World Organisation for Animal Health
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African swine fever in wild pigs in the Asia and the Pacific Region





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Foreword

African swine fever (ASF) is a contagious viral disease of pigs which has high fatality rates. Since its introduction to the Asia and the Pacific region in 2018, the disease has caused severe losses to domestic pig populations and spread throughout the region with long-term impacts on all pig-production systems from small backyard farms to large commercial ones.

The Standing Group of Experts on African Swine Fever in Asia and the Pacific (SGE-ASF AP) was set up under the umbrella of the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (WOAH) Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) to allow the region to coordinate among regional members and experts, share information, discuss technical issues and make recommendations to progress understanding of ASF in the region to ensure effective prevention and control.

While much progress has been made in understanding and controlling ASF in domestic pigs in Asia and the Pacific, it is recognised by the SGE-ASF AP that there is still limited knowledge and understanding of the role of wild pigs (both feral and native) in the epidemiology of ASF and other swine diseases in the region. It is also recognised that there are several native pig species unique to the Asia and the Pacific region that are engaged and may be under threat of extinction if ASF spreads through these groups. There is also limited published information on the ecology and distribution of wild pigs across the region. A better understanding of the different populations and their interactions with humans and domestic pigs is also needed.

This report was recommended by the SGE-ASF AP to review current knowledge of ecology, distribution, and role in swine disease epidemiology of wild pigs in the Asia and the Pacific region, and to make recommendations on ways to manage populations of wild pigs, their interface with domestic pigs and other actions that will contribute to the prevention and control of ASF in Asia and the Pacific.

This publication was created following on from the recommendations of the SGE-ASF AP under the umbrella of the GF-TADs.

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Abbreviations and acronyms

Abbreviation	Definition
ASF	African swine fever
ASFV	African swine fever virus
AHC	Animal Health Committee
AHAW	Animal health and welfare
CSF	Classical swine fever
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organization of the United Nations
iSIKHNAS	Indonesia's animal health information system
IUCN	International Union for Conservation of Nature
WAHIS	World Animal Health Information System
WOAH	World Organisation for Animal Health

Executive summary

Background

African swine fever (ASF) is an important viral disease of pigs that has caused a global panzootic over the last decade and a half. In recent years it has spread through central Asia, the People's Republic of China and 14 countries in South-East Asia. It recently reached the Pacific (Papua New Guinea), but many areas of Asia and most of the Pacific region remain free of disease.

There has been high-quality research on ASF in wild boar in Europe, parts of the Caucasus and central Asia. This research enables informed development of disease-control policy in those regions. However, in the Asia and the Pacific region, there has been only a modest amount of research documenting ASF in either domestic or wild pigs. Given the significant ecological and production differences between the regions, it is uncertain if this prior research has utility for the Asia and the Pacific region and thus what knowledge gaps exist. For example, the Asia and the Pacific region has many species of wild pigs beyond *Sus scrofa*, with differences in ecology; there are also considerable differences in climates (with Asia and the Pacific generally warmer in many areas), which may affect environmental persistence, and in the production of domestic pigs (e.g. smallholder subsistence farming in poor socio-economic environments). In particular, some areas of the Asia and the Pacific region have World Organisation for Animal Health WOAH, (founded as OIE) Members that are the least developed in the world, limiting the resources available for ASF prevention and control.

Objectives

The objectives of this report were to:

1. review knowledge of ASF in wild pigs and the ecology and distribution of wild pigs in the Asia and the Pacific region;
2. make recommendations and suggest actions that should be taken to manage wild pigs in the Asia and the Pacific region.

Methods

Several steps were taken to complete the project, including:

1. literature review (scientific literature review in Biosis Web of Science);
2. expert knowledge (consultation with wild pig experts, including with the WOAH coordinated expert working groups);
3. survey of Members in Asia and the Pacific (a survey on wild pigs, transmission and control);
4. case studies.

Results

Species, ecology and epidemiology

Species of wild pigs in the region

There are 12 species of wild pigs in the Asia and the Pacific region (all part of the Suidae family). These are from the *Sus*, *Babyrousa* and *Porcula* genera.

One species, *Sus scrofa*, is very common in the region. This species is either endemic as wild boar or feral in parts of South-East Asia, Australasia and most of the Pacific. In either case, *S. scrofa* is generally abundant or over-abundant and often invasive. It is the most relevant species to consider in the control of ASF due to its wide distribution, density and abundance.

There are 11 species of locally endemic wild pig species throughout the region, such as *S. barbatus* (bearded pig) and *Porcula salvania* (pygmy hog). These species are generally decreasing in range and abundance, with International Union for Conservation of Nature statuses of near threatened to critically endangered. These species generally are likely to have only a small role in ASF epidemiology as they are small in number with limited distributions. Instead, ASF may have population-level impacts on these wild pig species – in particular, threatening populations with local extirpation or extinction.

Ecology relevant to African swine fever

The ecology of wild pig species varies. *Sus scrofa* is discussed as it is widespread and abundant and therefore considered to be of greater relevance to ASF in the region.

The species is highly social and non-territorial, with overlapping home ranges. It is often co-distributed with domestic pigs (because they are the same species, they can interbreed and share a similar diet), and it can be impossible to exclude *S. scrofa* from low-biosecurity domestic pig production based on European data. *Sus scrofa* can be found at very high densities and can occupy a variety of habitats (e.g. sub-alpine to tropical regions). It is a cryptic species at times and is found near dense vegetation, making control difficult. *Sus scrofa* shows interest in carcasses, and ASF is persistent in carcasses for long periods where temperatures are cool. Together, these features mean that the wild *S. scrofa* may be significant to the epidemiology of ASF.

Epidemiology of African swine fever in wild pigs

The role of wild pigs in ASF epidemiology is largely uncertain throughout much of the Asia and the Pacific region. Despite this, some things are known:

- ASF has been confirmed in three species of wild pig in the region.

These species are wild boar/feral pigs (*S. scrofa*), bearded pigs (*S. barbatus*) and Philippine warty pig (*S. philippensis*) and were identified during outbreak investigations. While uncertain, it is likely that many or all of the other species are susceptible to ASF.

- Research in Europe and the Caucasus has revealed that the role of wild pigs as a reservoir or spillover host can vary depending on the situation.

For example, wild boar are a known reservoir in Europe, but wild pigs are less important than domestic pigs in transmission in the Caucasus. There is some data to suggest that wild boar can be a reservoir in some areas of the region for ASF (e.g. Republic of Korea) and classical swine fever (e.g. Japan). In other areas of the region wild pigs may simply be a spillover host, or at least less important for disease maintenance than transmission in the small-scale domestic pig production sector with poor biosecurity.

- Transmission of ASF was reported by Members to occur in both directions.

This included from domestic to wild pigs, from wild to domestic pigs, and from wild to wild pigs.

- The role of carcasses and environmental transmission has not been confirmed but is important in other regions.

This role is known to be temperature dependent. It may be more important in cooler areas of the region (e.g. Republic of Korea, Japan), but less important across many parts of the region with warmer climates (e.g. parts of Australia and the Pacific Islands).

- More research and surveillance are required to understand the role of wild pigs in the epidemiology of disease in the Asia and the Pacific region. In general there appears to be an absence of reports on wild pigs being important to the epidemiology of ASF in the region. In contrast, in other areas where more research has occurred (e.g. Europe) wild pigs have been shown to be vitally important.

Control, eradication and management

Socio-economic and cultural contexts to managing African swine fever

The capacity, capability and acceptability of control programmes for ASF in wild pigs vary across the region and are affected by several factors, including:

- the species of wild pig and conservation status;
- the affluence of the society, which affects resources available to control ASF;
- production practices (e.g. smallholders with poor biosecurity associated with free-ranging pigs);
- societal attitudes to pigs and conservation;
- trade routes and supply chains;
- cultural links and uses for wild pigs;
- who has responsibility for wild pigs (e.g. Ministry of Environment or Agriculture).

Design of ASF control or eradication programmes needs to acknowledge these factors to ensure that such programmes are effective, relevant and acceptable to the local area.

Control versus eradication of African swine fever

A decision should be made as to whether ASF is eradicable in wild pigs or whether it should simply be accepted as endemic and managed.

In general, eradication may be more likely on islands (where natural migration can be prevented). It is also more likely in developed countries where domestic production tends to be large in scale with good biosecurity and where suitable resources and capability are available to attempt eradication. Eradication of ASF does not require eradication of wild pigs, but instead for transmission to decline. Areas where eradication is suitable may be limited. Eradication has been successful in several areas in the past, even with wild boar present.

In many Members, eradication may not be possible, for example where there is significant small-scale production with poor biosecurity or mixing between wild and domestic pigs, and the resources available to implement an eradication programme may be limited. Regardless, if eradication is not achievable, the control of ASF should focus on both protecting important wild populations of endemic pigs and reducing transmission from wild to domestic pigs to protect food security.

Strategies to consider when planning African swine fever management in wild pig populations

The main strategies to use to either control/manage or attempt eradication of ASF include:

- **prevention**: border quarantine, which is especially relevant to islands in areas of the Asia and the Pacific region where transmission through natural wild pig movements cannot easily occur and where Members or areas within Members' borders are still free of ASF.

- **detection**: general surveillance activities are often the most practical means of surveillance for disease (e.g. passive surveillance). Efforts are required to detail the abundance and distribution of epidemiologically relevant wild pig populations.

- **response**: to manage ASF transmission to, from and within wild pigs.

Response – managing transmission to and within wild pig populations

The principal ways of managing ASF spread within wild pigs include:

- **reduction** of wild pig population density to minimise transmission, using lethal control – noting that this is only relevant for *S. scrofa*, as other species have high conservation value and are in low abundance, meaning they have a minor role in ASF epidemiology and that population control is not appropriate;

- **wild pig carcass removal** to break the wild boar–habitat cycle (if it is confirmed to be relevant in the outbreak area);

- **fencing** to provide a barrier to wild pigs and therefore disease transmission;

- **preparation for a possible vaccine**, including research and development of bait delivery strategies while awaiting development and registration of an oral vaccine;

- **biosecurity strategies** to minimise direct and indirect contact between and within domestic and wild pigs (for example, confinement of domestic pigs with appropriate fencing, hygiene and movement restrictions);

- **vector control processes** (where and if indicated; based on European research, primarily relevant to domestic pig production).

Tools for reducing wild pig density

Control tools aim to reduce wild boar/feral pig density in order to reduce transmission, perhaps enough to induce disease fade-out. There are many control tools (mostly lethal) that can be used to reduce *S. scrofa* populations. The main tools available, in approximate order of efficacy, are:

- poison baiting

- aerial shooting

- trapping

- snaring

- hunting

- fertility control.

Each of the tools has relative advantages and disadvantages. For example, aerial shooting can easily lead to 80% population reduction over a few days across considerable areas but is not as effective in thick forest areas. Most tools are expensive and may not be practical across very large areas or as an ongoing strategy. In general, less effective tools (largely hunting) have been used to attempt to manage population densities and ASF transmission and maintenance. Consideration of more tools may allow for more effective population control and hence disease management.

Response – protecting endemic pig populations

Strategies to protect endemic pig populations include:

- protecting populations of endemic wild pigs with biosecurity strategies;
- creating *in situ* and *ex situ* insurance populations (and where a species is threatened but little is understood about successful captive management, researching this area to enable insurance populations);
- devising bait delivery strategies, in preparation for a possible vaccine;
- reducing incidence in domestic pigs to reduce likelihood of spillover of infection;
- quarantining populations and analysing risk to determine where quarantine could break down.

Recommendations

Context – develop a strategic objective for wild pig African swine fever management

Recommendation 1: Context and appropriate programmes

Local disease managers must consider the context of ASF in wild pigs and develop a locally appropriate management objective for ASF in wild pigs that is acceptable to all stakeholders. These objectives will vary across Members and will consider eradication versus control of disease and protection of conservation and domestic pig production.

Prevention – quarantine and biosecurity

Recommendation 2: Inter-Member quarantine

The transmission of ASF can potentially be reduced or prevented across much of the region through appropriate quarantine between Members. Quarantine should be implemented by following the normative international standards of the ASF chapter of the WOAH *Terrestrial Animal Health Code*. This will protect both domestic and wild pigs.

Recommendation 3: Intra-Member quarantine

Local implementation of quarantine between nearby islands within and between adjacent Members can prevent further transmission. As enforcement is difficult, especially in developing countries, research to understand trade, social and cultural factors affecting pig and meat movement will enable the development of effective and appropriate quarantine rules. For example, compliance may be enhanced by education of some groups on the virulence and transmissibility of ASF and impacts on their own domestic pigs or culturally important wild pigs.

Recommendation 4: Biosecurity

Enhance biosecurity of domestic pig production to reduce transmission of ASF to and from wild pigs, recognising that the ability to implement biosecurity will be variable depending upon the type and scale of domestic pig production. Encouragement of biosecurity will require different approaches at different levels of production.

For commercial or intensive piggeries, the biosecurity management system of the compartmentalisation guidelines from WOAH (Pfeiffer *et al.*, 2021) should be implemented. This system focuses on segregation (e.g. fencing), cleaning and disinfection for each risk pathway into a compartment (i.e. pig supply chain). As an example within the region, the Republic of Korea has imposed better intensive piggery biosecurity in response to the ASF outbreak.

Biosecurity at the smallholder pig producer level should often be implemented at the village level as the village is the functionally smallest unit in which biosecurity can be implemented throughout much of the region. Implementation of biosecurity for smallholders will be more basic and could concentrate on the education of pig producers about pig infectious diseases (and their impacts) as well as basic biosecurity measures, such as confinement of pigs, hygiene of swill feeding, isolation of newly purchased pigs for a period of time, village-level fencing if practical and biosecurity of pig trade.

In general ASF control in wild pigs is closely linked to control in domestic pigs. It is important to consider the epidemiology and control of ASF outbreaks in domestic pigs so that control programmes for ASF in wild pigs can be holistically embedded in the overall control programme.

Detection – collection and sharing of surveillance and disease control data

Recommendation 5: General surveillance for dead and dying wild pigs is recommended as the most sensitive and efficient approach for the detection of ASF incursions in wild pigs in new areas. This is due to the high mortality in affected wild pig populations.

Recommendation 6: Surveillance in ASF-affected areas should be undertaken to provide data on trends in the incidence of disease and to allow investigation of the efficacy of control of ASF. This can occur by periodic collection of diagnostic samples from carcasses, or preferably, if using effective control tools such as aerial shooting, by sampling recently culled pigs and serology and virus detection across different age categories of pigs.

Recommendation 7: Disease surveillance information systems that allow real-time and finely/locally scaled knowledge of ASF should be used to share information about the prevalence and incidence of ASF, both within Members and between adjacent Members. This will enable an understanding of risk and pre-emptive control activities. Indonesia's animal health information system, iSIKHNAS, is an example of a suitable system. Such systems should focus on social principles (providing value to users), wide deployment and education to encourage data entry and use.

Response – population control

Recommendation 8: In appropriate contexts, rapid population control using an effective mix of tools (e.g. aerial shooting, poison baiting, trapping) may lead to a rapid reduction of wild pig populations and potentially reduced disease transmission.

Recommendation 9: Notwithstanding Recommendation 8, research to explore the relationship between depopulation and ASF transmission is required. This research can test the hypothesis that depopulation can lead to a disease fade-out or determine the population reduction required. Additional understanding is likely to be most easily generated with simulation modelling or surveillance during culling programmes. Simulation modelling in New World contexts supports this recommendation.

Recommendation 10: Research should be conducted to determine the effectiveness, target specificity and application of these additional tools before they are used in new regions. Registration and approvals may be required; for example, poison baiting may require a similar approval process to rodent poisoning.

Response – protection of endemic species

Recommendation 11: Ancillary preparatory research for oral vaccine deployment to wild pigs (e.g. bait delivery and strategy research) should begin immediately and before an oral vaccine is developed in order to save several years of research. It may enable earlier vaccination programmes to protect endemic pig species and thereby have better conservation outcomes.

Recommendation 12: Identify critical conservation populations of wild pigs and isolate these from other pigs to protect them from ASF. There are two broad ways to do this: having good biosecurity to protect geographically isolated populations of pigs (e.g. on islands) or captive insurance populations under quarantine (e.g. pygmy hogs) to breed excess individuals for later release into ASF-decimated areas.

Other recommendations

Interagency coordination

Recommendation 13: Better coordination is recommended between national agencies that are responsible for either managing wildlife or managing disease in animals. As a practical recommendation, a working group should be convened between Ministries of Agriculture and Environment (or equivalents) and joint policy, implementation and extension activities implemented.

Education

Recommendation 14: Where domestic and wild pigs are important economically and ecologically, societal education about ASF is required. This includes basic education about infectious diseases (as many village pig producers do not understand basic infectious diseases in pigs) and more detailed education along the entire supply chain.

Knowledge gaps

Current knowledge gaps regarding ASF in the Asia and the Pacific region include:

- understanding how ASF affects different wild pig species in Asia – for example, whether all genera are susceptible to ASF, and, within susceptible species, whether infection can commonly be subclinical or have a chronic infection state. This would require good surveillance for outbreaks and diagnostic testing as pen trials would not be acceptable;
- the ecology of wild pig species and how that influences ASF transmission;
- mechanisms of spread and persistence of ASF in wild boar populations and whether and where wild pigs are spillover or reservoir hosts;
- the importance of carcasses in the transmission of infection in different climates and times of the year in the Asia and the Pacific region;
- the role of vectors in disease transmission in the region;
- the trade and cultural links between sites of importance (e.g. islands with threatened endemic pig species) and other locations, and how these links may influence ASF infection risk;
- the most effective and efficient means of implementing smallholder pig producer biosecurity sufficient to minimise transmission of ASF between wild and domestic pigs;
- host density thresholds for persistence of ASF and how and what level of culling may lead to reduced disease transmission and disease fade-out;
- efficacy of alternate and more efficient control tools for culling pigs, such as aerial shooting and poison baiting, in new areas beyond where they are currently used (e.g. United States of America [USA], Australia, New Zealand);
- social, cultural and practical acceptability of alternative disease control tools.

Conclusion

Asia and the Pacific is one of the world's most diverse and rapidly changing regions. There is a wide diversity of contexts for wild pigs, which are variably considered an important social and cultural resource; damaging feral species; or important for conservation, with the region home to a diverse collection of some of the rarest and most unique wild pig species in the world. Much of the region has a heavy reliance on domestic pigs for food security. African swine fever, a deadly and infectious viral pig disease, is now heterogeneously distributed and spreading across the region in both wild and domestic pigs. Delivering a holistic and unified series of management recommendations for ASF is difficult as what suits one WOAH Member will not suit another. Despite this, there are some common and sensible findings that can assist management.

While there are a number of species of wild pigs, the group can be divided into small and endangered populations of high conservation value wild pigs (11 species) and *S. scrofa* (wild boar or feral pigs). The high conservation value wild pigs require protection from ASF. This can be undertaken through insurance populations, quarantine (and risk analysis), biosecurity, surveillance and advanced planning for field delivery of an oral vaccine, should one become available. Enhancing biosecurity management of ASF in domestic pigs where they co-exist with wild pigs will also assist the protection of wild pigs.

In contrast to high conservation value species, wild boar and feral pigs (*S. scrofa*) may be important epidemiologically in an ASF outbreak and therefore require population and biosecurity management. This management should first consist of contextual and strategic planning to determine what the objective of a management programme will be. In a developing country with subsistence smallholder pig production, poor resources and uncertainty of wild boar/feral pig populations, there may be no feasible option for eradication. Instead, ASF may be managed to protect domestic production, using enhanced domestic pig biosecurity, surveillance (especially general surveillance looking for dead or dying pigs) and education of pig owners about ASF.

In a developed island nation with feral pigs and considerable expertise, an attempt at eradication may be the objective of a control programme. In this case, enhanced surveillance and biosecurity, various tools to contain infected wild pig populations or exclude them from domestic populations (e.g. fencing), and population control tools to cull feral pigs (to reduce their population density and thus transmission of ASF) may be warranted. The most effective control tools are poison baiting, aerial shooting and trapping (depending on ecological circumstances) but, thus far, hunting has been the main control tool used globally. Additional tools may assist management and eradication of ASF from wild pig populations.

There are several important knowledge gaps that could be addressed, including the distribution and population density of wild pig species, the epidemiological role of wild pigs in an ASF outbreak and effective control tools that can lead to a large enough population reduction that disease fade-out can occur (or even if fade-out can occur) in ecological settings in the Asia and the Pacific region. These should be addressed in order to assist informed decision making.

1 Introduction

African swine fever (ASF) is a viral infection responsible for an ongoing global pandemic of high mortality in suids. The high mortality rates of this pandemic threaten domestic pig populations and thus the livelihood of farmers (particularly smallholders), the food supply chain and food security (Woonwong *et al.*, 2020). The pandemic may also put further pressure on the population viability of endemic wild pig species, most of which are already threatened (International Union for Conservation of Nature [IUCN], 2021; Luskin *et al.*, 2021).

African swine fever is transmitted by direct contact with an infected pig or pig carcass, scavenging of infected carcasses or pork products from infected animals, contact with fomites contaminated with blood, faeces, urine or saliva from infected pigs (including bedding, feed, equipment, clothes and footwear, and vehicles), and spread by *Ornithodoros* spp. ticks (particularly *O. moubata*) (Penrith and Vosloo, 2009). The virus is robust in pork products and in the environment (Chenais *et al.*, 2019). The current global pandemic involves transmission of genotype II strains of the 'Georgia 2007' type virus (Pikalo *et al.*, 2019). Some attenuation has been observed in Estonia (Gallardo *et al.*, 2018; Sehl *et al.*, 2020) but most strains observed during the current ASF pandemic are highly virulent (Gallardo *et al.*, 2018; Sehl *et al.*, 2020). There is currently no vaccine available for use in controlling the disease (Rock, 2021).

There are several forms of ASF disease: acute, which leads to death of up to 100% of infected pigs, typically after 6 to 13 days; subacute, in which mortality rates are lower (30% to 70%) and clinical signs can be exhibited for long periods of time; and chronic, in which mortality is low and a small number of affected individuals may become virus carriers for life with periodic viraemia (Dixon *et al.*, 2020; Eblé *et al.*, 2019; WOAH, 2019a). However, some authors contend that there is insufficient evidence of a subclinical carrier state (Petrov *et al.*, 2018; Ståhl *et al.*, 2019).

In terms of broad geographical progression of the current pandemic, domestic pig and wild boar (*Sus scrofa*) populations in Georgia and Russia were first exposed to the virus in 2007, with exposure in European domestic pigs and wild boar from 2014 (Gogin *et al.*, 2013; Sauter-Louis *et al.*, 2021a). In Asia, ASF was first reported in August 2018 in domestic pigs in Northeast China (Mighell and Ward, 2021). It has since spread to affect many other World Organisation for Animal Health (WOAH, founded by OIE) Members in the Asia and the Pacific region, primarily in Asia; Papua New Guinea is the only Member known to have the infection in the Pacific/Australasian part of the region.

Wild boar in Europe have proved highly susceptible to disease, with clinical signs and mortality rates equivalent to those seen in domestic pigs (Gallardo *et al.*, 2015). Evidence obtained from particular geographical, ecological and epidemiological circumstances indicates that the ASF transmission cycle between wild suids and domestic pigs can be an important contributor to ASF virus (ASFV) maintenance and spread in domestic pig populations (Alkhamis *et al.*, 2018).

This project aims to review the role of all wild pigs in ASF across Members of the Asia and the Pacific region and to present recommendations for management of wild pigs for ASF control, from a regional point of view. For this project, 'wild pigs' are considered to be unmanaged suid populations, including wild or feral populations of *S. scrofa*, other wild Suidae and hybrids (Table I). While free-ranging domestic pigs in Asia are commonly also known as 'wild boar, *Sus Scrofa*', in this report *Sus scrofa* specifically refers to unmanaged populations, with domesticated populations referred to as such (Table I). Members for the Asia and Pacific region are listed in Table II.

Table I Definitions of suid populations used in this report

Category/subcategory	
Suid category	**Definition**
Wild[1] pigs	Any members of the taxonomic family Suidae that are living freely in the ecosystem without close human management, or that are held in captivity in zoos or breeding programmes. There are two main types of wild pigs, (i) *Sus scrofa* and (ii) other wild Suidae.
Sus scrofa	Feral pigs and wild boar In general, wild boar are locally endemic and feral pigs have been introduced to an area.
Other wild Suidae	The 11 species of endemic pigs found locally across the Asia and the Pacific region (*Babyrousa celebensis, B. babyrussa, B. togeanensis, Sus barbatus, S. verrucosus, S. celebensis, S. philippensis, S. oliveri, S. ahoenobarbus, S. cebifrons, Porcula salvania*)
Hybrids	Wild pigs that are hybrids of wild pig species
Domestic pigs	Any members of the taxonomic family Suidae that are managed by humans, excluding wild pigs held in zoos or breeding programmes. Where *S. scrofa* are farmed, either intensively or extensively, they are referred to as 'domestic' pigs. 'Domestic pigs' include farmed wild boar.

[1] While the term 'wildlife' is used by WOAH to define feral animals, captive wild animals and wild animals, the term 'wild pigs' is used for fluency of language.

Table II WOAH Asia and the Pacific region Members

Members for the Asia and the Pacific region		
Australia	Japan	New Zealand
Bangladesh	Korea (Democratic People's Republic of)	Pakistan
Bhutan	Korea (Republic of)	Papua New Guinea
Brunei	Laos	Philippines
Cambodia	Malaysia	Singapore
China (People's Republic of)	Maldives	Sri Lanka
Chinese Taipei	Micronesia (Federated States of)	Thailand
Fiji	Mongolia	Timor-Leste
India	Myanmar	Vanuatu
Indonesia	Nepal	Vietnam
Iran	New Caledonia	

2 Ecology

Broadly, the distribution of endemic wild suid species in the Asia and the Pacific region reflects zoogeographical regions, with endemic wild pig populations of 12 suid species found within the Oriental and Sino-Japanese regions (Figs 1 and 2). Within these regions, distribution of all species except wild boar is restricted to relatively small geographical areas and is often patchy (Sections 2.1 and 2.2, Appendix A). Some populations of some endemic species (particularly *S. scrofa*) can occur at pest levels, typically as a result of anthropogenic effects on habitat (e.g. agriculture) (Lewis *et al.*, 2017), which can cause marked agricultural and ecological damage. In certain areas within the Oriental and Sino-Japanese regions where there are no endemic pig species, pigs have been introduced.

There are no endemic pig species in the Oceanian and Australian zoogeographical regions; pig species found in these regions are introduced *S. scrofa* (Australian Pork Limited, 2021; Wehr *et al.*, 2018). These introduced (feral) pigs are of no conservation value and are usually invasive, causing major ecological and agricultural damage. In the Asia and the Pacific region, feral pigs are located in the Pacific Islands, New Zealand, Australia and other islands in the Oceanian and Australian zoogeographical regions.

Sulawesi warty pig *(S. celebensis)* © IUCN

Eleven of the 12 extant endemic pig species in the Asia and the Pacific region are on the IUCN Red List of Threatened Species. There is also at least one undescribed species of endemic wild suid in the region (IUCN Red List, 2021a). Where the trend is known, populations of all of the described species are decreasing due to loss of habitat and resources, hunting, invasive species and hybridisation (IUCN Red List, 2021b). The population trend status for pygmy hogs is not known (Table III).

The *Sus* spp. endemic wild pigs interact or interbreed with wild, feral or domestic *S. scrofa* (Blouch, 1988; Burton *et al.*, 2018; Drygala *et al.*, 2020; Melletti *et al.*, 2018). This can create difficulties in differentiating the endemic species from crossbreeds (Tabaranza *et al.*, 2018).

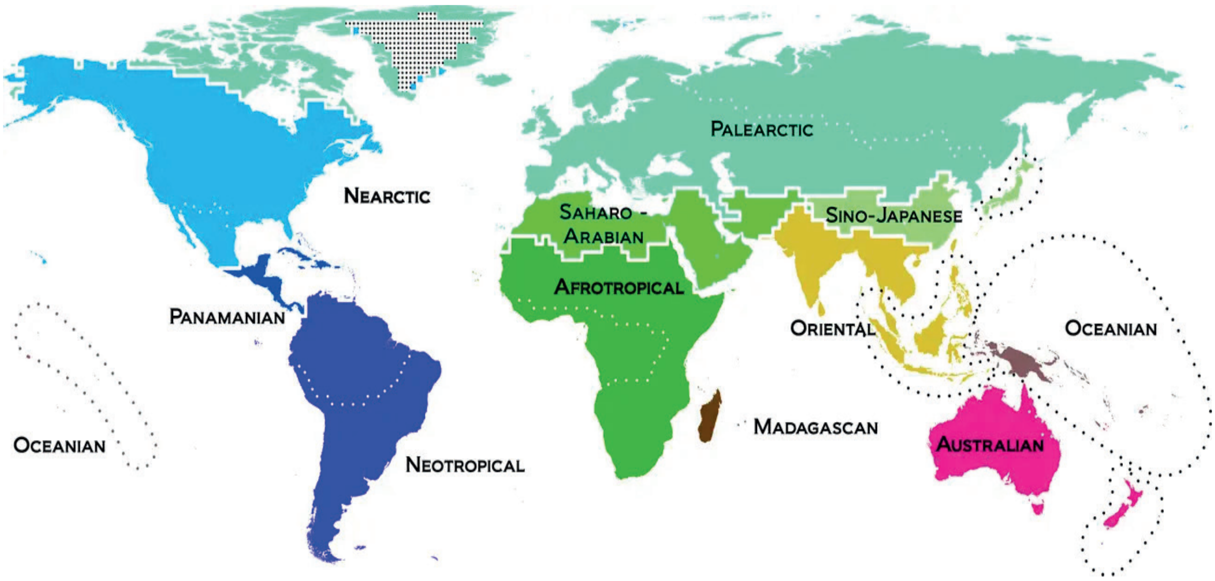

Fig. 1 Zoogeographical regions of the world, per Holt *et al.* (2013)

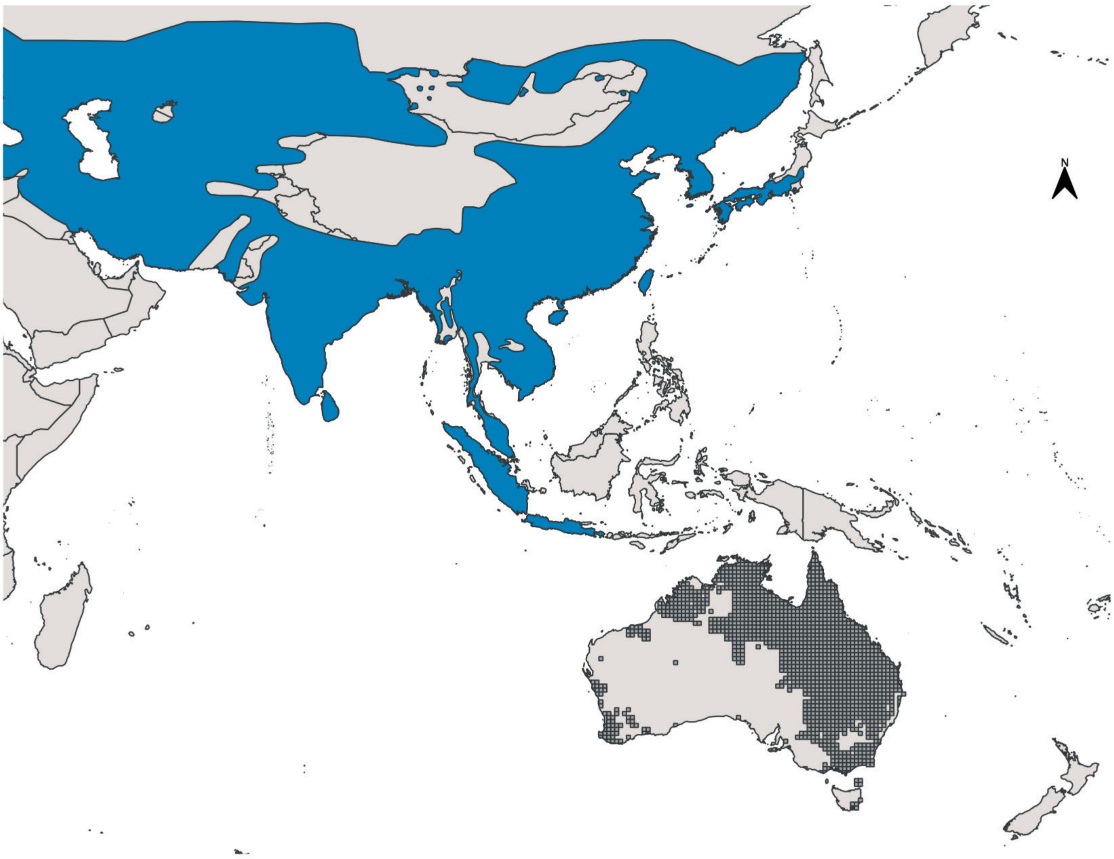

Fig. 2 Documented distribution of extant populations of endemic pig species (blue) and introduced populations (dark grey) across WOAH Asia and the Pacific region Members

Endemic pig species' distributions are from the IUCN Red List (mapped in blue). Feral pig population distribution in Australia is mapped in grey (West, 2008).

