with overall high biosecurity in the production sector and low proportion (less than 20 percent) of domestic pigs kept in low biosecurity holdings (e.g. backyard and smallholder farms).

DISCUSSION

This risk assessment focuses on the risk of ASFV introduction from Haiti and the Dominican Republic to unaffected countries/territories of the Americas during the period December–February 2022. Six major pathways for ASFV entry were covered separately to allow for better accuracy of the assessment given their multi-factorial nature. Moreover, the likelihood of entry and the likelihood of exposure were not combined to avoid losing information through qualitative combination and better reflect each ASFV introduction scenario (Annex 4).

Importantly, the likelihood of exposure was assessed separately, regardless of the pathway the virus would take to enter into a country or territory. This is to better account for the wide geographic scope (35 countries and 18 territories) as well as the limited data available, since only 35 responses out of 53 questionnaires were received. Nonetheless, the assessment of the likelihood of exposure is based on major risk factors that are known to play a key role in ASFV introduction into unaffected areas, and additional information collected from peer-reviewed publications allowed for providing a more accurate assessment. Furthermore, most of the uncertainty levels associated with the different likelihoods of entry and the likelihood of exposure were high, except for pathways involving formal trade of certain commodities such as live pigs, pork products and genetic material. The high uncertainty is linked to the complexity of ASFV epidemiology involving multiple risk factors for which data is not necessarily retrievable or even available.

As per the risk assessment, pathways with the highest likelihood of disease entry (i.e. at least moderate) for several countries/territories include the informal importation of pork products, fomites and food waste. The Americas have been on alert since the emergence of ASF in the Dominican Republic reported in July 2021, which is expected to have resulted in reducing the likelihood of entry through some of the different pathways. Importantly, the COVID-19 pandemic related travel restrictions (required negative PCR or antigen tests or vaccination and/or several days of quarantine) have also played a role by reducing the flow of tourists and migrants to certain countries/territories (e.g. Canada), which in turn indirectly reduces the likelihood of ASFV entry through pathways involving those anthropogenic factors.

Beyond the Americas, ASFV circulates and is endemic in multiple countries across Eurasia and Africa. In fact, never in history has ASFV been so geographically widespread. Its risk of introduction from those countries should not be ignored. As the Dominican Republic and Haiti became infected from some virus source outside the continent, the same may happen again in the future.

The introduction of ASFV into China in 2018 led to the spread of the infection into most of the countries of East and Southeast Asia. The infection has become established and continues to circulate, with recent introduction into Malaysia and Bhutan in 2021. This shows how quickly the disease can progress once the virus makes its way into an unaffected area.

In Europe, more than 1 200 outbreaks have been reported in domestic pigs just in 2021, most of them occurring in countries from Eastern Europe. In addition, the disease is entrenched in the wild boar population, which contributes to the persistence of the disease in the region.

Strict regulations have been implemented by countries/territories to ensure safe and continuous trade of live pig and pork products with other trading partners. However, bans on imports of live pigs and pork products were also imposed against ASF-affected countries.

The risk of ASFV introduction through informal importations from affected countries beyond the Americas to unaffected countries or territories of the Americas exists, especially through air and sea travel, which constitute major pathways for virus introduction. The illegal importation of pork products (e.g. in mislabelled containers) and the waste from airlines, cruise ships and other vessels also remain major risk pathways. However, legal importation of live pigs, pork products, feed of animal-origin, or semen from areas beyond the Americas are considered secondary pathways for virus introduction, given the awareness of the ASF situation worldwide and the trade regulatory frameworks enforced for such commodities.

Economic impact of ASF in the Americas

IMPORTANCE OF THE PORK INDUSTRY

While the Americas account for only 13.2 percent of the world's population, the region was responsible for 23 percent of the pork and other pig products (fat and offal) produced globally in 2019 (FAO, 2021b). In 20 years (1998–2018), pork production in Latin America and the Caribbean grew by 111 percent, and it is expected to keep growing by 2.2 percent per year until 2028[1] (OECD-FAO, 2018).

Most of the countries in the region have a deficit on their pork trade balance to fulfil their national demand. However, three of the top pork exporters in the world also belong to this region: the United States of America, Canada and Brazil. Therefore, the pork sector in the region is characterized by a wide range of production systems, which go from an industrialized export-oriented pork industry in some countries to smallholder low-input low-output systems oriented to meet (at least partially) the domestic demand in less developed countries.

Understanding the economic impact of ASF can support decision-making and guide cost-effective efforts to prevent or control the disease. Despite the devastating impact produced by ASF in other regions, only few studies looking at the potential impact of ASF in the Americas are available. A literature review published in 2020 found just six studies assessing the impact of ASF, from which only one is relevant to the region (Brown *et al.*, 2020). According to this study, which uses data from 1993, the net benefits of preventing ASFV introduction to the United States of America were almost USD 4 500 million over ten years (Rendleman and Spinelli, 1999). However, a more recent study focusing on the potential impact of trade bans due to ASFV detection in the United States of America shows that the impact would be substantially higher. Trade bans on US pork would generate losses to the pork industry of up to USD 15 billion in the case where disease is controlled and bans are lifted after two years, and up to USD 50 billion over ten years in the case where disease becomes endemic (Carriquiry *et al.*, 2021).

METHODOLOGY

To better understand the potential consequences of ASFV spreading across the continent, we analysed the impact on pig mortality and pork production, as well as the implications for food security, trade and the labour market. We used official figures from Viet Nam and China to estimate the reduction on the pig herd and pork production. In 2019, China's pig herd and pork production experienced a reduction of -28 percent and -21 percent

[1] This estimate does not consider the introduction of ASF.

respectively while Viet Nam's pig herd experienced a larger decline (-30 percent) but a smaller decline in terms of pork production (-13 percent). Therefore, we considered a -29 percent contraction in the pig herd and -17 percent reduction on pork products.[2] Extensive or backyard farms are more vulnerable to ASF because of their limited biosecurity. They comprise almost 70 percent of the outbreaks in some countries (Woonwong *et al*., 2020). Compared to China, the prevalence of small farms with less than 100 pigs is very similar in Central America (excluding Mexico) and higher in the Caribbean, but lower in South America and almost zero in North America (Gilbert *et al*., 2015, adjusted to FAOSTAT 2015 data). Therefore, while our scenario is representative for assessing the spread of ASFV in naïve populations, we may be overestimating the impact of ASF on pork production in countries with a highly intensive pork industry and underestimating the impact in countries characterized by a large extensive sector.

Pork prices are highly variable within the region with farm gate prices ranging between USD 1.7/kg and USD 6.5 /kg in 2019 (FAO, 2021b). To monetize the losses due to the reduction of pork production, we used USD 1.64 /kg, which is the average price reported by the European Union at the end of 2020 and a good proxy for global prices.

