# Mapping the pig value chain in the Dominican Republic with emphasis on the risk of transmission of African swine fever

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Swedish University of Agricultural Sciences, SLU
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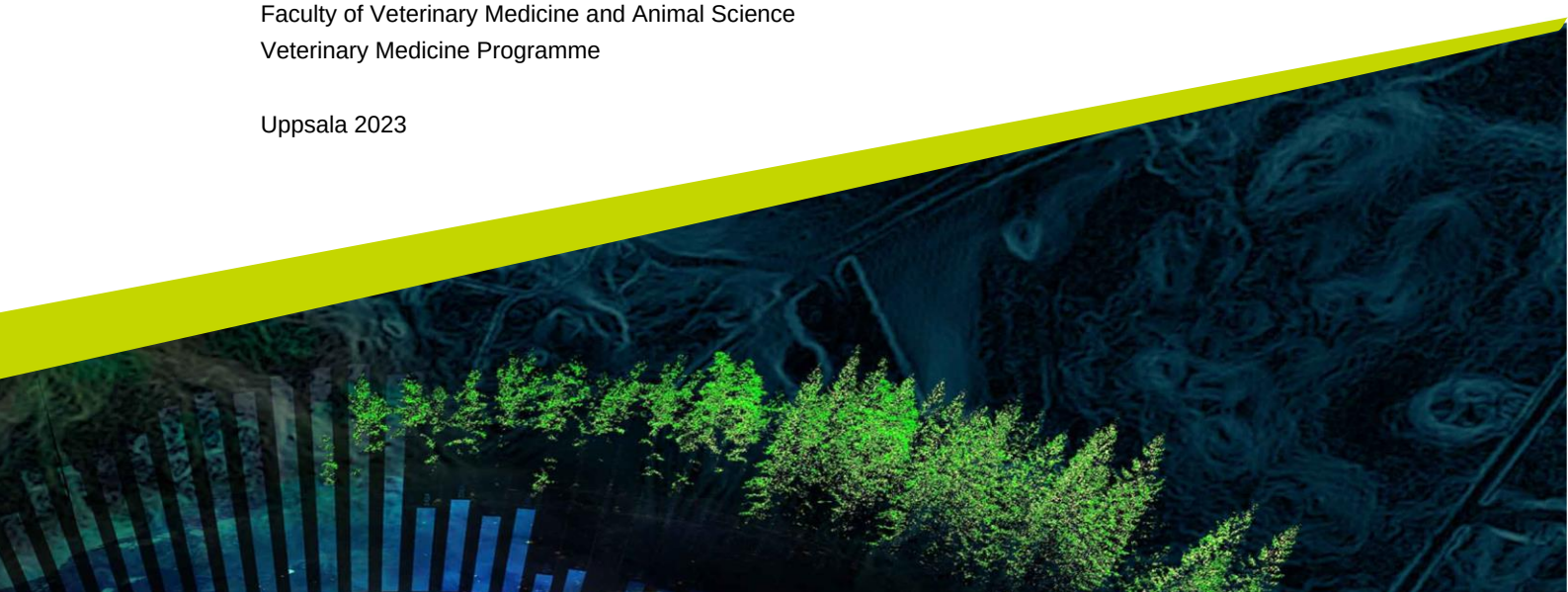

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## Abstract

As in many other parts of the world, pigs provide an important source of food and income in the Dominican Republic (DR). However, the pig production in the country faces great challenges since African swine fever (ASF) was reintroduced in 2021, after being absent for over 40 years.

ASF causes a severe hemorrhagic fever with high lethality in domestic pigs *Sus scrofa domesticus)* and European wild boars (*Sus scrofa).* ASF outbreaks are often associated with human activities and movement of pigs. Today no comprehensive overview is available for the pig production, including the movement of pigs, in DR. Therefore, this study aims to map the pork value chain to increase the know-ledge and understanding about how pigs and pork products move within the country. The study consisted of individual and group interviews at five different locations, mainly in the central and eastern parts of the country.

The results show that many different actors are involved in an intricate system which forms the pork value chain. Many farmers breed their own pigs and sell them to other actors such as slaughterhouses, markets, and middlemen. This often results in pigs travelling into other areas of the country and due to lack of animal identification it is hard to trace pigs and pork back to the origin. In case of an outbreak of ASF many actors seem to hesitate before contacting the authorities which may make the mapping of diseases such as ASF difficult.

*Keywords:* African swine fever, Domestic pig, Value chain mapping, Pig production, Biosecurity, Disease risk

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# 1. Introduction

In 1921 Eustace Montgomery described African swine fever (ASF) for the very first time from what we today know as Kenya. He pictured a severe hemorrhagic fever with high mortality that affected members of the family *Suidae* (Montgomery 1921).

Since then, ASF has spread over most parts of Sub-Saharan Africa and recently also to many countries in Europe, Asia, and last year to the Americas. ASF causes enormous consequences economically as well as socially for the farmers and the pig sector (Dixon *et al.* 2019b; Brown *et al.* 2021; Gonzales *et al.* 2021). In 2018, China, one of the world's biggest pig producers, was hit by ASF. This led to a decrease of 28% in number of pig herds and a production loss of 21%. In Vietnam, the introduction of ASF in 2019 meant a 30% decrease in pig herds and a reduction of 13% in pig production (Rozstalnyy 2022). Similar scenarios of the devastating effects of the introduction of ASF have been seen in other countries, for example Russia (Callaway 2012).

The Dominican Republic (DR) in the Caribbean had been free from ASF since the 1980s when the new outbreak hit the country in 2021. This was also the first outbreak in an equally long time in the Americas which means that ASF now has spread to four continents. This geographical expansion further means an even bigger threat to the global pig industry (Gonzales *et al.* 2021).

So far, no treatment or efficient and safe vaccine is commercially available, which calls for other disease control measures. For these to be effective, a profound understanding of local disease ecology and epidemiology is crucial. One key element in such understanding is the value chain. Understanding how pigs and pork products move, as well as the livelihood situation of stakeholders is paramount for adapting and thus optimizing the implementation and impact of control measures (Niemi *et al.* 2020; Shyaka *et al.* 2022).

Unfortunately, a comprehensive overview of the pork value chain in DR is lacking. As one step towards improving the understanding of the movement of pigs and pork products, this study aimed to investigate and map the pork value chain.

# 2. Literature review

## 2.1 African swine fever virus

ASF is caused by the African swine fever virus (ASFV), the only member of the family *Asfarviridae*, a large double-stranded DNA virus with a quite complex structure, including both an internal and an external envelope (Alonso *et al.* 2018). Currently, 24 genotypes and 8 serogroups of ASFV are known based on the p-72-protein sequence. Being able to classify the virus allows identification of the origin when introduced into a new area or country (Qu *et al.* 2022).

The main target cells for ASFV are macrophages and monocytes but the virus is able to replicate in all types of cells within the mononuclear-phagocytic system and cause viremia (Pikalo *et al.* 2019). The exact mechanisms of the interplay between virus and host however remain not fully understood (Dixon *et al.* 2019a; Li *et al.* 2022), and it seems to be several ways in which ASFV can evade host defense mechanisms. A natural infection will trigger production of antibodies, but infected pigs often die before the levels of antibodies are high enough to be protective, especially if the strain is highly virulent (Luong *et al.* 2022).

In a pig showing clinical signs of ASF, the virus is detectable in all body secretions and excretions as well as in tissues (Iacolina *et al.* 2021). The highest titers are usually found in blood, but also spleen, bone marrow, lymph nodes, lungs, kidneys, and liver, all of which contain a large component of the mononuclear-phagocytic system. Secretions such as oronasal discharge, genital fluids, and lachrymal secretion as well as excretions contain viruses in varying amounts.

ASFV is highly resistant especially if embedded in a protein-rich environment such as in blood, organs or meat (Iacolina *et al.* 2021). In these materials, the virus can remain viable and infectious for up to 1,000 days if frozen. In temperatures between 4-8 degrees, the virus can remain viable for 155 days in meat, and for 204 days in spleen tissue. In skin and fat, it can be viable for up to 300 days. This means that a carcass from an ASFV infected pig can remain a source of infection for other pigs or wild boar for a long time.