While it is believed that feral pigs are distributed widely throughout South-East Asia and the Pacific, there are no accessible distribution data publicly available to apply to this map.

Table III Summary of extant distribution and conservation status of wild pigs in Asia and the Pacific

Species	Country of endemicity	Conservation status	Est. population size
Wild boar (*Sus scrofa*)	Widely distributed across Asian countries in the Oriental and Sino-Japanese zoogeographical regions[1]	Least concern	Abundant throughout the region
Sulawesi babirusa *(Babyrousa celebensis)*	Indonesia	Vulnerable	9,999 (IUCN Red List, 2021c)
Hairy babirusa *(Babyrousa babyrussa)*	Indonesia	Vulnerable	No recent data available[2]
Togian Islands babirusa *(Babyrousa togeanensis)*	Indonesia	Endangered	1,000 (IUCN Red List, 2021d)
Bearded pig *(Sus barbatus)*	Indonesia, Brunei, Malaysia[3]	Vulnerable	No recent data available
Javan/Bawean warty pig *(Sus verrucosus)*	Indonesia	Endangered	*S. v. blouchi:* 172–377 (Rademaker *et al.*, 2016)[4]
Sulawesi warty pig *(Sus celebensis)*	Indonesia	Near threatened	No recent data available
Philippine warty pig *(Sus philippensis)*	Philippines	Vulnerable	No recent data available
Mindoro/Oliver's warty pig *(Sus oliveri)*	Philippines	Vulnerable	No recent data available
Palawan bearded pig *(Sus ahoenobarbus)*	Philippines	Near threatened	No recent data available
Visayan warty pig *(Sus cebifrons)*	Philippines	Critically endangered	No recent data available
Pygmy hog *(Porcula salvania)*	India, Bhutan[5]	Endangered	100–250 (IUCN Red List, 2021e)

[1] As defined in Holt *et al.* (2013).

[2] In 2000, an estimate was put at 4,000 individuals (Tislerics, 2000).

[3] Extinct in Singapore, possibly extinct in the Philippines (IUCN Red List, 2021f).

[4] No recent data are available for the species more broadly.

[5] Presence in Bhutan is uncertain (IUCN Red List, 2021e).

2.1 Ecology of wild *Sus scrofa* populations in Asia and the Pacific relevant to transmission of African swine fever

Wild boar are endemic in the Sino-Japanese and Oriental zoogeographical regions of the Asia and the Pacific region. In contrast, they are introduced in the Oceanian and Australian zoogeographical regions, where they inhabit almost all islands, including Australia, New Zealand and Papua New Guinea. In many of these locations, the populations are a hybrid mix of wild boar and domestic pigs (Wehr *et al.*, 2018).

Broadly, wild boar are widely distributed and abundant across Asia and the Pacific (Denstedt *et al.*, 2020; Keuling and Leus, 2018; Luskin *et al.*, 2021) (Fig. 2, Appendix A). However, specific information on the distribution, density and ecology of the unmanaged populations of wild boar within the Asia and the Pacific region tends to be limited, with few exceptions (e.g. Australia [West, 2008; Hone, 2020]). Therefore, it must be considered that the ecological patterns observed in the various studies listed here may reflect local conditions and thus differ from those in particular locations in the Asia and the Pacific region.

Wild *S. scrofa* are a cryptic species: they frequently inhabit remote areas away from people, and often vegetated areas where visibility is low; they are also frequently nocturnal in areas dominated by human activity, or only partially diurnal (Keuling and Leus 2018). This behaviour can make them difficult to observe and survey and thus also make management and surveillance difficult.

Wild boar are very adaptable and are thus found in various subalpine, temperate, subtropical and tropical habitats in the region, including riparian areas, semi-desert areas, rainforests, woodlands, grasslands and reed jungles (Dexter, 1998; Keuling and Leus, 2018; Saunders, 1993; Wehr *et al.*, 2018). They are typically found near thick vegetation and, if the area is warm and/or dry, close to a water source (Dexter, 1998). Although rarer, wild boar can also adapt to urbanised environments, taking advantage of anthropogenic food sources (Castillo-Contreras *et al.*, 2021).

Wild boar are opportunistic omnivores: their diet varies depending on location and availability. It is usually predominantly plant material, with some animal components such as carrion (including pig carcasses), small mammals and livestock (e.g. sheep) (Ballari and Barrios-Garcia, 2013; Choquenot *et al.*, 1997; Cukor *et al.*, 2020; Keuling and Leus, 2018). As well as cannibalistic scavenging, wild boar can also show particular behavioural interest in conspecific carcasses, including investigating the soil next to and under them and making direct contact (Probst *et al.*, 2017). Both of these factors represent considerable risk in the transmission of ASF to wild boar in some environments, as carcasses can remain infectious for substantial periods of time under favourable (cold) conditions (Fischer *et al.*, 2020).

Social behaviour and group size of 'sounders' – the matrilineal groups wild boar live in – can also considerably affect disease transmission. *Sus scrofa* are non-territorial and social, with overlapping home ranges and interactions between separate sounders or larger herds of wild pigs. Sounders can comprise up to 50 individuals, although larger groups of up to 100 pigs have been observed when water is scarce and sounders aggregate on available water sources (Haynes *et al.*, 1991; Wehr *et al.*, 2018). Population densities of sounders can be greater than 20 pigs/km^2, with large home ranges of up to 30 km^2, depending on available food resources (where food resources are scare – for example, during colder or drier seasons – home ranges may be relatively higher) (Caley, 1997; Giles, 1980; Korn and Bomford, 1996; Saunders, 1988). Proximity to water sources is important in hot environments for thermoregulation (Dexter, 1998), and the animals' sociability leads to close contact at such aggregation points. Given that wild boar infected with ASF are thought to specifically seek cool, moist and sheltered environments (including water-related areas) to ease clinical signs of the disease (Lim *et al.*, 2021), the potential for spread of infections such as ASF within and between separate groups of pigs at such points may be large.

In the Asia and the Pacific region, domestic pigs may be free ranging or semi-free ranging and can be housed in close proximity to wild pig populations. Interaction and contact have been observed globally between free-ranging or housed domestic pigs and wild pigs in Europe (Cadenas-Fernández *et al.*, 2019; Jori and Bastos, 2009; Wu *et al.*, 2012) and the Asia and the Pacific region (Hayama *et al.*, 2020; Pearson *et al.*, 2016). These interactions may be an important factor in the spread of ASF to wild pig populations.

2.2 Ecology of other wild suid populations in Asia and the Pacific relevant to transmission of African swine fever

There are 11 species of locally endemic wild pig species in the region. This includes seven *Sus* spp., three *Babyrousa* spp. and *Porcula salvania*. These species contribute significantly to the diversity of Suidae species globally and are an important conservation resource for the world.

These 11 species are declining in population distribution and abundance. Their conservation status varies from near threatened to critically endangered due to various threatening processes (including habitat loss).

There are some unique features of the wild pig species that could contribute to the epidemiology of ASF. For example, bearded pigs (*S. barbatus*) can migrate vast distances to forage for masting fruits, which could facilitate spread of ASF. However, this is not confirmed as it is unknown whether there are carrier states for ASF in bearded pigs or what the incubation period is.

In general, these 11 species are unlikely to have an important role in ASF epidemiology as their populations are small with limited distributions. This is especially true when relative numbers are compared with the numbers of pigs found in domestic production and the population of wild boar or feral pigs. Instead, ASF may have catastrophic population-level impacts on these wild pig species (e.g. threatening populations with local extirpation or extinction).

Information about each species is detailed in Appendix B and is largely drawn from the IUCN-associated resources.

Sulawesi babirusa *(B. celebensis)* © Thiemo Braasch, IUCN/SSC Wild Pig Specialist Group

2.3 Cultural contexts of wild pigs in the region

There is a diversity of cultures and affluence within and between the 32 WOAH Members of the Asia and the Pacific region. Features such as religions, food resourcing, employment and conservation attitudes can influence thinking on wild pig populations (Nelson, 1998) and thus may influence attitudes to disease management interventions in these populations.

This heterogeneity in attitudes within Members may present a particular challenge in devising and implementing management strategies for disease control in wild pigs that are broadly considered acceptable to society and that achieve reasonable compliance from the general public where relevant. For example, where domestic and/or wild pigs are an important food source to a subset of society, wild pig disease management strategies to control ASF spread may be considered warranted and economically justifiable. However, where cultures do not utilise pigs in such ways, ASF disease management may not be considered an economic priority.

Examples of the divergence of attitudes across the region and within Members are listed below.

- In Bhutan, there are strong Buddhist cultural elements of disapproval towards the rearing and slaughtering of pigs. In contrast, in the Hindu and other cultures in the country, pig ownership can be prestigious (conveying wealth and power) and pigs are given as gifts and used as sacrificial animals in cultural ceremonies (Nidup *et al.*, 2011).
- In China, in agricultural settings wild pigs are considered pests impacting agricultural crop yields. However, as wild pigs are also an important food source for the Siberian tiger (*Panthera tigris*), wild boar management strategies can affect tiger conservation efforts (Jin *et al.*, 2021).
- In Mongolia, wild boar are considered an endangered species, with hunting of wild boar in reeds illegal (Xuxin, 2021).
- In Japan, wild boar are endemic but cause concern as a result of urban encroachment, given the potential for spread of infectious disease, property damage and negative impacts on cropping (Yuji, 2020).
- In Indonesia, there is a diversity of attitudes. In the mostly Muslim areas (generally speaking, to the west) pigs are less tolerated; and in agricultural settings they can be detrimental to crop production and thus subject to culling measures (Rode-Margono *et al.*, 2016). Meanwhile, in other areas of Indonesia pigs are raised as an important food production animal and can be important culturally (Burton *et al.*, 2018; Paddock, 2019). Preferred sources of pig meat can also differ: in Sulawesi, the Minahasa people in the north have a strong preference for wild pig meat, while the Toraja people in the south prefer domesticated pig meat (Burton *et al.*, 2018).
- In the Philippines, warty pigs are considered a healthy source of meat and thus hunted, and they are also killed to protect crops (Tanalgo, 2017).
- In Papua New Guinea, pigs are a central part of cultural traditions. They are also regularly gifted as part of social relationships at the individual, family, clan and tribal levels and are traded to seal marriages or end disputes; they are thus also a symbol of social status (Ayalew *et al.*, 2011).
- In the Pacific Islands, feral pigs are an important part of the folklore and traditions of contemporary native people (Wehr *et al.*, 2018). However, feral pigs are also considered pests and an invasive species due to their adverse effects on native and non-native flora and fauna and agriculture (Litton, 2019).
- In Australia, attitudes towards wild *S. scrofa* are generally negative because it is an invasive species that causes environmental and agricultural damage and creates risk for domestic pig production (Australian Department of Agriculture, Water and the Environment, n.d.). Meanwhile, in New Zealand similar sentiments are balanced with views of feral pigs as being a food and hunting resource (New Zealand National Pest Control Agencies, 2018).
- Across the Asia and the Pacific region, the value placed on conservation of the endemic species can vary substantially. As previously described, wild pigs are commonly viewed as pests regarding their impacts on agriculture; meanwhile, there have been conservation programmes put in place for various species, such as the pygmy hog (Pygmy Hog Conservation Programme, n.d. -a, n.d. -b), the Visayan warty pig (Asian Species Action Partnership, 2021) and *Babyrousa* spp. (World Association of Zoos and Aquariums, n.d.).

3 Role of wild pigs in African swine fever epidemiology in the region

Wild pigs may contribute to the spread of ASF between domestic pig populations and to the maintenance of the presence of infection in a given geographical region. However, evidence as to the epidemiological role of wild pigs across the Asia and the Pacific region is generally lacking, with the exception of a few areas such as the Republic of Korea (Jo and Gortázar, 2020). For example, poor surveillance of wild pigs has led to uncertainties about whether ASF is circulating in wild boar (Vergne *et al.*, 2020).

Generalised comments on the role of wild pigs in ASF are often inferred from the role of wild boar in the pandemic in other geographical regions of the world. Much more is known about the epidemiology of ASF in wild pigs in areas of Europe, where more surveillance, research and epidemiological analyses have been conducted (European Food Safety Authority [EFSA] *et al.*, 2020; Boklund *et al.*, 2020; Dixon *et al.*, 2020; Glazunova *et al.*, 2021).

Epidemiological factors such as the susceptibility to infection and infectivity of wild pigs, the duration of infectivity, disease and mortality rates, and degree of contact between wild and domestic pigs are important factors in disease transmission but generally not quantified in endemic wild pigs in the Asia and the Pacific region.

3.1 Susceptibility to African swine fever virus infection and presence of infection and disease in wild pigs

3.1.1 Wild pig species with documented cases of African swine fever

African swine fever outbreaks have been reported in domestic pig populations within Members' borders in the Asia and the Pacific region, and spread of disease is predicted to continue (Food and Agriculture Organization of the United Nations [FAO], 2021a; Sur, 2019). With regard to wild pig species in the same region, ASF was identified in *S. scrofa* in China in 2018 and Laos and Vietnam in 2019 (Denstedt *et al.*, 2020). Since then, cases of ASF (occurring among mass mortalities attributed to ASF) have been documented in bearded pigs in Borneo (Ewers *et al.*, 2021; FAO *et al.*, 2021; Kurz *et al.*, 2021) and Philippine warty pigs (Chavez *et al.*, 2021). In the case of Philippine warty pigs, it was specifically noted that the disease appeared to be similar to that in domestic pigs (Chavez *et al.*, 2021).

The lack of reporting of cases from other wild pig populations cannot be presumed to indicate absence of the infection: in many of these countries, there are no reported surveillance activities in wild pig populations, or activities are limited to general surveillance, which may be insensitive for detecting and confirming the infection in wild pigs (WOAH, 2020a; Vergne *et al.*, 2020). There may be logistical reasons for an inability to detect ASF in certain ecosystems (for example, the deep forests in Japan) or difficulties relating to local authorities and resources (Vergne *et al.*, 2020). Indeed, it is thought that there may be more ASF circulating across populations of wild boar in Asia, given detections of the infection in domestic swine in many countries across the region (Vergne *et al.*, 2020).

3.1.2 Susceptibility to infection

The susceptibility to ASF infection of wild pig species in which ASF has not yet been reported is poorly understood, though plausible (Dixon *et al.*, 2020; Luskin *et al.*, 2021). While all species of Suidae are believed to be susceptible to infection (Jori and Bastos, 2009; Luskin and Ke, 2018), questions remain regarding variation in susceptibility and severity of disease between pig genera. Pigs of the genus *Sus* (bearded pigs and warty pigs) are predicted to be similarly susceptible to infection and disease as other *Sus* species and subspecies; however, it is not known whether susceptibility or ASF virulence differ in wild pigs of other genera (*Babyrousa* spp. and *Porcula salvania*) (Netherton *et al.*, 2019).

3.1.3 Official reporting of african swine fever in wild pigs

Reporting of ASF in wild pigs to the World Animal Health Information System (WAHIS, the WOAH tool for recording disease data globally) is limited (as of 20 July 2021) (WAHIS, n.d.). Reports of ASF in wild pigs have been submitted to WAHIS by four Members in the region – China, the Republic of Korea, Laos and Malaysia (Table IV). However, the most recent information available from Members in the region can date from as far back as 2016. From reporting by the FAO, Indonesia is documented as having the disease in wild pigs (FAO, 2021a). In the wild pig reports from both WAHIS and FAO, the only definitively reported species is *S. scrofa*. Some ambiguously defined species entries, e.g. those reported as 'Suidae (unidentified)', are considered to represent wild boar, given the geographical origin of the reports. Neither WAHIS nor FAO reported the ASF outbreaks known to have occurred in wild boar in Vietnam (Denstedt *et al.*, 2020), bearded pigs in Borneo (Ewers *et al.*, 2021; FAO *et al.*, 2021; Kurz *et al.*, 2021) and Philippine warty pigs in the Philippines (Chavez *et al.*, 2021).

Sunda bearded pig *(S. barbatus)* © Graham Usher

Table IV Reports of to WAHIS of African swine fever in wildlife in Asia (WOAH, 2020b)

Country	Semester	Administrative division	Species	New outbreaks	Susceptible	Cases	Killed and disposed of	Deaths
China (People's Republic of)	Jul–Dec 2018	Heilongjiang	Wild boar		375	77	298	77
	Jan–Jun 2019	Inner Mongolia	Wild boar	1	222	222	12	210
	Jul–Dec 2018	Jilin	Wild boar			1	0	1
	Jul–Dec 2019	Shaanxi	Wild boar	1		9	0	9
	Jan–Jun 2020	Shennongjia	Wild boar	2		7		7
Laos	Jul–Dec 2019	Huaphanh	Suidae (unidentified)	2		6	0	6
Malaysia	Jan–Jun 2021	Beluran	Wild boar	9	21	43	0	43
	Jan–Jun 2021	Kinabatangan	Wild boar	6	8	10	0	10
	Jan–Jun 2021	Lahad Datu	Wild boar	10	12	16	0	16
	Jan–Jun 2021	Nabawan	Wild boar	2	1	2		2
	Jan–Jun 2021	Sandakan	Wild boar	4	7	7	0	7
	Jan–Jun 2021	Sandakan	—	2	5	5		5
	Jan–Jun 2021	Tawau	Wild boar	4	2	4	0	4
	Jan–Jun 2021	Tongod	Wild boar	6	7	14	0	14
Korea (Republic of)	Jan–Jun 2021	Cheorwon	Wild boar	1		1	0	1
	Jan–Jun 2021	Chuncheon	Wild boar	87		87	0	87
	Jul–Dec 2021	Chuncheon	Wild boar	5		5	0	5
	Jan–Jun 2021	Gangneung	Wild boar	2		2	0	2
	Jul–Dec 2019	Gangwon-Do	Wild boar			17	2	15
	Jan–Jun 2020	Gangwon-Do	Wild boar	265		269	7	262
	Jul–Dec 2020	Gangwon-Do	Wild boar	182		183	14	169
	Jan–Jun 2021	Gangwon-Do	Wild boar	118		123	4	119
	Jan–Jun 2021	Gapyeong	Wild boar	15		16	0	16
	Jul–Dec 2021	Gapyeong	Wild boar	1		1	1	0
	Jul–Dec 2021	Goseong	Wild boar	2		2	0	2
	Jul–Dec 2019	Gyeonggi-Do	Wild boar			38	1	37
	Jan–Jun 2020	Gyeonggi-Do	Wild boar	324		332	3	329
	Jul–Dec 2020	Gyeonggi-Do	Wild boar	70		74	10	64
	Jan–Jun 2021	Gyeonggi-Do	Wild boar	54		59	4	55
	Jan–Jun 2021	Hongcheon	Wild boar	1		1	0	1
	Jul–Dec 2021	Hongcheon	Wild boar	2		2	2	0
	Jan–Jun 2021	Hwacheon	Suidae (unidentified)	2		2	0	2
	Jan–Jun 2021	Hwacheon	Wild boar	57	2	60	0	60
	Jul–Dec 2021	Hwacheon	Wild boar	1		1	0	1
	Jan–Jun 2021	Inje	Suidae (unidentified)	1		1	0	1
	Jan–Jun 2021	Inje	Wild boar	27		27	1	26
	Jul–Dec 2021	Inje	Wild boar	11		12	7	5
	Jan–Jun 2021	Paju	Wild boar	2		2	0	2
	Jan–Jun 2021	Pocheon	Wild boar	40		41	1	40
	Jul–Dec 2021	Pocheon	Wild boar	3		3	2	1
	Jan–Jun 2021	Yanggu	Suidae (unidentified)	1		1	0	1
	Jan–Jun 2021	Yanggu	Wild boar	33		34	0	34
	Jan–Jun 2021	Yanggu	—	1		1	0	1
	Jul–Dec 2021	Yanggu	Wild boar	2		2	1	1
	Jan–Jun 2021	Yangyang	Wild boar	1		1	0	1
	Jan–Jun 2021	Yeoncheon	Wild boar	66		71	0	71

3.2 Likelihood of transmission of infection from wild pigs to domestic pigs

The role of wild pigs in ASF transmission and the types of transmission will depend on many factors. For wild pigs, these include the species of wild pig, the ecology, distribution and abundance of wild pigs and how these wild pigs interact with wild or domestic pigs (Section 2). Amongst the wild pigs, *S. scrofa* (wild boar or feral pigs) would be expected to be most significant to transmission compared with other wild pigs, given their wider distribution and higher abundance than other species of wild pig. In addition, the type of domestic pig production in an area and biosecurity implemented will affect transmission. Domestic pigs raised by smallholders with poor biosecurity will be more able to interact with wild pigs.

Transmission of ASF from wild pig species other than *S. scrofa* to domestic pigs is plausible but not confirmed in the literature (Luskin *et al.*, 2021).

Generally, the role of wild *Sus* spp. in the epidemiology of ASF in the Asia and the Pacific region is not well understood owing to a lack of surveillance and reporting of cases (Vergne *et al.*, 2020). It may vary geographically with differing environmental conditions, by host species and/or by ASF strain. Most strains observed during the ASF pandemic have high virulence, but some (for example, the Estonia 2014 strain) have been observed to be moderately virulent in domestic pigs while being highly virulent in wild boar (Pikalo *et al.*, 2020; Sehl *et al.*, 2020). It is possible that strains of lower virulence may emerge in wild pig populations, but only high-virulence strains have been reported thus far and there are no reports of a carrier state in wild pigs. In domestic pigs, there is insufficient evidence of a carrier state of ASF in this outbreak thus far (Pikalo *et al.*, 2019, 2020), though a carrier state has been demonstrated experimentally using different strains of ASF to those circulating in this pandemic (Eblé *et al.*, 2019).

3.2.1 Transmission of infection between wild and domestic pig populations

The likely routes of ASF transmission between domestic and wild pig populations are considered to be direct contact or scavenging of infected carcasses; transmission may also occur through wild pigs having access to swill and contact with fomites and effluent from pig production. However, information on the distribution, density and ecology of the free-ranging wild boar and other endemic suid species within the Asia and the Pacific region, and on their interactions with domestic pigs, is limited (Denstedt *et al.*, 2020; Luskin *et al.*, 2021; Vergne *et al.*, 2020). As a result, the extent to which transmission occurs between wild and domestic pigs in this region is not well understood. Considering other geographical locations, in Sardinia, where ASF has been endemic for the longest duration in Eurasia, free-ranging pigs indirectly interact with wild boars on average 1.31 times a day when considering a short critical time window, and on average 6.47 times a day when considering a long critical time window. These interactions occur primarily at water sources (Cadenas-Fernández *et al.*, 2019).

Management of domestic pigs contributes to transmission of infection between domestic and wild pigs. In particular, containment of domestic pigs to reduce the rates of contact between domestic and wild populations is considered an important component of ASF disease control (Jori and Bastos, 2009; Sur, 2019). In the Asia and the Pacific region, domestic pigs can be housed in close proximity to wild boar habitats and may be free-ranging or semi-free ranging, rather than restricted within relatively permeable boundaries; this is common among smallholder farmers in Indonesia, Laos, Vietnam and Cambodia (Denstedt *et al.*, 2020; Leslie *et al.*, 2015b; Matsumoto *et al.*, 2021). Similarly, in the Pacific Islands, such as Fiji, domestic pig keeping largely consists of backyard production by the Polynesian population. In these circumstances, there is limited or no control over contact between domestic pigs and wild pigs (as evidenced by hybridisation) and thus limited control of spread of ASFV infection between wild and domestic pigs and across the region (Denstedt *et al.*, 2020; Matsumoto *et al.*, 2021). However, despite the extensive potential for interaction, from the known outbreaks within the Asia and the Pacific region most are considered to have started in the domestic swine population then spread to wild boar, rather than having been spread between domestic populations by wild boar (Table V). Nonetheless, in the Republic of Korea wild boar populations have contributed to the geographical spread of the infection (Jo and Gortázar, 2020, 2021).

Evidence from Europe is similarly heterogenous across countries. A review recently concluded that the evidence for transmission of ASF between wild pigs and domestic pigs being an important feature of ASF epidemiology is limited (Brookes *et al.*, 2021), and in the current outbreak, wild boar movements did not predict ASF dynamics in regard to space or time in Poland (Podgórski and Śmietanka, 2018). Meanwhile, many European outbreaks in domestic pig populations have been attributed to a wild boar infection source (Vergne *et al.*, 2020). In some Mediterranean countries, it was observed that where the disease is actively circulating in domestic pig populations, with high densities of wild boar and contact between wild boar and free-ranging pigs, wild boar can have an important role in the spread of the virus (Jori and Bastos, 2009). In Spain and Estonia, modelling suggests that environmental transmission of infection is an important determinant of the severity of an ASF outbreak: where relatively high ambient temperatures and abundant scavengers cause faster degradation of carcasses, outbreak severity may be reduced (O'Neill *et al.*, 2020). The same study also found that higher host densities and longer breeding seasons can increase the severity and duration of the outbreak and that transmission from infected wild boar that survive initial infection can be important in the persistence of the virus (O'Neill *et al.*, 2020).

The evidence from infected areas of Eurasia reveals some trends in epidemiology and transmission. In general, with the exception of Western Europe, the ASF pandemic appears to be driven by domestic production cycles, with wild boar being of secondary importance to transmission although they undergo regular spillover events and sometimes transmit infection. For example, in the Russian Federation and Caucuses, transmission is associated with movement of live domestic pigs and pork products or with poor biosecurity of smallholder pig production (Glazunova *et al.*, 2021). It appears that where wild boar outbreaks occur, transmission is more commonly from domestic pigs to wild boar. For example, outbreaks in domestic pigs were found to be independent of outbreaks in wild boar, suggesting a spillover from domestic to wild boars (Glazunova *et al.*, 2021; Vergne *et al.*, 2017). In Western Europe the predominant transmission is within wild boar populations, suggesting that the wild boar population is a reservoir and maintains ASF, with rare spread to domestic pigs (Boklund *et al.*, 2020; Dixon *et al.*, 2020). In other areas, there may be a mixture of both. For example, in Eastern Europe (Romania), outbreaks in domestic pigs were associated with proximity to outbreaks in wild boar and wild boar abundance (Boklund *et al.*, 2020), indicating that transmission was also occurring from wild to domestic pigs.

Transmission may also be influenced by ecological factors, either directly or through influence on activities that represent a disease transmission risk. For example, in China it was observed that the majority of outbreaks were detected between April and September (Liu *et al.*, 2020). It is hypothesised that this is due to increased contact between farms (people, fomites and insects) in this warmer part of the year owing to the seasonal nature of field work. Meanwhile, it is suggested that in cooler environments, the relatively longer process of carcass decomposition may prolong the risk of ASF transmission from infected carcasses in the environment, and that the ASFV persists longer in the environment and on fomites (Lim *et al.*, 2021).