MORTALITY AND PORK PRODUCTION LOSSES

Considering ASF's high fatality rate, and the lack of vaccines or effective treatments, ASF causes substantial direct losses to the pork industry. Considering the Dominican Republic's net importer pork balance, one of the major risk pathways for spreading ASFV in the region is attributed to tourism and immigration (Jurado *et al.,* 2018). To estimate mortality and pork production losses, we focused on countries in the Americas[3] with the largest volume of tourists with the Dominican Republic and Haiti (UNWTO), namely Argentina, Bahamas, Brazil, Canada, Chile, Colombia, Dominica, Guyana, Jamaica, Mexico, Peru and the United States of America (including Puerto Rico). These countries represent more than 90 percent of the pig herd.[4]

According to the scenarios previously described, if ASFV were to spread following similar patterns to those observed in China and Viet Nam, the Americas' pig herd could lose more than 48 million heads with a contraction of more than 4.7 million tons of pork products (Table 10).

According to our scenario, if the disease spreads to countries in Table 10, the financial losses during the first year of the epidemic due to the pork reduction would be around USD 7.8 billion. Such a large impact would have consequences on market prices and other agricultural products, including inputs, such as corn or soybeans, and other animal proteins (Carriquiry *et al*., 2021).

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[2] Pork products include meat, fat and offal.

[3] Among the top 10 countries with the largest volume of tourists with the Dominican Republic, five of them were European: France, Russia, Germany, the United Kingdom of Great Britain and Northern Ireland, and Spain.

[4] France, Russia, Germany, the United Kingdom of Great Britain and Northern Ireland and Spain.

TABLE 10
Estimated impact of ASF on pig stocks and pork production in selected countries

	Live pigs (heads)		Pork (tons)	
Country	**2019 Stock**	**ASF Impact**	**2019 Production**	**ASF Impact**
Argentina	5 128 954	-1 482 952	797 907	-135 759
Bahamas	5,027	-1 453	401	-68
Brazil	40 556 892	-11 726 351	4 886 040	-831 327
Canada	14 399 339	-4 163 329	2 477 702	-421 565
Chile	2 566 782	-742 142	600 590	-102 186
Colombia	4 080 738	-1 179 878	463 714	-78 898
Dominica	5 073	-1 467	472	-80
Guyana	9 994	-2 890	1 052	-179
Jamaica	216 135	-62 492	10 532	-1 792
Mexico	18 365 289	-5 310 018	1 862 337	-316 864
Peru	3 258 928	-942 265	204 395	-34 776
United States of America	78 657 600	-22 742 537	16 729 435	-2 846 403
Total	**167 250 751**	**-48 357 773**	**28 034 577**	**-4 769 898**

Source: FAOSTAT for live pig numbers and FAO estimations for the impact.

FOOD SECURITY

Pork has become increasingly important for Latin American diets, which have been shifting from beef and dairy products to poultry and pork since 2000. While Latin America per capita consumption of pork increased by 38.1 percent from 2000 to 2018, beef consumption experienced a reduction of -2.2 percent over the same period (Williams and Anderson, 2019).

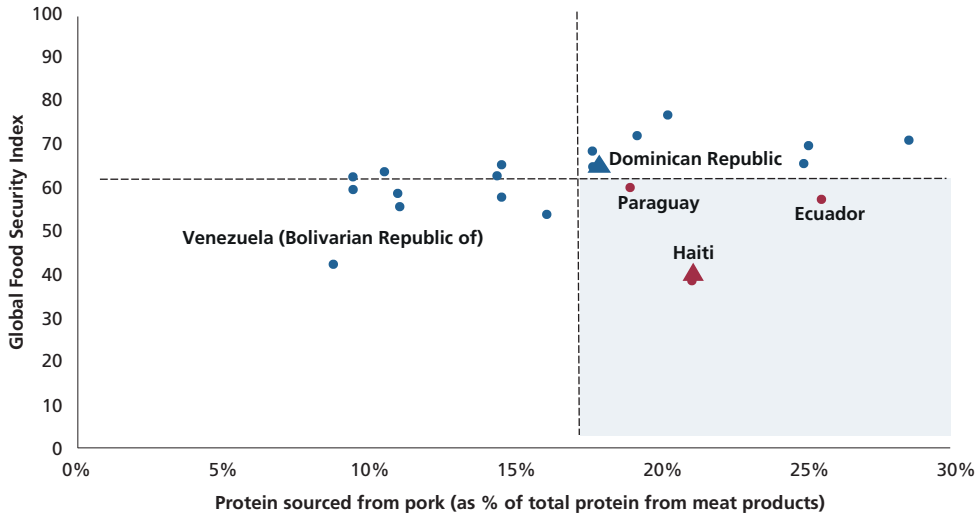
We used FAOSTAT's food balances and the Global Food Security Index (GFSI) to identify countries that rely on pork as an important source of protein and that suffer from food insecurity. Combining these two indicators allows us to identify populations that are highly vulnerable to food insecurity due to ASF. The dotted lines on Figure 7 represent the average values for a sample of 20 countries from Latin America and the Caribbean.

Paraguay, Ecuador and Haiti were identified as highly vulnerable to food insecurity due to ASF. Despite the Bolivarian Republic of Venezuela's low index for food security, most of its protein is sourced from poultry and beef, which makes it less vulnerable to food insecurity due to ASF. Haiti is the only country in the region that belongs to the top 10 countries with the highest levels of food insecurity in the world, with pork representing more than 20 percent of the protein sourced from meat products. Preference for pork is also high in Belize and Cuba so they are potentially also highly vulnerable despite not appearing in this analysis.[5]

ASF would reduce the availability of pork, driving prices up and forcing part of the population to substitute pork products with other animal proteins. This could lead to higher prices on all animal proteins as observed in China in 2019, where chicken, beef and mutton experienced an increase in prices of 24 percent, 20 percent and 17 percent respectively.

[5] Cuba and Belize are not part of the 113 countries for which the GFSI is published.

FIGURE 7
Countries highly vulnerable to food insecurity due to ASF



Source: FAOSTAT and the Global Food Security Index (GFSI).

An increase like this would make meat products prohibitively expensive for a larger share of the population, contributing to food insecurity and undernourishment in the region.

TRADE

Countries with an export-oriented pork industry would be susceptible to trade bans in the event of an ASF outbreak. Pork exports from Brazil, Canada and the United States of America represent more than 90 percent of the Americas' pork exports. These countries exported pork to more than 100 countries in the world and were responsible for 27 percent of the global pork exports in 2019 (FAO, 2021b).

Using the average price of United States of America pork exports,[6] these three countries accounted for more than USD 12.4 billion of pork exports in 2019. Trade bans would push exporting countries to find other markets to place their products (including their domestic market), which would likely reduce their market prices. When China banned imports of German pork due to the detection of ASF in wild boar, the price of German pork experienced a -14 percent reduction (Aug 2020 vs. Oct 2020) vis-à-vis a -5 percent reduction in mean EU prices. Therefore, the impact of ASF in exporting countries would not be limited to the reduction on pork exports but would expand to the whole sector through lower prices.

North America has a particularly integrated pork industry, which is reflected on the live pig exports from Canada to the United States of America. In 2019, Canada exported more

[6] According to the U.S. Meat Export Federation, the average selling price of exported pork in 2019 was USD 2 601.1/ton.