ASFV can further remain viable in a wide pH range (3.9-13.4) but becomes inactivated after 15 minutes at 60℃. Pork products processed by smoking, drying, or salting, where temperatures above 60℃ are not reached can contain viable virions. Dry-cured ham is an example of a product that is not processed in high temperatures and therefore can cause an outbreak if it is infected and fed to naïve pigs or wild boars. (Mazur-Panasiuk *et al.* 2019; Iacolina *et al.* 2021)

The shedding of the virus in secretions and excretions implies that ASFV can easily contaminate the environment which may act as a source of infection. ASFV in feces from affected pigs has proven to remain infectious for 8 days at 4 ℃ while urine might contain viable virus for up to 15 days at the same temperature. This entails a risk for pigs in the same herd or pen able to get in contact with the excretions. Fomites like clothes, shoes, and equipment as well as feed and water can easily get contaminated and have been shown to stay infectious for 30 days. This makes transmission to other pens, farms or even countries possible. (Davies *et al.* 2017; Mazur-Panasiuk *et al.* 2019)

## 2.2 Clinical signs and pathology

ASF is known for its high mortality but the disease is often associated with a broad range of symptoms depending on factors such as virulence, dose, route of infection and characteristics of the host (Salguero 2020). In most cases, the first clinical signs can be observed approximately four days post-infection, these include high fever ranging from 41 to 42℃, anorexia, somnolence, dyspnea, hemorrhages, cyanosis, ocular and nasal discharge, gastro-intestinal signs, central nervous signs and in pregnant sows' abortion (FAO n.d.). If peracute, the pig is often found dead prior to clinical symptoms whereas death often occurs within 4-21 days post-infection if the acute form (Blome *et al.* 2020). Low virulent strains can cause chronic forms showing low mortality and unspecific symptoms such as mild respiratory problems and joint swelling (Sánchez-Cordón *et al.* 2018).

The gross pathological findings in ASFV-infected individuals occur mainly due to widespread cell damage. The characteristic findings are strongly associated with destruction and malfunction of blood vessels, causing hemorrhagic splenomegaly, multifocal hemorrhagic lymphadenitis, petechial hemorrhages in the kidneys and other organs as well as pulmonary edema for example. If the pig dies peracutely no lesions are usually found *post mortem.* (Salguero 2020)

The symptoms and gross pathological findings described above are identical in domestic pigs and European wild boars. Meanwhile, wild African suids, such as bushpigs and warthogs do not show any clinical signs (Oura *et al.* 1998).

## 2.3 Diagnosis

Several serious pig diseases cause similar symptoms to ASF and clinically ASF cannot be differentiated from classical swine fever. Other differential diagnosis includes porcine reproductive and respiratory syndrome (PRRS), salmonellosis, leptospirosis, and poisonings. Laboratory diagnosis is needed for differential diagnosis. Samples that can be used for diagnosis are blood, serum, or tissues. (Oura *et al.* 2013)

Diagnosis of ASF can be done either by identification of the infectious agent (virus, virus genome or antigen) or antibodies. For identification of the infectious agent cell culture inoculation a haemadsorption test (HAD), fluorescent antibody test (FAT) or polymerase chain reaction (PCR) can be used. Enzyme-linked immunosorbent assay (ELISA) can be used for identifying antibodies. Antibody positive tests from an area free from ASF should be confirmed by either indirect fluorescent antibody (IFA) test, immunoblotting test or immunoperoxidase staining (WOAH n.d.-c). However, most of the pigs affected by ASFV die prior to developing antibodies.

## 2.4 Epidemiology

The epidemiology of ASF is complex and the epidemiological patterns vary between different context (Dixon *et al.* 2020).

### 2.4.1 Transmission routes

ASF is present in four different epidemiological cycles: the sylvatic cycle, the tick-pig cycle, the domestic pig cycle, and the wild boar-habitat cycle. Depending on the hosts present in the area different transmission routes are possible and the epidemiology thus varies between different countries and areas. Each epidemiological cycle is independent, but spillover in-between will occasionally occur. The absence of warthogs in the DR as well as in Asia and Europe makes the sylvatic transmission route non-existent in these locations.

*The sylvatic cycle*

The sylvatic transmission cycle includes warthogs and soft ticks of the genus *Ornithodoros* that co-habits the warthog burrows (Costard *et al.* 2013). If an adult warthog gets bitten by a tick, the virus will cause an infection but not viremia or clinical signs. However, if neonatal warthog piglets are bitten by an infected tick, they get a short viremia with titers high enough to infect naïve ticks. This is how the cycle continues. The viremia does not seem to be high enough to be able to infect domestic pigs directly (Thomson 1985). The ticks can carry ASFV for a long period of time without a new blood meal, acting as a virus reservoir. An infected tick is able to transmit the virus transsexually, transovarially and transstadially (Rennie *et al.* 2001; Dixon *et al.* 2020).

Other African native wild pigs such as bushpigs do not live in burrows and are thus not as exposed to the ticks as the warthogs (Thomson, 1985). Anderson *et al.* (1998) showed that bushpigs that had been experimentally infected could infect domestic pigs. Their role in the persistence of the virus as well as in the transmission of ASFV is however likely not epidemiologically important (Anderson *et al.* 1998; Ståhl *et al.* 2014).

*The tick-pig cycle*

*Ornithodoros* spp. that normally live their whole lives in warthog burrows may occasionally be transported by accident to farmed areas while parasitizing on an adult warthog. If transported into farmed areas the tick may inhabit places with similar conditions as the burrows such as pigsties surrounded by cracked wood. If an infected tick feeds on a domestic pig, transmission may occur and the pig will most likely become viraemic, show clinical signs and be able to spread the virus to other pigs as well as ticks. When transmission occurs like this, that is between ticks and domestic pigs, it is called the tick-pig cycle. (Jori *et al.* 2013)

In 1982, soft ticks of the genus *Ornithodoros* (*Ornithodoros puertoricensis)* were found in the DR for the first time. The ticks had until then been assumed absent because no ticks had been found during previous surveys. The tick lives in burrows made in the ground such as rat or burrowing owl nests. If allowed to feed on a pig infected by ASF, the tick has also been proven competent to transmit the virus (Butler *et al.* 1985). This may play a major role in the spread of AFSV and according to Golnar *et al.* (2019), *Ornithodoros puertoricensis* has a relatively high risk of being involved in ASFV transmission in the US. Unfortunately, not much research has been done in this area and more is needed.

*The domestic pig cycle*

In the third transmission route pigs get infected with ASFV without any involvement of vertebrate hosts or biological vectors. Instead, this cycle involves domestic pigs and pork products (Iacolina *et al.* 2021). Direct contact between domestic pigs with an oronasal infection route is important but transmission through indirect contact is equally important. This can be through contact with aerosols, saliva, feces, urine or with fomites, feed, soil, etc. contaminated by virus containing matter (Penrith & Vosloo 2009).

This is globally the most important route even in countries where soft ticks and warthogs exist (Jori *et al.* 2013), mainly because of anthropogenic factors such as the activities within the pork value chain. Humans are responsible for the long-distance spread both transboundary and transcontinental. This is mainly due to the transportation of infected pigs and pig products. When an infected pig or pork product ends up among susceptible pigs an outbreak may occur (La Roque *et al.* 2011; Chenais *et al.* 2019).

*Wild boar-habitat cycle*

The fourth transmission cycle includes Eurasian wild boar, wild boar-derived products and carcasses as well as their habitat (Chenais *et al.* 2019). When ASF gets introduced into a wild boar population the transmission route is characterized by direct transmission between infected and naïve wild boars as well as indirect via the habitat contaminated by ASFV. When a wild boar dies due to ASF the infected carcass will facilitate virus persistence over a long period of time through the carcass and contamination of the soil underneath. Naïve wild boars getting in contact with the carcass or the contaminated soil underneath poses a risk of getting infected and the cycle can start over (Chenais *et al.* 2018). Just like in the domestic pig cycle, anthropogenic factors affect certain aspects of transmission in this cycle, most notably new introduction to ASF-free areas.