Conservationist William Oliver helping in re-capture of pygmy hogs *(P. salvania)* at Nameri Wildlife Range, India © IUCN

Table V Reported outbreaks of African swine fever in Asia and the Pacific WOAH Members from 2018 to present

× = countries with no reported ASF outbreaks

Country	Outbreak start date, status	Classification of infected swine	Comments on source of infection and known spread	Reference
Australia	×	×	×	×
Bangladesh	×	×	×	
Bhutan	2021, 6 May (ongoing)	Wild boar (scavengers)	N/A	(WAHIS, 2021a)
Brunei	×	×	×	×
Cambodia	2019, March (resolved)	Domestic pigs	Backyard pigs in 2019 N/A Recent detections of smuggled infected pigs from Thailand	(WOAH, 2021a)
China (People's Rep. of)	2018, 1 August (ongoing)	Domestic pigs and wild boar	Majority occurred in suburban farms Likely domestic contaminated wild (report in 2020 of wild boar infected) Minimal interactions between hunters and pig producers, hypothesised spread due to tick-to-pig transmission	(Beek, 2020; Liu *et al.*, 2020; Tao *et al.*, 2020)
Chinese Taipei[1]	×	×	×	×
Fiji	×	×	×	
India	2020, 26 January	Domestic pigs and wild boar	Spread and transmission unknown due to COVID-19 pandemic First suspected in domestic pigs then in dead wild boars found in drainages/ rivulets Wild boar–habitat cycle predicted transmission	(WOAH, 2021a; Patil *et al.*, 2020)
Indonesia	2019, 17 December	Domestic pigs	Unknown source/inconclusive Spread by transportation of pigs and contaminated fomites from animal to human to vehicle to animal Analysis of the two outbreaks (North Sumatra and West Java) indicates a connection to each other and to those in Vietnam, China and Russia	(Dharmayanti *et al.*, 2021; WOAH, 2021a; WAHIS, 2021b)
Iran	×	×	×	×
Japan	×	×	×	×
Korea (Dem. People's Rep. of)	2019, 23 May	Domestic pigs	Detected in Chagang-do (border with China)	(Lundeen, 2019)
Korea (Rep. of)	2019, 17 September	Domestic and wild boar	Predicted to spread from domestic to wild boar by anthropogenic interactions First case of ASF in wild boar in Asian countries	(Jo and Gortázar, 2021)
Laos	2020, 20 June (resolved)	Domestic pigs and wild boar	Initially in domestic pigs, spread owing to anthropogenic interactions Spread to wild boar owing to free-ranging farming styles	(Denstedt *et al.*, 2020; WOAH, 2021a)

Country	Outbreak start date, status	Classification of infected swine	Comments on source of infection and known spread	Reference
Malaysia	2021, 8 February (ongoing)	Wild boar and backyard (domestic) pigs	First case detected following the death of a wild boar First case in domestic pigs was triggered after wild boar case and found in a dead backyard pig	(Heilmann *et al.*, 2020; WAHIS, 2021c)
Maldives	×	×	×	×
Micronesia (Federated States of)	×	×	×	×
Mongolia	2019, 10 January (resolved)	Domestic pigs	Likely spread due to swill feeding No wild boar ASF infections detected	(Heilmann *et al.*, 2020)
Myanmar	2019, 14 August (ongoing)	Domestic pigs	Recent outbreak in 2021, detected in a farm following death of pigs	(Linden, 2021)
Nepal	×	×	×	×
New Caledonia	×	×	×	×
New Zealand	×	×	×	×
Pakistan	×	×	×	×
Papua New Guinea	2020, 5 March (ongoing)	Free-ranging pigs	Indicated by the death of 396 free-ranging pigs Unknown/inconclusive source or origin	(WOAH, 2020c, 2021a)
Philippines	2019, 25 July (ongoing)	Domestic pigs and wild boar	Suspected to have spread after a resident brought a wild boar home ASF detected in villages	(WOAH, 2021a; The Pig Site, 2021)
Singapore	×	×	×	×
Sri Lanka	×	×	×	×
Thailand	×	×	×	×
Timor-Leste	2019, 9 September (ongoing)	Domestic pigs	Smallholder farms Unknown source, likely due to transporting infected pigs	(WOAH, 2019b, 2021a)
Vanuatu	×	×	×	×
Vietnam	2019, 1 February (ongoing)	Domestic pigs and wild boar	First detected in domestic pigs in February 2019, then wild boar mortalities in October were noticed, leading to confirmation in December Spread is likely due to farming method and spillover by domestic pigs	(Denstedt *et al.*, 2020; WOAH, 2021a)

[1] An infected carcass found at shore in 2019 (Strong, 2019) but the Member remains ASF free

3.2.2 Transmission and maintenance of African swine fever within wild pig populations

There is limited information available regarding transmission dynamics of ASF within wild pig populations in the Asia and the Pacific region. The dynamics are likely to be substantially influenced by the species of wild pigs present locally and their respective social and behavioural dynamics (Section 2). There is also very limited information available regarding the potential for maintenance of ASF in wild pig populations in this region, where species and ecological factors may play important roles.

In Indonesia, ASF observations suggest a lower rate of spread of ASF in wild pig populations than domestic, though with high mortality in wild pigs, and that environmental transmission occurs and may be persistent (Indonesian Ministry of Environment and Forestry, 2021). As previously mentioned (Section 3.2.1), under conditions of relatively high ambient temperatures and/or abundant scavengers, carcasses may degrade within shorter timeframes, and this may reduce transmission within wild pig populations in Members. Such a reduction in transmission may occur seasonally or may represent a relatively low rate of transmission year-round in countries with consistently hot climates.

Considering other geographical regions in the current pandemic, a wild boar–habitat epidemiological cycle has been described in Europe (Chenais *et al.*, 2019). This cycle involves direct transmission of the virus between wild boar, and indirect transmission through wild boar carcasses in the environment. In Europe, it has been demonstrated that ASF is more likely to spread in winter or when cold (Fischer *et al.*, 2020), that wild boar exhibit cannibalism (Cukor *et al.*, 2020) and that carcasses could remain infectious for significant periods of time (Fischer *et al.*, 2020). These findings have led to the assumption that infected carcasses that remain chilled over winter are maintaining ASF transmission and that this is a key epidemiological feature of ASF in Europe. In contrast, in warmer environments carcasses can degrade very rapidly due to action of heat, flies (maggots) and scavengers (Twigg *et al.*, 2005); thus, it is assumed that the likelihood of ASF transmission also rapidly declines under these circumstances. Many areas of the Asia and the Pacific region have warm climates (tropical, subtropical or warm temperate), and so the role of carcasses in the epidemiology of ASF may be less important across these areas. This is an area of research requiring further investigation.

Spread of ASF through natural movements of wild boar has undoubtedly occurred during the pandemic; for example, in infected areas of Europe, ASF has spread within wild boar populations at slow rates, such as 1.5 to 11.7 km/year (EFSA *et al.*, 2021; Boklund *et al.*, 2020; Podgórski and Śmietanka, 2018), leading to infections in new countries (Sauter-Louis *et al.*, 2021b). Under suitable ecological conditions the virus can persist in wild boar without reintroduction from infected domestic pigs (Boklund *et al.*, 2020; Dixon *et al.*, 2020). However, these findings contrast with observations from previous ASF epidemics. For example, in Sardinia and Spain the infection disappeared from wild boar populations in the absence of free-ranging, infected domestic pigs (Laddomada *et al.*, 1994). Equivalently, ASF was eradicated from Cuba in the presence of wild pigs, suggesting that the infection was not effectively maintained in that population (Simeón-Negrín and Frías-Lepoureau, 2002). The role of infected wild boar populations in maintenance of ASF in some Mediterranean countries was also thought to be considerably less important than the role of free-ranging pig production (Jori and Bastos, 2009). This may be explained by ecological factors – for example, the warm climates of these countries may break the wild boar–habitat cycle given that environmental persistence of ASF is considerably favoured by cold climates (Carlson *et al.*, 2020; Mazur-Panasiuk and Woźniakowski, 2020). Modelling considering Spain and Estonia similarly suggested that relatively rapid carcass decomposition under high ambient temperatures and scavenging pressure may mean that the role of carcasses is less significant in such environments (O'Neill *et al.*, 2020).

3.3 The role of soft ticks or other arthropods as vectors of infection in wild pigs

The role of soft ticks in the transmission of virus in the Asia and the Pacific region is unknown (Dixon *et al.*, 2020). Species of soft ticks related to known ASF tick vectors (genus *Ornithodoros*, particularly *O. moubata*) are present in central Asia and China – e.g. *O. tholozai*. In China, ticks have been hypothesised to play a role in recent outbreaks (Tao *et al.*, 2020); however, other sources have judged that ticks have not contributed significantly to the current outbreak (Blome *et al.*, 2020). There are no reports of *Ornithodoros* spp. ticks in South-East Asia (Frant *et al.*, 2017) and it is therefore considered implausible that vector-borne transmission of ASF occurs in this area. In Australia, there are two *Ornithodoros* spp. – a sea bird tick (*O. capensis*) and the kangaroo soft tick (*O. gurneyi*). Pigs have a different ecological niche in the country to the primary host species for these ticks (Doube, 1972) (Cowled, unpublished data), and neither tick species has been recorded to feed on pigs (Barker and Walker, 2014). It is thus considered that contact with feral pigs is likely to be limited, such that even if these tick species are capable of spreading ASF, their impact on disease transmission is likely to be limited.

Broadly, as soft ticks typically occupy burrows or nests (Vial, 2009) and none of the wild pig species in the Asia and the Pacific region are known to use burrows or other permanent resting places, it is considered unlikely that vector-borne spread of ASF will be significant in wild pig populations. For similar reasons, European wild boar in their natural environment are considered unlikely to come into contact with infected ticks and contribute to spread of infection by this route (Jori and Bastos, 2009).

Nonetheless, potential ASF-vector soft ticks may inhabit pigsties, so some contribution of soft ticks to maintaining ASF in domestic populations of pigs cannot be excluded (Golnar *et al.*, 2019). This may facilitate persistent spillover from domestic pigs to wild pigs. In known ASF tick vectors, transovarial, transstadial and/or venereal transmission of infection within tick populations occurs; these enable perpetuation of the infection in tick populations, even where disease transmission is not occurring between pig hosts (Burrage, 2013). Additionally, candidate ASF tick vectors are not host-specific, and this may facilitate spread of the infection between different pig species in the region (Luskin and Ke, 2018).

Other arthropod species, such as biting flies, may theoretically act as vectors of ASF infection. However, this role has not been confirmed, and if it is indeed a mechanism of disease spread, it is considered to be a great deal less important than contact between pigs (Bonnet *et al.*, 2020).

If there is a role of vector spread of ASF in the Asia and the Pacific region, the impact on maintenance and spread of disease in pig populations may vary geographically, particularly given the heterogenous distribution of various arthropods across different climates and microclimates (Vial, 2009). The impact may also vary seasonally, in consideration of fluctuations in soft tick populations and their activity (Lak *et al.*, 2007). It may also vary between suid species depending on habits of each species that may make them more prone to soft tick infections, including resting habits and interactions with domestic or other wild pigs.

Wild boar *(S. scrofa)* den, Japan © Shigeki Hirata, Institute of Livestock and Grassland Science, NARO

4 Summary of a survey of Asia and the Pacific WOAH Members and interested researchers

This section provides a brief summary of a survey of Asia and the Pacific Members and interested researchers regarding ASF and wild pigs in the region (Appendix C).

4.1 Introduction

A survey of Members and other relevant experts was conducted within Asia and the Pacific to provide insight into the wild pig situation and to assist in generating recommendations to better manage the risk of ASF in wild pigs. Specific areas of the survey focused on species present, distribution and abundance, farming methods used, ASF status and transmission pathway, and current control strategies in place for wild pigs.

4.2 Method

The survey was created by Ausvet and WOAH staff (Appendix D). The online survey tool Qualtrics (Qualtrics, 2021) was used to design, create and disperse the questionnaire. It was also converted into a Word document format for an alternative option for completion. The survey was distributed by email to Member delegates within Asia and the Pacific (usually the Chief Veterinary Officer) via the WOAH regional representative and was circulated for approximately six weeks. In instances where more than one Member provided a response to the survey, their results were combined to represent a single entry. If there were contradicting answers provided by multiple respondents from the same Member, the answer was taken where it provided a 'yes' to the question, and if there was an 'unsure' and a 'yes' response for the same question, 'yes' was used as the final answer.

4.3 Results

There were 35 responses representing 27 different Members within Asia and the Pacific; not all Members responded to all questions. The most common species present was *S. scrofa* (wild boar or feral pig) (96%, *n*=26/27 Members). Many Members (67%, *n*=18/27) noted there was no information on the distribution or density of wild pigs or left these sections blank on the survey, indicating a lack of knowledge.

Domestic pig farming of *S. scrofa* was reported in many participating Members (72%, *n*=18/25), of which small-scale (*n*=15) and medium-scale (*n*=14) production were reported to be the two most common methods. Large-scale production was also reported (*n*=9). The use of small-scale production systems occurred mostly in developing Members (*n*=11); 54.5% (*n*=6) reported using free-ranging/scavenging systems, of which half also had wild pigs present. The control measures implemented by these developing Members were minimal. For example, biosecurity was only used in 18% (*n*=2/11) and fencing was not used by any of the reporting developing Members with free-ranging systems.

Of the participating Members, ASF in wild pigs has been detected predominantly in wild boar/feral pigs (*S. scrofa*) (43.5%, *n*=9/23). It has also been detected in bearded pigs (*S. barbatus*) (by two Members) and Philippine warty pigs (*S. philippensis*) (by one Member). The transmission of ASF has been reported in both directions between wild and domestic pigs.

More than half of the responding Members (73.9%, *n*=17/23) indicated they used control or prevention strategies for ASF in wild pigs. A variety of control tools were used, including fencing and other biosecurity measures. Population control/culling tools were reported by 13% (*n*=3/23) of responding Members, of which hunting (i.e. shooting on the ground and trapping) was most common, used by all three Members. Some countries reported that other control tools such as poison baiting (33%, *n*=1/3) and aerial shooting (33%, *n*=1/3) were available. Six responding Members indicated that there were no control strategies in place (26%, *n*=6/23). The majority of responding Members reported the implementation of a managed hunting strategy for wild pigs (54.5%, *n*=12/22). Reasons for hunting were primarily for food (78%, *n*=7/9) and for game (67%, *n*=6/7).

4.4 Discussion

Wild pigs are widely distributed within Asia and the Pacific, although the density of wild pigs in several Members remains unclear. Transmission of ASF is occurring between wild pigs and domestic pigs in both directions, via both direct and indirect contact routes. Thus, managing ASF and wild pigs within the Asia and the Pacific region may be very important. Questions to resolve to understand the importance of wild pigs include their epidemiological role in ASF epidemics and the potential impact on small populations of endemic Suidae species that are important for conservation. For example, are wild pigs spillover hosts or reservoirs, and are they important in the epidemiology of disease?

In the context of ASF, farming methods can also contribute to the risk of exposure and spread (Leslie *et al.*, 2015b). Many Members, especially developing countries, rely heavily on small-scale production systems, especially free-ranging/roaming methods. It was found that the proportion of small-scale production was higher in developing Members (59%), which also had fewer control measures in place to prevent ASF transmission. It is very difficult to implement appropriate biosecurity measures with these methods of production, and as such transmission of ASF between wild and domestic pigs is an ongoing risk that will complicate management of ASF in the region. While the resources and ability to manage these risks can be limited, prior research has indicated that application of simple biosecurity improvements may reduce the risk of this transmission (Leslie *et al.*, 2015b). For example, education about infectious diseases, isolation of moved pigs, village-level biosecurity practices and penning pigs may improve biosecurity.

Culling was specifically used as an ASF control strategy by four developed Members and one developing Member, and it was only used in regions where wild boar is the sole wild pig species present. However, a larger proportion of respondents indicated there was a managed hunting season/strategy in place (41.9%), indicating culling may be operating in more regions than explicitly specified, although used for food more than for disease prevention. There is opportunity for developing Members to implement more strategic culling to target wild boar. Tools such as ground and aerial shooting, trapping and poison baiting could be used more widely and offer a more timely and efficient approach to population control of wild boar (if the resources are available and their use is suitable).

4.5 Conclusions

Transmission of ASF is occurring within and between wild and domestic pigs in the Asia and the Pacific region, indicating specific management strategies in the region should be reconsidered based on the analysis of this survey. It is evident that the types of production systems used for farming domestic pigs represent various levels of disease exposure and risks from wild pig populations. Thus, many developing Members are at high risk of ASF owing to their free-ranging or scavenging production systems, minimal resources for pig management, and a lack of available options. Implementing low-cost and effective methods to reduce immediate risks is a priority; for example, implementing biosecurity practices will assist in protecting the domestic pig production and reduce the spillover of wild pigs. Additionally, developed Members – whether affected by or currently free of ASF – could benefit from several of the population control measures recommended in this report, such as poison baiting and aerial shooting. Participating in preventive control strategies and implementing targeted measures is essential for being prepared and attempting to eliminate disease effectively.

5 Disease prevention and response activities utilised for wild suid populations

African swine fever infection in wild pigs is important for two main reasons:

- the impact of ASF on wild pig populations
    - Many wild pig species in the region are endemic and have a small range and limited population size, with conservation statuses ranging from near threatened to critically endangered in all species except wild boar. The introduction of ASF into such populations would be an additional threatening process and may lead to further population reduction, increasing the probability of extirpation and extinction.
- the role of wild pigs in transmission of ASF
    - *Sus scrofa*, bearded pigs and Philippine warty pigs are known to be susceptible to ASF. The susceptibility of the other nine species of pig in the region is unconfirmed, but all are believed to be susceptible (at least for precautionary reasons) (Luskin *et al.*, 2021). Wild pigs can thus complicate control of ASF in domestic pigs.

This section details the types of strategies, activities and tools that are available to prevent, detect and respond to ASF in wild pigs and to protect wild pigs. The appropriate mix of tools and strategies to apply in a given situation depends on the type of transmission that is occurring and the practicality of applying given disease control tools or approaches in the context of that outbreak. As there is not yet a vaccination available for ASF, strategies generally focus on reducing transmission.

For all disease prevention and response activities, implementation of training and education is an essential aspect of maximising effectiveness. In China, education and training played considerable roles in responding to the last outbreak (Liu *et al.*, 2020).

Disease prevention and response activities are discussed in greater detail below.

5.1 Context – wild or feral pigs and local production practices

The context is important when considering a local response to ASF in wild pigs. Pertinent factors include those listed below.

- The species of wild pig, regarding conservation status and aspects of the wild pig species' ecology relevant to ASF transmission in the area

The conservation status is affected mostly by whether wild pigs are a feral species (with feral species usually being *S. scrofa*) or an endemic species and, if the species is endemic, whether it a widely abundant species (endemic wild boar [*S. scrofa*]) or one of the other 11 species that are all of conservation concern (vulnerable to critically endangered) (Section 2).

The ecology of the local species may provide insights into the likelihood of it being important in the transmission/maintenance of ASF in the region and thus whether control measures may be warranted.

- The socio-economic status of a region
    - For example, in developed countries (such as the Republic of Korea, Singapore and Japan) there are extensive resources that can be

deployed to manage an outbreak. However, in some other countries in the region, for example the least developed Members of the Greater Mekong area, there may be other pressing needs that would take priority over the management of ASF in wild pigs.

- Available resources
    - o This is closely related to the socio-economic status of a region but can also affect implementation of control measures in relatively well-resourced Members where affected areas are particularly demanding (e.g. a very large area affected, or areas that are hard to access and require relatively more resources).
- The type of domestic production that is present
    - o For example, if there is a large proportion of production by subsistence farmers with backyard production and poor biosecurity, control programmes will be harder to manage as meaningful change to biosecurity practices by producers is hard to implement. This may mean that there is constant spillover from domestic to wild pigs.
    - o In contrast, if the production is commercially based, biosecurity may be easier (for example, with compartmentalisation approaches) and thus minimise the risk of spillover to wild pigs. Production type is often correlated with socio-economic status.
- Ecological and climatic conditions
    - o Ecological and climatic conditions may have an important role in ASF transmission-related factors, such as the persistence of the virus in the environment and the activity of wild pig species. Thus, response activities may be influenced accordingly.

In consideration of the context of the infection, ASF outbreak preparation and response activities can be prioritised accordingly to maximise their effectiveness.

5.2 Prevention – border quarantine and islands

Quarantine measures for the movement of pigs and regulation of importation of pork products are key means of minimising the risk of spread of ASF. The WOAH *Terrestrial Animal Health Code* (*Terrestrial Code*) presents normative international standards, compliant with the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures, on how to trade in pig and pig products safely (WOAH, 2021b). Implementation of an effective quarantine system and of these technical practices from trade of pork products will reduce the risks of ASF transmission between Members. Nonetheless, despite the existence of border quarantine, the ASF pandemic has spread widely across numerous borders, including in the Asia and the Pacific region. It is likely to be attributable to non-compliance with quarantine rules and/or natural movements of wild pigs (especially *S. scrofa* or wild boar).

5.2.1 Prevention through border quarantine with training and education

Quarantine can have two purposes: it can aim to prevent spread of ASF to protect domestic pigs, and it can be targeted at islands with significant populations of endemic wild pigs.

Quarantine likely has a particular role to play in the Asia and Pacific region to prevent spread of the pandemic to uninfected islands, as islands form a natural boundary to movement of domestic and wild pigs and pork products. While some wild pig species are known to swim between islands in the region (e.g. the bearded pig [Luskin and Ke, 2018])), and an infected carcass is known to have washed up on an uninfected island in the region (Strong, 2019) (Appendix A), these are likely very rare events and thus not an important means of transmitting ASF between islands except where islands are geographically very close. Members of the region that remain uninfected by ASF include island nations within the Pacific, Japan, Australia and New Zealand; and many countries that comprise islands, for example archipelago nations such as Indonesia and the Philippines, have large areas of their country that remain free of disease.

Clearly, control of ASF spread with quarantine will be easiest between geographically distinct island nations. For example, the spread of ASF between Papua New Guinea and Fiji could be relatively easy to prevent – Fiji and Papua New Guinea have few trade or cultural relationships, and there is a substantial distance between the two nations. In comparison, trade and cultural links within island nations and between some neighbouring island nations may make implementation of a quarantine strategy more difficult. For example, studies on domestic pig movements in eastern Indonesia (East Nusa Tenggara, Timor province) reveal that both formal and informal movements occurred for income-generating and cultural reasons across substantial distances within and between island nations (Leslie *et al.*, 2015b). In this case, control of classical swine fever (CSF) was not possible solely with regulation of movements; instead, actions to reduce prevalence at village level involving biosecurity and vaccination programmes were required. Similar complexities with pig movements have been recorded in other areas of the Asia and the Pacific region – for example, within the Philippines (Alawneh *et al.*, 2014), and in a non-island setting regarding movements from Thailand to the Greater Mekong subregion (Kerr *et al.*, 2012). Wild pig meat is also known to be transported for trade and culture, for example between Sumatra and Sulawesi in Indonesia (Sheherazade, Wildlife Conservation Society, personal communication, November 2021).

For an effective quarantine programme, the key issue is application of epidemiologically appropriate rules that are suitable to the social, cultural and economic features associated with pig and pork value chains so that people can feasibly follow quarantine and are motivated to do so (Dixon *et al.*, 2020). Social and economic research is likely required to understand movements of pigs and pig products and thus the most appropriate means of managing risk through quarantine and trade regulations, including regarding incentivisation. Introduction of quarantine and border control strategies with the aim of prevention of spread of ASF to protect domestic pigs would likely gain the support of local pig producers, whereas targeting of quarantine solely based on protection of endemic wild pigs may be harder to implement successfully as there may be less immediate perceptible value to locals.

Educating the public that trade of meat risks introducing ASF and subsequently killing all local pigs, including their own, may encourage compliance but is unlikely to be sufficient as a stand-alone tool. Appropriate resourcing of Veterinary Services, enforcement and communication are also essential to ban all imports from infected areas (Dixon *et al.*, 2020).

5.2.2 Prevention through control of wild boar

It can be exceedingly difficult to prevent the natural transmission and dispersal of ASF through wild boar across land that is not separated by a natural boundary (e.g. ocean). In the longer term, it is important that natural movements of wild boar populations are allowed to occur to enable the normal ecological processes of maintaining genetic diversity and replenishment within wild boar populations, and in any case, it is very difficult to prevent the movement of wild boar across borders. While pig-proof fencing is possible (Hone and Atkinson, 1983), it can be very expensive and difficult to maintain. Fences often need to be very long, with considerable expense in building materials and labour to erect the fence to be pig proof. The fence then needs to be maintained for long periods of time (for example, by clearing fallen trees from fences and repairing after adverse weather), and maintenance expenses can be high. Fence locations often in remote areas compound these issues (Hone and Atkinson, 1983; Lavelle *et al.*, 2011). Nevertheless, there are pig-proof fence designs – for example, electric fences usually used to contain stock, but these are difficult to implement (Hone and Atkinson, 1983; Lavelle *et al.*, 2011).

5.3 Detection – surveillance for African swine fever and increasing knowledge of disease ecology in the Asia and the Pacific region

5.3.1 Surveillance for African swine fever

Surveillance for ASF and to improve understanding of population ecology in wild pigs is important to effectively manage ASF.

5.3.1.1 Detection of outbreaks

Early detection of ASF enables timely implementation of appropriate control measures to minimise resources required to manage the infection. For early detection of ASF, general surveillance[1] is usually the most effective and efficient approach. General surveillance is ongoing and involves maintaining continuous observation of the disease profile of a population so that unexpected changes (such as the emergence of ASF) can be detected and acted upon as rapidly as possible (Sergeant and Perkins, 2015). Due to the high mortality in affected wild pig populations, general surveillance for dead and dying wild pigs is considered the most sensitive approach to the detection of ASF incursions in wild pigs in new areas (Carlson *et al.*,

1 Passive surveillance is a type of general surveillance.

2018; Frant *et al.*, 2017; Pautienius *et al.*, 2020; Sauter-Louis *et al.*, 2021a; EFSA Panel on Animal Health and Welfare [AHAW] *et al.*, 2018). Education of relevant stakeholders (e.g. farmers, hunters, forest rangers and people with a deep knowledge of wild pigs), including prompt reporting to the relevant authorities, can help to maximise the effectiveness of general surveillance in early detection of the disease. In this context, provision of financial compensation to producers and others associated with the pork value chain for culling of pigs in response to ASF is an important aspect of encouraging early reporting of cases in domestic pig populations (Dixon *et al.*, 2020).

Ideally, collaboration with groups of people who are in close contact with wild pigs should enhance the sensitivity of general surveillance for ASF incursions in wild populations of pigs. For example, hunters or other land managers can identify wild suid carcasses and help to obtain samples to enhance general surveillance activities (Animal Health Committee [AHC] African Swine Fever Feral Pig Task Group, 2020; Jori and Bastos, 2009; Marcon *et al.*, 2019; Indonesian Ministry of Environment and Forestry, 2021; Government of the Hong Kong Special Administrative Region of the People's Republic of China, 2021). Biosecure sampling and testing of wild pig carcasses for ASF is also proposed to facilitate early detection of the disease in wild populations of warty pigs and babirusa species in South-East Asia (Luskin *et al.*, 2021).

The sensitivity of general surveillance in wild populations may be influenced by seasonal activity of hunting. For example, in north Sulawesi, demand for wild pig meat peaks with ceremonies (usually July to October and the Christmas/New Year period) (Burton *et al.*, 2018); this pattern may influence the time-to-detection of an incursion in that area. In Estonia, there was an equivalent situation in obtaining samples through hunters, where sampling had a distinct peak in winter with hunting activities (Schulz *et al.*, 2020).

5.3.1.2 Understanding transmission within known outbreaks

In areas of known ASF outbreaks, disease modelling with information gained from general surveillance and regular active searching for wild pig carcasses may assist in understanding disease transmission and monitoring changes in the disease incidence in wild pig populations (Gervasi *et al.*, 2020). Obtaining samples through hunting may also be possible, depending on local approaches to hunting in the event of an ASF outbreak (Jori and Bastos, 2009; Marcon *et al.*, 2019). In areas where alternative control tools (such as aerial shooting, poison baiting with a rapidly lethal toxin or trapping) are used, disease managers may have easy access to recently killed wild pig carcasses. These carcasses can be useful for collection of diagnostic samples, and thus effective control of populations and surveillance can occur concurrently.

In areas where ASF is known to be present, surveillance provides insights into the distribution of disease and, depending on surveillance approaches, can also provide data on trends in the incidence of disease (for example, serosurveillance of different age structures of the wild pig population).

As an example, comprehensive surveillance is an important part of China's strategy regarding prevention and control of ASF (Liu *et al.*, 2020).

5.3.1.3 Sharing of surveillance data

Timely capture, collation and sharing of ASF surveillance data from both wild and domestic pigs are expected to be of value in predicting the spread of ASF and managing and responding to risk in both wild pig and domestic pig populations (Dixon *et al.*, 2020; Luskin *et al.*, 2021; Mighell and Ward, 2021). In general, WAHIS has proved useful in understanding the distribution of ASF in domestic pigs across the region. It provides excellent support for managing the risks of trade in pigs and pig products. However, the system is not designed to be used for local disease management activities as it lacks granularity (all reporting is at Member level). The gaps in reporting of ASF in wild pigs (Section 3.1.3) suggest that education of all relevant parties (e.g. researchers, zoos, veterinary clinics and Member departments of agriculture and conservation) regarding the importance of reporting ASF to authorities may be beneficial.

In Indonesia, the national animal health information system, iSIKHNAS, was used in the detection of ASF in 14 provinces (Indonesian Ministry of Environment and Forestry, 2021). A similar system that is granular and crosses borders would aid neighbouring Members in understanding their risks of ASF and could improve the ability to respond to those risks or an incursion of infection. However, the costs, time, political will and resources required to implement such systems should not be underestimated.

5.3.1.4 Possible refinements to surveillance

Several approaches have enabled improvements to surveillance at the national level or may be useful to the process. These include:

- statistical analysis of surveillance data to determine risk factors associated with disease, to inform a risk-based surveillance approach that can more efficiently detect disease incursions. For example, sampling in winter and testing samples originating from general surveillance activities (rather than targeted surveillance) results in an increased likelihood of detecting infection;

- sampling of faeces for ASF, enabling efficient field sampling (Nieto-Pelegrķn *et al.*, 2015);

- sampling of antibodies relative to virus, to increase understanding of disease transmission and facilitate identification of freedom from infection (Schulz *et al.*, 2020);

- environmental sampling to detect virus from carcasses (Lee *et al.*, 2021).

5.3.2 Understanding wild pig population distributions and abundance

A key feature of a successful surveillance programme for ASF in wild pigs is understanding of the abundance and distribution of epidemiologically relevant wild pig populations (Bosch *et al.*, 2017). This allows disease managers to plan surveillance efforts of optimal efficiency and identify current gaps in surveillance. In addition, ASF control activities can be focused on appropriate wild pig populations (e.g. where wild boar are coincident with domestic pigs and/or with high conservation value populations of wild pigs). However, in many Members, there has been minimal research to document the distribution and abundance of wild pigs. With such information sometimes unknown to disease managers, disease interventions can be difficult to institute in an efficient and effective manner.

Although wild pigs are generally large ungulates and might be assumed to be highly visible, many of the species are cryptic and difficult to survey. For example, wild boar and feral pigs (*S. scrofa*) can at times be difficult to observe owing to the remote, often vegetated areas they inhabit and the fact that they may be nocturnal or only partially diurnal (Keuling *et al.*, 2018). Nevertheless, there are a variety of means of surveying wild pigs to understand their distribution and abundance. These include complex methods that require systematic measurement, repeated sampling and numerical analysis that may be useful for larger-scale assessment and management of pigs, and simple methods that provide indices of abundance that are useful locally to allow on-the-ground management (Korn and Bomford, 1996).