TABLE 11
Direct and total jobs (direct and indirect) attributed to the pork industry

Country	Direct jobs	Total jobs
United States of America (2016)[a]	37 000	514 000
Brazil (2019)[b]	130 000	900 000
Mexico (2013)[c]	350 000	1 700 000
Canada (2016)[d]	31 000	103 000
Chile (2020)[e]	11 000	21 000

[a] Meyer and Goodwin, 2021.
[b] Daniel, 2019.
[c] Towers, 2014.
[d] Bergmann, 2016.
[e] PorciNews, 2021.

than 5.1 million pigs to the United States of America, which represented 98.6 percent of the live pig exports in the Americas (FAO, 2021b). In 2019, Mexico was the largest buyer of US pork (27 percent of total US pork exports) and US live pigs (47 percent of total US live pig exports). In order to mitigate the impact of a potential introduction of ASFV, the United States of America and Canada signed a protocol in 2021 to minimize trade disruptions in case they detect ASFV in wild pigs (USDA/APHIS, 2021b;[7] Meyer and Goodwin, 2021).

JOBS

The United States of America, Brazil, Mexico, Canada and Chile have the largest pork industries in the Americas, which generate hundreds of thousands of direct jobs. Additionally, millions of indirect jobs are attributed to the pork industry (Table 11). In addition to the impact on production, ASF would have a negative effect on employment. According to Carriquiry *et al*. (2021), a trade ban on pork from the United States of America would generate between 6 201 and 6 380 job losses in the first year of the epidemic. In the scenario where the disease becomes endemic, more than 142 000 jobs could be lost over ten years. Women and young people are usually vulnerable groups lacking safety nets, so efforts oriented to support these groups would be needed (Pyburn *et al*., 2015).

Finally, ASF has been identified as a threat to endangered wild pig species in other regions (Luskin *et al*., 2021); however, the native South American peccaries are not susceptible to ASFV (EAZA, 2019). Feral pigs in the Americas are considered invasive so the impact of ASF on these populations is not considered in this analysis. However, if infected, feral swine will serve as a reservoir for the disease, which would make eradication difficult and extremely costly. If not eradicated from the feral population, reintroduction to the commercial pig population will always be a risk. Therefore, there is an economic impact related to the cost of surveillance and control measures in the feral pig population.

[7] www.aphis.usda.gov/aphis/newsroom/news/sa_by_date/sa-2021/asf-protocol

Recommendations for prevention and control of ASFV introduction

PREVENTION AND EMERGENCY PLANNING

Prevention of infectious diseases is far more effective than their control. While this is true for all transboundary animal diseases (TADs), it is even more important in the context of ASF, against which there are no vaccines or treatments available to eliminate it. Therefore, it is particularly important that ASF-free countries and ASF-free farms be maintained as such. Prevention is achieved by not allowing the virus to cross national borders (i.e. enforcement thorough inspection for pork products at points of entry into the country seaports, airports, etc.) and by not allowing the virus to enter farms through the enforcement of strict biosecurity measures. As described in earlier sections and considering previous experiences with ASF genotype II in other regions, prevention should be based on the identification via risk assessment of the target areas and holdings at highest risk of ASFV introduction and exposure (Table 12, Table 13). FAO developed manuals on the preparation of ASF contingency plans (FAO, 2009) to assist in prompt recognition and detection of the disease and the immediate control steps at farm level (Beltrán-Alcrudo, *et al.*, 2017).

Ideally, all countries should have in place an emergency response plan dedicated to ASF, providing clear objectives and steps on how to manage an ASF outbreak. Care should be taken when adapting emergency response plans from countries with abundance of resources, as not all measures might be appropriate or sustainable in other settings. However, the key elements of these emergency response plans should be considered and properly adapted to the local context. All emergency response plans for ASF should be ideally tested through regular and realistic simulation exercises and be reviewed and updated periodically.

Emergency response plans for countries with high numbers of small-scale producers, and/or an unstructured swine production system must consider the level of biosecurity in swine operations and along the pig and pork value chain, as well as the capacity of the veterinary (and other) services to implement all required response actions of such a plan. This should include epidemiological outbreak investigations to inform source identification and tracing. Furthermore, emergency plans need to consider other competent authorities including those responsible for the control of wild boar and hunting, or the private sector. This should also include assessing the capacity to manage an outbreak where thousands of pigs have to be culled and carcasses managed safely, including asking questions such as: Are the necessary equipment and skilled operators available for humane destruction? Have appropriate methods for carcass disposal been assessed and tested? Emergency plans should ensure provision of compensation to farmers with all details related to recording, evaluation of losses and disbursal of funds as part of emergency response planning.

Preparedness also includes maintaining capacity for (particularly passive) surveillance, accurate and quick diagnosis; and reviewing standard operating procedures on reporting,

sampling, temporary movement stand stills, and diagnostics to be able to recognize disease incursion as early as possible. Where possible, improve value chain mechanisms to be able to trace backward and forward as fast as possible. Share information on best/better practices for traders, markets, farmers, travellers as well as the general public, and advocate how and why their behaviour change can prevent ASF. Authorities may prepare an easy environment for farmers and traders to report any CSF-like disease and sudden death of a pig for early detection.

TABLE 12
Preventive measures targeting major risk pathways for ASFV introduction

Risk pathways for *ASFV introduction*	**Preventive measures**
Infected pork /wild pork products and by-products importation: • Through trade • Through travellers (tourists, refugees, seasonal workers, exchange students, etc.) by land, sea or air • Humanitarian assistance/ donation	Strictly follow the OIE Terrestrial Code (https://www.oie.int/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=1&htmfile=chapitre_asf.htm) for the import of products. Only allow import of products from ASF-free countries, compartments (https://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/ASF/ASF-CompartmentalisationGuidelines_EN.pdf) or zoning.[a] Also pork and pork products provided by humanitarian organizations that could be brought from infected countries (e.g. frozen pork, fat, sausages, etc.) should be subject to the same rules as restrictions as any other imports. Conduct risk assessments of potential sources of infected pork products, based on known patterns of legal import and intelligence on illegal movement of people, live pigs and pork products (FAO guidelines on rapid risk assessment). Obtain information on levels of threat posed by imports based on testing of seized imported produce for evidence of infection. Be aware of the lag time between initial cases and official reporting of the disease that has occurred in many countries (sometimes weeks to months prior), which might mean national borders of your country/territory have been vulnerable to inadvertent import of infected pork or pigs. Strengthen regional cooperation for early reporting of suspect cases. Reinforce border inspection capacities: • Fines/penalties/disincentives for smugglers. • Improve detection of animal products at airports (if possible, consider deploying sniffer dogs for meat detection or scanners). • Ensure full collaboration among law enforcement and authorities, including customs, port management, airport management, coast guard, international post office and international couriers. Introduce or strengthen strict garbage management at sea/airports (from aircraft or boats, including pleasure boats), but also international buses and trains, ensuring the safe destruction of all plant and animal products. Garbage bins destined to collect food waste from cruise ships and airplanes are available, sealed, locked, are often inspected and then the contents are properly incinerated. Responsible person shall be registered, the certified record on garbage collection from aircraft/boats must be kept for at least three years. Unscheduled inspection and testing of seized pork products shall be carried out. Raise awareness among the general public, particularly travellers (https://trello.com/b/GloiZoik/african-swine-fever-oie), and also relevant stakeholders (e.g. farmers, veterinarians, hunters, etc.): • Raising awareness about African swine fever. • African swine fever (ASF) kills pigs. • Biosecurity is key to stop African swine fever. • Disease Prevention on the Farm: African Swine Fever (https://www.youtube.com/watch?v=PM7Oeexsqbs). • ASF poster for veterinarians (English http://www.fao.org/3/cb6495en/cb6495en.pdf), (Spanish http://www.fao.org/3/cb6495es/cb6495es.pdf). • ASF poster for farmers (English http://www.fao.org/3/cb6496en/cb6496en.pdf), (Spanish https://www.fao.org/3/cb6496es/cb6496es.pdf).
Fomites	Reinforce biosecurity measures during importation thorough cleaning and disinfection of containers, vehicles, vessels, or any other transportation means.