An infected, but still alive, domestic pig can transmit the virus to susceptible wild boars or free ranging pigs. Most introductions from wild boars to pig herds has occurred via indirect transmission supported by human activities. (Iacolina *et al.* 2021)

### 2.4.2 History and distribution

ASF was described for the very first time in 1921 from what is today Kenya (Montgomery 1921). The article describes outbreaks of a disease in the eastern part of Africa with symptoms such as a sudden onset of sick animals showing high fever of 40 degrees Celsius or higher, difficulty walking, reduced general condition, refusing to eat, cyanosis and death.

In 1957, ASF was introduced to Europe for the first time in Lisbon, Portugal. The outbreak was successfully contained, but ASF reemerged in 1960. The virus (which was found to be of genotype I) then managed to spread from Portugal through Europe and across the Atlantic Ocean to Brazil, Haiti and Dominican Republic. During the 1990s the disease was yet again brought under control and restricted to Africa, apart from remaining endemic in Sardinia, Italy. (Costard *et al.* 2009)

ASFV genotype II was then confirmed in 2007 in Georgia in eastern Europe. From there the virus has spread gradually, first to the neighboring countries and from there to other European countries and later emerging in Asia and Oceania. In 2021 the Americas were struck and as of today 74 countries on 4 continents have reported cases of ASF since 2005. (WOAH n.d.-a)

## 2.5 Prevention and control

Development of a safe and efficient vaccine is an important tool to beat ASF. Over several years, not at least since the introduction of ASF to Europe and China, a lot of work has been done in the field of vaccine development (Bosch-Camós *et al.* 2020). A recent systematic review by Gladue and Borca (2022) summarizes current information about attenuated ASFV strains, regarded as the most promising vaccine candidate. They have shown to be efficacious against the highly virulent strain ASF genotype II currently spreading in mainly Europe and Asia. The lack of a vaccine and treatment makes medical prophylaxis impossible and other measures such as biosecurity becomes crucial to prevent further spread and control outbreaks.

Due to ASFV's ability to survive in many environments and spread in many ways, it can easily travel over long distances and into new areas and countries, especially with human assistance. Anthropogenic factors are what introduces ASF into new areas and prevention is possible by implementing strict and targeting biosecurity measures. These measures must include all actors throughout the whole pig value chain. (Penrith & Vosloo 2009)

Despite having a small number of animals, smallholder farming plays a major role in ASF epidemiology on a local level. Historically and globally most ASF transmission occurs in smallholder settings (Chenais *et al.* 2022). The biosecurity on these farms is often very low, lacking hygiene routines and practices concerning sick pigs and carcasses (Chenais 2017). Lack of knowledge, a low financial capacity and structural constraints are often reasons behind the low level of biosecurity (Lestari *et al.* 2022).

On a national level, border inspection can be used to prevent introduction into a country free of ASF by reducing the risk for legal and illegal importation of infected pork products and pigs as well as food waste (Rozstalnyy 2022). By awareness campaigns, it is also possible to increase the knowledge about ASF amongst people and reduce risky human behaviors such as leaving pork products in the nature, swill feeding, and uncontrolled pig trading (Dixon *et al.* 2020).

## 2.6 Impacts of African swine fever

ASF is not a direct threat to human health but has a devastating impact on pig populations as well as on the farming economy and pig farmers´ livelihoods. When ASF enters a country, not only the farmers and their animals are affected. The disease has an impact on society from farmers to national levels. Due to these negative impacts, ASF is a notifiable disease by the World Organization for animal health. (WOAH n.d.-b)

In addition to the direct negative effects of the disease, measures to control the disease and loss of status for international trade also contribute to the total impact (Berthe 2020).

Carriquiry *et al.* (2020) evaluated the economic impacts if ASF would enter the USA and spread to feral pigs. They presented a scenario with losses of over 50 billion dollars and 140,000 jobs if all of the export from the USA is eliminated for 10 years. The US accounts for about 98% of the imported pork to the DR as well as for 11% of the world´s pork supply. An introduction that involves trade restrictions would therefore have severe consequences not only for the DR but worldwide (Haines 2022).

In a study by Cooper *et al.* (2022), with focus on the impacts of ASF in the Philippines, the authors present a negative overall impact on society. Backyard farmers experienced significant losses while larger-scale farms often had a financial buffer able to absorb some of the financial shock. In this study, it also became apparent that some actors along the pork value chain in varying degrees even benefitted from ASF in a short term, mainly from taking advantage of people selling healthy pigs in panic. A study from Uganda by Chenais *et al.* (2017) indicates that an increased herd size might be connected to a greater impact from ASF outbreaks.

## 2.7 The Dominican Republic

### 2.7.1 Background

DR occupies almost 2/3 of the Island Hispaniola while Haiti makes up the rest. The Island is situated between Cuba and Puerto Rico with the Atlantic Sea in the north and the Caribbean Sea in the south. The country is home to approximately 10 million people of which about 3.4 million live in the capital Santo Domingo on the southern shore. (Landguiden 2018)

In the past DR has experienced long periods of military rule, dictatorship and civil disorder and the country is still struggling with inequalities, corruption and low trust in the authorities (World bank 2022). Even though DR has had one of the fastest growing economies during the past 25 years, a third of the population still lives in extreme poverty, using the definition of less than 1.9 USD/day (FN-förbundet 2021).

The country has a mixed economy, mainly based on services such as tourism but also trade, construction, and manufacturing. Agricultural production is also important and accounts for about 1/8 of the workforce, as well as for 1/8 of the gross domestic products (GDP) today. (Britannica n.d.-a)

### 2.7.2 The pig production and pork value chain in DR

Mapping a pork value chain involves investigating and describing the movement of animals and products along with the key actors all the way from farmer to consumer. Such mapping can give valuable information on the role of each actor which can be used to design successful control strategies against ASF (Dione *et al.* 2016). Up till now a comprehensive overview of the pork value chain in DR is not available.

DR has one of the largest productions of pigs in the Caribbean pig sector. With 62,884 breeding sows on 334 organized farms and another 33,340 sows in backyard production it generates more than 58,000 jobs (Caraballo 2022) and can produce about or 115,000 tons of pork which accounts for approximately 70% of the pork consumption in the country (Azevedo 2022; Caraballo 2022; Rozstalnyy 2022).

The Dominican Republic is also home to feral pigs (*Sus Scrofa)* brought to the island in 1493 by Christopher Columbus (Majo 2022). Feral pigs are known to play a key role in transmission in Europe (Chenais *et al.* 2019) and more research is needed to clarify their role in the DR.

The pig production in DR is mainly concentrated to the north-central region of the country (Raysa Reyes, professor and researcher at La Universidad Autónoma de Santo Domingo, personal communication). Furthermore, the production is characterized by many different types of pig management and farm sizes. From big farms with modern stables, often influenced by the systems used in the United States to backyard farmers and everything in between. A lot of people, especially in poorer areas, have pigs as a sideline while other work provides the main income. Despite this, the pig sector provides work for many people. Apart from work at the farms, this includes butchers, meat sellers, feed production, veterinarians, government officials, etc.

### 2.7.3 ASF in the Dominican Republic

The Americas and DR had been free from ASF for almost 40 years when two outbreaks were confirmed in July 2021. The outbreaks were situated in two different provinces and the strain proved to be genotype II, similar to the ones in China, Russia and eastern Europe. At the time when this thesis is written the virus has spread to all provinces of the country. Until September 2021, 98% of the outbreaks were reported in backyard and subsistence farms. It is unclear how the virus was introduced to the country this time, but three different hypothesized routes are the illegal introduction of pork products, incursion from Haiti, and untreated infectious garbage fed to pigs. (Gonzales *et al.* 2021)

# 3. Material and Method

This was a cross-sectional interview study involving individual and group interviews. A semi-structured questionnaire was used, developed based on previous studies and expert opinion and pre-tested in the field before the roll-out of the study. Complete interview material is included in appendix 1.