Some of the more complex methods include aerial survey methods (especially the use of helicopters flying transects) (Fleming and Tracey, 2008) and ground survey methods (e.g. mark-recapture) (Caley, 1993).

Simpler measures of damage caused by wild pigs (e.g. rooting in soil) can also be used to understand distribution and relative abundance (West, 2008). Alternatively, a method focused on questioning people who know about wild pigs and can represent a broad area of a country can achieve such results. For example, data on the national distribution and relative abundance of feral pigs across the continent of Australia were refined through a survey of institutional knowledge. For this, biosecurity and vertebrate pest managers from a variety of national and state governments were interviewed to determine where pigs were found and how many there were; from this information, a national distribution and abundance map of feral pigs was produced to complement existing estimates of feral pigs (West, 2008). Other methods include habitat suitability indices (Cowled *et al.*, 2009), while some methods combine expert opinion and habitat suitability measures such as vegetation cover (Bosch *et al.*, 2017).

5.4 Response – manage African swine fever transmission to and within wild pigs

The key approaches and tools available to manage transmission to and within wild pig populations include:

- fencing, to provide a barrier to disease transmission;
- reduction of wild pig population density (*S. scrofa*) to minimise transmission;
- wild pig carcass removal to break the wild boar–habitat cycle;
- biosecurity strategies to minimise direct and indirect contact between and within domestic and wild pigs (e.g. confinement of domestic pigs with appropriate fencing, hygiene and movement restrictions) to reduce spillovers from domestic pigs;
- in preparation for a possible vaccine, research and development of bait delivery strategies;
- vector control processes (if indicated).

5.4.1 Interagency coordination

Frequently, there is a separation between government ministry responsibilities for agricultural production and livestock disease (e.g. Ministry of Agriculture) and those for the environment and wildlife populations (Ministry of Environment). This division can result in poor cooperation, collaboration and communication between disease managers and environmental managers and thus sub-optimal ASF response – for example, a lack of surveillance for ASF in wild pigs complicating an ASF response (Vergne *et al.*, 2020).

5.4.2 Fencing

Pig-proof fencing can be used to prevent incursion of ASF into protected or free areas (Section 5.2.2) and in response to incursions to contain ASF-infected areas or to assist in population control programmes for wild pigs (especially on relatively small islands).

Pig-proof fencing has significant limitations, including expense and logistical difficulties (Section 5.2.2). Nevertheless, the Republic of Korea has used fencing to successfully contain infected wild boar locally during its response to ASF (Jo and Gortázar, 2020). Germany has constructed fencing to prevent transmission of ASF in wild boar from Poland (Sauter-Louis *et al.*, 2021b).

5.4.3 Reducing wild suid population density through population control tools

5.4.3.1 Theories and evidence about wildlife and wild pig culling

Some of the earliest wildlife disease ecology work was conducted using mathematical modelling and generated some key concepts – for example, density-dependent and frequency-dependent transmission (Anderson and May, 1979). In density-dependent transmission, transmission increases when there is a higher density of hosts. A practical outcome of density-dependent transmission is that there is a theorised threshold density of hosts below which disease will fade out in a population (Lloyd-Smith *et al.*, 2005). However, wildlife disease has proved to be more complex than predicted with mathematical modelling, with most transmissions consisting of a mix of density- and frequency-dependent transmission (Hudson *et al.*, 2002) and threshold densities difficult to predict or being not as abrupt as might be predicted (Lloyd-Smith *et al.*, 2005). For ASF in Europe, there was not a discernible threshold density, with ASF found in low-density wild boar populations (Pejsak *et al.*, 2018; EFSA Panel on AHAW *et al.*, 2018). However, management to reduce abundance of wildlife to control diseases can be effective given that high host population densities can result in increased outbreak severity and duration (Lloyd-Smith *et al.*, 2005; O'Neill *et al.*, 2020).

African swine fever disease modelling in Europe has suggested that population density is an important feature in the transmission and persistence of disease, or that control of ASF often requires a reduction in population density of wild boar, generally using hunting (Bergmann *et al.*, 2021; Gervasi and Guberti, 2021; Halasa *et al.*, 2019; Mur *et al.*, 2018; O'Neill *et al.*, 2020; Taylor *et al.*, 2021). In some circumstances it does appear possible to eradicate disease, but not the wild boar population, using population control and carcass removal (O'Neill *et al.*, 2020). Reviews of real-world data and research reveal that control measures used successfully in Europe focus on detection and removal of contaminated carcasses, culling to lower the density of wild pigs, and limitation of movement of wild pigs with fences or depopulation areas (pre-emptive culling) (Sauter-Louis *et al.*, 2021a). The modelling and field data reported are generally consistent in showing that culling of pigs to reduce densities (usually using hunting in Europe) is a key feature of existing control programmes for ASF in wild boar.

However, there is some disagreement in the literature. Given the high mortality rates associated with ASF, some studies have raised questions about the need to actively reduce the population density as a response strategy as ASF disease mortality has been suggested to be more effective at reducing population densities than hunting (Morelle *et al.*, 2020). It is suggested that hunting is reasonable only as a pre-emptive measure where disease incursions are anticipated and that it should cease if an epidemic occurs, to be replaced by carcass removal (Morelle *et al.*, 2020). Other authors in Europe, such as the EFSA Panel on AHAW *et al.* (2018), support this argument, suggesting the use of culling be restricted to pre-emptive reduction in wild boar populations before ASF arrives in an area, or culling around an outbreak as a containment strategy. However, the EFSA Panel on AHAW *et al.* were careful to distinguish between feral pigs and wild boar. Feral pigs in their range represent a different context in which the public and legal factors mean that more effective control tools can be used and populations controlled with means other than hunting.

In summary:

- Lethal wild pig population control tools (e.g. hunting, aerial shooting, trapping and poison baiting) can be used in the face of an outbreak to reduce population density and hence reduce contact rates and probably ASF transmission between wild pigs. However, the way that these tools can be used will depend on context, largely associated with the conservation status of wild pigs and local attitudes towards different tools.
- The efficacy of population control is limited in areas where the full suite of control tools is not available; for example, in Europe, ASF may kill more pigs than control with hunting can achieve. Likewise, in parts of the Asia and the Pacific region, legal and societal impediments and lack of research and development reduce the number of control tools available and the efficacy of any control programmes. For example, hunting will rarely kill a high proportion of the population or be faster than an ASF outbreak, and the use of population control tools (such as pre-emptive culling to contain infection) may be limited to the area surrounding an outbreak.
- In areas of feral pigs or where wild boar are invasive (e.g. Australia, New Zealand, some Pacific Islands), several highly effective tools are already available and it may be possible to use these tools within an area of ASF infection to induce disease fade-out more quickly and effectively than ASF would alone. In addition, pre-emptively culling in areas surrounding an outbreak could be used to contain infection. Although eradication of ASF may be possible, rarely will the application of tools be able to eradicate feral pig populations.

A disease threshold for ASF fade-out in wild pigs has not been demonstrated in Europe, and it is uncertain whether one exists (Lloyd-Smith *et al.*, 2005; EFSA Panel on AHAW *et al.*, 2018). Despite this, most complex simulation modelling for ASF in Europe and practice indicate lethal population control tools can assist disease management

Controlling ASF in other endemic wild pig species (not *S. scrofa*) that have less resilient populations using culling will not usually be suitable – this is generally illegal and may threaten the survival of the species to a greater degree than ASF. In these cases, other tools will be important to reduce the risks of ASF impacts on the population (e.g. quarantine and biosecurity).

5.4.3.2 Integrated pest management

It is important to use any population control tools, especially those that involve culling wild pigs, in an integrated pest management approach for greater success. Integrated pest management is defined as 'a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks' (United States Government, 2006). Integration of pest management options and techniques has been mandated in some countries during feral pig control – for example, in the Australian model code of practice (Sharp and Saunders, 2012). Effectively, this means that several tools in concert are required to manage wild pigs optimally, not just a single lethal control tool such as hunting. This could include, for example, prevention of feeding of wild boar (Guberti *et al.*, 2019), increased hunting and additional control tools (e.g. aerial shooting), all in concert to induce a sustainable reduction in a wild boar population where and if this is desired.

In a broader sense, this same philosophy applies to ASF control in wild pig populations. Control of ASF through population control with culling is only one of the tools that should be used. Other ASF control tools such as fencing, biosecurity measures to prevent contact with domestic pigs (Section 5.4.6) and removal of infected carcasses in appropriate areas (Section 5.4.5) are essential for effective control of ASF transmission.

5.4.3.3 Scale of culling programmes

Successful population control through culling using a variety of tools is costly and resource intensive. It can generally only be applied across relatively small areas in widespread populations of wild pigs. This makes it difficult to conduct pre-emptive culling or to instigate culling across very broad areas during a widespread outbreak of ASF. However, small and inappropriately scaled wild pig control programmes can be similarly ineffective owing to local migration and breeding (Cowled *et al.*, 2006). Therefore, if culling is to be undertaken as a tool there should be sufficient resources to fund culling programmes that are large enough to be effective.

Nevertheless, targeted culling may be a feasible tool in preventing establishment and spread of infection (AHC African Swine Fever Feral Pig Task Group, 2020). Strategic culling around and inside outbreak areas would be an essential approach to allow an efficient and effective control and eradication programme for ASF in feral pigs. To be effective, the use of such strategic culling would require a strong early detection surveillance system to ensure that new outbreaks are detected early and thus maximise chances of success.

5.4.3.4 Issues to consider when determining whether to cull wild pig populations for African swine fever control

There are several key issues that should be considered when implementing a population control programme for wild pigs to reduce ASF transmission.

- The epidemiology of transmission.

Are wild pigs contributing to the transmission and therefore maintenance of ASF? If pigs are simply a spillover host in the region and infection is originating in domestic pigs, then culling of wild pigs is not required. Alternatively, if wild pigs maintain the infection as a reservoir, then culling may be a suitable strategy.

In different geographical regions of the pandemic, the role of wild pigs has variably been seen as one of spillover host, reservoir of infection, or both. Surveillance data from a particular area is required to determine the role of wild pigs in the Asia and the Pacific region. While a precautionary principle could be followed in the absence of knowledge of wild pigs' role, with wild pigs presumed to be epidemiologically significant in transmission and therefore potentially subject to population control, this is unlikely to be considered acceptable for any species except wild boar.

- Focusing on outcome (e.g. reduced transmission of ASF), not the numbers of pigs killed.

Vertebrate pest management science has encouraged a shift in emphasis from killing the largest number of vertebrate pests (for example, feral pigs) to reducing the population density to a level where damage is acceptable (Braysher *et al.*, 2012). This has parallels with culling for ASF control: where culling is used as a strategy, enough wild pigs should be culled to reduce transmission of ASF within the population and no more. Currently, there is not enough research about threshold densities under various scenarios; in these cases, surveillance is required. Culling effort must be matched against the incidence of disease observed using surveillance to determine whether more or less culling is required to reduce transmission.

- The legal and social license to kill wild pigs.
- The candidate species (for example, species that are endemic or threatened are unlikely to be suitable candidates for culling).
- Potential impacts on non-target species, either directly (for example, by ingesting poison intended for pigs) or indirectly (for example, conservation implications for the ecosystem of the loss of pigs, considered against expected effects from ASF).
- How wild pig population control would affect local communities, where wild pigs may be important culturally and an important food source (these considerations would need to be taken against the expected effects from ASF).
- The welfare impacts of the tool used to kill wild pigs.
- Alternatives to lethal control, such as fertility control.

5.4.3.5 Types of wild pig population control tools

There are many tools that can be used for feral pig population control. These can be divided broadly into two types: fertility control and lethal control.

1. Fertility control

There are a wide variety of fertility control tools both in research and available as commercial products. These vary from immunocontraceptives (for example, vaccines that immunise an animal against critical parts of its reproductive system, such as the zona pellucida) to hormonal controls (e.g. prostaglandins) and surgical sterilisation.

However, these methods are not yet practically useful for widespread wild pig populations. For example, their use often first requires that populations be subject to lethal culling, followed afterwards by maintenance with fertility controls; fertility controls are not effective in producing large enough population declines in the short term for ASF control purposes. In addition, application is difficult, requiring surgery, a periodic injection or regular oral dosing in baits (see Asa and Moresco [2019] for a recent and authoritative review).

Nonetheless, fertility control has been used widely in Hong Kong, Special Administrative Region of the People's Republic of China, where the population of wild pigs is small and close to urban areas. Despite this, in recent times it became apparent that fertility control was not able to control wild pig populations in Hong Kong, Special Administrative Region of the People's Republic of China, and authorities have again reverted to lethal control programmes in black spot areas[2] and New Zealand.[3]

2. Lethal controls

- Poison baiting

Poison baiting is an effective means of controlling feral pigs in many jurisdictions around the world, including Australia (Saunders *et al.*, 1990), New Zealand (Latham and Yockney, 2020), the Pacific Island region (Wehr *et al.*, 2018) and the USA (Poché *et al.*, 2018). This method focuses on encouraging pigs to eat an attractive bait material, such as grain, that contains a toxin that will kill pigs that consume it.

Baiting can be deployed from the air or on the ground. Ground baiting is usually more effective and target specific as it allows for best practices, such as pre-feeding and use of pig-specific hoppers to exclude non-target animals. Various toxins are used, including warfarin (Saunders *et al.*, 1990), sodium fluoroacetate (Cowled *et al.*, 2006) and sodium nitrite (Cowled *et al.*, 2008). Registration of poisons for baiting purposes is required, alongside expertise in their use. While warfarin has been discontinued in Australia for animal welfare reasons (and was never permanently registered for pig control), it remains registered in the USA. Sodium nitrite in particular is a new and useful toxin, as it is highly lethal to wild pigs and thus considered far more humane than other toxins (Royal Society for the Prevention of Cruelty to Animals, 2021). There is also an antidote (methylene blue), and as it is a commonly used food preservative, health and safety concerns for users are reduced. It is available commercially in Australia[4] and is being researched in the USA (Campbell *et al.*, 2013). The poisoned bait is administered in feed hoppers that reduce the risk of non-target species poisoning.

- Aerial shooting

In aerial shooting, wild pigs are shot by a marksman in a helicopter (Campbell *et al.*, 2010; Saunders, 1993). This is a highly effective, humane and target-specific means of controlling wild pig populations and has not been shown to affect dispersal or behaviour of surviving feral pigs where studied in North America and Australia (Campbell *et al.*, 2010; Dexter, 1996). It is best used in appropriate habitat that is open with low or sparce vegetation (e.g. not heavily forested) with good visibility to the ground. It can be relatively expensive, requiring helicopter hire. Considerable regulation is enacted to assure public safety.

- Hunting (e.g. recreational shooting, ground shooting, hunting with dogs and snaring)

There are a variety of hunting techniques for wild pig control. These include:

  - snaring – wire snares are placed and wild pigs place their heads in the snare while walking or foraging and are caught and strangled. Sometimes they are attracted with bait material. These are used in some places such as the Pacific;
  - recreational shooting – hunters walk or drive through wild pig habitat and shoot observed wild pigs. This occurs throughout the range of *S. scrofa;*
  - ground shooting – like recreational shooting, except with professional shooters with a higher level of competence;
  - hunting with dogs – driving or walking through wild pig habitat, with dogs released to chase observed pigs. When a pig is caught it is bailed or actively attacked and held by biting to keep it still until the hunter can arrive and kill the wild pig with a knife.

The various hunting techniques are less efficient and effective than other techniques such as poison baiting, aerial shooting and trapping. In particular, there tends to be a limited ability to locate and kill large proportions of pigs, and hunters may target certain demographics of the wild pig population. However, with enough recreational hunters available, the hunting effort can in certain circumstances be quite high. Therefore, collaborations with local hunting communities can be an important aspect of attaining depopulation goals (Dixon *et al.*, 2020).

2 https://www.news.gov.hk/eng/2021/11/20211112/20211112_194756_181.html
3 https://animalcontrol.com.au/products/hoggone
4 https://www.connovation.co.nz/pages/product-labels

- Trapping

Trapping is a relatively effective means of controlling feral pig populations. Traps are usually metal and established in areas of wild pig activity. After pre-feeding, traps are set and pigs can be trapped. Pigs can then be shot, be translocated, undergo fertility control or have tracking collars fitted for ecological research.

Wild pig trapping, including design and practice, has been well described (Korn and Bomford, 1996). Generally, it is best used after other, more effective control tools in smaller areas of land.

5.4.4 Wild pig carcass search and removal

Carcasses and contaminated environments appear to play an important role in the transmission of ASF in wild boar in Europe (Carlson *et al.*, 2020). Carcasses can remain infectious for significant periods of time at low temperatures (Fischer *et al.*, 2020), and demonstrated cannibalism in wild boar in winter in Europe may thus support transmission of ASFV from carcasses (Cukor *et al.*, 2020).

In general, the pandemic in wild boar appears to be characterised by a high mortality rate and low contagiousness, with a slow geographical spread of infection (Carlson *et al.*, 2020). Hence, it is hypothesised that it is persisting through infected carcasses and environments. Consistent with this hypothesis, countries in the European Union that have successfully contained or eradicated ASF from wild boar have concentrated on carcass removal.

Alongside its use in early detection of disease and understanding transmission within known outbreaks (Section 5.3.1), systematic and biosecure wild boar carcass search and removal can be used as a disease control measure. This may be as a stand-alone tool or in conjunction with population control measures (Section 5.4.4) in infected areas. Carcass search and removal reduces the risk of spread of disease in wild pigs by reducing opportunities for scavenging of infected carcasses and by reducing the environmental viral load (Marcon *et al.*, 2019; Probst *et al.*, 2017). Research in Italy found wild boar were attracted to two-week-old carcasses as they fed on invertebrates associated with carcasses (Bassi *et al.*, 2018; Marcon *et al.*, 2019). This suggests that there may be a window of opportunity to systematically remove carcasses to lower the risk of scavenging by other suids.

Of relevance to the Asia and the Pacific region, there is disagreement in the literature about the importance of carcass transmission, particularly in warmer climates. Recent field research in Lithuania demonstrated that most pig carcasses had viral remnants but none had virus that could be isolated (although the authors acknowledged that bioassays may be more accurate than isolation by culture) (Zani *et al.*, 2020). They hypothesised that the reason for the lack of isolation of virus was that it was inactivated due to warm summer temperatures in Lithuania. Other research has indicated that a temperature of 37 °C for 20 days inactivates virus (Mazur-Panasiuk *et al.*, 2019) and that decomposing carcasses are several degrees warmer than ambient temperature (Johnson *et al.*, 2013).

Therefore, carcass search and removal may be a lower-priority task in warmer climates, where relatively elevated temperatures and scavengers may limit ASF transmission and outbreak severity (O'Neill *et al.*, 2020). In the Kimberley region of northern Australia, Twigg *et al.* (2005) found most pig carcasses rapidly degrade after death due to scavenging and fly larvae. All 40 feral pig carcasses monitored had 'degraded' between one and ten days after death, dependent on size, with 'degraded' defined as when the carcasses no longer represented a source of food for vertebrate scavengers. This may not be reflective of how long a carcass would remain infectious for ASF but may indicate a relatively reduced likelihood of transmission of the virus after this time, where virus is present, if scavenging is relatively unlikely beyond ten days.

Taken together, these results along with the model-assisted conclusions of O'Neill *et al.* (2020) indicate that further research is needed to confirm hypotheses about carcasses being central to transmission in the Asia and the Pacific region, and most particularly in the warmer climates within this region. For example, if decomposing infected carcasses are hot and inactivate virus quickly, or rapidly decompose and disappear, are they a risk for maintaining ASFV in the environment? Or will their infectious period be long enough to be epidemiologically significant? Answers to these questions are essential to allow justification of the allocation of the extensive resources required for searching, collecting and disposing of carcasses as occurs in Europe.

Biosecure destruction and disposal of animals infected with ASF can involve incineration or deep burial. Active surveillance for dead and dying individuals, with burial or incineration of carcasses, was used in response to an incursion of ASF in Philippine warty pigs (Chavez *et al.*, 2021).

5.4.5 Biosecurity – minimising direct and indirect contact between wild and domestic pigs

5.4.5.1 What is biosecurity and is it useful for wild pigs?

The WOAH *Terrestrial Code* defines biosecurity as:

'A set of management and physical measures designed to reduce the risk of introduction, establishment and spread of animal diseases, infections or infestations to, from and within an animal population.'

In theory, biosecurity should be useful to prevent contact (direct or indirect) between wild and domestic pigs to prevent transmission to and maintenance of ASF in wild pig populations, or to prevent transmission from wild pigs to domestic pigs. In particular, biosecurity would appear logical to protect small and isolated populations of endemic wild pigs and to prevent transmission from wild boar to domestic pigs. For example, strict biosecurity is now implemented at the Pygmy Hog Conservation breeding and conservation areas to protect the last remaining populations of pygmy hogs (Parag Deka, Pygmy Hog Conservation Programme, personal communication, November 2021).

5.4.5.2 Scale of pig production and role in biosecurity

When considering the degree of biosecurity exhibited by pig producers, it is important to consider the scale and type of production; scale is often correlated with biosecurity. For example, large-scale producers have economies of scale, motivation, resources and training to introduce meaningful biosecurity measures. In contrast, smallholders often have poor biosecurity practices (Leslie *et al.*, 2015b).

There are several scales of domestic pig production across the Asia and the Pacific region. For example, Huynh *et al.* (2006) categiorised production in the Philippines, Vietnam, Laos and Cambodia as:

- small-scale production (1–2 sows or 1–20 fatteners) – ranging from free range to intensive.
- medium-scale production (5–500 sows or 20–4,000 fatteners)
- large-scale production (>500 sows or >4,000 fatteners)

Large commercial producers are largely distributed in the more developed countries of the Asia and the Pacific region (for example, Japan and the Republic of Korea). In less developed nations such as Cambodia, Laos, the Philippines and Vietnam, large- and medium-scale production comprises only 30% to 35% of domestic pig production, with smallholders responsible for up to 70% of all production (Huynh *et al.*, 2006).

5.4.5.3 Implementation of biosecurity

It is important to note that practical biosecurity standards now exist to provide guidance on how to separate subpopulations of animals, such as domestic and wild pigs, through the application of management practices and biosecurity in line with the compartmentalisation chapter of the WOAH *Terrestrial Code* and specific adaptations for the ASF pandemic (WOAH, 2012; Pfeiffer *et al.*, 2021). These could form a general basis for best practice biosecurity to separate wild and domestic pigs, although generally only among large commercial pork producers.

Good biosecurity practices to separate wild and domestic pigs include:

- biosecure containment of domestic pigs to physically separate them from wild pigs, and including exclusion fencing around high-risk transmission areas such as rubbish tips or intensive farms (AHC African Swine Fever Feral Pig Task Group, 2020; Jori and Bastos, 2009; Indonesian Ministry of Environment and Forestry, 2021; Sur, 2019);
- biosecure disposal of domestic pig carcasses and food waste so they cannot be scavenged by wild pigs, including around trade routes (Jori and Bastos, 2009; Luskin *et al.*, 2021; Indonesian Ministry of Environment and Forestry, 2021);
- biosecure movements on and off farm in consideration of the potential for fomite spread, including equipment, people and pigs;
- minimisation of interactions between wild pigs and the people involved with domestic pigs (AHC African Swine Fever Feral Pig Task Group, 2020). For example, veterinary staff handling infected pigs should not have involvement in other uninfected farms or wild pig captive breeding populations (Marcon *et al.*, 2019).

However, the efficacy of biosecurity is affected by context, especially depending on socio-economic status of the area and the type of domestic pig production present (e.g. smallholder versus commercial production). For example, Nusa Tenggara Timur province in Indonesia is the country's poorest province, with 95% of rural people living in poverty and with smallholders comprising the majority of pig production (Leslie *et al.*, 2015b). Biosecurity was minimal, with mixing of the pigs within a village, sharing of animals between villages, poor understanding of transboundary pig diseases such as CSF and minimal contact with veterinarians or animal health workers. Pigs were often tethered, for example in local forests, where contact with feral pigs would be possible (Edwina Leslie, Ausvet, personal communication, November 2021). Better biosecurity practices could be implemented relatively easily, at least at the village level with some simple education, access to extension services, improvements in swill feeding practices and better housing (for example, all pigs housed in pens) (Leslie *et al.*, 2015b).

In contrast, in the Republic of Korea biosecurity practices for ASF are extensive and well developed. For example, there is a strategy of fencing off sites with infected wild boar. Once ASF infection was confirmed in wild boar, the site was fenced immediately in a three-layer fencing system to prevent further spread (Kim *et al.*, 2021).The three-layer system comprised an internal electric fence encapsulating the area where the wild boar carcasses were found, with 1 to 2 km distance around the confirmed cases; a second layer of a 1.5 m high semi-rigid wire mesh surrounding the electric fence with a 5 to 10 km distance between the two; and thirdly, a long fence 20 to 30 km away from the second layer, as a defence against movement in the directions of disease-free areas. In conjunction with this fencing, population control included cage trapping inside the second fence and hunting (under permit) outside of the second fence (Kim *et al.*, 2021). However, such fencing can have substantial negative impacts on non-target wildlife species (Smith *et al.*, 2020). In domestic pigs near the same outbreaks, enhanced biosecurity has been a key focus, backed up by financial disincentives (if a farm becomes infected but has poor biosecurity practices, compensation is not awarded [FAO, 2021a]). Enhanced biosecurity at the farm includes better barriers and repellents to exclude wild boar, fomite control through quarantine and disinfection of farm equipment, and disinfection and hygiene of personnel.

Movement controls for domestic pig populations, and stamping out policies for infected domestic pig premises with biosecure disposal of carcasses and decontamination of the production facilities, may also decrease contact rates between infected and at-risk domestic pigs and wild pigs in the face of an outbreak (AHC African Swine Fever Feral Pig Task Group, 2020). However, as a strategy, this is only feasible where logistical capabilities and adequate compensation for the producers are available.

In the Philippines, after ASF was identified in Philippine warty pigs there were attempts to catch other warty pigs and isolate them from ASF, but they were not successful (Chavez *et al.*, 2021).

5.4.6 Minimising movement of wild pigs and wild pig products

Prohibition of hunting of wild pigs and prohibition of movement of wild pigs and wild pig products from specified areas (except under permit) is a recommended principle of control or prevention of ASF (AHC African Swine Fever Feral Pig Task Group, 2020). This may be appropriate for certain Members, such as those where wild pigs are not an important source of food. Hunting bans may also be of conservation value, particularly regarding threatened species, in the face of an ASF outbreak (Section 5.5).

However, in developing countries, the veterinary and enforcement infrastructure, education of stakeholders about ASF, price differentials and trade and cultural links may mean that informal trade in both domestic pigs (Leslie *et al.*, 2015a) and wild pig bushmeat (Sheherazade, Wildlife Conservation Society, personal communication, November 2021) is common. In some cases it would be difficult or impossible to regulate such trade, especially as some governments have more pressing priorities (e.g. COVID-19). Where bans will generally not work and are hard to enforce, education to manage risks associated with movements may assist in reducing transmission. In particular, the main means of reducing this risky trade may be by education of purchasers. Messaging that purchase of such products can transmit the lethal disease ASF to their pigs, and advice on straightforward and practical management practices that can reduce the risks associated with such movements, may reduce ASF transmission. These can be as simple as determining the source of pigs and pork products and avoiding those from infected areas or isolating imported pigs for a time when moved and cooking pork products and swill appropriately.

5.4.7 Preparation for a vaccine

Despite some promising research trials (Barasona *et al.*, 2019), there is currently no registered and market-ready oral ASF vaccine for wild pigs (or domestic pigs). Significant further research will be required for development and then registration, and it is also possible a vaccine may never be available. However, it would be wise to assume a vaccine will become available and thus to prepare for delivery of the vaccine to wild pigs now. Several years of ancillary research and preparation are required to develop efficient and effective methods of delivering oral baits and vaccines to wild pigs, in addition to the research to develop the vaccine itself. Hence, earlier undertaking of this ancillary research and preparation may result in the ability to effectively deliver an ASF vaccination to wild pigs years earlier than if the research were left until after the vaccination is developed. Despite this, the scale and difficulty of delivery of oral vaccinations should not be underestimated, and it is possible this would only be practical for small and isolated populations of vulnerable wild pig species (e.g. pygmy hogs).

In the case of the 11 endemic species of conservation importance in the region, that extra time may be critical in protecting the species from local extirpation/extinction. In the case of wild boar or feral pigs, this may also enable better management of transmission within these populations, thereby managing risk for domestic pigs and within wild *S. scrofa* populations, although the scale of these populations means that oral baiting of *S. scrofa* may be limited.

Questions to resolve in preparation for a vaccine include:

- What is the efficacy and safety for diverse wild pig species and wild boar?

Initial research may occur in wild boar and will determine whether an oral vaccine is effective in this species. Even if this is demonstrated, the efficacy and safety of the vaccine for use in the 11 endemic wild pig species in the region will be unknown. It would be challenging to generate efficacy and safety data for species where there are no captive populations or where populations are small. However, this data is required to ensure the vaccine does not harm wild pigs and is effective and worth the significant resources it will take to deliver vaccination programmes.

- How would registration occur and who would apply for registration?

Registration of a vaccine would be required before use to ensure the vaccine is safe and effective. Generating data for this and writing a registration dossier is generally expensive, though emergency use or minor use permits can be cheaper and easier to apply for in some jurisdictions. There would be little commercial incentive for a pharmaceutical company to write a dossier and register a vaccine for the endemic species of wild pig where sales volumes will always be small, although there may be commercial incentive to register for wild boar. Hence, in cooperation with a pharmaceutical company, public funding would be required for the generation of data and the registration process. Consideration needs to be made as to whether such funding is available for development and submission of a registration dossier for all wild pig species. Who would champion the vaccine and for which species and in which Members or regions?

Prior registration of vaccines may be useful for some countries that are free of ASF but have populations of wild pigs or feral pigs, as that would add an additional tool for managing an outbreak if one were to occur.

- Which use cases are indicated?

Small populations of endemic species of high conservation value may benefit from an oral vaccination programme to protect these species from mortality due to ASF. The use of vaccines in wild boar may have a different objective, to enable management of transmission of ASF, similar to CSF vaccination programmes in Europe and Japan (Bazarragchaa *et al.*, 2021; Kaden *et al.*, 2000, 2005; Kaden and Lange, 2001). Outlining use cases will be important to guide further research. Realism about the scale and resources required to deliver oral baits is required and may limit the ability to oral bait to small populations of endemic species.