(Cont.)

TABLE 12 *(Cont.)*

Risk pathways for *ASFV introduction*	**Preventive measures**
Live pig formal/informal importation	Import from ASF-free countries or zones only Reinforce border inspection capacities. Fines/penalties/disincentives for smugglers. Continuous awareness raising campaign among farmers, traders and other stakeholders.
Pig semen importation	Import from ASF-free countries or zones only
Animal-origin feed importation	Import from ASF-free countries only. Holding time sufficient for inactivation of ASFV. Heat treatment or chemical treatment of feed (Niederwerder, 2021).

[a] Under OIE Terrestrial Animal Health Code Compartment contained in one or more establishments, from other susceptible populations by a common biosecurity management system, and with a specific animal health status with respect to one or more infections infestations for which the necessary surveillance biosecurity and control measures have been applied for the purposes of international trade or disease prevention and control in a country or zone. Zoning means a part of a country defined by the Veterinary Authority, containing an animal population or subpopulation with a specific animal health status with respect to an infection or infestation for the purposes of international trade or disease prevention or control (OIE, 2018).

TABLE 13

Preventive measures targeting major risk pathways for ASFV exposure (i.e. to prevent the index case)

Risk pathways for *ASFV exposure*	**Preventive measures**
Exposure of wild boar and scavenging or feral pigs	Regulation and fencing of landfills to exclude access of wild/feral pigs. Awareness of the general public to always dispose animal products safely, rather than just throwing them away.
Exposure of domestic pigs	Biosecurity practices improvement (FAO/OIE/WB, 2010) Confinement of pigs with double fencing. Do not allow scavenging at any time. Ban on swill or garbage feeding. If not realistic, provide regulated swill feeding protocol for the treatment kitchen waste (e.g. by boiling with stirring and cooling down before feeding). Producers that feed kitchen waste must be registered, licensed and regularly inspected. Restricted access of visitors, particularly those who have regular access to agricultural sites or who have engaged in hunting activities. Cleaning and disinfection of equipment, vehicles, boots/shoes, pens, barns and other premises. Pig farm workers should not keep pigs of their own farms at home and not hunt wild/feral pigs. Provide change of footwear and clothing for workers at the farm entrance. Adequate ablution facilities for workers. Dedicated area for workers to consume food, and no food to be taken into pig barns. Safe method for waste disposal. Forbidden or at least regulated swill feeding. If any equipment is shared with pig-keeping neighbours, it should be thoroughly cleaned and disinfected before coming into contact with the pigs. New pigs should come from trusted sources and be isolated before introduction to the rest of the herd during at least 15 days. Minimize and regulated home based slaughtering to ensure minimal biosecurity practices (the less blood and lymphoid tissues in the environment the better). Control of insects, ticks, or flies that could serve as biological or mechanical vectors. Control rodents and vermin. In countries where live/wet markets exist, they should be regulated, with regular cleaning and disinfection.

Once the disease has been introduced in the country, there are additional measures that will prevent further spread:

- Quick and safe collection and disposal of carcasses of dead pigs pigs (Miller *et al.*, 2020).
- Prevention of spread between domestic and wild /feral pigs and vice versa.
- Surveillance in wild/feral pigs through cooperation with wildlife keepers, foresters, hunters.
- Biosecurity measures to limit contact between domestic and feral/wild pigs (double fencing, electric fencing odour fencing).
- Wild/feral pigs population management (FAO, OIE and EC., 2019).
- Quick and biosecure collection and disposal of carcasses and internal organs of feral, and wild pigs/boar.
- Government and private sector initiative to buy out pigs from households with low biosecurity production systems and agreement with farmers to refrain from pig keeping. It could be possible at the condition that compensation is provided to farmers and alternative sources of income and food are provided.

DIAGNOSTICS

Early detection of an ASF outbreaks is essential. In many countries, like in the recent introductions in the Americas, there has been a delay of weeks to months from the first case until official diagnosis. This delay allowed the virus to spread, hindering preventive and control efforts and reducing the likelihood of eliminating the virus.

A laboratory diagnostic algorithm (FAO, 2020) based on OIE recommendations was developed by the Australian Centre for Disease Preparedness (ACDP, formerly the Australian Animal Health Laboratories) (FAO, 2020). Three categories of guidance for the laboratory testing of pig samples for the presence of ASF virus are provided: i) overview of primers and probes; ii) PCR protocols; and iii) surveillance laboratory flow chart.

In resource-limited settings both in the field and in basic laboratories, a portable real-time PCR machine and an insulated isothermal PCR (iiPCR) have been tested and validated for the rapid diagnosis of ASF and proved to have similar sensitivity as real-time PCR.

DISEASE CONTROL

ASF control approaches need to consider the epidemiological situation, prevailing biosecurity and husbandry practices in pig production, the whole pig and pork value chain, as well as available resources of governments and farmers. Recent experiences in Europe and Asia suggest that a "one-size-fits-all" approach to ASF control has very limited impact and can even be counterproductive (Busch *et al.*, 2021).

Early detection and early response are crucial for achieving eradication or at least effective control with limited socio-economic impact of the disease. In countries with high pig density, large numbers of small and medium scale independent farmers, and weak biosecurity, it may not be possible to eliminate the virus once introduced.

Risk-based control programmes are based on the following principles:

1) To prevent contact between ASFV and susceptible hosts (i.e. domestic and wild swine): through quarantine, movement control, and biosecurity measures that include prevention of contacts between domestic pigs (as well as its carcasses) and wild/feral pigs.

2) Stop the multiplication of ASFV within infected groups of pigs (sheds or whole farms) through within-farm biosecurity measures, and depopulation and disposal of infected and potentially infected swine with prioritization based on diagnostic testing and epidemiological information that can increase effectiveness.
3) Prevent establishment of ASFV in wild/feral pigs. As the European and Asian experience has shown, once ASFV has been introduced into the wild boar/feral pig population there is a high risk of sustained transmission among wild pigs. An early warning programme, with awareness raising and education modules for hunters, game keepers, foresters and veterinarians, is an important element for early detection and early response. The legal and logistical arrangements should be foreseen (made) prior to introduction of ASFV into wild/feral pigs in terms of biosecurity during and after hunting, facilities for ASFV testing of hunted trophies and for collection and disposal of contaminated carcasses, offal and wastes.
4) Stop the transmission of ASFV by vectors and blood-sucking insects that can mechanically spread ASF virus within herds.