## 3.1 Study area

The information presented in this project has been gathered through interviews during September and October 2022 at five different locations in the Dominican Republic: San Fransisco de Macoris, Moca, La Noria, San Pedro de Macoris, and El Puerto San Geronimo. These locations were purposely selected based on the density of the pig population, having suffered from ASF outbreaks and convenience for interviews.

San Francisco de Macoris, home to approximately 133,000 people (2010), is a city in the north-central part of the country most known for its production of cacao, coffee rice and beeswax (Britannica n.d.-c).

Moca is a city in the central part of DR and houses approximately 65,000 people in the urban area (2010). Agriculture, especially of plantain, cacao, coffee and yukka is important and forms the livelihood of many inhabitants (Britannica n.d.-b).

La Noria is a district in the southern part of the island where interviews were held in two different villages, Las Tumbas and Batey El Gato (Tripmondo n.d.).

San Pedro de Macoris is a city and municipality in the southeast region of DR close to the sea. The city has approximately 195,000 inhabitants and is mostly known for its production of sugar and for handling a large quantity of the country's export (Wikipedia n.d.).

El Puerto San Geronimo is a municipal district in the municipality San José de los Llanos in the region of San Pedro de Macoris. San José de Los Llanos is a medium-

sized city, home to approximately 5,500 residents and is most famous for its off-road trails and mosques (Travel Planner 2020).

## 3.2 Data collection

The interviews followed a pre-established questionnaire including questions about A) the pork value chain, B) knowledge about diseases, as well as C) questions about what happens during an outbreak. Some questions, especially the ones in part B will form part of a study presented by student Ellinor Fuglsang.

Apart from the author of this thesis and Ellinor Fuglsang, another Swedish veterinary student, the field team also consisted of Maria Victoria Ogando and Tomás Mendez, students from the Universidad Autónoma de Santo Domingo (UASD) as well as Karla Collantes who translated during the interviews. Before the roll-out of the study, one of the local students revised the questionnaire and translated it from English to Spanish.

Due to the circumstances in the field, it was not possible to conduct the interviews in similar setups. Most of the interviews were done by driving home to pig owners and interviewing them on, or close to, their farms, others were done at bigger factories selling feed.

All interviews including the group interviews were conducted in the same way regardless of the location. First, one national student presented the project, informed the participants about the purpose and ensured informed consent to the participants. Following, the student facilitated the interview and asked the questions. The questions and the answers were simultaneously interpreted by the translator into Swedish. Notes were taken by the author or the second Swedish veterinary student, on a computer or paper. If on paper, it was transferred to a computer later and saved in a Google Drive document. The other Swedish student, depending on who was busy taking notes, double checked that no question was missed. Most of the interviews were audio-recorded by using an Olympus VN-541 PC tape recorder making it possible for the author to verify the notes. All interviews were proofread by the author or the other Swedish student within 24 hours from the time of the interview. The interviews varied in time but in general lasted 20-40 minutes, except for two of the group interviews that lasted 96 and 95 minutes respectively.

## 3.3 Participant selection

Participants were recruited in different ways depending on the conditions at each location. The inclusion criteria for participating in the study were that the participants owned or cared for pigs and were willing to participate. Individuals who earlier owned pigs but lost them were also included. Sex and age were considered irrelevant. The focus was on smallholders but all farmers willing to participate were allowed to do so.

In San Fransisco de Macoris, the interviews were held at a feed company, Coopenor. One of the employees asked the pig farmers coming to buy feed if they would consider participating in the study. Interviews were also held at farms in the area around San Fransisco. An employee from Instituto Agrario Dominicano (The Dominican Agrarian Institute), purposely selected based on his knowledge about the local farmers, introduced us to farmers and butchers at different locations in the area.

In Moca, interviews were held at Coopcibao, another feed company. Here, like in San Fransisco de Macoris, an employee asked the customers if they wanted to be part of the study. One of the employees also took us by car to different farmers in the area.

In La Noria we had contact with an association for smallholder farmers (Asociación de productores ovino caprine y apicola La Noria). This contact was introduced to the project by the Dominican supervisor. The interviews were conducted firstly in the village Batey El Gato where the contact person had gathered some farmers to be interviewed, she also informed the team about another village: Las Tumbas where we held additional interviews.

In San Pedro de Macoris only two interviews took place outside a hardware store. Due to the low number of participants and the non-suitable interview situation, a decision was made not to continue with the interviews at this location.

## 3.4 Ethical considerations and consent

Since this study did not involve any manipulations on human or animal subjects, ethical permission was not needed according to national regulations.

Prior to the interviews, brief information was given to the participants about the purpose of the study. They were also asked if they agreed to the recording of the interviews and informed that they did not need to answer any questions they did not

wish to answer and that the interviews would be published anonymously. All participants agreed to the terms presented above.

## 3.5 Data analysis

When all the data had been collected, each question and answer was read multiple times, data coded and grouped into common categories. These emerging categories are further explained in the result section.

# 4. Result

## 4.1 The recruited participants

The results of this study were collected from 80 interviews, consisting of 76 individual interviews and four group interviews making a total number of 93 participants. The individual interviews consisted of 68 males and 8 females with ages ranging from 22 to 77 years. Among these, eight individuals considered themselves both farmers and meat sellers, while another three identified themselves as mainly meat sellers. The participants who identified themselves as farmers and meat sellers are included in the "Farmers" column in every table except in Table 10. Five of the participants in the individual interviews were veterinarians as well as farmers. The group interviews were divided as follows: Group A and B consisted of two male participants. Group C consisted of nine male participants and one female, while group D consisted of two males and one female.

Results from the veterinarians are presented in a separate column due to their knowledge. Results from the group interviews are presented separately.

## 4.2 Movement of pigs

### 4.2.1 Buying and selling pigs

This category summarizes the information from questions considering the participants buying and selling behavior. The meat sellers who also identified themselves as farmers are included in the left column of Table 1.

*Buying pigs*

As can be seen in Table 1, most of the farmers stated that they never buy new pigs and only have their own recruitment stock. Apart from this, the answers varied and many reported to buy from whoever had pigs. One of the farmers said that after the introduction of ASF into the country, there are not as many pigs in total as there has

been and it can be tricky to buy one. He told that he must buy wherever and whenever a pig is for sale.

*Table 1. Answers to the question "Where do you buy your pigs?" from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| Never purchases | 41 | 5 |
| Buys in the neighborhood | 9 | |
| Buys from whoever happens to have pigs for sale | 5 | |
| 10-20 km away | 3 | |
| 20-35 km away | 2 | |
| 252 km away | 1 | |
| Don't know where the pigs are purchased | 1 | |
| Buys but does not say from where | 1 | |
| **Number of participants** | **63** | **5** |

Group interviews

When asked where they buy their pigs the answer within each group were quite consistent. The first group never bought pigs. In group B, only one bought but did not say from what location. Group C and D bought their pigs in the neighborhood, but all of the participants in group D claimed that they sometimes bought pigs from other areas in the eastern part of the country, depending on where they could find a pig.

*Selling pigs*

As Table 2 shows, most participants sold their pigs in their neighborhood, but as also can be seen in the same table, pigs could move long distances, ending up in other districts or cities. Six participants did not know where their pigs end up, probably due to the fact that some of them sell to middlemen or to different places each time depending on the price. In some cases it was told that the buyer comes to the farm which makes it hard to know where the pig is going. A lot of pigs ended up in slaughterhouses (Table 3), which in DR hold a wide range of standards and can be anything from very simple conditions, no more than a small concrete slab in a clearing where water is available (see Figure 1), to large modern facilities, fully equipped and able to maintain a higher standard both in terms of equipment as well as hygiene. Here, the slaughter facilities have not been further divided depending on their standard. Many farmers were also not consistent in where they sell their pigs. Some participants reported to usually sell to a middleman but might sell to a slaughterhouse or on a market the next time. Each participant could therefore give multiple answers to this question (Table 3).