- How would the vaccine be delivered given diverse ecology and diets?

Most wild pigs cannot be given an injectable vaccine – they generally require an oral vaccine, meaning that commercial vaccines developed for domestic pigs will have little use except to protect captive populations of wild pig species. There is significant development work required to orally immunise wild pigs, beyond research to develop the oral vaccine. Given that both wild boar and the 11 species of endemic wild pigs in the Asia and the Pacific region have different ecology (e.g. diets) to wild boar in Europe, where a bait will likely originate, will bait substrates and vaccine delivery mechanisms work, or will changes be required? Determining this will require research, as effectiveness of oral vaccines in the field also depends on the success of the delivery mechanism. An example of investigation of vaccine delivery strategy is provided in Cowled *et al.* (2008).

- Design of vaccine programmes

Effective baiting programmes need to immunise a large proportion of a local wild pig population. A considerable amount of research is required to develop effective baiting practices to achieve high population coverage, as the ecology, distribution and abundance of wild pigs are important factors to be considered in designing an effective strategy. There will need to be sufficient information to identify the density of baiting delivery that is required, and over what area and what time frame. For example, reproductive rates, breeding seasons and other features affecting population dynamics will affect the recruitment of new naïve animals into the population, which will mean adjustment of the frequency of baiting programmes to immunise different species of wild pigs. This may be best achieved through simulation modelling – for example, see Cowled *et al.* (2012).

5.4.8 Vector control processes

Vector control processes are considered highly unlikely to be necessary for pigs in countries in South-East Asia (Section 3.3).

Vector control may be required in domestic pig populations in central Asia and China, should it be identified that there is transmission by regional species of soft ticks, as has occurred in other countries such as Portugal (Boinas *et al.*, 2011). However, the lack of burrows or permanent resting sites among wild pigs in these countries suggests that domestic pigs are the only plausible persistent source of soft tick infections to wild pigs (Section 3.3). Thus, in the presence of vector control in domestic pigs and appropriate biosecurity strategies, vector control among wild pig populations may not be necessary. In any case, effective vector control in wild pigs is likely to be particularly logistically challenging and associated with extensive environmental damage.

5.5 Response – protection of endemic species

As domestic pigs are an important source of spillover infection to wild pigs, strategies to prevent ASF incursions and transmission among domestic pigs are important but are not within the scope of this report.

The key additional approaches for protecting endemic pig populations, in areas where ASF is likely endemic and there will be ongoing risks, include:

- protecting populations of endemic wild pigs with biosecurity strategies and creation of insurance populations;
- devising bait delivery strategies in preparation for a possible vaccine;
- reducing incidence in domestic pigs to reduce the likelihood of spillover of infection;
- quarantine and risk analyses.

5.5.1 Context to protection of wild pigs

5.5.1.1 Sus scrofa

Where *S. scrofa* is a feral species (for example, in Australia), conservation of the species usually is not a consideration. However, where feral pigs are an important food or cultural resource to the local population (for example, in Papua New Guinea), preserving the populations is important. Meanwhile, where *S. scrofa* are endemic but overabundant and damaging, conservation of the species is important, but conservation of the species locally may not be impacted by control actions designed to manage ASF (e.g. careful use of population control tools to reduce population density and transmission or exclusion fencing).

Despite this, care is being exercised by some Members to manage wild pig harvesting in the presence of ASF. For example, in Indonesia in 2021, the Directorate General of Nature Resources and Ecosystem Conservation issued quotas for the use of wild boar for nine provinces (Aceh, Riau, Bengkulu, South Sumatra, East Java, West Nusa Tenggara, Southeast Sulawesi, North Sulawesi and Bengkulu). This initiative was undertaken to minimise hunting pressure in view of the impact of ASF on the sustainability of wild boar populations and harvesting (Indonesian Ministry of Environment and Forestry, 2021).

5.5.1.2 Other endemic wild pigs

For other wild Suidae in the region, conservation is an important consideration. In an estimation of the risk of ASF to the viability of wild pig populations in Asia, considering factors such as trade from infected countries, pork consumption in human populations within the home range, local domestic pig production systems and the presence of *S. scrofa*, the risk of major population declines, local extirpation or extinction associated with ASF was assessed to be high or very high for all endemic species except for Togian babirusa (medium risk) and hairy babirusa (low risk) (Luskin *et al.*, 2021).

These possible effects on wild pig populations are expected to have flow on effects to other wild species and ecosystems – for example, due to removal of a food source from local food chains, which may affect threatened carnivores, and due to loss of wild pigs' role as rainforest 'ecosystem engineers' (Ewers *et al.*, 2021; FAO *et al.*, 2021; Jin *et al.*, 2021).

5.5.1.3 Endemicity of disease

It is highly likely that ASF will become or remain endemic in many areas of the Asia and the Pacific region given practices associated with domestic pig production, such as minimal biosecurity. Some of these endemic areas will be coincident with the 11 species of endemic wild pigs. Thus, ASF is expected to remain a threatening process to the survival of several species of wild pig for an extensive period of time. Therefore, any responses should be framed with that in mind. The appropriate responses will be different for different species in different locations and under different circumstances. The following discussion outlines some of the options that can be implemented to protect endemic wild pigs. However, the exact combination and approach will be unique for different species, countries, settings and circumstances.

5.5.2 Protected populations of wild pigs

The principle here would be to maintain wild pig populations in isolation from other pigs to protect them from ASF. There are two broad ways to do this: employing good biosecurity to protect geographically isolated populations of pigs from ASF, or using captive insurance populations to breed excess individuals for later release into ASF-decimated areas.

In the absence of vaccination, protecting populations in geographically defensible locations may be the most appropriate approach for conserving the populations (Ewers *et al.*, 2021). Nonetheless, it would be a logistically challenging operation and may be particularly complex in some species, such as bearded pigs owing to their patterns of tracking mast-fruiting, which provides a key source of nutrition for the species (Section 2.2, Appendix B). The use of islands to maintain or establish geographically isolated populations may be effective. However, in the case of establishing populations, the impact of pigs on islands' conservation values should not be underestimated, and appropriate risk analyses for the impact of pigs would need to be conducted prior to release.

Captive insurance populations can be established to create a supply of animals to re-establish decimated populations when particular threats have occurred and passed. These insurance populations would need strict quarantine to protect them from ASF, similar to what has been instituted for the pygmy hogs in India. Theoretically, insurance populations could be a viable option for some species – captive breeding programmes are established or have been successfully used for bearded pigs (Luskin and Ke, 2018), Visayan warty pigs (Melletti *et al.*, 2018) and pygmy hogs (Pygmy Hog Conservation Programme, n.d. -a, n.d. -b). However, for other species, either captive populations and successful breeding of captive animals have not yet been achieved despite some efforts (e.g. Sulawesi warty pig [Burton *et al.*, 2018]), they have been achieved a very limited number of times (e.g. the Philippine warty pig [Meijaard and Melletti, 2018]), or there is no recorded information on the occurrence of successful rearing and breeding in captivity. Therefore, successfully creating insurance populations would require:

- research and development of approaches to rear and breed species where inadequate information and experience exists;
- capturing sufficient individuals from the wild without further threatening remaining populations in doing so;
- gaining knowledge on how to successfully rear and breed from the various species in captivity while maintaining the species' ability to be successfully re-introduced to the wild;
- preservation of continuing efforts to ensure the genetic diversity of insurance populations.

5.5.3 Preparing for vaccination

Oral vaccines may be developed that could provide immunity to wild pigs. However, as previously discussed, research required to develop suitable delivery and baiting strategies is extensive and should begin prior to development of an oral vaccine (Section 5.4.3). This will allow protection of wild pigs several years earlier than if this research only began after a vaccine was developed.

5.5.4 Reducing the incidence of African swine fever in domestic pigs

The distributions of the endemic wild pig species of concern in South-East Asia are often coincident with domestic pig farming (Luskin, Meijaard *et al.* 2021), where ASF is likely to be introduced and potentially become endemic if it is not already present. A critical step to protecting wild pigs is therefore to reduce the incidence of ASF in local domestic pig populations to minimise viral spillover events. This will require basic disease control and biosecurity efforts in domestic pigs to reduce the burden of disease (Section 5.4.6). While this is challenging and beyond the scope of this report, earlier research in Indonesia has indicated that some simple steps such as education and extension could be effective at improving biosecurity and reducing infectious pig diseases in smallholder pig producers (Leslie *et al.*, 2015b) (Section 5.4.6). As another example, considerable extension work is being conducted in areas of Assam in India around national parks containing pygmy hogs (*P. salvania*) to establish safe zones to reduce the chance of spillover from domestic pigs (Parag Deka, Pygmy Hog Conservation Programme, personal communication, November 2021). In addition, assistance to develop alternative livelihoods that allow people to avoid domestic pig production in critical areas close to vulnerable wild pig populations may be a possible solution.

5.5.5 Risk analyses and quarantine

Formal risk analyses can be useful to assess the risk of ASF being introduced into captive insurance populations and thus identify effective risk mitigation strategies.

This has been undertaken in Assam, India, through the work of the Pygmy Hog Conservation Programme and partners to protect captive breeding populations (Parag Deka, Pygmy Hog Conservation Programme, personal communication, November 2021). Quarantine was then instigated: biosecurity or quarantine is applied to protect small populations and consists of the absolute prevention of direct and indirect contacts between the captive population and other local pigs. For example, pygmy hog breeding centres considered all the possible risks to introduction of ASF into captive populations, then mitigated these risks (for example the risk of bedding material sourced for the pygmy hogs [Parag Deka, Pygmy Hog Conservation Programme, personal communication, November 2021]).

Given the threat that domestic pigs pose to wild pigs as a source of ASF infection, efforts to prevent ASF incursion and limit the spread of ASF post-incursion in domestic pigs are an essential component of protecting wild pigs. This includes comprehensive border controls and quarantine policies, movement controls of domestic pigs, removal and biosecure disposal of domestic pig carcasses and food waste, and education regarding effective heat treatment of swill prior to feeding domestic pigs.

Temporary bans on hunting endemic pig species may not have an impact on species preservation without considerable proactive attempts at enforcing bans, particularly where endemic pigs are an important source of food. Removal of a food source from local communities would be particularly challenging in terms of replacing that food source and achieving compliance with bans through public education (for example, successfully raising awareness of the threat to the survival of the species and thus the long-term benefits to communities of immediate actions to preserve the species). In Indonesia, monitoring of the circulation of wild boar products is undertaken using the Domestic Plant and Animal Transport Certificate system, in consideration of quotas of capture in various provinces (Indonesian Ministry of Environment and Forestry, 2021). Control measures used by Members in Asia and the Pacific are displayed in Table VI.

Feral pig *(S. scrofa)* in a trap © Brendan Cowled

Table VI Control measures reported as being in place for African swine fever in wild pigs, per WAHIS reporting and FAO (FAO, 2021a), in the Asia and the Pacific region

Country	General surveillance	Targeted surveillance	Disease notification	Monitoring	Movement control inside the country	Zoning	Control of wildlife reservoirs	Control of vectors
Australia	Yes	-	Yes	Yes	-	-	-	-
Bangladesh	Yes	-	-	-	-	-	-	-
Bhutan	Yes	Yes	Yes		Yes			
Brunei	Yes	-	Yes	-	-	-	-	-
Cambodia	-	-	-	-	Yes	-	-	-
China (People's Republic of)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chinese Taipei	-	-	Yes	-	Yes	-	-	-
Fiji	Yes	-	Yes	-	-	-	-	-
India	-	-	Yes	-	Yes	-	-	-
Indonesia	Yes	-	Yes	Yes	Yes	-	-	-
Iran								
Japan	Yes	-	Yes	Yes	Yes	-	Yes	-
Korea (Democratic People's Republic of)	-	-	Yes	-	-	-	-	-
Korea (Republic of)	Yes	-	-	-	Yes	Yes	Yes	-
Lao	Yes	Yes	-	-	Yes	Yes	-	-
Malaysia	Yes	-	Yes	Yes	Yes	-	-	-
Maldives	-	-	Yes	-	-	-	-	-
Micronesia (Federated States of)	-	-	Yes	-	-	-	-	-
Mongolia	Yes	-	-	-	-	-	-	-
Myanmar	Yes				Yes			
Nepal	Yes	-	-	-	-	-	-	-
New Caledonia	-	-	Yes	-	-	-	-	-
New Zealand	Yes	-	Yes	-	-	-	-	-
Pakistan	-	-	-	-	-	-	-	-
Papua New Guinea	Yes	-	-	-	Yes	Yes	-	-
Philippines	Yes	-	Yes	-	Yes	Yes	-	-
Singapore	Yes	-	Yes	Yes	-	-	-	-
Sri Lanka	-	-	-	-	-	-	-	-
Thailand	-	-	Yes	-	-	-	-	-
Timor-Leste	-	-	-	-	Yes	-	-	-
Vanuatu	-	-	Yes	-	-	-	-	-
Vietnam	Yes	-	-	-	Yes	-	-	-

5.6 Case studies of preparatory activities or response in Asia and the Pacific

5.6.1 African swine fever preparatory activities in Australia

- Species

Australia has a large population of feral pigs (*S. scrofa*). Feral pigs are located across approximately 38% of the Australian continent (Choquenot and Lukins, 1996) and number approximately 3.2 million (95% CI: 2.4–4.0) with a mean density of approximately 1.03 pigs/km^2 (Hone, 2020).

- ASF status

Australia is free of ASF.

- Planned management actions in wild pigs

Australia has conducted substantial research on feral pigs for more than 30 years. This research has concentrated on agricultural and environmental impacts, preparation for transboundary disease transmission and how to control feral pig populations, using a variety of control tools, including lethal culling methods and fencing.

In the absence of ASF, Australia has conducted emergency preparedness planning and exercises to prepare the country for an incursion of ASF. If an ASF incursion occurs, according to a report of the ASF feral pig task group (AHC African Swine Fever Feral Pig Task Group, 2020) the following activities will be considered:

- targeted pre-emptive culling in limited areas after an outbreak;
- biosecurity (prevent transmission between feral and wild pigs);
- communication relevant to various stakeholders;
- movement controls on pigs, pig products, fomites and vectors (if relevant);
- destruction, disposal and decontamination – in particular, culling of 70% to 80% of pigs in an infected area and surrounding that area using lethal control tools;
- surveillance (passive surveillance for ASF, densities and distributions of feral pig populations).

5.6.2 Response to ASF in wild boar in the Republic of Korea

- Species and sub-species

Wild boar in Korea are a subspecies of *S. scrofa* (*S. scrofa coreanus* Heude), which are endemic in the Republic of Korea. Before the outbreak of ASF they were found at a mean density of approximately 10 pigs/km^2 (Jo and Gortázar, 2021).

- ASF status

African swine fever was detected in the Republic of Korea in September 2019 (Jo and Gortázar, 2021).

As of December 2021, ASF had been detected in 21 domestic pig farms and there had been 1,772 ASF-infected wild boar confirmed across approximately 11 administrative areas (FAO, 2021b). African swine fever is mostly found in wild boar rather than domestic pigs, as there is a stamping-out policy in infected domestic pig farms (Jo and Gortázar, 2021).

- Management actions in wild pigs

As per Jo and Gortázar (2021), this includes:

1. Reducing wild boar density by culling (trapping or hunting [silently] or hunting with dogs).
2. Removing carcasses rapidly (including using drones to locate carcasses) (Jo and Gortázar, 2021).
3. Containing ASF with fencing (several types of fencing).

In general, ASF control in wild boar has not been successful in the Republic of Korea: the distribution of ASF has increased over time and ASF is still widely dispersed in wild boar populations after several years.

However, some case studies do allow nuanced examination of what worked well or did not work well.

There is evidence that control was effective where fast decision making occurred and geography assisted containment. In this area, fencing and silent culling (trapping and shooting) occurred, leading to local eradication of ASF.

In other situations, where hunting with dogs was implemented, this practice was believed to be associated with dispersal.

Penan hunters in Borneo with a bearded pig *(S. barbatus)* © David Hiser

Provision of a bounty scheme to reward hunting and carcass collection but without implementation of biosecurity may also have led to dispersal. Carcass collection was also impractical due to military zones with mines.

5.6.3 Response to classical swine fever in Japan

- Species and subspecies

Wild boar in Japan are a subspecies of *S. scrofa (S. scrofa leucomystax)*. The subspecies is endemic throughout Japan except on Hokkaido and Ryukyu islands.

- ASF status

Japan is free of ASF. However, in recent years, there have been introductions of foot and mouth disease and CSF, indicating that there is a probability that ASF could also be introduced. Classical swine fever re-emerged in 2018 and has since spread in wild boar populations, despite control efforts. Thus, it is hypothesised that if ASF is introduced to Japan it may also be difficult to contain (Ito *et al.*, 2020).

- Management actions for CSF in Japan and learnings for ASF preparedness

Domestic pig biosecurity from wild boar

In the CSF outbreaks in Japan from September 2018, wild boar were considered a substantial contributor to the spread of infection between domestic herds (Isoda *et al.*, 2020; Shimizu *et al.*, 2020). It was also identified that pig farms within 5 km of infected wild boar were at relatively increased risk of infection (Hayama *et al.*, 2020). Thus, alongside disease control measures in domestic pig populations, measures of particular relevance to wild boar involved ensuring fencing around pig farms would prevent the entry of wild animals, including wild boar (Shimizu *et al.*, 2020). In addition, surveillance and monitoring the distribution of infected wild boars was considered an important aspect of responding to the infection, with wild boar trapped and sampled (Isoda *et al.*, 2020). However, monitoring of CSF in wild boar was hampered by the lack of a specific legal and organisational system for disease surveillance in wild animals (Shimizu *et al.*, 2020).

Wild boar classical swine fever control

The current outbreak was also caused by a moderately virulent CSF strain, which resulted in delayed detection of cases due to subclinical carriers (Bazarragchaa *et al.*, 2021). Wild boar populations can thus act as a reservoir of CSV in the absence of infected domestic pigs (Isoda *et al.*, 2020). Therefore, depopulation may not be an effective or logistically feasible method of improving control of CSF in wild pigs (Rossi *et al.*, 2015). For example, depopulation strategies are unlikely to quell population density to a sufficiently low level to impact transmission, and high uncertainty in wild boar population size and density estimates impedes measuring of the depopulation efforts (Isoda *et al.*, 2020).

As per Bazarragchaa *et al.* (2021), in response to the outbreak, Japan implemented the following control measures:

- surveillance
- fencing to restrict wild boar movements
- increased depopulation of wild boars
- increased disinfection of infected areas
- oral vaccination for CSF.

In particular, vaccination reduced the proportion of infected pigs and increased the proportion of pigs with immunity (Shimizu *et al.*, 2021). However, piglets remained susceptible and need to be addressed to allow good disease management with oral vaccination, for example with continuous vaccination programmes (Bazarragchaa *et al.*, 2021).

Key learnings for ASF control can be found in the response to CSF. These are especially associated with vaccination strategies and include the importance of good population coverage across all ages and how to achieve good vaccination coverage to reduce transmission of CSF. Such research may save several years of research and programme refinement in the event of an ASF outbreak and the development of an ASF vaccine.

5.6.4 Protection of the pygmy hog from African swine fever

- Species

The pygmy hog (*P. salvania*) is the smallest wild pig species and is found in India (and maybe Bhutan) in the foothills of the Himalayas. The species is listed by the IUCN as critically endangered.

- ASF status

African swine fever was detected in northeastern India in 2020. Assam in northeastern India has active ASF outbreaks and is the Indian state where pygmy hogs are found.

- Management actions for ASF in pygmy hogs

The pygmy hog is found wild in Manas National Park. There is a captive breeding population of 89 individuals spread across three sites. There have been successful releases into three additional wild populations at Sonai Rupai Wildlife Sanctuary, Barnadi Orang National Park and Manas. There are perhaps 400 individual pygmy hogs left (Deka and Routh, 2020).

Management activities have focused on two areas: protecting wild populations with biosecurity, and biosecurity and quarantine of captive populations.

Wild populations have been protected through education of local pig owners, aimed at lowering ASF risks in local domestic pigs to reduce the chance of spillovers, and enhanced biosecurity. Biosecurity enhancements have consisted of digging trenches to prevent domestic pig incursions, preventing park vehicles from entering pig raising areas, prohibiting pork in the national park and enhancing surveillance.

Captive populations have had their ASF risk mitigated in two steps. A formal risk analysis was conducted to identify risks and their size, and then risk mitigation measures were introduced. These risk mitigation measures were broad. They focused on the prevention of introduction of ASFV through pork and products and prevention of fomite transmission (bedding, vehicles, staff), and remediation of drainage lines through the centre that could be contaminated with ASFV. In addition, zoning was established, and cleaning, disinfection and barriers were introduced between zones. Animal health management procedures, movement restrictions on pygmy hogs and disease response plans were also established. It could be argued that these measures constitute enhanced biosecurity, although it might be more accurate to call them quarantine.

This information was provided in a presentation to the WOAH working group on wild pigs in Asia and the Pacific by Dr Parag Deka and through an unpublished manuscript (Deka and Routh, 2020).

5.6.5 Legislation in place for management of wild pigs in the Asia and the Pacific region

A survey was dispersed to WOAH Asia and the Pacific Members to assess the current situation surrounding wild pig management and risks associated with ASF (Section 4). There were specific questions in the survey covering legislation or regulations regarding protection of wild pigs for conservation reasons, control of ASF in wild pigs and regulation of hunting in wild pigs.

Of the 29 responses, 28 were from Asia and the Pacific Members, representing 22 Members (multiple responses were received from 4 Members). Responses from each Member were merged (Table VII).

The responses from over half of the Members indicated that there was no legislation in place for the conservation of wild pigs (11/21; 52%); responses from a further four Members indicated uncertainty about the presence of such legislation (Table VII). One reason for these responses is that wild pigs are invasive/pests, and so no conservation actions are occurring. Six Members do have legislative measures in place for conservation (6/21; 29%) (Table VII).

Nine Members indicated current legislations for ASF control (9/21; 43%) (Table VII). Regulation of hunting of wild pigs was reported by ten Members (48%, 10/21) and involved requiring prior permission/authorisation in the form of either a permit or a licence to carry out hunting.

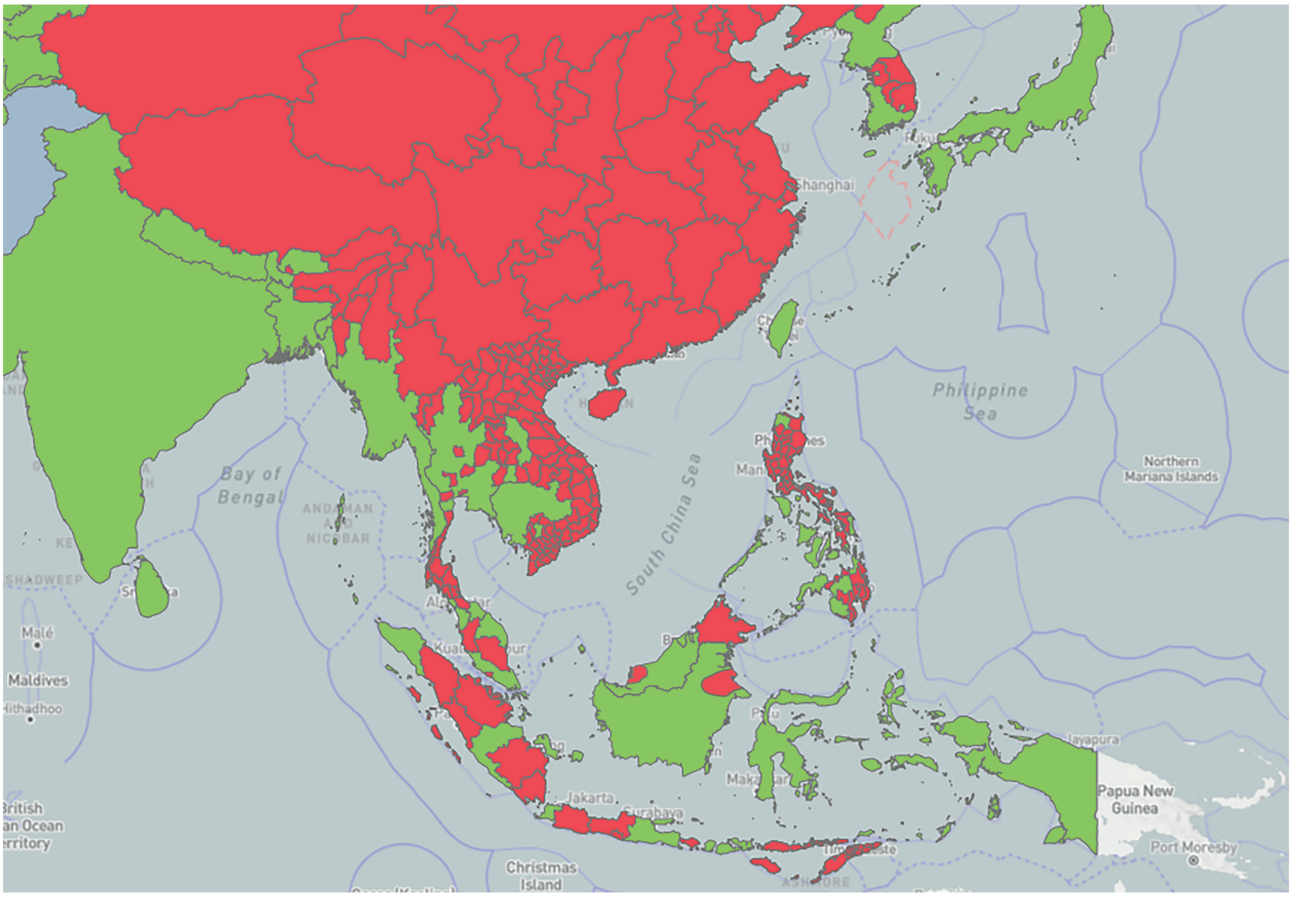

Fig. 3 African swine fever disease situation in Asia Pacific, December 2021 / World Organisation for Animal Health, World Animal Health Information System

Table VII Asia and the Pacific region WOAH Member legislations regarding the conservation of wild pigs, control of African swine fever and hunting of wild pigs, obtained via a survey (Section 4)

Responses were not received from 11 Asia and the Pacific Members.

WOAH Member	Conservation of wild pigs	Control of ASF	Regulation of hunting of wild pigs
Australia	None	Emergency Animal Disease Response Agreement (EADRA) Biosecurity Act Australian Veterinary Emergency Plan (AUSVETPLAN) for African Swine Fever	Yes (State and territory-based legislations; specific legislation not named)
Brunei	None	None	None
China (People's Republic of)	Wildlife Protection Law of the People's Republic of China	Wildlife Protection Law of the People's Republic of China	Wildlife Protection Law of the People's Republic of China
Chinese Taipei	None	Statute for Prevention and Control of Infectious Animal Diseases	Wildlife Conservation Act
Fiji	None	Biosecurity Act 2008	None
India	None	None	None
Indonesia	Yes (specific legislation not nominated)	Unsure	Unsure
Iran	None	None	Yes (specific legislation not nominated)
Japan	None	Act on Domestic Animal Infectious Disease Control, The Guidelines for Control of Specific Domestic Animal Infectious Disease Concerning ASF	Wildlife Protection and Hunting Management Law
Korea (Republic of)	Unsure	None	Yes (specific legislation not nominated)
Laos	None	None	None
Malaysia	Wildlife Protection Ordinance 1998 Schedule 3 of the Wildlife Conservation Enactment 1997	Wildlife Protection Ordinance 1998	Wildlife Protection Ordinance 1998 Wildlife Conservation Enactment 1997
Myanmar	Unsure	Directive for ASF free certification for movement of live pigs for prevention within country	Unsure
New Caledonia	None	None	None
New Zealand	None	Biosecurity Act 1993	Yes (specific legislation not named)
Philippines	Republic Act 9147, the Wildlife Conservation and Protection Act	None	Republic Act 9147, the Wildlife Conservation and Protection Act
Singapore	Wildlife Act (Chapter 351)	Animals and Birds Act (Chapter 7) Animals and Birds (Disease) Notification	None
Thailand	Unsure	Unsure	Unsure
Pakistan	Yes (specific legislation not named)	None	Yes (specific legislation not named)
Vanuatu	None	None	Unsure
Vietnam	Unsure	None	None

6 Recommendations: activities to manage African swine fever in wild pigs

6.1 Context – develop a strategic objective for wild pigs

The response to ASF in wild pigs will differ markedly across the region. This is affected by:

- the species and conservation status of wild pigs;
- the epidemiological role of wild pigs in ASF transmission;
- the socio-economic status of the local region (affecting availability of resources to control ASF);
- the type of domestic pig production (e.g. smallholder versus intensive commercial);
- cultural attitudes to wild pigs and wild pig control.

Therefore, at the Member level, the ability, desire or approach to managing ASF in wild pigs will be variable but should be guided by a well thought out strategic objective.

Recommendation 1: Local disease managers must consider the context of ASF in wild pigs and develop a locally appropriate management objective for ASF in wild pigs. These objectives will vary across Members.

The following three examples illustrate the variability in objectives.

1. ASF threat to wild pigs of conservation importance in Asia

Some rare pig species (e.g. pygmy hogs, bearded pigs) are of high conservation importance, with very few individuals left globally. African swine fever outbreaks in these species could thus lead to extinction of these species.

The management objective is therefore to protect these rare and valuable species from ASF to enable conservation of the species. This could be achieved by maintaining a geographically isolated population of wild pigs free from ASF through good biosecurity and quarantine, and through establishment of an insurance population.

2. ASF introduced to feral pigs (*S. scrofa*) in a developed country

Feral pigs in some Members in the region (e.g. Australia and New Zealand) have no conservation value and cause ecological damage. Disease control objectives therefore centre on feral pigs infected by ASFV being a risk to domestic pig production through ASF transmission.

There would be two management objectives in the event of ASF in feral pigs in a developed country: (1) protect domestic pigs from ASF transmission from feral pigs; and (2) attempt to eradicate ASF in feral pigs so they do not constitute an ongoing transmission risk to domestic pigs.

For Members such as Australia, there would be significant resources, experience or effective tools available to manage feral pig populations in the event of an ASF outbreak. There would therefore be an attempt to eradicate ASF in affected feral pig populations by culling feral pigs to induce disease fade-out (reduce R_0 <1). Likely tools include population control, fencing and carcass collection, depending on location. Biosecurity could be enhanced to prevent transmission from wild pigs to domestic pigs through fencing, hygiene and other biosecurity practices. Very effective population control tools such as aerial shooting, poison baiting and trapping may also be used, depending on circumstances.