Public-private partnership (OIE and FAO, 2021) support, and international assistance, should be mobilized in countries or territories with poor or limited resources to address challenges related to prevention and control, and to decrease the overall impact. Elimination may be possible in individual farms, groups of farms, compartments, and/or zones. Experiences from several countries (e.g. South Africa, Kenya, Philippines and Thailand) have shown that the private sector (especially large integrated producers, feed factories companies and breeding companies) can offer valuable support during emergency response. Policies implemented to control and eradicate a disease will be greatly influenced, at least initially, by the spread and severity of the initial ASFV incursion before its first detection, the biosecurity level of the pig production sector and the pork value chain, and capacities of the government and the private sector to prevent and control ASF. Large integrated producers in affected countries have developed their own sophisticated systems for early detection and management of the disease. In some cases, they have been successful in implementing selective rather than whole-herd culling.

The effectiveness of ASF control and eradication are based on many aspects and factors with major ones being:

i) the timeliness of the detection and response, for example if the introduction of ASFV is detected rapidly and control is immediately and effectively implemented, the virus can be quickly confined to limited areas as opposed to delayed detection resulting in large areas of the country affected by ASF;
ii) location and characteristics of the susceptible population and pork value chain, including the location with presence or absence geographical barriers, density of domestic pigs and the level of biosecurity implemented (noting that this may be variable within a country for example between commercial farms and small holders, or between official abattoirs and home-based/unofficial slaughter points); the abundance of wild/feral pigs must also be considered as well as the potential for contact between wild and domestic pigs;
iii) capacity of government veterinary services and other competent authorities to implement timely and effective control including:

- surveillance, diagnostics, bloodless culling of pigs, disposal of carcasses and disinfection of premises, compensation, quarantine, movement control, tracing back and forward, and zoning;
- emergency preparedness/contingency plans should be regularly tested through simulation exercises, drills and backed by technical and financial resources; and
- the effectiveness of control is also influenced by the level of trust and cooperation among government authorities and farmers, veterinary practitioners, butchers/packers, dealers, hunters and all stakeholders along pig/pork value chain, which will be formed from previous experience with transboundary animal diseases control (FMD, CSF, PRRS, PED, etc).

iv) capacity of private sector to control ASF:

- importance of commercial pig sector versus smallholders;
- capacity of the pork industry to address ASF control;
- capacity of farmers communities and their engagement in ASF control; and
- presence of public-private partnership and level of engagement in transboundary animal disease prevention and control.

DISCUSSION

African swine fever is an emerging disease threat for countries of the Americas. Despite recent awareness campaigns, many veterinarians, farmers, butchers, dealers, packers, hunters, international travellers and other stakeholders still lack knowledge of ASF clinical signs and effective risk mitigation measures.

Many countries and territories do not have sufficient laboratory diagnostic capacity for rapid and accurate implementation of ASF diagnostic tests, and this was aggravated by the COVID-19 pandemic. Farmers often do not report suspected cases in the absence of compensation or insurance after the detection and destruction of their animals resulted in delay detection of ASFV introduction and consequently response to outbreaks, hence facilitating further spread of the virus.

Presence of low input production systems with limited investment in biosecurity, housing, cleaning and disinfection, and feeding of pigs, pose considerable challenges for disease prevention and control, although rigorous application of a few core measures can usually prevent animals from being exposed to the virus. Free ranging/scavenging pigs, and the use of kitchen waste containing pork products for feeding of pigs, are common practices among backyard farmers. Lack of efficiently regulated and biosecure production and market chains of pigs and pork, in the absence of traceability and certification processes can lead to rapid ASFV spread, domestically and beyond borders. At the same time, the commercial, high-input production that has been developing dynamically in many countries across the Americas is now threatened by ASF.

The lack of funding and absence of regulations for timely and fair compensation to farmers for culled animals is another serious challenge. Stamping out infected pigs without fair and timely compensation may lead to a situation observed in many countries, where farmers quickly sell their sick pigs or infected pork products at a discounted price, resulting in the subsequent spread of the virus through the value chains. Prevailing low capacity for

carcass disposal leads to the situation where farmers dispose of dead pigs in rivers or in the sea, contaminating the water and the environment, therefore exposing other susceptible hosts in the surroundings. Waste that may contain infected products is often disposed in non-regulated or open dump sites, where wild boar and scavenging pigs have easy access.

African swine fever virus re-emerged in the region 40 years after its eradication. During these years many changes occurred, including: increased domestic pigs' inventories and abundance of invasive susceptible species of wild boar as well as feral pigs; pork value chain became more complex with long distance global networking of genetic and feed supply; and the intensified mobility of people and trade. These transformations would complicate ASF control in the region. The conventional control approaches based on stamping out, disposal cleaning and disinfection and movement control might not be sufficient. Governments needs to provide alternate sources of livelihoods for pig raising farmers and other ASF affected stakeholders through consensus building approaches.

Currently no effective vaccines are available. Vaccine development has been hindered by large gaps in knowledge concerning aspects of ASFV infection and immunity, the extent of ASFV strain variation, and the viral proteins responsible for inducing protective immune responses in the pig. Promising experimental vaccine candidates are available and at various stages of safety and efficacy testing. More efforts are required to speed up development and authorization of ASF vaccines. Innovations and technologies for biosecurity in pig production and pork value chain, lab diagnostics, early detection of the disease needs to be adopted and practiced. Continuous and high level of awareness and communication are to be maintained for early warning, early detection and early response to ASF.

FAO and the OIE developed the six-year Global Control of ASF Initiative under the umbrella of the GF-TADs. The Global Initiative and the associated two-year operation plan are published in the ASF section of the GF-TADs website where additional information is regularly added and updated.

FAO and its partners remain available to member countries for technical advice and capacity development to address the ASF challenge.

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Annexes

Annex 1

Estimated national domestic pig populations of countries and territories targeted by the risk assessment