*Figure 1. To the left: one of the simpler slaughterhouses. To the right: a slaughterhouse that is not being used anymore (authors photographs).*

*Table 2. Answers to the question "Where do you sell your pigs?" from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| In the neighborhood/within 6 km | 15 | |
| 10–20 km | 14 | 1 |
| 25–35 km | 8 | |
| 45–65 km | 2 | |
| 125–145 km | 7 | |
| 285-370 km | 2 | 1 |
| Do not give a location | 7 | 2 |
| Do not know, can end up anywhere | 6 | 1 |
| **Number of participants** | **61** | **5** |

*Table 3. Answers to the question "To what type of place do you sell your pigs?" from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| Slaughterhouse | 19 | 2 |
| Meat sellers | 16 | |
| Charcuterie | 12 | 2* |
| Whoever wants to buy | 12 | |
| Middleman | 12 | 1 |
| Market | 10 | |
| Within the neighborhood | 8 | |
| Other producers | 3 | |
| Friends | 2 | |
| **Number of participants** | **67** | **5** |

**One of the vets was in the stuffing sector. His company produced their own pigs, slaughtered them, and made sausages and other charcuteries as well. All parts of the production, from breeding to the making of charcuteries were in different locations in the area of Santiago/Moca.*

Group interviews

When asked this question, the answers were quite consistent within the groups but varied between them. All the participants in group B sold exclusively in the neighborhood. Group C and D from the same village mostly sold to buyers coming from bigger cities such as Santiago or Santo Domingo, cities located about 240 km respectively 90 km away. One of the farmers explained that the buyers, especially those from Santo Domingo think that the pigs from this location taste better than pigs from other areas. In group A, one participant sold to a charcuterie 23 km away and the other one to a middleman.

### 4.2.2 Market value

Many of the participants stated that the price for pigs and pork has risen since the introduction of ASF into the country and claimed it to be due to a decrease in the pig population. Many farmers sold their pigs when heard about ASF, in that way they would not lose as much in case of an outbreak. Most of the participants sold per kilogram of live pig (see Table 4) but some sold at a price per pig instead. The price given by most of the farmers varied between 2000-2500 pesos for a piglet and between 2300 and over 7000 pesos for an adult pig. One of the participants claimed that when he had sold last time (in May), he had received between 18 000 and 30 000 pesos per pig. Two farmers also stated that the price depends on the customer and/or what pig they want, if the buyers want an old sow unable to produce more piglets, they will sell her for 80-90 pesos per kilo.

Table 4 shows the answers from the participants from those selling per kilo. Included in the column "farmers" are the meat sellers that also identified themselves as farmers. Also, the people who did not own pigs at the moment but have sold in the last 12 months are included.

*Table 4. Answers to the question "To what price per kilo do you sell your pigs?" from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| 40-70 pesos | 6 | |
| 70-100 pesos | 5 | |
| 100-130 pesos | 6 | |
| 130-160 pesos | 32 | 5 |
| 170-190 | 1 | |
| **Number of participants** | **50** | **5** |

**100 Dominican pesos is about 20 Swedish krona.*

Group interviews

In the group interviews prices from 125 pesos up to 152 pesos per kilo were mentioned with a slight shift toward the higher amount.

*Identification of pigs*

Due to circumstances in the field and misunderstanding, this question cannot be analyzed. In DR every pig vaccinated against CSF gets a yellow ear tag. By doing so the authorities are able to know how many and which pigs that have been vaccinated. This is however no identification tag, which many farmers did not seem to understand. Some participants just answered "yes, with ear-tags" to the question "Do the pigs have individual numbers or farm numbers to make it possible to follow them through the value chain?" Otherwise, the different types of identification techniques on pigs seem to be ear tags, different cuts in ears or tail or other types of markings on the body. Some interviewees argued that they did not need identification on their pigs because they knew which pigs were theirs anyway.

## 4.3 Breeding systems

When asked about their breeding system most of the farmers used natural mating with a boar as can be seen in Table 5. The meat sellers who also identified themselves as farmers are included in the "farmers" column. 30 participants answered a follow-up question stated as "do you ever lend or rent out your boar?" if they did not own a boar, we asked them if they ever rent or borrow a boar for their sow. Twelve participants answered that they never lend or rent out their boar. Another twelve participants did lend or rent out their boar while nine borrowed or rented other farmers' boar. Out of these twelve respectively nine participants, three individuals who both lend out their pig and borrow from other farmers.

One of the participants explained that boars are expensive and that is the reason why lending a boar in the same neighborhood is quite common. As compensation, the owner of the boar gets a piglet in return.

*Table 5. Answers to the question "What type of breeding system do you use at your farm?" from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| Natural mating | 38 | 1 |
| Artificial insemination | 6 | 4 |
| Mixed | 15 | |
| **Number of participants** | **59** | **5** |

Group interviews

Natural mating was the by far most common way of getting the sows pregnant and only group A mentioned artificial insemination as an alternative. One group (group C) explained that in their area everybody borrows pigs from each other.

## 4.4 Other contacts on the farm

This part of the interview was meant to map other contacts on the farm that may or may not contribute to the spread of infection. Due to different circumstances and misunderstandings, a great majority of the participants just answered whether they had employees or not. Of the participants that stated that they did not have any employees, one stated that another person helps him now and then to check on the pigs. One person worked as a meat seller as well and one worked at a plantation for cacao in addition to the work with his pigs. Some farmers had employees that also worked at other places such as with cows or on different plantations. Only one had employees that worked at other pig farms as well and that was before the entry of ASF into the country.

*Table 6. Answers to the question about other contacts/employees on the farm, from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| Employees that only work at that place | 32 | 4 |
| No employees | 26 | 1 |
| Employees that also work at other farms | 6 | |
| **Number of participants** | **58** | **5** |

Group interview

The participants had in general no employees and the few that had, stated that the workers only work at their farm. Only in group D were employees that also worked at other places mentioned. One of these farmers said that the workers were like prostitutes, working where they get the best payment.

## 4.5 Pig management

44 farmers were asked if the overall management around the pigs was the same all year round, and all of them said yes.

### 4.5.1 Types of housing

The participants were asked different questions about how their pigs were being held. At the question *"How do you keep your pigs?"* a wide range of options were

presented (see Table 7.). Under roof or in a pigsty means that the pigs were held in pens containing one or a group of individuals which could be made of wood or concrete (see Figure 2). Only some of the bigger farms had more modern stables with pigs kept on slatted floor. Six farmers had two or more different types of housing on the farm. One of them had some of his pigs inside and some of them outside in a paddock. Another example was a participant that kept the piglets free, but the sow tied to a tree. A majority of the participants separated the piglets from the sow. Paddocks existed in many variants, more or less escape-proof. Some farmers also informed that the paddocks were some distance away from their home, in some cases in the mountains/forest.

*Figure 2: Two types of housing, to the left pens made of concrete and to the right a pen made of wood (authors photographs).*

*Table 7. Answers to the question "How do you keep your pigs?" from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| Indoor/semi-open/under roof | 53 | 5 |
| Paddock | 9 | |
| Free ranging | 3 | |
| Bound to a tree | 2 | |
| Fenced farmyard | 2 | |
| **Number of participants** | **63** | **5** |

Group interviews

The types of housing that were mentioned during the group interviews (sorted by descending number of mentions) were under roof in pens, paddocks, bound to trees with free ranging piglets, and free ranging. Almost all participants separated the piglets from the sow after weaning.

### 4.5.2 Feed management

As can be seen in Table 8 most farmers gave their pigs commercial feed. This can be bought at different locations such as at feed factories, "colmados" (a small local convenience store), veterinarians and markets. 19 farmers feed their pigs food waste as well. Different reasons mentioned for this were that pig feed was too expensive and that they grow better with food waste. It was common that the food waste was collected in the villages in large barrels, bought cheaply or given from supermarkets before being given to the pigs. Some of the farmers giving food waste heated it prior to feeding to get rid of pathogens. Five of the farmers that gave food waste stated that they feed their pigs with food waste but not meat for reasons such as they would never give something as expensive as meat to the pigs or simply because it did not feel right.