3. ASF introduced to wild boar in a developing country

Wild boar (*S. scrofa*) have conservation value, for biodiversity and their ecological role (e.g. as a habitat engineer or as a food source for endangered predators). However, wild boar are widespread and abundant across the region, and extinction or even local extirpation of wild boar has not occurred in ASF-affected Europe (Morelle *et al.*, 2020). Despite this, wild boar may maintain ASF as a reservoir and could transmit ASF to domestic pigs. Veterinary resources for managing ASF are limited in developing countries.

The objective of management of ASF in wild boar in many developing countries should principally be to reduce impact on domestic pig production.

This may be best achieved by enhancing biosecurity in domestic pig production to prevent transmission to and from wild boar populations. This will reduce the impact on wild boar through a reduced chance of spillovers to wild boar, but most importantly will reduce the chance of a wild boar reservoir spreading and reintroducing ASF to domestic pigs. Enhanced domestic pig biosecurity will also reduce the chance of ASF transmission within domestic producers.

6.2 Prevention – quarantine and biosecurity

6.2.1 Biosecurity and quarantine measures

African swine fever transmission is incomplete across much of the Asia and the Pacific region (Fig. 3). Many WOAH Members are islands separated by sea that acts as a barrier to dispersal of ASF in wild pigs. This is especially true of the Pacific (e.g. Fiji, New Caledonia) and many other Members more broadly in the region (e.g. Japan, Australia, New Zealand and Singapore).

Recommendation 2: The transmission of ASF can potentially be reduced or prevented across much of the region through appropriate quarantine between Members. Quarantine should be implemented following the normative international standards of the ASF chapter of the WOAH *Terrestrial Code*. This will protect both domestic and wild pigs.

(Note: some Members may apply more restrictive quarantine if their appropriate level of protection exceeds that detailed in the WOAH *Code*).

Cultural and trade links between and within some Members, especially within archipelago nations, mean that movement of pigs and pig meat is likely and quarantine compliance can be poor, resulting in transmission of ASF along islands within a country or between close-proximity countries. This is especially true where resources to enforce quarantine are limited. Some of this trade will be in wild pigs and meat and may transmit ASF to uninfected islands.

Recommendation 3: Implementation of quarantine between nearby islands within and between adjacent Members. As enforcement is difficult, especially in developing countries, social research to understand trade, social and cultural factors affecting pig and meat movement will inform development of practical, effective and appropriate quarantine rules.

For example, compliance may be enhanced by education of some groups to understand the virulence and transmissibility of ASF and potential impacts on their own domestic pigs or culturally important wild pigs.

The following are steps to target and implement appropriate quarantine to protect important wild pig populations.

- Identify key populations of wild pigs that remain uninfected by ASF and require protection. These may include both wild pig species (e.g. extant populations of unique wild pig populations) and areas where commercial pig production is important or local pig production forms an important cultural and food source for local people.
- Ensure accurate and timely surveillance and reporting of disease across the region so that the differential status of ASF between or within island states can be accurately determined, especially where these key pig populations are located.
- Identify areas at risk of infection transmission in key areas such as archipelago states or between close-proximity island nations with differential status for ASF.
- Determine the key social, cultural and economic drivers of ASF infection in those key areas to ensure appropriate quarantine is designed.
- Implement appropriate quarantine to protect important pig populations, acknowledging the sociological and economic factors, and enforce these quarantine requirements.

6.2.1.1 Biosecurity between wild and domestic pigs

African swine fever does move between wild and domestic pigs and has been an important feature of the pandemic globally. One means of managing this risk is with biosecurity. Biosecurity is defined by WOAH as: 'A set of management and physical measures designed to reduce the risk of introduction, establishment and spread of animal diseases, infections or infestations to, from and within an animal population' (WOAH, 2012).

However, the ability to implement and understand biosecurity are variable across the region and are often associated with the scale of pig production.

Recommendation 4: Enhance biosecurity of domestic pig production to reduce transmission of ASF to and from wild pigs, recognising that the ability to implement biosecurity will be variable depending upon the type and scale of domestic pig production. Encouragement of biosecurity will require different approaches at different levels of production.

For commercial or intensive piggeries, the biosecurity management system of the WOAH's compartmentalisation guideline (Pfeiffer *et al.*, 2021) should be implemented. This focuses on segregation (e.g. fencing), cleaning and disinfection for each risk pathway into a compartment (i.e. pig supply chain). As an example within the region, the Republic of Korea has imposed better intensive piggery biosecurity in response to the ASF outbreak.

Biosecurity at the smallholder pig producer level should often be implemented at the village level as the village is the functionally smallest unit where biosecurity can be implemented throughout much of the region. Implementation of biosecurity for smallholders will be more basic and could concentrate on education of pig producers about pig infectious diseases (and their impacts) as well as basic biosecurity measures such as confinement of pigs, hygiene of swill feeding, isolation of newly purchased pigs for a period of time and village-level fencing if practical.

6.3 Detection, collation and sharing of surveillance and disease control data

6.3.1 Surveillance for African swine fever

Recommendation 5: General surveillance for dead and dying wild pigs is recommended as the most sensitive and efficient approach for detection of ASF incursions in wild pigs in new areas. This is due to the high mortality in affected wild pig populations.

Recommendation 6: Surveillance in ASF-affected areas should be conducted to provide data on trends in the incidence of disease and to allow investigation of the efficacy of control of ASF. This can occur by periodic collection of diagnostic samples from carcasses, or preferably, if using effective control tools such as aerial shooting, by sampling of recently culled pigs and serology and virus detection across different age categories of pigs.

Recommendation 7: Disease surveillance information systems that allow real-time and finely/locally scaled knowledge of ASF should be used to share information about the prevalence and incidence of ASF, both within Members and between adjacent Members. This will enable an understanding of risk and pre-emptive control activities. iSIKHNAS, Indonesia's animal health information system, is an example of a suitable system. Such systems should focus on social principles (providing value to users), wide deployment and education to encourage data entry and use.

In addition, more regular reporting of ASF in wild pigs to WAHIS is required by Members. This will enable a broader understanding of risk.

6.4 Response – population control

Population control works by killing wild pigs to reduce density of wild pig populations and therefore reduce contact and probably transmission. It is used globally to assist control of ASF in wild pigs, often to contain an epidemic by reducing populations around an outbreak in Europe. It is justified based on empirical evidence, modelling studies, global practice and scientific theory; however, if relying on mathematical modelling, it is difficult to pinpoint a 'threshold density' for disease fade-out.

Control programmes should be designed systematically. The parameters listed below should be considered in these programmes.

- Context – the legal, social, welfare, safety and conservation considerations.
- The scale of the ASF outbreak in wild pigs (area and size of population).
- Epidemiology – are wild pigs a reservoir that will sustain infection, or will control in associated domestic pigs lead to disease fade-out?
- Integrated control programmes – the use of several control tools and approaches concurrently is more effective than just one tool or approach (e.g. hunting). This is true of using several population control tools together and particularly combining population control with disease control tools (e.g. biosecurity and carcass removal).
- Culling should aim to reduce the population enough to reduce disease transmission, rather than to achieve a certain proportion of the population killed.
- Surveillance and monitoring are required as control occurs to look at resulting changes in ASF transmission to determine if more or less culling is required.
- Application of control: in some circumstances, control of populations can occur around outbreaks (pre-emptive culling), but in other areas, rapid and high levels of culling in an infected wild pig population may induce faster disease fade-out and reduce viral load in the environment more rapidly than allowing ASF to burn through the population after pre-emptive culling.
- Currently, a limited number of control tools are used globally to manage ASF outbreaks, including hunting and occasionally trapping. These are amongst the least effective population control tools. A wider variety of effective population control tools has been researched to manage *S. scrofa* in the New World (Australia, New Zealand, the Pacific Islands and the USA). These tools are far more effective than the currently widely used tools.
- Application of effective tools such as aerial shooting and poison baiting does not result in dispersal of wild pigs and will thus have minimal impact on ASF dispersal but does lead to a very rapid reduction in wild pig populations. Technically, these tools could be used on feral pig or invasive wild boar populations.

Recommendation 8: In appropriate contexts, rapid population control using an effective mix of tools (e.g. aerial shooting, poison baiting, trapping) may lead to a rapid reduction of wild pig populations and potentially reduced disease transmission.

Recommendation 9: Notwithstanding Recommendation 8, research to explore the relationship between depopulation and ASF transmission is required, specific to the Asia and the Pacific region. This can test the hypothesis that wild boar depopulation can lead to a disease fade-out locally or determine the population reduction required. Additional understanding is likely to be most easily generated with simulation modelling or surveillance during culling programmes. Simulation modelling in some contexts such as Australia does support this recommendation.

Recommendation 10: Research should be conducted to determine the effectiveness, target specificity and application of these additional tools before they are used in new regions. Registration and approvals may be required – for example, poison baiting may require a similar approval process as poison baiting of rodents does.

6.5 Response – protection of endemic species

6.5.1 Preparation for vaccination

An oral ASF vaccination may be developed and could be an effective tool in future (Barasona *et al.*, 2019), although caution is indicated as the research may not be successful. A vaccine may enable protection of small populations of endemic pig species from mortality or allow management of ASF transmission in *S. scrofa* (wild boar and feral pigs), similar to oral delivery of CSF vaccines to wild boar (Bazarragchaa *et al.*, 2021).

However, significant research and development work must occur before vaccination can occur, independently of research to develop and commercialise an oral vaccine (Sections 5.4.3 and 5.5.3). This ancillary research may not be a priority for pharmaceutical companies that may develop the oral vaccine. Examples of this work are listed below.

- How to ensure oral delivery is effective given diverse ecology and diets – review and research ecology to identify palatable baits that can be manufactured in bulk and are shelf stable. There are a number of commercial wild pig baits globally that could be trialled.
- Design of vaccine programmes given ecology – review ecology of relevant species and conduct modelling and field work to address key questions to enable development of a vaccination strategy.
- Identify a champion to commit to registration in cooperation with pharmaceutical developer. Identify registration pathways, although development of a registration dossier cannot begin until an oral vaccine is available.

Recommendation 11: Ancillary preparatory research for oral vaccine deployment to wild pigs (e.g. bait delivery and strategy research) should begin immediately and before an oral vaccine is developed in order to save several years of research. It may enable earlier vaccination programmes to protect endemic pig species and thereby have better conservation outcomes.

6.5.2 Protected populations of wild pigs

Recommendation 12: Identify critical conservation populations of wild pigs and isolate these from other pigs to protect them from ASF. There are two broad ways to do this: by having good biosecurity to protect geographically isolated populations of pigs (e.g. on islands) or captive insurance populations under quarantine (e.g. pygmy hogs) to breed individuals for later release into ASF-decimated areas.

6.5.3 Reducing the incidence of African swine fever in domestic pigs

There are several considerations additional to biosecurity to prevent spillover events between domestic and wild pigs.

The distribution of the endemic wild pig species of concern in South-East Asia is often coincident with domestic pig farming (Luskin *et al.*, 2021), where ASF is likely to be introduced and potentially become endemic if it is not already present. A critical step to protecting wild pigs is therefore to reduce the incidence of ASF in local domestic pig populations. This will require basic disease control and biosecurity efforts in domestic pigs to reduce the burden of disease; this should then reduce viral spillover to wild pigs. While this area is challenging and beyond the scope of this report, earlier research in Indonesia has indicated that some simple steps such as education and extension could be effective at improving biosecurity and reducing infectious pig diseases in smallholder pig producers (Leslie *et al.*, 2015b) (Section 5.4.5.3). As another example, considerable extension work is being conducted in areas of Assam in India around national parks containing pygmy hogs to establish safe zones to reduce the chance of spillover from domestic pigs.

6.6 Other recommendations

6.6.1 Inter-agency coordination

Recommendation 13: Better inter-agency coordination is recommended between national agencies that are responsible for either managing wildlife or managing disease in animals. As a practical recommendation, a working group should be convened between ministries of agriculture and the environment (or equivalents) and joint policy, implementation and extension activities implemented.

6.6.2 Education

Recommendation 14: Where domestic and wild pigs are important economically and ecologically, societal education about ASF is required. This includes basic education about infectious diseases and managing risks associated with movement of pigs and pig products (as many village pig producers do not understand basic infectious diseases in pigs), with more detailed education along the entire supply chain.

Recommendation 15: Related to Recommendation 7, educate researchers and environmental agencies about the importance of notification of known or suspected cases of ASF in wild pig populations, and promote reporting of infection in wild pigs by all Members. Better capture of data regarding ASF in wild pigs in the WAHIS system will improve its utility in ASF prevention, early detection and response activities among Members.

Pygmy hog *(P. salvania)* © Thiemo Braasch, IUCN/SSC Wild Pig Specialist Group

7 Research: gaps in knowledge in implementing management strategies to control African swine fever

Current knowledge gaps regarding ASF in the Asia and the Pacific region include:

- understanding how ASF affects different wild pig species in Asia; for example, whether all genera are susceptible to ASF and, of susceptible species, whether infection can commonly be subclinical or have a chronic infection state, which facilitates spread of ASF and maintenance of the infection in wild pig populations;
- the ecology of wild pig species and how it influences ASF transmission; for example, population density, and understanding of clustering of infection by environmental characteristics. This information could be used to improve risk-based surveillance and inform intervention strategies (Lim *et al.*, 2021);
- mechanisms of spread and persistence of ASF in wild boar populations (EFSA *et al.*, 2019) and whether and where wild pigs are spillover or reservoir hosts;
- the importance of carcasses in the transmission of infection in different climates and times of the year in the region;
- the role of vectors in disease transmission in the region. Prioritisation of control strategies could change substantially if a competent vector of ASF is identified;
- the trade and cultural links between sites of importance (e.g. islands with threatened endemic pig species) and other locations, how these links may influence ASF infection risk, and how these can be managed in view of ASF;
- the most effective and efficient means of implementing smallholder pig producer biosecurity sufficient to minimise transmission of ASF between wild and domestic pigs;
- social, cultural and practical acceptability of alternative disease control tools;
- host density thresholds for persistence of ASF and how and what level of culling may lead to reduced disease transmission and disease fade-out;
- efficacy of alternate and more efficient control tools for culling pigs, such as aerial shooting and poison baiting, in new areas beyond where they are currently used (e.g. USA, Australia, New Zealand).

Filling these knowledge gaps would enhance control, inform the prioritisation of surveillance and response activities and distribution of resources, and clarify the implications of ASF for the conservation status of wild pig species.

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Appendix A. Distribution of suid species in the Asia and the Pacific region

Table VIII Current distribution of suid species in the Asia and the Pacific region

E = present and endemic; **I** = present introduced species; **U** = presence uncertain; x = absent

	Wild boar *(Sus scrofa)*	Sulawesi babirusa *(Babyrousa celebensis)*	Hairy babirusa *(B. babyrussa)*	Togian Islands babirusa *(B. togeanensis)*	Bearded pig *(S. barbatus)*	Javan/Bawean warty pig *(S. verrucosus)*	Sulawesi warty pig *(S. celebensis)*	Philippine warty pig *(S. philippensis)*	Mindoro/Oliver's warty pig *(S. oliveri)*	Palawan bearded pig *(S. ahoenobarbus)*	Visayan warty pig *(S. cebifrons)*	Pygmy hog *(Porcula salvania)*
Australia	**I**	x	x	x	x	x	x	x	x	x	x	x
Bangladesh	**E**	x	x	x	x	x	x	x	x	x	x	x
Bhutan	**E**	x	x	x	x	x	x	x	x	x	x	**U**
Brunei	**E**	x	x	x	**E**	x	x	x	x	x	x	x
Cambodia	**E**	x	x	x	x	x	x	x	x	x	x	x
China (People's Rep. of)	**E**	x	x	x	x	x	x	x	x	x	x	x
Chinese Taipei	**E**	x	x	x	x	x	x	x	x	x	x	x
Fiji	**I**	x	x	x	x	x	x	x	x	x	x	x
India	**E**	x	x	x	x	x	x	x	x	x	x	**E**
Indonesia	**E**	**E**	**E**	**E**	**E**	**E**	**E**	x	x	x	x	x
Iran	**E**	x	x	x	x	x	x	x	x	x	x	x
Japan	**E**	x	x	x	x	x	x	x	x	x	x	x
Korea (Democratic People's Rep. of)	**E**	x	x	x	x	x	x	x	x	x	x	x
Korea (Rep. of)	**E**	x	x	x	x	x	x	x	x	x	x	x
Laos	**E**	x	x	x	x	x	x	x	x	x	x	x
Malaysia	**E**	x	x	x	**E**	x	x	x	x	x	x	x
Maldives	x	x	x	x	x	x	x	x	x	x	x	x
Micronesia (Federated States of)	**I**	x	x	x	x	x	x	x	x	x	x	x
Mongolia	**E**	x	x	x	x	x	x	x	x	x	x	x
Myanmar	**E**	x	x	x	x	x	x	x	x	x	x	x
Nepal	**E**	x	x	x	x	x	x	x	x	x	x	x
New Caledonia	**I**	x	x	x	x	x	x	x	x	x	x	x
New Zealand	**I**	x	x	x	x	x	x	x	x	x	x	x
Pakistan	**E**	x	x	x	x	x	x	x	x	x	x	x
Papua New Guinea	**I**	x	x	x	x	x	x	x	x	x	x	x
Philippines	**E**	x	x	x	**U**	x	x	**E**	**E**	**E**	**E**	x
Singapore	**E**	x	x	x	x	x	x	x	x	x	x	x
Sri Lanka	**E**	x	x	x	x	x	x	x	x	x	x	x
Thailand	**E**	x	x	x	x	x	x	x	x	x	x	x
Timor-Leste	**I**	x	x	x	x	x	x	x	x	x	x	x
Vanuatu	**I**	x	x	x	x	x	x	x	x	x	x	x
Vietnam	**E**	x	x	x	x	x	x	x	x	x	x	x

Appendix B. Distribution and ecology of non-*Sus Scrofa* endemic wild pigs in the WOAH Asia and the Pacific region

Bearded pig (*Sus barbatus*)

The bearded pig is endemic to Indonesia, Brunei and Malaysia (Fig. 4) (IUCN Red List, 2021f). The subspecies *S. barbatus oi* is endemic to Sumatra; *S. barbatus barbatus* is endemic and extant in Malaysia and Borneo (Luskin and Ke, 2018). Both subspecies occur in all habitat types in their range, including forests, palm oil plantations, wetlands and tidal areas (Love *et al.*, 2018).

As part of their omnivorous diet, bearded pigs will consume carrion (Luskin and Ke, 2018) and thus are vulnerable to ASF infection by this route. Bearded pigs are mobile over large areas in Borneo and Sumatra, tracking mast-fruiting events. Movements can be scattered or in condensed herds (occasionally >1,000 individuals) and can last for months at a time, covering 25 km to 650 km annually (IUCN Red List, 2021f; Luskin and Ke, 2018). These features of movement and population density may facilitate the speed of infection transmission and the geographical spread of infection, depending on features of the epidemiology of ASF in bearded pigs (for example, incubation periods, mortality rates and the presence of carrier animals). Bearded pigs are good swimmers and have been known to swim out to sea as well as regularly cross rivers (Luskin and Ke, 2018); drowned infected carcasses may be a risk when washing up on surrounding islands.

Bearded pig population density can vary considerably over time, particularly considering tracking of mast-fruiting, and probably varies by habitat type (Caldecott *et al.*, 1993). The rate of transmission of ASF infection in infected populations may therefore fluctuate accordingly.

Bearded pigs are prolific breeders in good conditions, with relatively large litters (seven to nine piglets per litter). They are thus considered relatively good candidates for captive breeding programmes (Luskin and Ke, 2018) and have reasonable prospects of surviving the ASF outbreak in the longer term (Kurz *et al.*, 2021). Captive breeding programmes may be an important contributor to population recovery in the aftermath of an ASF incursion.

Data collected in Sabah, Malaysia, by the Sabah Wildlife Department (SWD) and reported during a presentation to the WOAH Asia and the Pacific region *ad hoc* wild pig group reveals an epidemic of ASF in bearded pigs within the province (Sen and Mischellena, SWD, unpublished data, July 2021). This epidemic may have peaked in March 2021, and live bearded pigs have been observed after the epidemic. There is a small captive bearded pig population held by the SWD that may be released to repopulate affected areas.

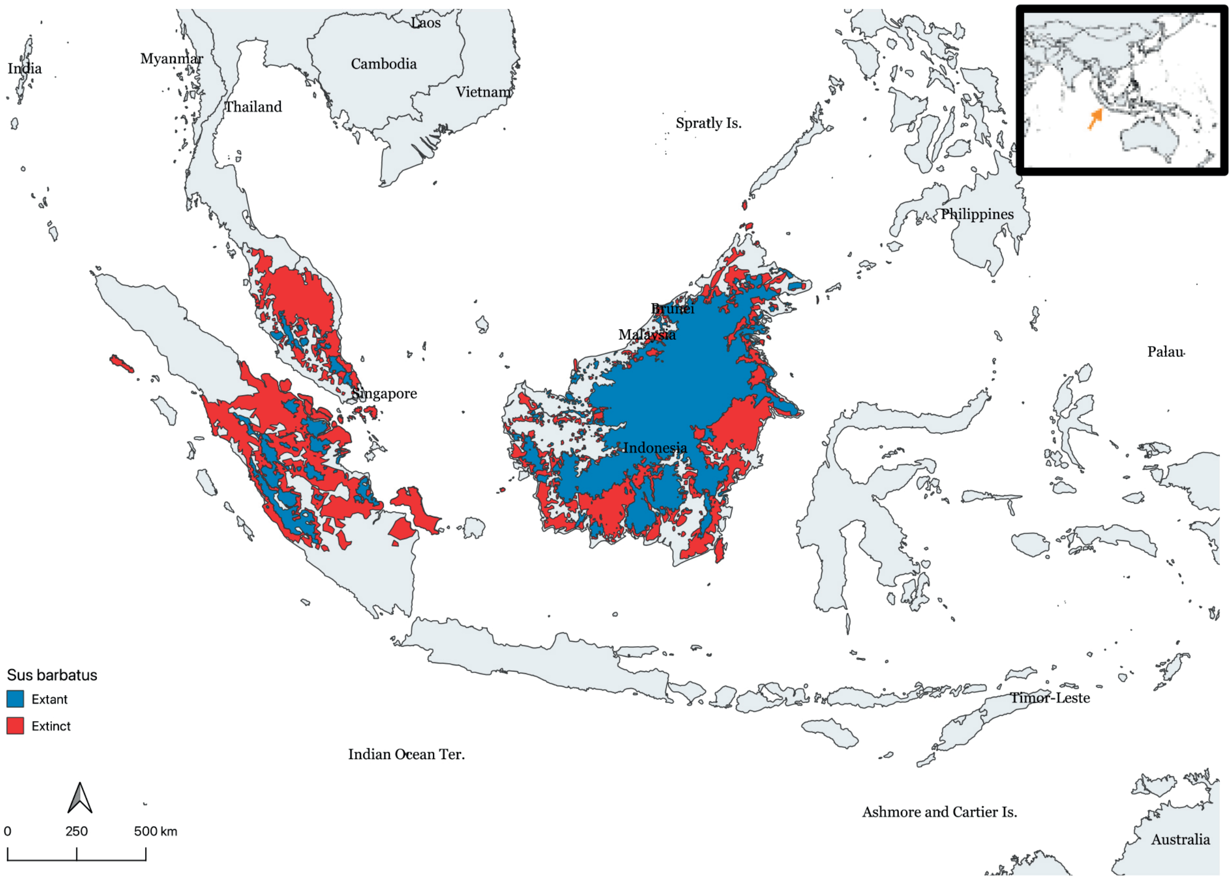

Fig. 4 Distribution of *Sus barbatus*

Source: IUCN Red List (2021f)

Javan warty pig/Bawean warty pig (*Sus verrucosus*)

The Javan warty pig, *S. verrucosus*, is endemic to Java, Indonesia, where it inhabits teak forests, grasslands and cultivated landscapes (IUCN Red List, 2021g) in a very fragmented distribution (Fig. 5). A subspecies, *S. v. blouchi*, is known as the Bawean warty pig, which is endemic to Bawean and is a habitat generalist with a preference for semi-open cultivated habitat (Rademaker *et al.*, 2016). The species' dietary habits are not well documented. *Sus verrucosus* often occur in small groups of up to three animals, though during the mating season there may be up to six animals per group. There are suggestions that the species may previously have occurred in larger groups when the population was more abundant (IUCN Red List, 2021g).

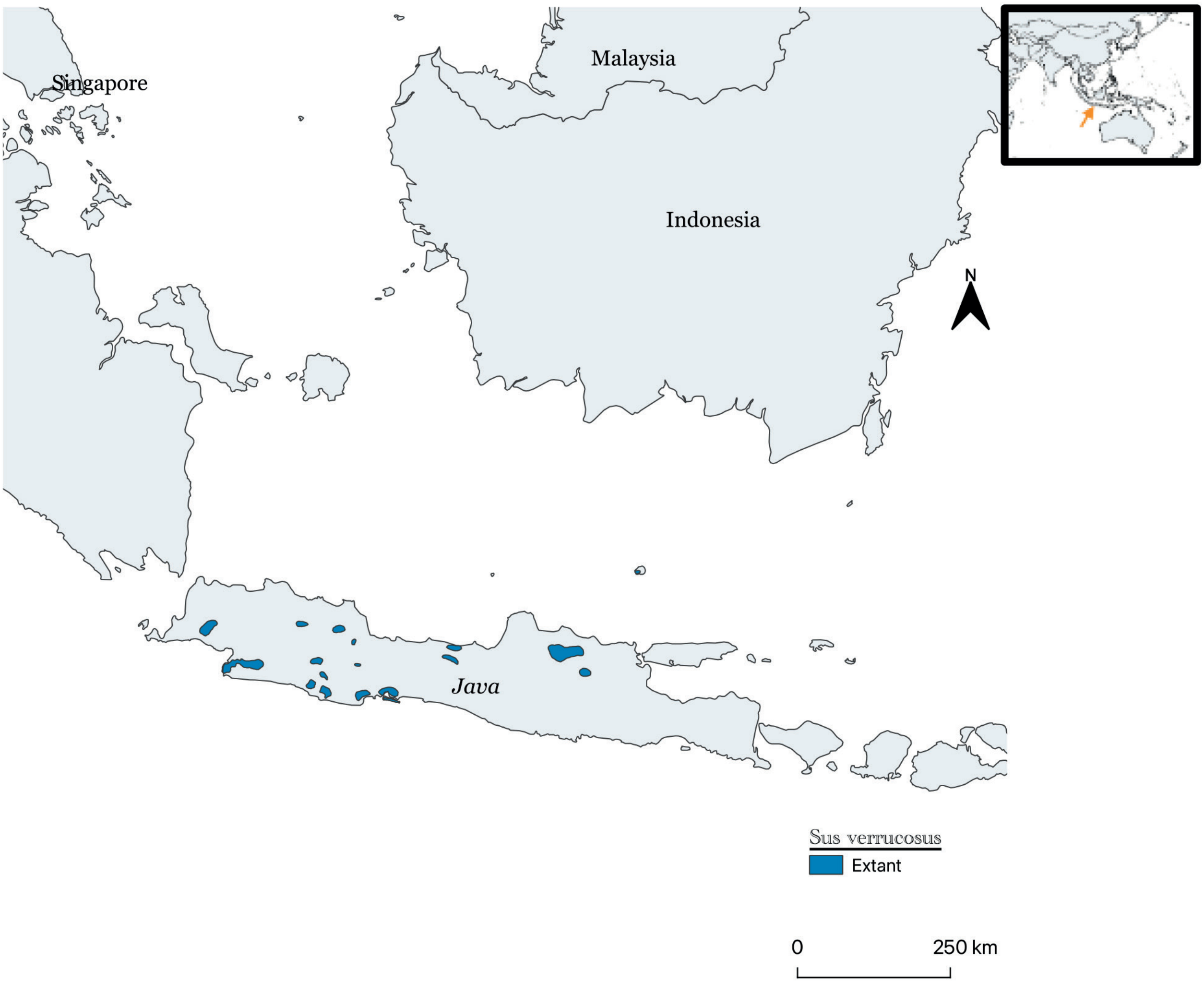

Fig. 5 Distribution of *Sus verrucosus*

Source: IUCN Red List (2021g)

Sulawesi warty pig (*Sus celebensis*)

The Sulawesi warty pig is endemic to Sulawesi, Indonesia; it has also been introduced to other islands in Indonesia and Timor Leste (Fig. 6) (IUCN Red List, 2021b). The species is present in a wide range of habitats, including forest, wetlands, grasslands, rural gardens and agricultural land (Burton *et al.*, 2018; IUCN Red List, 2021b). There is thus opportunity for contact with domestic pigs.

Sulawesi warty pigs are omnivorous and will eat carrion, which is a considerable risk in the transmission of ASF. There are no data on home ranges and movement patterns (Burton *et al.*, 2018). Groups usually comprise one to six animals though may be somewhat larger, and based on studies published up to 15 years ago, population density estimates were variable across regions, ranging from 1.54 to 26.4 individuals per square kilometre (Burton *et al.*, 2018). They have been observed swimming (Burton *et al.*, 2018), so, as for *S. barbatus*, drowned infected pig carcasses being moved between islands is a possibility.

Sulawesi warty pigs have never been successfully bred in zoos and are rarely kept in captivity (Burton *et al.*, 2018).