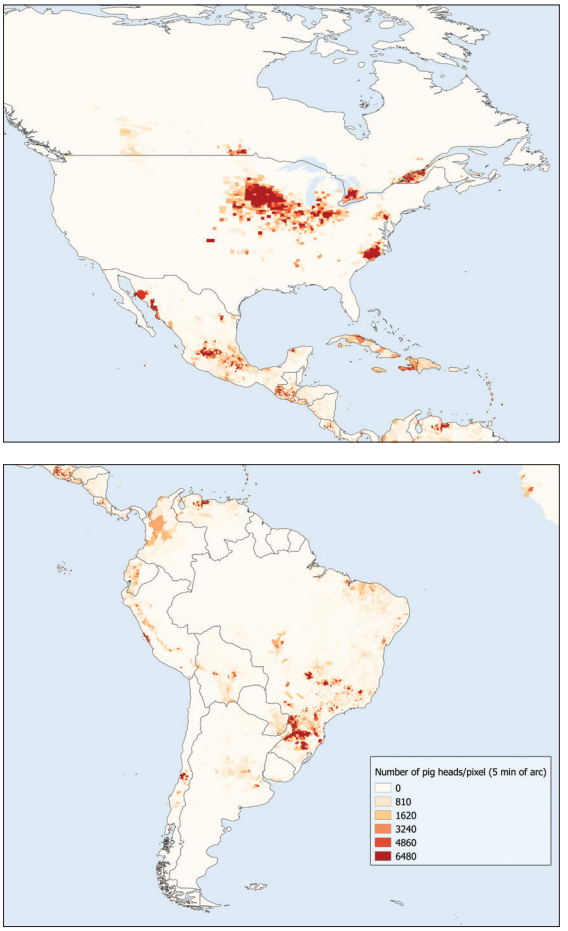
Country/territory	Estimates of domestic pig population in heads	Country/territory	Estimates of domestic pig population in heads
United States of America	78 657 600	**Suriname**	33 577
Brazil	40 556 892	**Belize**	24 258
Mexico	18 365 289	**Barbados**	23 315
Canada	14 399 339	**Trinidad and Tobago**	20 071
Argentina	5 128 954	**Guadeloupe**	15 000
Colombia	4 080 738	**Saint Lucia**	14 349
Peru	3 258 928	**Martinique**	11 000
Bolivia (Plurinational State of)	3 103 898	**Guyana**	9 994
Guatemala	2 976 244	**Saint Kitts and Nevis**	7 750
Venezuela (Bolivarian Republic of)	2 902 919	**Saint Vincent and the Grenadines**	5 880
Chile	2 566 782	**Dominica**	5 073
Cuba	2 369 459	**Antigua and Barbuda**	5 038
Paraguay	1 332 224	**Bahamas**	5 027
Ecuador	1 162 685	**French Guyana**	4 123
Haiti	1 016 836	**Curaçao**	3 000
Nicaragua	524 223	**Grenada**	2 885
Costa Rica	493 000	**Barbados**	~2 000
Dominican Republic	491 746	**United States Virgin Islands**	~1 700
Honduras	464 761	**Cayman Islands**	~1 000
Panama	354 500	**Bonaire**	~1 000
Jamaica	216 135	**Saint Martin**	~1 000
Uruguay	127 660	**Aruba**	<1 000
El Salvador	94 276	**Sint Eustatius**	<1 000
Puerto Rico	45 102	**Turks and Caicos Islands**	<100

Source: Questionnaire answers, FAOSTAT; other country/territory official census.

Annex 2

Distribution of domestic pigs in the Americas in 2010

Distribution of pigs is expressed in total number of pigs per pixel (5 min of arc – about 8.3 km at the Equator level) according to the Gridded Livestock of the World database (GLW 3)



Source: adapted from Gilbert *et al.*, 2018.

Note: Extreme North part of Canada and Alaska are not showing for layout purposes, however no domestic pig data is available and/or no live domestic pigs are present in those regions.

Annex 3

Self-evaluation scores of countries and territories regarding aspects of preparedness for ASF control and prevention

Each aspect was ranging from 1 to 3 (poorly, moderately, or highly prepared), and scores of the different aspects were summed up on a total of 15.

	Preparedness in terms of provisions for…					
Country/territory	Laboratory diagnosis	Quarantine and movement control	Stamping out	Carcasses disposal	Affected premises cleaning and disinfection	Total score out of a maximum of 15
United States of America	3	3	3	3	3	15
Mexico	3	3	3	3	3	15
Chile	3	3	3	3	3	15
Paraguay	3	2	3	3	3	14
Cuba	2	3	3	3	3	14
Brazil	3	3	2	3	3	14
Colombia	3	2	3	2	3	13
Panama	3	3	2	2	3	13
French Guyana	3	1	3	3	3	13
Bonaire	3	2	2	3	1	11
Jamaica	1	2	3	2	3	11
Peru	3	2	2	2	2	11
Costa Rica	3	2	2	2	2	11
Guadeloupe	3	2	2	2	2	11
Martinique	2	2	2	2	3	11
Dominica	2	2	2	2	2	10
Trinidad and Tobago	2	2	2	2	2	10
Uruguay	1	3	2	2	2	10
Nicaragua	2	2	2	2	2	10
Honduras	2	2	2	2	2	10
Saint Vincent and the Grenadines	2	2	1	1	3	9
Curaçao	1	2	1	3	2	9
Ecuador	2	2	1	1	3	9
Puerto Rico	2	3	1	1	2	9

(Cont.)

	Preparedness in terms of provisions for…					
Country/territory	**Laboratory diagnosis**	**Quarantine and movement control**	**Stamping out**	**Carcasses disposal**	**Affected premises cleaning and disinfection**	**Total score out of a maximum of 15**
Barbados	1	2	1	2	2	8
British Virgin Islands	1	2	2	1	2	8
Venezuela (Bolivarian Republic of)	1	2	1	1	3	8
Suriname	2	1	1	1	2	7
Aruba	2	1	1	2	1	7
Saint Martin	2	1	2	1	1	7
El Salvador	1	1	1	1	2	6
Cayman Islands	1	1	1	1	2	6
Turks and Caicos Islands	1	1	1	1	1	5
Sint Eustatius	1	1	1	1	1	5
Saint Lucia	1	1	1	1	1	5

Annex 4
Likelihood estimates per country/territory and risk pathway addressed

Country/territory	Pathways				
	Introduction through informal live pig importation	Introduction through informal importations of pork products	Introduction through food waste	Introduction through fomites	Introduction through importation of feed of animal origin
Cuba	Low to moderate	Moderate	Moderate	Moderate	Low
Jamaica	Low to moderate	Moderate	Moderate	Moderate	Low
Puerto Rico	Low to moderate	Moderate	Moderate	Moderate	Low
Aruba	Negligible to very low	Moderate	Moderate	Moderate	Low
Bonaire	Negligible to very low	Moderate	Moderate	Moderate	Low
Colombia	Negligible to very low	Moderate	Moderate	Moderate	Negligible to low
Curaçao	Negligible to very low	Moderate	Moderate	Moderate	Low
Mexico	Negligible to very low	Moderate	Moderate	Moderate	Negligible to low
Panama	Negligible to very low	Moderate	Moderate	Moderate	Negligible to low
Turks and Caicos Islands	Negligible to very low	Moderate	Moderate	Moderate	Low
Venezuela (Bolivarian Republic of)	Negligible to very low	Moderate	Moderate	Moderate	Negligible to low
United States of America	Negligible to very low	Moderate	Low	Moderate	Negligible to low
Argentina	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Bolivia (the Plurinational State of)	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Brazil	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Chile	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Costa Rica	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Dominica	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Ecuador	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
El Salvador	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Guadeloupe	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Guatemala	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Honduras	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Martinique	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low

(Cont.)