*Table 8. Answers to the question "What do you feed your pigs with?" from a study performed in the Dominican Republic in 2022.*

| | Farmers[#] | Veterinarians |
|---|---|---|
| Commercial feed | 56 | 2 |
| Own production | | 3* |
| Food waste | 19 | |
| Afrecho (minced corn) | 8 | |
| Peel | 5 | |
| Leaves | 2 | |
| Root vegetables like yucca or potato | 1 | |
| Chicken intestines | 1 | |
| **Number of participants** | **65** | **5** |

**These three veterinarians had their own production of maize, soy and other types of pig feed. [#]The meat sellers who also identified themselves as farmers are included in the left column.*

<u>Group interviews</u>

All the groups gave commercial feed to their pigs. In group C and D food waste and different types of peels and leaves are mentioned as feed to pigs as well. In group C, two participants gave their pigs whey as a complement.

*Figure 3: Minced corn, Afrecho, which is a common and cheap type of pig feed in the Dominican Republic (authors photograph).*

### 4.5.3 Management of carcasses

Burying was the most common way to manage dead pig carcasses, see Table 9. Burning was another popular way of getting rid of the body and while some stated that they burn very well because of their fat, some said that burning them with tires is the most effective way. Some participants reported to put the body in a hole in the ground, burn it, and cover the ashes with soil.

*Table 9. Answers to the question "What do you do if you find a dead pig on your farm?" from a study performed in the Dominican Republic in 2022.*

| | Farmers | Veterinarians |
|---|---|---|
| Buries the pig | 40 | 5 |
| Burns the body | 16 | 1 |
| Have never found a dead pig | 10 | |
| Dumps it in the forest/mountains | 4 | |
| Sells it | 3 | |
| Eats it, put it in the trash, gives it to the dog | 1 | |
| Autopsy | | 3 |
| **Total number of participants** | **65** | **5** |

Group interview

Burying was common amongst the participants in the groups as well. Although in group A and B, participants told they might sell the body if it was considered edible and a buyer could be found. Group C and D said they got rid of the body simply by throwing it away in the mountains/forest. However, a participant in group C stated, that the right way is to bury them and that the farmers in general have gotten better at doing so since the reintroduction of ASF.

## 4.6 Meat sellers

Eleven meat sellers and/or butchers were interviewed in the city of San Fransisco de Macoris. Eight of the participants have also answered questions about their farming and are therefore included as such in all tables above. One is even a veterinarian as well and has been counted as such in the results above. In this part, the veterinarian will be presented alone due to the special knowledge in the field. All but two of the eleven ones selling meat produced their own pigs for slaughter and only sold their own meat. The ones that did not breed their own pigs, purchased grown-up pigs, slaughtered them and sold the meat, see table 10.

*Table 10. Answers to the question about slaughter practices of meat sellers from a study performed in the Dominican Republic in 2022.*

| | Meat sellers | Veterinarians |
|---|---|---|
| Slaughter the pigs and sells the meat | 5 | 1* |
| Do not slaughter but sell the meat | 3 | |
| Sell pigs for slaughter and slaughter them in person | 1 | |
| No answer | 1 | |
| **Total number of participants** | 10 | 1 |

**Owns a slaughterhouse but does not slaughter them in person, the meat goes straight to their production of charcuteries or is sold directly.*

In general, the whole body of the pig was taken care of in the process of slaughter. Most of the meat sellers just stated that the whole animal is used. Even the intestines were being sold in most cases. One seller said that people use it in a fried dish (frituras). One meat seller stated that he gives the intestines to the dogs.

Most of the meat sellers sold their meat from a small boutique at home or from a colmado (a small local convenience store) selling mostly to neighbors. The meat from two meat sellers went to factories making charcuteries and the products could end up over large parts of the country. One sold both from his store and to restaurants and markets. None of the sellers were able to trace the meat back to the pig with some sort of identification number.

## 4.7 Recent outbreaks and actions

This part of the interviews aimed to find out the actions taken during an outbreak and to get an image of the spread within a village. In this part, all participants except the group interviews and the veterinarians were included in the "farmers and meat sellers" column.

### 4.7.1 Recent outbreaks

This question was originally stated as "Have you heard of any outbreaks in the neighborhood or has your farm or business been affected by ASF? When was this?" but due to circumstances in the field and misunderstandings within the team this question was translated into "Have you recently heard about an outbreak of African swine fever, when was this? (Farms, neighbors, yourself in case of breeding)".

*Table 11. Answers to the question "Have you heard of any outbreaks recently?" from a study performed in the Dominican Republic in 2022.*

| | Farmers[#] | Veterinarians* |
|---|---|---|
| Have not heard of outbreaks recently | 41 | 4 |
| Have suffered from ASF | 20 | 1 |
| Have heard of outbreaks recently | 14 | |
| **Total number of participants** | **71** | **5** |

**The person that is both farmer, veterinarian and meat seller counts only as a veterinarian in this table. [#]This column includes farmers and the meat sellers, both the ones counting themselves as farmers and meat sellers and those who identifies themselves as only meat sellers.*

The result of the question can be seen in Table 9. Those presented as "have not heard of outbreaks recently" were those that had not heard about it for at least several weeks. Some of those who had suffered from ASF were affected between seven years ago and ten days ago with one extreme, that was affected in the 1970s. The person who claimed to have been affected seven years ago was asked the question one more time to ensure that it was seven years ago the participants' pigs were affected. The same procedure was carried out with one participant that claimed the pigs got affected by ASF two years ago, neither of them changed their answer. The others were mostly affected between November 2021 and January 2022.

Group interviews

Most of the participants in the group interviews had not heard of any recent outbreaks. In group C one person along with all the participants in group D claimed that their pigs got affected by ASF in January or February 2022.

### 4.7.2 Actions during outbreaks

To the farmers affected by ASF, a question about how they had acted during the outbreak at their farm was asked. To the farmers who had not been affected the question was instead asked as "how would you act during an outbreak?". See Table 12.

Some of the persons said that they would do multiple things, for example, both euthanize and bury/burn. One participant answered that he wanted to call the authorities when his pigs got affected because he knew that he could get compensation, but his colleague did not want to involve the government, so they did not report it.

One participant initially answered that the pigs that did not die were sold but then changed his mind and claimed that they were euthanized and stuck to that explanation. Another person explained that if his pigs would die in the outbreak, he would bury them, but if they survived, he would give them an injection (did not

specify) or sell them. On the other hand, he also claimed that he would never dare to sell infected meat and if somebody buys a sick pig, transmission might be possible to other pigs.

Many participants did not report to the authorities and some of them said that they did not think it would do any difference. In some cases, participants had reported but nothing had happened.

*Table 12. Answers to the question "How did/would you act during an outbreak?" from a study performed in the Dominican Republic in 2022.*

| | Farmers and meat sellers | Veterinarians |
|---|---|---|
| Euthanize | 16 | 1 |
| Call the authorities/agriculture | 12 | 1 |
| Burn/bury the dead | 7 | |
| Get rid of or sell the pigs before they die | 4 | |
| Close the farm | 3 | |
| Call a vet | 3 | |
| Dump the bodies in the forest/mountains | 3 | |
| Nothing | 2 | |
| Vaccinate/medicate | 2 | |
| Call a boss/colleague | 1 | |
| Sell the meat | 1 | |
| **Total number of participants** | **49** | **2*** |

**Only 2 veterinarians answered this question.*

Group interviews

Group A and B claimed that their farms had remained free from ASF. In group C one of the participants stated that his farm was affected in February 2022. At the question of what he did, he just answered that he left the pigs to die and when he returned 15-20 days later the bodies just lay there. When asked about what happened with the corpses, he just answers that "over 100 pigs died and I was not able to bury them all". A majority of the participants in group C had sold most of their pigs when they started to hear rumors about ASF, with the intention to lose fewer pigs if affected. In group C everybody had suffered from ASF, and they had all tried to cure them with antibiotics and even called the vet. When the pigs died, they had taken a transport and dumped all the bodies in the mountains/forest.

Group B, C and D claimed that none of them would sell a pig or meat they suspected may be infected with ASFV. Group A did not answer the question.

# 5. Discussion

African swine fever is now present in every district of DR. How this spread has taken place has however not yet been investigated. The aims of this study were to investigate and map the pork value chain giving an insight into how the system works, from breeding to slaughter.