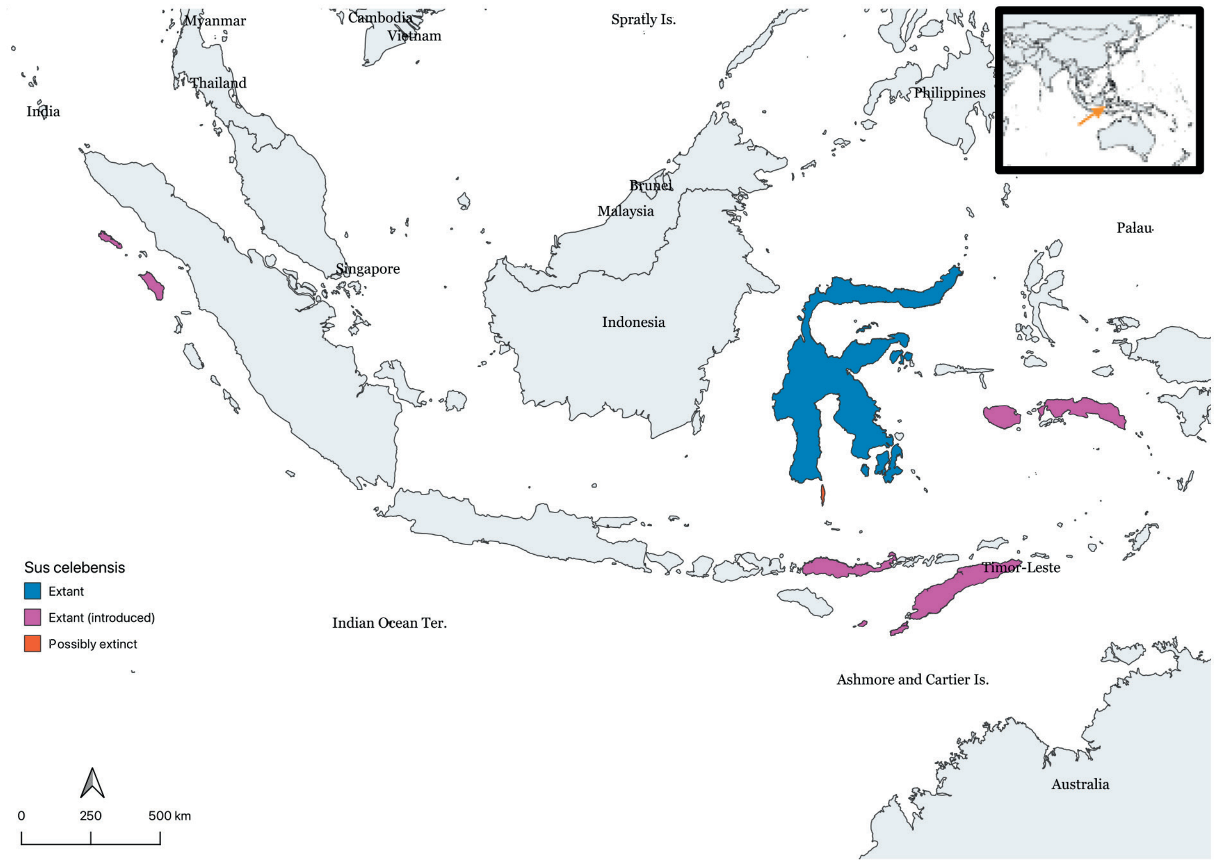

Fig. 6 Distribution of *Sus celebensis*

Source: IUCN Red List (2021b)

Philippine warty pig (*Sus philippensis*), Mindoro (Oliver's) warty pig (*S. oliveri*), Palawan bearded pig (*S. ahoenobarbus*) and Visayan warty pig (*S. cebifrons*)

There are at least four species of endemic pigs in the Philippines with distinct areas of endemicity across the country. The Philippine warty pig (*S. philippensis*) is the most widespread, with areas of endemicity across most of the country, with *S. oliveri*, *S. cebifrons* and *S. ahoenobarbus* separately occupying other geographical niches (Figs 7 and 8). Further, an undescribed novel warty pig species occupies another niche, the Sulu Faunal Region (IUCN Red List, 2021a).

The Philippine warty pig is endemic to the central and eastern islands of the Philippines (Fig. 7) (IUCN Red List, 2021h). While the animals formerly could be found in most habitats across their geographical range, they now occupy principally remote forest at high altitudes (Meijaard and Melletti, 2018) with a fragmented population distribution (Fig. 7). Their contact with domestic swine may therefore be limited, which could affect the degree of exposure to ASF. They are omnivorous, and though there is limited information on specifics of their diet (Meijaard and Melletti, 2018), it is known to vary seasonally based on food availability (Tanalgo, 2017). There are limited data on size of groups; however, local knowledge suggests occasional movement in large migrating herds, in which circumstances ASF could spread quickly throughout the herd. Outside of these occasional large migratory movements, they move in small family groups (e.g. one or two adult females and their young). Their home range may be limited, with movements estimated to be no further than 10 km (Meijaard and Melletti, 2018). The Philippine warty pig has only been bred in captivity once and will typically only have two piglets per litter (Meijaard and Melletti, 2018). Hunting targeting Philippine warty pigs varies seasonally, mainly occurring from March to May (Tanalgo, 2017).

The Mindoro (Oliver's) warty pig is endemic to Mindoro, Philippines (IUCN Red List, 2021i). Limited information suggests that though the species previously occupied most habitat types within its range, it is currently more restricted, particularly to forests and grasslands at high elevations. As for the Philippine warty pig, this may affect their degree of exposure to ASF. There are few data available regarding this species' movement patterns, social groupings and diet. It is presumed that they have feeding patterns similar to the omnivorous *S. philippensis*. They are also known to invade crop fields (Tabaranza *et al.*, 2018).

The Palawan bearded pig is endemic to Palawan and surrounding islands in the Philippines (Fig. 8). This species is known to occur in all major forest types from sea level to 1500 m, grasslands, wetlands and cultivated areas. The animals' home range is unknown. There are no mass movement events in this species, though they are known to swim between islands to forage. It is believed that they eat a wide variety of plant and animal food stuffs, including crops and carrion, though their dietary patterns are not well documented. Reproductive habits are largely unknown. They have nocturnal habits in many locations, with groups of pigs typically consisting of two to three individuals. Groups may be larger during reproductive periods and in areas that are relatively undisturbed (Widmann, 2018).

The Visayan warty pig is endemic to the Visayan Islands in the Philippines (Fig. 8). These animals inhabit forested areas, with a fragmented distribution (Fig. 8), but little is known of their movements and home range. The Visayan warty pig is omnivorous and may live in groups of up to 12 individuals often consisting of an adult male, several adult females and their offspring (Melletti *et al.*, 2018). There is an established captive breeding programme for this species (Melletti *et al.*, 2018).

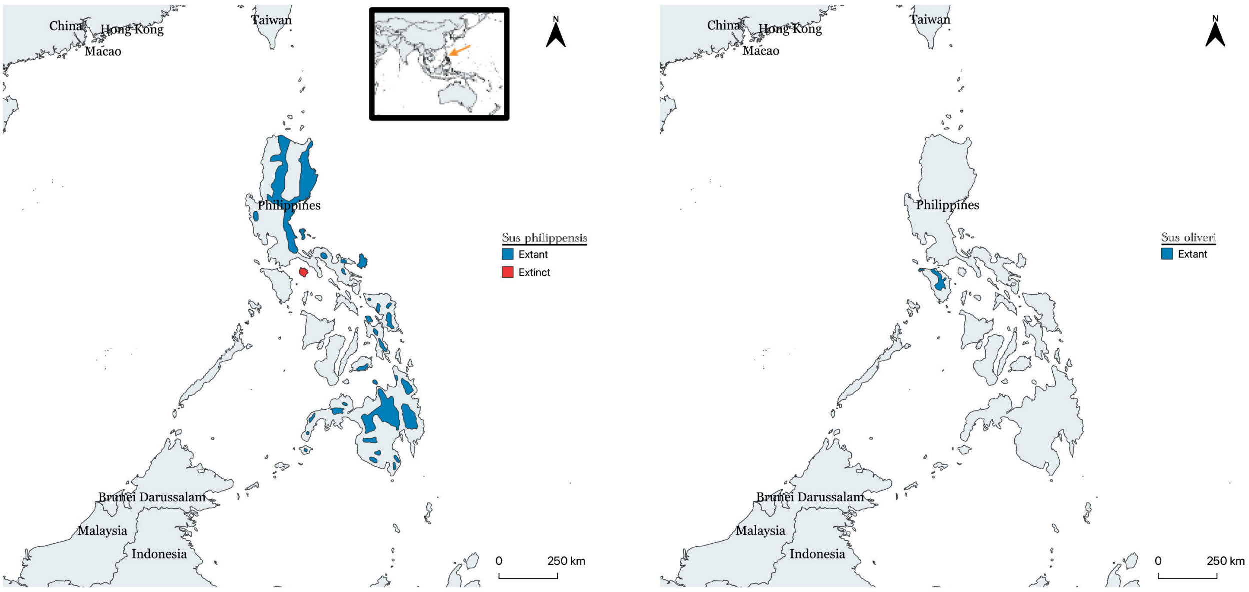

Fig. 7 Distribution of *Sus philippensis* (left) and *S. oliveri* (right)

Source: IUCN Red List (2021a, 2021i)

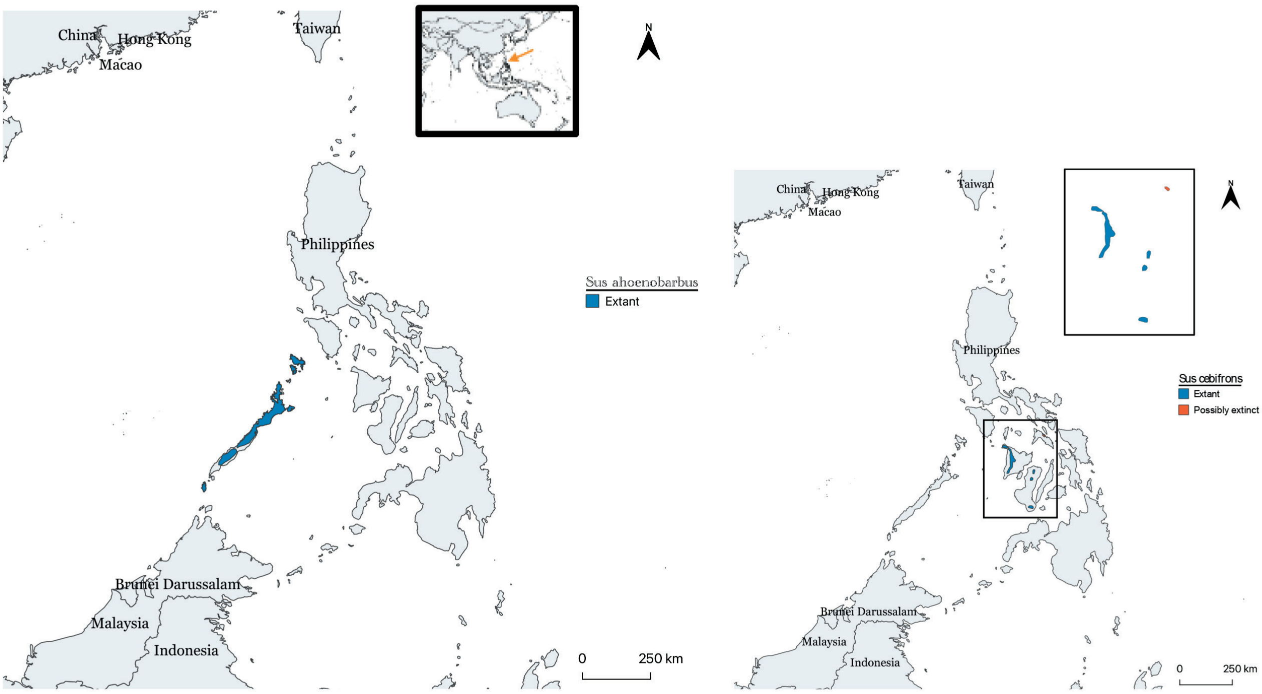

Fig. 8 Distribution of *Sus ahoenobarbus* (left) and *S. cebifrons* (right)

Source: IUCN Red List (2021j, 2021k)

Sulawesi babirusa (*Babyrousa celebensis*)

The Sulawesi babirusa is endemic to Sulawesi and some offshore islands (Fig. 9) (IUCN Red List, 2021c). It is estimated that less than 1,000 mature individuals remain in the wild (IUCN Red List, 2021c). Hairy babirusa are omnivorous and will eat small vertebrates; whether they consume carrion is unknown. They inhabit subtropical/tropical forests by water sources, and wetlands. They are known to live in groups of up to 13 individuals (though more commonly ≤5, often a female with young animals), but adult males are often observed alone (IUCN Red List, 2021c).

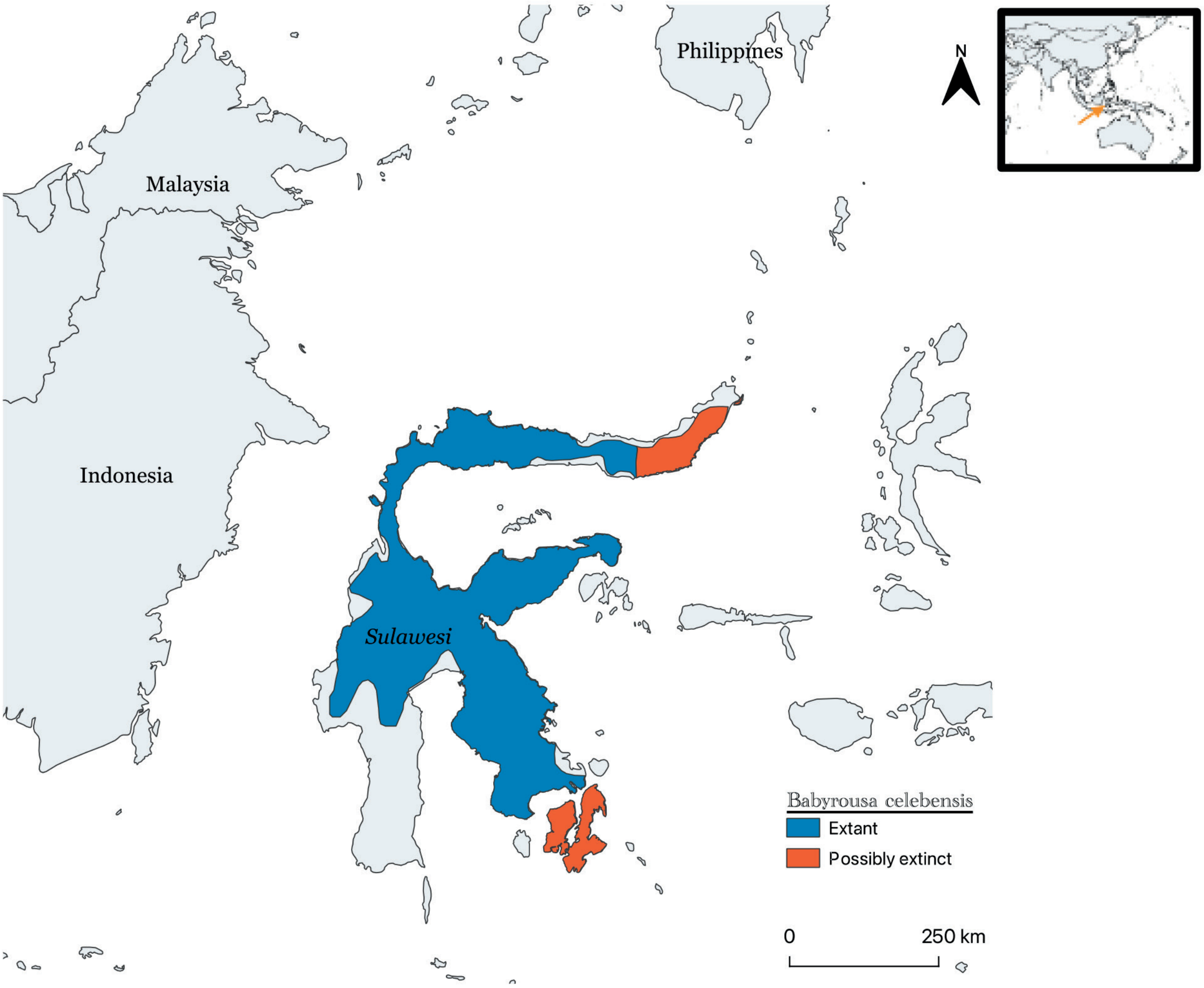

Fig. 9 Distribution of *Babyrousa celebensis*

Source: IUCN Red List (2021c)

Hairy babirusa (*Babyrousa babyrussa*)

The hairy babirusa is endemic to Buru and the Sula Islands, Indonesia (Fig. 10) (IUCN Red List, 2021h). Hairy babirusa are omnivorous; they primarily eat fruits and leaves, although they also eat animal material in relatively small proportions (Sheherazade and Indrawan, 2018). They are recorded as inhabiting subtropical/tropical forests by water sources, and wetlands. Group sizes have been observed as ranging from one to eight animals (median two animals), with many sightings of solitary animals (usually adult males; adult females were usually in groups, particularly with juveniles and subadults) (Patry *et al.*, 1995). The relatively solitary nature of this species may entail slower spread of ASF within the species; however they may congregate around salt licks (Patry *et al.*, 1995; Sheherazade and Indrawan, 2018), which could facilitate ASF spread. There are no data available on their movements and home range. Hairy babirusa have been found at sea, far from land (Sheherazade and Indrawan, 2018), again raising the prospect of spread of ASF between islands by infected pig carcasses.

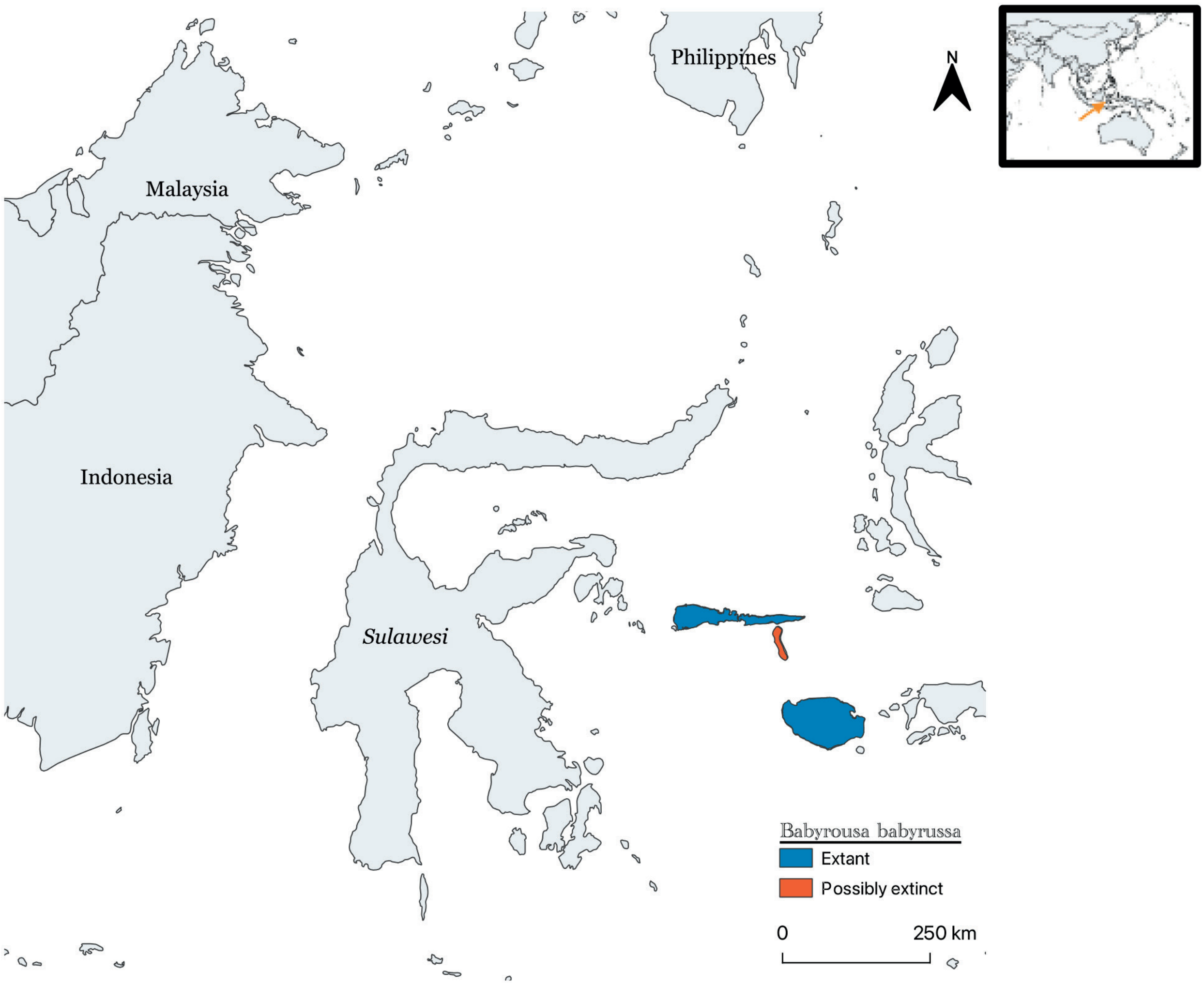

Fig. 10 Distribution of *Babyrousa babyrussa*

Source: IUCN Red List (2021h)

Togian Islands babirusa (*Babyrousa togeanensis*)

The Togian Islands babirusa is endemic to the Togian Archipelago, Indonesia (Fig. 11), with an estimated population size of 1,000 mature individuals (IUCN Red List, 2021d). Locals have reported babirusa crossing the straits between islands of the archipelago (Ito and Melletti, 2018). Like the other babirusas, Togian Islands babirusas are omnivorous and will consume small vertebrates, though whether they consume carrion is unknown. They inhabit tropical rainforests and riverbanks and are also known to occur in urbanised habitats such as gardens, plantations and farming areas, including at the edges of villages. Therefore, contact rates with domestic swine may be relatively high for this species and represent a particular risk in the spread of ASF. Groups of up to 11 individuals have been seen; however solitary behaviour has also been reported.

Though the Togian Islands have been part of a national park (Taman Nasional Kepulauan Togean) since 2004, low awareness of wildlife conservation means that the threats to the population have not abated (Ito and Melletti, 2018). However, in contrast to many other native pigs species in South-East Asia, Togian Islands babirusa are not in demand for their meat because of the religious beliefs of local people (Ito and Melletti, 2018).

There are no known instances of these animals being kept in captivity.

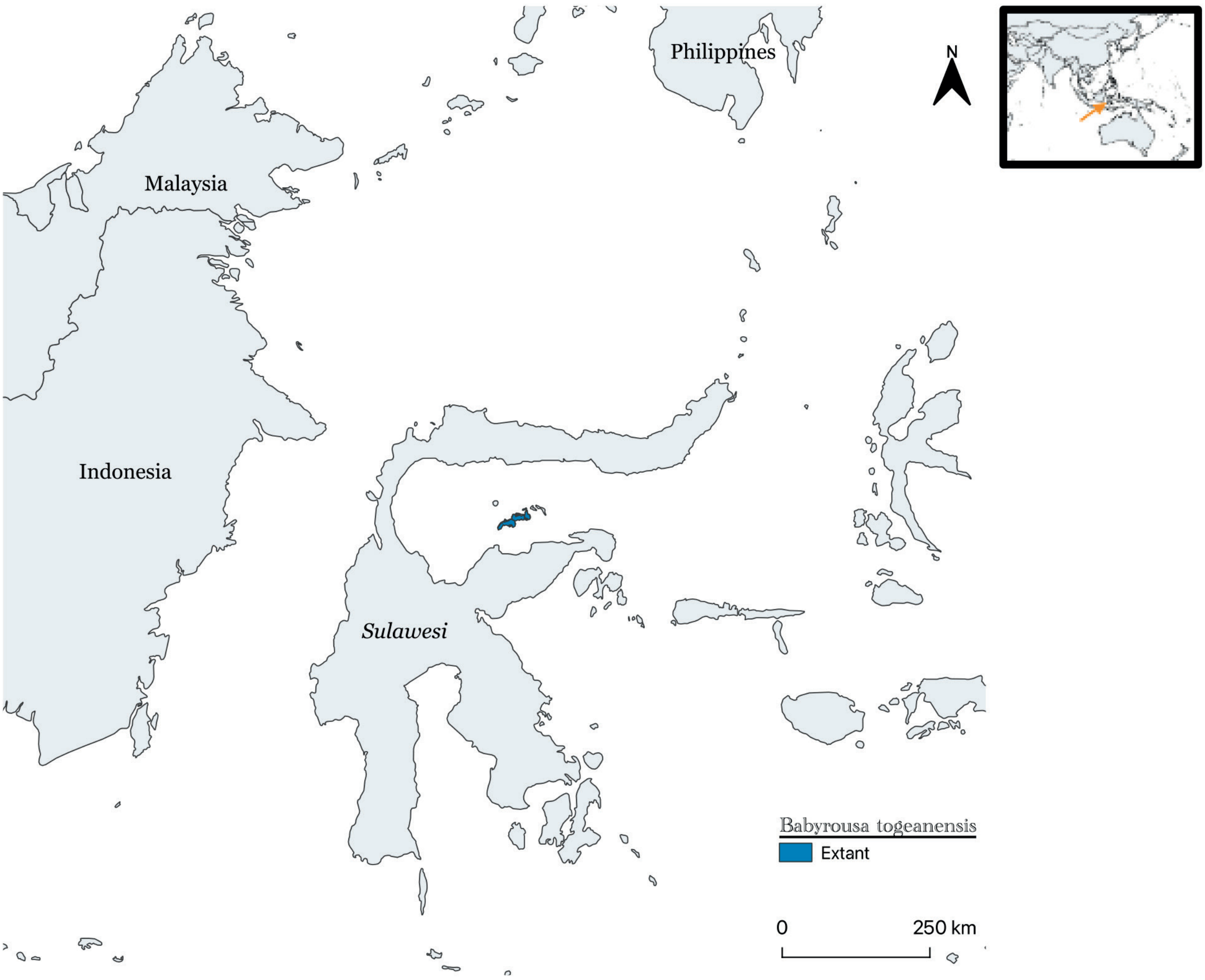

Fig. 11 Distribution of *Babyrousa togeanensis*

Source: IUCN Red List (2021d)

Pygmy hog (*Porcula salvania*)

The pygmy hog is endemic and extant in India and may still be present in Bhutan (Fig. 12) (IUCN Red List, 2021e). It is estimated that the mature animal population size is 100 to 250 (IUCN Red List, 2021e). The animals inhabit subtropical grasslands in a very restricted range (Visser *et al.*, 2021) and occur as isolated, small populations. They have an omnivorous diet but are considered to feed primarily on plants (Visser *et al.*, 2021). There is very little further published information available on the biology and ecology of this species.

There is an established captive breeding effort for conservation of pygmy hogs, with release into the wild (Pygmy Hog Conservation Programme, n.d., n.d.)

Fig. 12 Distribution of *Porcula salvania*

Source: IUCN Red List (2021e)

Appendix C. Wild pigs in the Asia and the Pacific region: survey analysis

Summary

A survey was conducted within Asia and the Pacific to provide valuable insight into the wild pig situation and to provide recommendations to better manage the risk of ASF. Specific areas of the survey focused on species present, relative distribution, farming methods used, ASF status and transmission pathway, and current control strategies in place for wild and endemic pigs. The aim was to provide accurate, concise recommendations regarding ASF management, control, transmission and maintenance within the region.

It is evident that wild pig species are widely distributed within Asia and the Pacific, although the exact density of wild pigs in several areas remains unclear. The analysis highlighted that ASF is present within several reporting regions, so far limited to three different species (*S. scrofa*, *S. philippensis* and *S. barbatus*) and mostly detected in *S. scrofa*. Transmission of ASF is occurring between wild pigs and domestic pigs in both directions, via both direct and indirect contact routes. Thus, managing ASF and wild pigs within Asia and the Pacific is crucial.

The implementation of various control and management strategies varies among the reporting Members. A large area of consideration in what methods are used concerns which wild pig species are present (*S. scrofa* or others), whether they are native or invasive to the region, and the availability of resources to Members. There are opportunities to implement more targeted and strategic pig management methods for several Members.

Additionally, the use of specific control strategies to prevent ASF may be improved to be more efficient and effective. For example, targeted control strategies may be used in certain situations where small-scale production systems are more prevalent than large-scale production systems. It was found that developing Members had a higher proportion of small-scale production (59%) as well as fewer control measures in place to prevent ASF transmission. Of those measures, biosecurity and fencing were not used in many situations where free-ranging/scavenging systems were in place, creating a high risk of ASF exposure. Thus, implementing simple biosecurity (e.g. education, fencing, confinement of domestic pigs) would reduce these risks.

Specific management methods must be applied and targeted to suit each situation as best as possible. Of the Members that have the necessary resources and thus the ability to improve current control and management strategies as recommended in this report, doing so will greatly reduce the risk and extent of the incursion of ASF.

Introduction

Background to survey

African swine fever is of great concern across many parts of Asia and the Pacific. Within the region, there is a diverse range of pigs, including domestic, wild and non-endemic populations, which are all susceptible to ASF. Consequently, investigations into areas concerning the domestic and wild pig populations are required to assist the evolving situation and mitigate potential risks for current or future outbreaks. An extensive review of the literature indicated there is minimal research or information available within Asia and the Pacific.

The purpose of this survey was for WOAH delegates, representatives and knowledgeable scientists of numerous countries and territories within the Asia and the Pacific region to provide valuable insight into areas such as species present, ASF status and transmission, relative distribution, farming methods used and current control strategies in place for wild and endemic pigs. The results will enable provision of accurate recommendations regarding ASF management, control, transmission and maintenance within the region.

Main objectives of the survey

The design of the survey focused on several areas to understand ASF in Asia and the Pacific, including:

- general information on the density, distribution and species of wild pigs in each WOAH Member;
- ASF transmission in wild and between wild and domestic pig populations;
- basic production questions about domestic pig production to infer about biosecurity;
- the utilisation of wild pigs for social and cultural reasons (e.g. consumption, rituals);
- control or preparedness measures, for example to prevent ASF transmission or manage wild pig populations.

Methods

The online survey tool Qualtrics (Qualtrics, 2021) was used to design, create, disperse and analyse results for the questionnaire. The online version of the survey was additionally converted into a Word document format to cater for different preferences of the respondents and improve accessibility if internet connection was difficult (included in the Appendix).

The questionnaire included several broad topic areas, including:

- respondent details
- species of wild pigs
- farming types/methods
- transmission of ASF
- control of ASF
- maintenance of ASF
- regulations/legislations for wild pigs.

Within each of these categories, further defined and focused questions followed. The questionnaire mostly consisted of closed questions with the opportunity for respondents to include supplementary information if necessary. This method was chosen to ensure the survey was timely, coherent and interpreted by respondents correctly, especially if English was not their first language. Each question comprised an 'Other' option with an open text box available if categories were not comprehensive for every possibility or if the respondent wished to add information.

The survey was dispersed through email to Member delegates within Asia and the Pacific (usually the Chief Veterinary Officer) via the WOAH regional representative. In addition, the survey was distributed to several knowledgeable scientists. When respondents used the Word document instead of the online Qualtrics survey, the completed survey was manually entered into the Qualtrics format for data retention and analysis. Approximately six weeks after the initial circulation of the survey, the results were collected and analysed.