Country/territory	Pathways				
	Introduction through informal live pig importation	Introduction through informal importations of pork products	Introduction through food waste	Introduction through fomites	Introduction through importation of feed of animal origin
Nicaragua	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Paraguay	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Peru	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Belize	Negligible to very low	Low to moderate	Low	Low	Negligible to low
French Guyana	Negligible to very low	Low to moderate	Low	Low	Negligible to low
Guyana	Negligible to very low	Low to moderate	Low	Low	Negligible to low
Saint Lucia	Negligible to very low	Low to moderate	Low	Low	Negligible to low
Suriname	Negligible to very low	Low to moderate	Low	Low	Negligible to low
Trinidad and Tobago	Negligible to very low	Low to moderate	Low	Low	Negligible to low
Uruguay	Negligible to very low	Low to moderate	Low	Moderate	Negligible to low
Anguilla	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Antigua and Barbuda	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Bahamas	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Barbados	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
British Virgin Islands	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Canada	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Cayman Islands	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Grenada	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Montserrat	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Saba	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Saint Barthélemy	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Saint Kitts and Nevis	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Saint Martin	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Saint Vincent and the Grenadines	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Sint Eustatius	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
Sint Maarten	Negligible to very low	Very low to low	Very low	Very low	Negligible to low
United States Virgin Islands	Negligible to very low	Very low to low	Very low	Very low	Negligible to low

Note: Likelihood levels for entry of ASF virus through formal importations of live pigs and pork products (i.e. negligible to very low for all countries/territories), and formal and informal importations of pig genetic materials (i.e. negligible for all countries and territories) are not shown in the table.

FAO TECHNICAL PAPERS
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1 Animal breeding: selected articles from the *World Animal Review*, 1977 (En, Fr, Es, Zh)
2 Eradication of hog cholera and African swine fever, 1976 (En, Fr, Es)
3 Insecticides and application equipment for tsetse control, 1977 (En, Fr)
4 New feed resources, 1977 (En/Fr/Es)
5 Bibliography of the criollo cattle of the Americas, 1977 (En/Es)
6 Mediterranean cattle and sheep in crossbreeding, 1977 (En, Fr)
7 The environmental impact of tsetse control operations, 1977 (En, Fr)
7 Rev.1 The environmental impact of tsetse control operations, 1980 (En, Fr)
8 Declining breeds of Mediterranean sheep, 1978 (En, Fr)
9 Slaughterhouse and slaughterslab design and construction, 1978 (En, Fr, Es)
10 Treating straw for animal feeding, 1978 (En, Fr, Es, Zh)
11 Packaging, storage and distribution of processed milk, 1978 (En)
12 Ruminant nutrition: selected articles from the *World Animal Review*, 1978 (En, Fr, Es, Zh)
13 Buffalo reproduction and artificial insemination, 1979 (En*)
14 The African trypanosomiases, 1979 (En, Fr)
15 Establishment of dairy training centres, 1979 (En)
16 Open yard housing for young cattle, 1981 (Ar, En, Fr, Es)
17 Prolific tropical sheep, 1980 (En, Fr, Es)
18 Feed from animal wastes: state of knowledge, 1980 (En, Zh)
19 East Coast fever and related tick-borne diseases, 1980 (En)
20/1 Trypanotolerant livestock in West and Central Africa – Vol. 1. General study, 1980 (En, Fr)
20/2 Trypanotolerant livestock in West and Central Africa – Vol. 2. Country studies, 1980 (En, Fr)
20/3 Le bétail trypanotolérant en Afrique occidentale et centrale – Vol. 3. Bilan d'une décennie, 1988 (Fr)
21 Guideline for dairy accounting, 1980 (En)
22 Recursos genéticos animales en América Latina, 1981 (Es)
23 Disease control in semen and embryos, 1981 (En, Fr, Es, Zh)
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27 Deer farming, 1982 (En)
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29 Echinococcosis/hydatidosis surveillance, prevention and control: FAO/UNEP/WHO guidelines, 1982 (En)
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31 Hormones in animal production, 1982 (En)
32 Crop residues and agro-industrial by-products in animal feeding, 1982 (En/Fr)
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34 Breeding plans for ruminant livestock in the tropics, 1982 (En, Fr, Es)
35 Off-tastes in raw and reconstituted milk, 1983 (Ar, En, Fr, Es)
36 Ticks and tick-borne diseases: selected articles from the *World Animal Review*, 1983 (En, Fr, Es)
37 African animal trypanosomiasis: selected articles from the *World Animal Review*, 1983 (En, Fr)
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44/1 Animal genetic resources conservation by management, data banks and training, 1984 (En)
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47 Réfrigération du lait à la ferme et organisation des transports, 1985 (Fr)
48 La fromagerie et les variétés de fromages du bassin méditerranéen, 1985 (Fr)
49 Manual for the slaughter of small ruminants in developing countries, 1985 (En)
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50/2 Better utilization of crop residues and by-products in animal feeding: research guidelines – 2. A practical manual for research workers, 1986 (En)
51 Dried salted meats: charque and carne-de-sol, 1985 (En)
52 Small-scale sausage production, 1985 (En)
53 Slaughterhouse cleaning and sanitation, 1985 (En)
54 Small ruminants in the Near East – Vol. I. Selected papers presented for the Expert Consultation on Small Ruminant Research and Development in the Near East (Tunis, 1985), 1987 (En)
55 Small ruminants in the Near East – Vol. II. Selected articles from *World Animal Review* 1972-1986, 1987 (Ar, En)
56 Sheep and goats in Pakistan, 1985 (En)
57 The Awassi sheep with special reference to the improved dairy type, 1985 (En)
58 Small ruminant production in the developing countries, 1986 (En)
59/1 Animal genetic resources data banks – 1. Computer systems study for regional data banks, 1986 (En)
59/2 Animal genetic resources data banks – 2. Descriptor lists for cattle, buffalo, pigs, sheep and goats, 1986 (En, Fr, Es)
59/3 Animal genetic resources data banks – 3. Descriptor lists for poultry, 1986 (En, Fr, Es)
60 Sheep and goats in Turkey, 1986 (En)
61 The Przewalski horse and restoration to its natural habitat in Mongolia, 1986 (En)
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63 Proceedings of the FAO expert consultation on the substitution of imported concentrate feeds in animal production systems in developing countries, 1987 (En, Zh)
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67/1 Trypanotolerant cattle and livestock development in West and Central Africa – Vol. I, 1987 (En)
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68 Crossbreeding *Bos indicus* and *Bos taurus* for milk production in the tropics, 1987 (En)
69 Village milk processing, 1988 (En, Fr, Es)
70 Sheep and goat meat production in the humid tropics of West Africa, 1989 (En/Fr)
71 The development of village-based sheep production in West Africa, 1988 (Ar, En, Fr, Es) (Published as Training manual for extension workers, M/S5840E)
72 Sugarcane as feed, 1988 (En/Es)
73 Standard design for small-scale modular slaughterhouses, 1988 (En)

74 Small ruminants in the Near East – Vol. III. North Africa, 1989 (En)
75 The eradication of ticks, 1989 (En/Es)
76 Ex situ cryoconservation of genomes and genes of endangered cattle breeds by means of modern biotechnological methods, 1989 (En)
77 Training manual for embryo transfer in cattle, 1991 (En)
78 Milking, milk production hygiene and udder health, 1989 (En)
79 Manual of simple methods of meat preservation, 1990 (En)
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81 Veterinary diagnostic bacteriology – a manual of laboratory procedures of selected diseases of livestock, 1990 (En, Fr)
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83 Training manual on artificial insemination in sheep and goats, 1991 (En, Fr)
84 Training manual for embryo transfer in water buffaloes, 1991 (En)
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100 Programme for the control of African animal trypanosomiasis and related development, 1992 (En)
101 Genetic improvement of hair sheep in the tropics, 1992 (En)
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104 The management of global animal genetic resources, 1992 (En)
105 Sustainable livestock production in the mountain agro-ecosystem of Nepal, 1992 (En)
106 Sustainable animal production from small farm systems in South-East Asia, 1993 (En)
107 Strategies for sustainable animal agriculture in developing countries, 1993 (En, Fr)
108 Evaluation of breeds and crosses of domestic animals, 1993 (En)
109 Bovine spongiform encephalopathy, 1993 (Ar, En)
110 L'amélioration génétique des bovins en Afrique de l'Ouest, 1993 (Fr)
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113 The technology of making cheese from camel milk (*Camelus dromedarius*), 2001 (En, Fr)
114 Food losses due to non-infectious and production diseases in developing countries, 1993 (En)