Transportation of live pigs is known to pose a risk of spreading diseases such as ASF into new areas (Costard *et al.* 2009; Neumann *et al.* 2021). Even though the results in this study indicate that most farmers buy and sell their pigs mainly in the neighborhood close to their farm, some pigs travel over long distances into other provinces. The results show that many farmers sell their pigs to many different actors which may mean that pigs from the same farm might end up at different locations in the country. In China, the trade and movement of pigs have been identified as one of the major transmission routes together with swill feeding and contaminated employees and vehicles (Zhai *et al.* 2019; Hu *et al.* 2021). It can thus be suggested that the spread of ASF within DR has a connection with pig movement. Disinfection of transports may play a significant role in hindering spread (Gao *et al.* 2021; Neumann *et al.* 2021), but this was unfortunately not investigated in this study.

In DR, large farms with modern production systems, and small backyard farms try to coexist side by side, something that is not always uncomplicated. During our interviews, some farmers stated that all backyard farms should be extinguished due to their lack of biosecurity and the risk of transmitting ASF. Apart from affecting most of the pig producers in DR, this would lead to the country having to import a vast majority of its consumed pork, affecting other parts of the pig sector as well such as butchers, middlemen, meat sellers, feed producers, etc. Unfortunately, ASF has already led to an increase in imported pork, mainly from the United States, which according to some of the farmers in the study had affected actors within the pork value chain, such as butchers.

Since the introduction of ASF, the price of pigs and pork products has increased according to many participants. A possible explanation for this may be that when ASF was first introduced many farmers sold their pigs quickly in an attempt to

reduce the loss of pigs in case of an outbreak. This, in combination with a reduced interest in pork products, led to an initial drop in market price (Beek 2022). When a considerable quantity of pigs started to die or got culled due to ASF, together with recuperation of consumption, a deficit was formed, and the prices for pigs and pork increased considerably. Many participants testified that it had become more difficult to get hold of pigs which in some cases led to buyers having to look further afield to buy them. This may contribute to an increased movement of pigs and by extension an increased risk for spread of infection. Apart from the increased movement, it could conceivably be hypothesized that many pig farmers must buy pigs from several sources in order to get hold of enough pigs. Purchasing pigs from different sources with poor biosecurity such as markets, small pig producers or abroad are all unsafe practices and may increase the risk of spreading ASF (Iacolina *et al.* 2021). Thus, a suggestion is that this might have led to increased movement of pigs during a period of time which possibly could have affected the spread of ASF.

One measurement relevant for ASF protection on pig farms is identification of animals and recordings of animal movement (Iacolina *et al.* 2021). Lack of proper identification of the pigs and meat in general, seems to be a widespread problem in DR, even if these results need to be interpreted with caution due to the low number of meat sellers and farmers who participated in the study. Almost all meat sellers in this study slaughtered their own pigs but that may not always be the case. It can therefore be assumed that due to the trading habits in general where pigs often get sold to different places and pigs from the same farm end up at different locations in combination with poor animal identification, tracing a potential outbreak of ASF back through the value chain is almost impossible. Not only is a animal traceability system important for surveillance and food safety but can also help identify problem farms in case of disease outbreaks, for example ASF outbreaks (Madec *et al.* 2001; Mutua *et al.* 2020).

According to the result, lending or renting of boars occurs frequently, especially within villages between friends and neighbors. It is a cheap way of getting piglets without owning your own boar and a way to get an extra income for the boar owner, sometimes in the form of an extra piglet. Even though these pigs do not travel over large distances, an increased movement of pigs can possibly contribute to the spread of pathogens locally and eventually to the feral pig population if caution regarding food waste and other biosecurity measures is lacking. Although currently the ASF epidemic in Europe in most settings is maintained in the wild boar populations, it started with spillover from the domestic pig cycle into the wild boar populations via human activities (Chenais *et al.* 2018). Human activities are also causative factors

for ASF spreading over long distances (Chenais *et al.* 2019). Perhaps a spillover into the population of feral pigs can be seen in DR in the future as well.

Burying or burning were the most common ways of disposing of carcasses, but interestingly, some participants, especially in the group interviews, claimed that they throw carcasses in the mountains or forest. Doing so poses a risk for wild boars to get in contact with infected meat or soil (Chenais *et al.* 2018). This may lead to outbreaks in the feral pig population, who in theory is able to spread the infection back to naïve live pigs, especially if kept in paddocks or free ranging outside the village (Jori *et al.* 2013). Since the tick *Ornithodoros puertoricensis* is present in DR there is also a risk for establishing a tick-pig cycle (Butler *et al.* 1985). This accords with earlier observations from Portugal where *Ornithodoros erraticus* may have had a role in the persistence of ASFV in the field and in the re-emerge of ASF in 1999 after being absent for several years (Boinas *et al.* 2011).

Apart from feral pigs, vultures are common in DR. Some participants claimed that these feed on the carcasses of dead pigs, thus might have a role in the spread of ASF. Probst *et al.* (2019) investigated the potential role of different scavengers for spreading ASF and concluded that scavengers only represent a minor risk. Surprisingly, they may even contribute to reducing the local persistence of the virus when metabolizing the carcasses according to the same study.

A quite high percentage of the participants feed their pigs food waste which is a known risk factor for introducing ASF into new areas (Iacolina *et al.* 2021). The food waste is often collected in the immediate area in large barrels. These were often seen during the field studies. The current study also found that many farmers got their food waste from big supermarkets, it can thus be suggested that the food waste origins from different locations both from within and outside the borders of DR. This could therefore be a possible entrance of ASF into new areas or perhaps into the country in the first place. Similar scenarios has been before, for example in Europe and Asia where feeding the pigs contaminated feed is one possible explanation for the introduction of ASF (Niederwerder 2021).

During some of the field trips, several locations with large piles of dumped garbage outside the cities were noted. The authors were also told that some farmers actively bring their pigs to scavenge in these piles of garbage (Raysa Reyes, professor and researcher at La Universidad Autónoma de Santo Domingo, personal communication). This, and if wild boars are allowed to scavenge as well, means a risk for transmission of ASF.

One interesting finding is that most of the employees did not work at other farms. An explanation for this could be that the farms big enough to benefit from employees also are able to keep a higher level of biosecurity and are aware of the risks of having employees that work at other places as well. Smaller farms probably neither can afford nor need to hire anyone since the pigs are more of a sideline. Contaminated equipment, vehicles and employees moving between farms with ineffective biosecurity is a known risk for spreading ASF (DAERA n.d.). In a study by Hu *et al.* (2021) three different transmission routes were investigated in an attempt to clarify which one of them were more risky. The transmission routes were movement of infected pigs and pork products, swill feeding and employees and vehicles carrying the virus from farm to farm. One conclusion from this study was that the risk of transmission was highest with employees and vehicles contaminated with the virus moving between farms. The impact of ASF can be minimized by a higher level of biosecurity, something that unfortunately are often absent in smallholder pig farms (Barongo *et al.* 2016). A study by Mutua *et al.* (2020) with focus on application of biosecurity in smallholder pig systems in Africa, found that even though biosecurity measures can make a huge difference in preventing ASF, compliance is a challenge. Many of the control measures recommended today are not designed for developing countries that in addition to education needs cheap and easy solutions that are easy to implement (Mutua & Dione 2021). As has been stated earlier in this thesis the pig production in DR consists of a large proportion of backyard and smallholder farms. It can therefore be suggested that farmers in DR faces the same challenges.

Most participants said they would euthanize the pigs in case of an outbreak and a smaller part claimed they would call the authorities. Unfortunately, some of the participants also seemed to think that it would not make a difference whether they called or not, as the authorities would still not care. It is however not clear why the participants would not call the authorities, but several explanations are possible. A study by Vergne *et al.* (2016) investigating attitudes and beliefs towards reporting in Bulgaria, Germany and parts of Russia showed that factors associated with unwillingness to report a possible outbreak were fear for adverse effects on their reputation locally, the incapacity to provide a diagnostic result that is fast enough (within one week) and that the farmers felt that they would be able to handle the outbreak themselves. This might be a possible explanation for DR as well.