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117 L'hygiène dans l'industrie alimentaire, 1993 – Les produits et l'aplication de l'hygiène, 1993 (Fr)
118 Quality control testing of rinderpest cell culture vaccine, 1994 (En)
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120 Manual para la instalación del pequeño matadero modular de la FAO, 1994 (Es)
121 A systematic approach to tsetse and trypanosomiasis control, 1994 (En/Fr)
122 El capibara (*Hydrochoerus hydrochaeris*) – Estado actual de su producción, 1994 (Es)
123 Edible by-products of slaughter animals, 1995 (En, Es)
124 L'approvisionnement des villes africaines en lait et produits laitiers, 1995 (F)
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127 World livestock production systems – Current status, issues and trends, 1996 (En)
128 Quality control testing of contagious bovine pleuropneumonia live attenuated vaccine – Standard operating procedures, 1996 (En, Fr)
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130 Manual de prácticas de manejo de alpacas y llamas, 1996 (Es)
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133 Prevention and control of transboundary animal diseases, 1997 (E)
134 Tratamiento y utilización de residuos de origen animal, pesquero y alimenticio en la alimentación animal, 1997 (Es)
135 Roughage utilization in warm climates, 1997 (En, Fr)
136 Proceedings of the first Internet Conference on Salivarian Trypanosomes, 1997 (En)
137 Developing national emergency prevention systems for transboundary animal diseases, 1997 (En)
138 Producción de cuyes (*Cavia porcellus*), 1997 (Es)
139 Tree foliage in ruminant nutrition, 1997 (En)
140/1 Analisis de sistemas de producción animal – Tomo 1: Las bases conceptuales, 1997 (Es)
140/2 Analisis de sistemas de producción animal – Tomo 2: Las herramientas basicas, 1997 (Es)
141 Biological control of gastro-intestinal nematodes of ruminants using predacious fungi, 1998 (En)
142 Village chicken production systems in rural Africa – Household food security and gender issues, 1998 (En)
143 Agroforestería para la producción animal en América Latina, 1999 (Es)
144 Ostrich production systems, 1999 (En)
145 New technologies in the fight against transboundary animal diseases, 1999 (En)
146 El burro como animal de trabajo – Manual de capacitación, 2000 (Es)
147 Mulberry for animal production, 2001 (En)
148 Los cerdos locales en los sistemas tradicionales de producción, 2001 (Es)
149 Animal production based on crop residues – Chinese experiences, 2001 (En, Zh)
150 Pastoralism in the new millennium, 2001 (En)
151 Livestock keeping in urban areas – A review of traditional technologies based on literature and field experiences, 2001 (En)
152 Mixed crop-livestock farming – A review of traditional technologies based on literature and field experiences, 2001 (En)
153 Improved animal health for poverty reduction and sustainable livelihoods, 2002 (En)

154 Goose production, 2002 (En, Fr)
155 Agroforestería para la producción animal en América Latina – II, 2003 (Es)
156 Guidelines for coordinated human and animal brucellosis surveillance, 2003 (En)
157 Resistencia a los antiparasitarios – Estado actual con énfasis en América Latina, 2003 (Es)
158 Employment generation through small-scale dairy marketing and processing, 2003 (En)
159 Good practices in planning and management of integrated commercial poultry production in South Asia, 2003 (En)
160 Assessing quality and safety of animal feeds, 2004 (En, Zh)
161 FAO technology review: Newcastle disease, 2004 (En)
162 Uso de antimicrobianos en animales de consumo – Incidencia del desarrollo de resistencias en la salud pública, 2004 (Es)
163 HIV infections and zoonoses, 2004 (En, Fr, Es)
164 Feed supplementation blocks – Urea-molasses multinutrient blocks: simple and effective feed supplement technology for ruminant agriculture, 2007 (En)
165 Biosecurity for Highly Pathogenic Avian Influenza – Issues and options, 2008 (En, Fr, Ar, Vi)
166 International trade in wild birds, and related bird movements, in Latin America and the Caribbean, 2009 (Es[e] En[e])
167 Livestock keepers – guardians of biodiversity, 2009 (En)
168 Adding value to livestock diversity – Marketing to promote local breeds and improve livelihoods, 2010 (En, Fr, Es)
169 Good practices for biosecurity in the pig sector – Issues and options in developing and transition countries, 2010 (En, Fr, Zh, Ru** Es**)
170 La salud pública veterinaria en situaciones de desastres naturales y provocados, 2010 (Es)
171 Approaches to controlling, preventing and eliminating H5N1 HPAI in endemic countries, 2011 (En, Ar)
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174 Invisible Guardians - Women manage livestock diversity, 2012 (En)
175 Enhancing animal welfare and farmer income through strategic animal feeding – Some case studies, 2013 (En)
176 Lessons from HPAI – A technical stocktaking of coutputs, outcomes, best practices and lessons learned from the fight against highly pathogenic avian influenza in Asia 2005–2011, 2013 (En)
177 Mitigation of greenhouse gas emissions in livestock production – A review of technical options for non-CO_2 emissions, 2013 (En, Es[e])
178 Африканская Чума Свиней в Российской Федерации (2007-2012), 2014 (Ru)
179 Probiotics in animal nutrition – Production, impact and regulation, 2016 (En)
180 Control of Contagious Bovine Pleuropneumonia – A policy for coordinated actions, 2018 (En, Zh**)
181 Exposure of humans or animals to SARS-CoV-2 from wild, livestock,companion and aquatic animals. Qualitative exposure assessment, 2020 (En)
182 The economics of pastoralism in Argentina, Chad and Mongolia. Market participation and multiple livelihood strategies in a shock-prone environment, 2020 (En)
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Following the re-introduction of the African swine fever virus (ASFV) in the Americas after 40 years of absence, FAO conducted a qualitative risk assessment for the likelihood of entry of ASF from the Dominican Republic and Haiti to unaffected countries and territories of the Americas and the likelihood of exposure to susceptible animal populations should the disease be introduced. In addition, the potential economic and social impact of ASFV spreading across the continent was assessed. The risk assessment covers the period of December 2021 to February 2022 and considered six risk pathways of introduction and spread. The methodology, information used and results of the risk assessment and economic impact assessment are available in this publication along with recommendations for prevention and control of ASFV introduction and spread in the region. In addition, the publication compiles information collected from 35 countries/territories in the Americas through a questionnaire and presents evidence on the complex swine/pork value chains in the region retrieved from various sources.

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