This study has some biases, some of them are directly associated to the interview set up and situation. Prior to the interviews, the questionnaire was translated from English to Spanish by national students. Unfortunately, some of the questions had been translated incorrectly which was discovered during the first interviews. As there were two students facilitating the interviews, it cannot be certain that the

interviewers understood the questions in the same way, and because of that, the result may differ. One example is the question about other contacts on the farm which may have been interpreted differently. After the first interviews, it was clear that some questions needed to be asked in another way for the participants to understand. It was also necessary to explain the purpose of each question to the interviewers to minimize the risk of misinterpretations. In one of the cities, the driver taking us to different farmers was one of the employees at a bigger feed factory. A possible selection bias in connection to that could be that he drove us to people he knew, i.e., probably customers of the feed company.

Another possible selection bias could have been present as some of the interviews were conducted at feed factories where the participants bought their feed. This may result in a limited selection of participants, for example only pig farmers giving their pigs commercial feed. Most of them were also quite stressed in this type of environment which may have affected the results. Due to the environment with loud noises inside the feed factory, it was sometimes hard to hear the answers from the participants and the translator. The participants may also have found it difficult to hear the questions correctly. In general, there is a risk that some information got lost in translation.

Social desirability bias is another type of bias worth mentioning in this study, this refers to the fact that some participants' respond the way they think is the more correct or socially desirable one (Grimm 2010).

The meat sellers interviewed during the field studies were all conducted in the city of San Fransisco de Macoris. Having interviews from different cities could have allowed to generalize the results more broadly.

## 5.1 Conclusion

The result of this study indicates that the pork value chain in DR involves many different actors connected in an intricate and complicated way. One conclusion is that all local practices such as moving pigs to different places, the management of carcasses and feed the pigs wit food waste can contribute to the transmission of ASF. However, there are still many unanswered questions and geographical areas not covered and further work is required to get a more complete picture of the movement of pigs and pork, other types of risk factors and prevention in the entire country.

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# Popular science summary

Pigs are an important livestock in large parts of the Dominican Republic. Here, as in many other countries worldwide, the pigs often provide an important source for food and income. African swine fever (ASF), one of the most important pig diseases worldwide does not pose a direct threat to human health but causes a severe hemorrhagic fever among domestic pigs and wild boars. The disease often leads to high mortality rates and affects many people´s livelihoods throughout the whole value chain. Due to for instance loss of status for international trade and great costs for control measures, ASF has an impact on national level as well.

ASF is caused by a complex virus and no safe and efficient vaccine or treatment is currently available. The virus can be spread in many ways and historically the virus circulates between wild hogs and soft ticks. The wild hogs show no signs of clinical illness. If a tick feeds on a domestic pig, the pig will get infected, get sick and often dies. Between domestic pigs the virus is mainly spread through direct or indirect contact. European wild boars are also susceptible to the disease and show clinical signs of sickness.

The virus is highly persistent and can survive in tissues or meat over long periods of time. It can also survive in pork products, especially in products where the production does not involve high temperatures such as smoked or dry-cured products. If a domestic pig or wild boar consumes these products or other tissues from an infected pig or gets in contact with the virus through contaminated environments or equipment the virus will cause sickness. Human activity plays a major role in transmission over both short and long distances. If infected products are being intentionally or unintentionally fed to domestic pigs or wild boars, transmission may occur. The virus can also survive on contaminated clothes, boots, vehicles, or other types of equipment which may act as a source for indirect transmission. The long-distance jumps of ASF are mainly caused by humans spreading infected meat products, which are then ingested by pigs or wild boars, or by movement of infected pigs getting in contact with naïve pigs or wild boars.

Today, no comprehensive overview is available for the pig production including the movement of pigs in DR. In an attempt to understand the movement of pigs in the pork value chain, in total 93 Dominican farmers and meat sellers at five different locations were interviewed individually or in groups about their pig management, trading habits, animal identification and recent outbreaks.

The results show that many different actors are involved in the pork value chain in an intricate system. Many breed their own pigs and sell them to different places depending on the price. This often results in pigs travelling into other areas of the country. Often the pigs are sold to slaughterhouses, but intermediaries and different types of marketplaces exists as well. The identification on animals is inconsistent and some sort of identification on meat to be able to trace it back to pig or farm seems to be non-existent. In case of an outbreak of ASF many actors seem to hesitate before contacting the authorities which may make the mapping of diseases such as ASF difficult.

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# Appendix 1

- **Interview code:**
- **Date:**
- **GPS coordinates/village:**
- **Starting and finish time:**
- **Note taker:**

**Introduction**

***The purpose of this part is to welcome the participants, get to know them a bit and map the background of the participants to be able to make a fair assessment.***

- Presentation of us and the project (specify that we are only here to learn from them and not to judge them. We are not from the authorities).

- Presentation of the participant (fill in the table).

    - No names will be present in the final presentation

| **Name/number** | **Age** | **Sex** | **Main activity with pigs** | **Number of years in business/ with pigs** | **For farmers: Number of pigs (specify*)** |
|---|---|---|---|---|---|
| | | | | | |

*= specify how they count their pigs, does the piglets count or only the sows?

**A. Map the pig value chain and the risks.**

***The purpose is to map the knowledge about the spread of infection and different risks. But also to map the pork value chain.***

Farmers:

1. Can you describe the "journey" of pigs in this village, from being born until they are eaten? From feed to carcass. (We draw a map afterwards).
    a. Where is your farm (in what part of the area)?
    b. In what place in the area do you buy your pigs? Do you buy them at markets? Breeders? Neighbors etc. We want to know where the place is situated.
    c. To whom/what place do you sell your pigs? Is it always to the same place? Slaughtered or alive? Where is the slaughterhouse/ other place situated, in what part of the area?
    d. How does the breeding work? Do they use insemination, own boar or borrow one? If they have their own boar: do they rent it out? To whom/where? If they rent a boar: from where?
    e. Who visits the farm (vets, extension workers, feed sellers etc.)? Do the people working on the farm, work in other places as well, where?
2. Do the pigs have individual numbers or farm numbers to make it possible to follow them through the value chain? (ask only if not answered before interview)
3. How do you keep your pigs? For example: indoor/outdoor? Fences? Differences between sows and piglets.
4. What do you feed your pigs with? food waste, meat?
5. From where do you buy your food? (commercial or not?)
6. Is the feed, management, trade etc. the same all year around?
7. How do you/ the workers take care of food waste from the household? is it possible for dogs and other animals to get in contact with foodwaste from the household?
8. How much have you been paid for the pigs/meat (price/kg) sold alive or slaughtered in the last 12 months? Market vs butcher? (Average)
9. What do you do if a pig is found dead? (Make a list)

Butchers/meat sellers

1. Explain the process of your slaughter?
    a. from where do you buy your pigs, location?
    b. Do you own pigs yourself?

    c. Is it possible for the pigs to stay overnight, or are they always slaughtered the same day they arrive? If not slaughtered at home.
2. What do you do with the waste?
    a. What do you do with the blood?
    b. What do you do with the intestines?
    c. What do you do with the head and feet?
    d. What do you do with the feces and urine? Where do throw it?
3. Is it possible for dogs, pigs or rats to get in contact with the slaughtered meat?
4. To what villages/people do you sell the meat and other parts of the pig? Is any exported?
5. Do the pigs have individual numbers or farm numbers to make it possible to follow them through the value chain?
6. Is there a number connected to the meat to make it possible to trace it back to the farm?
7. Can you describe the "journey" of pigs in this village, from being born until they are eaten? From feed to carcass.

**C. Reflection about what happens during and after an outbreak. (If a village has had an outbreak we ask them more about how it was spread between villages and farms, how it started and the consequences. If possible, we draw a map of how the disease progressed. If no one has any experience of ASF, ask some of the same questions about CSF to rule out how they act during an outbreak of CSF)**

***The purpose is to find out what happens during an outbreak according to the participants and if they know how to act, but also their motivation to prevent the spread of ASF.***

1. Have you heard of any outbreaks in the neighborhood or has your own farm or business been affected by ASF? When was this?
2. How did you act with your pigs/business during the outbreak? If no outbreak: what would you do during an outbreak?
3. Have you ever sold pigs or meat that your suspect might be infected with ASF?

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