The Qualtrics survey tool presents descriptive analyses of the survey. These were examined to understand the survey results as the questions were generally closed questions. The responding Members were commonly categorised as 'developing' or 'developed' regions based on the latest world data (United Nations, 2021). Throughout the analysis, the specific category of *S. scrofa* present within responding Members was considered either as 'wild boar' if it is of native and endemic origin to the region or as 'feral pigs' if it has been introduced and is considered invasive to the region (Fig. 13) (CABI, 2021).

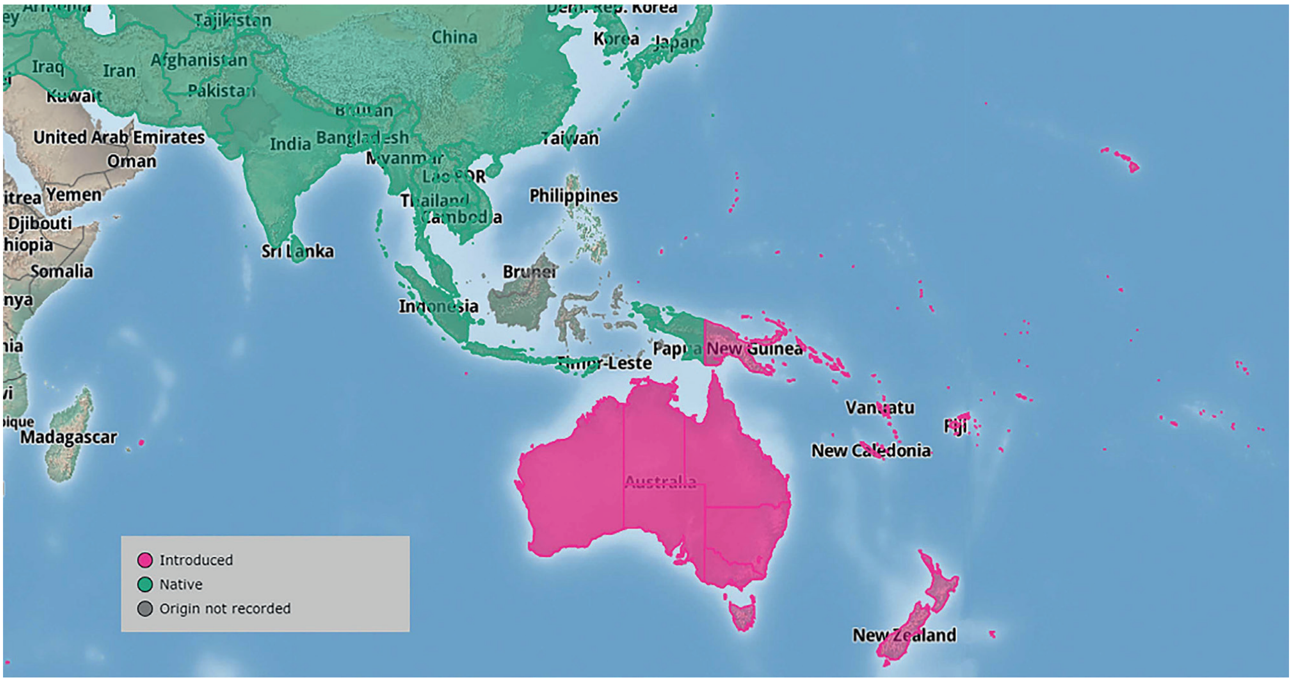

Fig. 13 Distribution of *Sus scrofa* in terms of wild boar and feral pigs in Asia and the Pacific regions of interest (map generated from CABI [2022])

Results

Species present

The data received from the questionnaire were from 36 responses from 27 different Members within Asia and the Pacific (some Members had more than one representative submit a survey). The results discussed are represented as ‘counts’ of the total entries received by each representative; these were not combined per Member due to variability of answers received from the same Member. Wild boar or feral pig (*S. scrofa*) was the most common species (63%, 32/51 total counts). The bearded pig (*S. barbatus*) was reported as present by five respondents (10%), and Sulawesi warty pig (*S. verrucosus)* was reported by two (4%) of the respondents. Each of the remaining nine wild pig species were reported to be present at least once (2%). Each Member that reported any other wild pig species also had *S. scrofa* present. The presence of ‘Hybrids’ and ‘Landers’ was reported once each for two separate countries. One country reported no pigs (2%).

From the results, 67.7% (*n*=21/31) of Members have native/endemic *S. scrofa* within their region, therefore categorised as wild boar. Additionally, 32.3% (*n*=10/31) of all *S. scrofa* in the region were introduced and invasive (not native) and are therefore feral pigs. Table IX depicts this categorisation by reporting Members.

Table IX The incidence of *Sus scrofa* in terms of wild boars and feral pigs within developed and developing Members in Asia and the Pacific

	Wild boar (*S. scrofa*, native)	Feral pig (*S. scrofa*, invasive)
Proportion reported in developing Members	16.1% (*n*=5/31)	22.6% (*n*=7/31)
Proportion reported in developed Members	51.6% (*n*=16/31)	9.7% (*n*=3/31)

Conservation of wild pigs

Many participating Members do not have any legislative protection (82.1%, *n*=23/28) or breeding programmes in place (92.9%, *n*=26/28) for conservation reasons for wild boar (*S. scrofa)*. For the other wild pig species, the results were collected from seven individual responses representing four different Members. Of these, protection for conservation was reported at least once for all species, although results for breeding efforts varied across species (Fig. 14).

Active disease surveillance in feral pigs in Australia © Brendan Cowled

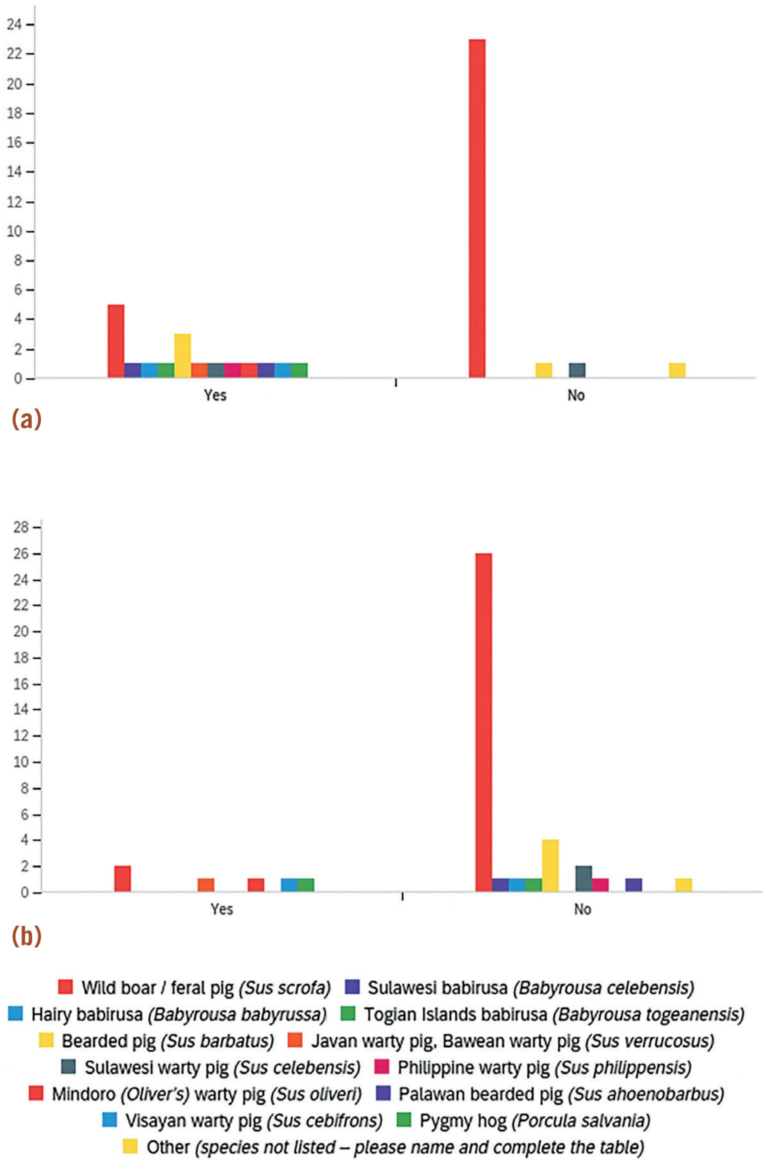

Fig. 14 Proportion of species reported by Members involved in (a) protection for conservation and (b) breeding efforts for conservation

Wild pig densities and country distribution

Many Members (70%, *n*=19/27) noted there was no information on the distribution or density of wild pigs or left these sections blank on the questionnaire, indicating a lack of knowledge regarding the minimum and maximum pig densities within their territory. Despite this, most Members understood the habitats that pigs used, reporting that wild pigs were found in areas such as national parks or forests (Fig. 15). The proportions of wild boars or feral pigs (*S. scrofa)* reported by respondents included those in national areas (33.7%, *n*=28/83), agricultural areas (27.7%, *n*=23/83), semi-rural areas (26.5%, *n*=22/83) and urbanised areas (12.1%, *n*=10/83). Of the other wild pigs, in addition to national areas, the bearded pig was reported in agricultural and semi-rural areas and the Javan warty pig in agricultural areas (Fig.15).

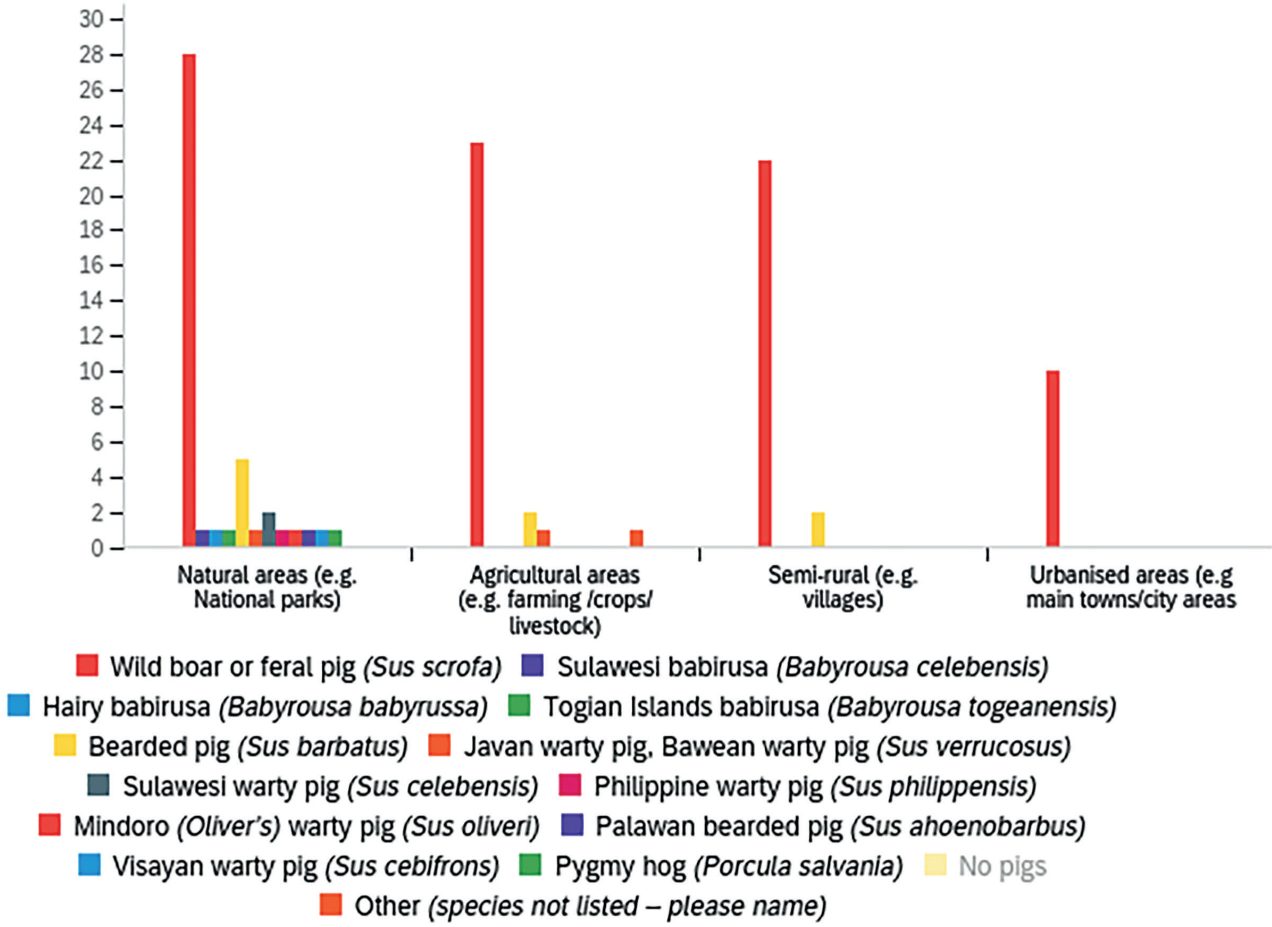

Fig. 15 Distribution of locations of wild pig species reported by respondents

Farming methods and wild pig use

Domestic pig farming of *S. scrofa* was reported by many participating Members (80.7%, *n*=25/31), with small-scale (*n*=19) and medium-scale (*n*=20) production reported to be the two most common methods. Large-scale production was also reported (*n*=12). Of the small-scale production systems, the subcategories of farming varied from intensive and semi-intensive to free-ranging/scavenging and integrated systems (Table X).

Table X Analysis of the types of farming methods used in Asia and the Pacific as reported by WOAH Members*

Type of domestic pig production in Member	Proportion of Members reporting	Type of domestic production	Number of Members reporting	Mean proportion of production across all Members (95% CI)	Total number of Members reporting each type of small-scale production	Mean proportion of each small-scale production method across the reporting Members (95% CI)
Domestic pig production present	80.7% (25/31)	Large scale	12	55% (37.6–72.6)	~ ~	~
		Medium scale	20	28.2% (16.4–40.02)		
		Small scale	19	23% (1.47–45.28)	Free-ranging/ scavenging (11)	15% (5.81–24.19)
					Semi-intensive (15)	35.8% (10.03–61.62)
					Intensive (15)	48.8% (21.78–75.72)
					Integrated (1)	NA
No domestic pig production present	19.3% % (6/31)	~	~	NA	~	~

*Not all Members that specified the type of domestic production system in operation also specified the proportion of the production systems in further detail (percentages). Thus, only those that provided this information were able to be included in this analysis.

Wild pigs were indicated to have a use in society by many respondents (83.9%, *n*=26/31). Most commonly, *S. scrofa* was used for food (diet [45.5%] and ceremonial [12.7%]), for hunting/sport (29.1%) and for payment/monetary reasons (5.5%). Of the other wild pigs, the bearded pig (*S. barbatus*) was the most reported as being used, mostly for food (diet [42.9%] and ceremonial [28.6%]) and for hunting/sport (28.6%).

African swine fever status and transmission

Of the participating countries and territories, ASF has been detected predominately in wild boar/feral pigs (*S. scrofa*) (31%, *n*=9/29). However, it has also been detected in bearded pigs (*S. barbatus*) and Philippine warty pigs (*S. philippensis*). It was also reported to be detected within hybrids of *S. scrofa*. The remaining wild pig species were not reported to have been infected with ASF prior to the time this survey was finished. For each of the species that have been reported to have been infected with ASF, the direction of transmission between wild and domestic pigs and transmission mechanisms is displayed in Table XI.

Table XI Species that have been reported to have ASF within regions of Asia and the Pacific and the specified transmission route of the disease

Species	ASF reported status	Direction of transmission (if occurred)	Transmission mechanism (if known)
Wild pigs (*Sus scrofa* and others)	32.6% (*n*=15/46)	• Domestic–wild (33%, *n*=5/15) • Wild–wild (33%, *n*=5/15) • Wild–domestic (33%, *n*=5/15) • Unsure (13%, *n*=2/15)	• Direct contact (pig–pig) (*n*=7) • Direct contact with infected dead pig carcass (*n*=7) • Scavenging of food/waste from domestic pig farms (*n*=5) • Indirect contact (i.e. human interactions or fomites) (*n*=5) • Pig effluent from domestic piggery (*n*=1) • Pig products (i.e. pork) (*n*=1)

n: the number of total counts collected for the respective category

Female and juvenile north Sulawesi babirusas *(B. celebensis)* © Thiemo Braasch, IUCN/SSC Wild Pig Specialist Group

Control strategies

More than half of respondents (54.8%, *n*=17/31) indicated they used control or prevention strategies for ASF in wild pigs. Several respondents indicated that either there were no strategies in place (22.6%, *n*=7/31) or they were unsure (22.6%, *n*=7/31). The specified control measures were used mostly for *S. scrofa,* with only one respondent reporting control measures for hybrids (fencing and biosecurity). The types of control methods reported are described in Table XII.

Of the surveillance methods used, the specific strategies conducted involved searching for pig carcasses (72.7%, *n*=8/11), random or frequent testing of wild pigs (27.2%, *n*=3/11), observing signs of pig mortality (90.9%, *n*=10/11) and aerial/ground surveillance (0.1%, *n*=1/11). A developed Member specified the additional strategies of using thermal imaging and field cameras to monitor the presence of feral pigs. Overall, surveillance is implemented by 45.5% of developing Members and 54.5% of developed Members.

There were five separate responses received for the question in the survey specifying the type of culling or population control used. The responses came from four different OIE Members; therefore, two of the responses were combined to provide an accurate representation in the results (Table XII). Overall, 25% of Members implementing culling (*n*=1/4) are developing Members and 75% (*n*=3/4) are developed Members.

Table XII Proportion of different control methods for *Sus scrofa* applied throughout Asia and the Pacific*

	Fencing	Zoning	Biosecurity	Surveillance	Carcass disposal	Vector control	Culling/ population control	Border quarantine
*Sus scrofa**	11.% (*n*=5/44)	9.1% (*n*=4/44)	25% (*n*=10/44)	25% (*n*=11/44)	13.6% (*n*=6/44)	2.3% (*n*=1/44)	9.1% (*n*=4/44)	18.2% (*n*=8/44)
Proportion implemented in developing Members	40% (*n*=2/5)	25% (*n*=1/4)	30% (*n*=3/10)	45% (*n*=5/11)	33% (*n*=2/6)	100% (*n*=1)	25% (*n*=1/4)	25% (*n*=2/8)
Proportion implemented in developed Members	60% (*n*=3/5)	75% (*n*=3/4)	70% (*n*=7/11)	55% (*n*=6/11)	67% (*n*=4/6)	-	75% (*n*=3/4)	75% (*n*=6/8)

n: the number of total counts collected for the respective category

*A total of 44 counts was recorded in the survey by the 36 respondents for the various control methods as several Members reported the use of multiple strategies.

Correlation between several control measures and other relevant factors

Biosecurity, pig production type and wild species present

Biosecurity practices were implemented in mostly developed Members (73%), which reported the presence of only *S. scrofa* (feral pigs [*n*=5] and wild boar [*n*=2]). There was no reporting of the presence of any other wild pig species by developed Members using biosecurity control measures.

The use of small-scale production systems occurred mostly in developing Members (*n*=12), of which 50% (*n*=6) reported using free-ranging/scavenging systems. Three developing Members using small-scale systems also reported the presence of other wild pig species. The control measures implemented by these developing Members were minimal; for example, biosecurity was only used in 25% (*n*=3/12) and fencing in 8% (*n*=1/12) of reporting Members.

Large-scale production systems were reported to occur in developing (50%, *n*=6/12) and developed Members (50%, *n*=6/12) equally. However, where large-scale production was operating (even in the presence of wild pigs), it was found that developed Members had implemented more biosecurity measures (*n*=5/7) than developing Members, offering greater protection against ASF transmission.

Carcass disposal and temperature

The disposal of pig carcasses was reported to be used by six different Members, of which four are considered to commonly experience winters below –5 °C, whereas during summer these Members rarely experience temperatures above 25 °C. The other two reporting Members rarely experience such extreme cold weather, although temperatures above 30 °C are common during summer.

Border quarantine and land type

Border quarantine was reported to be implemented by eight responses representing seven different Members, of which five represent land classified as islands.

Wild pig management strategies

Wild pigs were indicated to be involved in a managed hunting system by 41.9% respondents (*n*=13/31). However, 51.6% (*n*=16/31) noted that there was no managed hunting system or season in place. Two respondents were unsure (6.5%, *n*=2/31). The percentage of Members reporting there was a managed hunting system operating where *S. scrofa* is considered an endemic species (wild boar) was 41.4% (*n*=12/29), whereas where *S. scrofa* are an invasive introduced species (feral pigs), a managed hunting system was reported by 3.4% (*n*=1/29) of Members. Thus, endemic *S. scrofa* regions are more likely to have a managed hunting system compared to where they are invasive.

A proportion of Members that participate in a managed hunting system/season indicated the type of hunting system implemented (Table XIII). The reasons for implementing these systems included prevention of crop damage by wild pigs (*n*=12/12), potential traffic incidents (*n*=2/10) and invasion into urban areas (*n*=4/10) and for disease control (*n*=7/10).

Table XIII Specific managed hunting systems reported by practicing Members

Context of managed hunting system	Proportion of reporting Members implementing hunting systems
A specific hunting period	66.7% (*n*=8/12)
Pigs hunted for game	70% (*n*=7/10)
Pigs hunted for food	83% (*n*=10/12)
A quota/limit when hunting wild pigs	50% (*n*=5/10)
A target species or demographic of wild pig (e.g. females)	25% (*n*=2/8)
Illegal hunting occurs	80% (*n*=8/10)

n: the number of total counts collected for the respective category

Regulations or legislations in place

The regulations or legislations surrounding wild pigs varied across the different categories and were for reasons such as conservation, control of ASF and hunting (Table XIV). Within these categories, laws surrounding the hunting of wild pigs are of highest concern, with ASF control laws being second.

Table XIV The proportion of Members implementing regulations or legislations towards conservation, ASF control and hunting of wild pigs

	Conservation of wild pigs	For ASF control	For hunting wild pigs
Yes	30% (*n*=9)	43.3% (*n*=13)	56.7 % (*n*=17)
No	53.3% (*n*=16)	43.3% (*n*=13)	33.3% (*n*=10)
Unsure	16.7% (*n*=5)	16.7% (*n*=5)	10% (*n*=3)

n: the number of total counts collected for the respective category

Discussion

The results collected from this survey provide insight into the current wild pig situation in many Asian and Pacific countries and territories. It is evident that wild pig species are widely distributed within the regions, with *S. scrofa* being the most abundant species overall. The analysis highlighted that ASF is present within several reporting Members and has so far been limited to three different species (*S. scrofa*, *S. philippensis* and *S. barbatus*), although most detected in *S. scrofa*. Transmission of ASF is occurring between wild pigs and domestic pigs in both directions. Thus, managing ASF and wild pigs within Asia and the Pacific is very important. This survey collected essential information within specific areas of concern and provides direction for the implementation of effective management strategies and recommendations to assist in reducing the risk and impacts of ASF outbreaks.

There are currently limited strategies in place to protect endangered pig species through conservation and breeding efforts. As such, ASF outbreaks in at-risk pig species have the potential to lead to extinction of certain species found in Asia. *Sus scrofa* are generally abundant and often considered an invasive pig species; therefore, conservation efforts are not a major concern for this species.

Many Members reported a proportion of their country in which wild pig species can be found (specifically *S. scrofa*), which ranged from 30% to 100% coverage. However, several respondents (*n*=6) did not have information on the density of pigs (e.g. pigs/km^2). It can be inferred that there is a lack of available data and knowledge on the exact abundance or distribution of wild pigs within these areas. As population density is a key parameter that is likely to impact transmission of disease, this is a major risk factor in many Asian and Pacific areas. Therefore, there is an urgent need to address this issue and to generate data on the distribution and abundance of wild pigs.

Farming of *S. scrofa* was conducted in many participating Members (80%). In the context of ASF, the type of farming methods can also contribute to the risk of exposure and spread (Leslie *et al.*, 2015b). Many Members, especially developing countries, report a heavy reliance on small-scale production systems, especially free-ranging/roaming methods. It was found that the proportion of small-scale production was higher for developing Members (59%), which also had fewer control measures in place to prevent ASF transmission. Of these, biosecurity and fencing were not used in many situations where free-ranging/scavenging systems were in place, creating a high risk of ASF exposure. It is very difficult to implement appropriate biosecurity measures with these methods of production, indicating transmission of ASF between wild and domestic pigs is an ongoing risk that will complicate management of ASF in the region. While the resources and ability to manage these risks can be limited, prior research has indicated that application of simple biosecurity improvements may reduce the risk of this transmission (Leslie *et al.*, 2015b). For example, education about infectious diseases, isolation of moved pigs, village-level biosecurity practices and penning pigs may improve biosecurity.

The transmission direction of ASF varied between wild and domestic pigs (Table XI), showing it is occurring directly and indirectly with contact of dead infected carcasses and through scavenging behaviours. Spread of ASF through pig products and effluent from piggeries was also indicated and remains a consistent threat to ASF-free locations. These transmission risks can be prevented or eliminated with strong and conventional control measures (Jurado *et al.*, 2018). In the survey, 22.6% of respondents noted that their country has no control strategies currently in place for protection against ASF, while 43.3% reported there are no regulations or legislations implemented for ASF control. These two components are vital for preventing, eliminating and controlling current or future outbreaks of ASF within both domestic and wild pig populations (Bellini *et al.*, 2016; Jurado *et al.*, 2018). This lack of preparedness should be addressed through development of appropriate emergency contingency plans, technical expertise and resources.

The implementation of various control and management strategies varies among reporting Members. What methods are used depends greatly on which wild pig species are present (*S. scrofa* or others), whether they are native or invasive to the region, and the availability of resources to Members. Culling is mostly used by developed Members (*n*=3/4) and only where *S. scrofa* is the only species present. Members that reported the presence of other wild pigs species as well as *S. scrofa* (*n*=4) reported having implemented managed hunting strategies (*n*=2/4) and ASF control methods (*n*=3/4). The presence of additional pig species with similar ecology may create complications and require ethical considerations to ensure the wild pig species are not impacted. Thus, target-specific control tools are needed, especially for regions where *S. scrofa* is co-distributed with other wild pigs in the environment.

There is opportunity for more strategic culling by Members to target *S. scrofa* when it is the only species present. The utilisation of tools such as ground and aerial shooting, trapping and poison baiting could be used more widely and offer a more timely and efficient approach for population control of *S. scrofa* (if the resources are available and their use is suitable). Additionally, the type of method used depends on the ecology and climate of the specific region. For example, in areas with dense forests, it may be more appropriate to use poison baiting over aerial shooting as visibility is limited. Thus, strategic methods may need to be specific and situational for each Member.

Moreover, using control strategies that may prove to be ineffective or unnecessary may decrease the availability of resources to be used on alternative, more effective methods. For example, carcass disposal of dead pigs was reported as being used by two Members whose climatic temperatures rarely drop below freezing in winter and commonly include extreme heat in summer. Therefore, preservation of dead carcasses in the environment is unlikely and is less of a risk for ASF transmission. As a result, other methods such as improved biosecurity or culling measures may be more worth the resources.

Use of a managed hunting system was found to be more prevalent among Members where *S. scrofa* is an endemic species (wild boar) (41.4%), whereas Members where *S. scrofa* is an invasive introduced species (feral pigs) were less likely to have a managed hunting system (3.4%). Thus, it may be inferred that regions with endemic *S. scrofa* are more inclined to preserve their wild boar population, compared to regions that may consider them as an invasive, 'pest' species. This may need to be taken into consideration when implementing specific control or management strategies.

Limitations

The analysis naturally involved a small number of target respondents (i.e. 32 Members in total), but it proved to be representative, with an 85% response rate. However, because the contents of the survey involve several subcategories, and owing to the unique situation in Asia and the Pacific, it was difficult to achieve diversity within specific situations. Overall, this created some difficulty in inferring or making judgements based on the results with confidence.

Conclusion

Evidently, wild pigs throughout Asia and the Pacific constitute a risk in spreading ASF if they are not managed appropriately. As a result, it is essential that the specific management methods applied be effective and targeted to suit each situation as best as possible. Of the Members that have availability of resources and ability to improve current control and management strategies as recommended in this report, taking such measures will greatly reduce the risk and extent of the incursion of ASF.

Appendix D. Wild pigs in the Asia and the Pacific region: survey design

Context of the survey

Introduction

African swine fever (ASF) is rapidly developing and is of great concern across regions within Asia and the Pacific.

A WOAH commissioned project is presently being conducted to review the potential role of wild and native suids within Asia and the Pacific in ASF transmission. This survey is part of that project.

This survey is being conducted by Ausvet Pty Ltd (a veterinary epidemiology company from Australia and France) and the University of Sydney on behalf of, and with assistance from WOAH.

All information will be reported anonymously so that the responding individual cannot be identified. Sensitive information from the survey will be reported by region rather than by individual country.

Definitions of the wild pigs in this survey

Table XV Definitions of suid populations used in this report

Suid category	Definition	Subcategory	Definition
Wild[1] pigs	Any members of the taxonomic family Suidae that are living freely in the ecosystem without close human management, or that are held in captivity in zoos or breeding programmes. There are two main types of wild pigs, (i) *Sus scrofa* and (ii) other wild Suidae.	*Sus scrofa*	Feral pigs and wild boar In general, wild boar are locally endemic and feral pigs have been introduced to an area. (Where *S. scrofa* are farmed, either intensively or extensively, they are referred to as 'domestic' pigs.)
		Other wild Suidae	The 11 species of endemic pigs found locally across the Asia and the Pacific region (*Babyrousa celebensis, B. babyrussa, B. togeanensis, Sus barbatus, S. verrucosus, S. celebensis, S. philippensis, S. oliveri, S. ahoenobarbus, S. cebifrons, Porcula salvania*)
		Hybrids	Wild pigs that are hybrids of wild pig species
Domestic pigs	Any members of the taxonomic family Suidae that are managed by humans, excluding wild pigs held in zoos or breeding programmes. 'Domestic pigs' includes farmed wild boar.		

1 While the term 'wildlife' is used in WOAH definitions to define feral animals, captive wild animals and wild animals, the term 'wild pigs' is used in this report for fluency of language in this context.

Survey questions

Respondent details

The data from this survey may be used in research and published. If you would like your data to remain unpublished, please specify 'No' below and your information reported will not be included in any publications. Otherwise, tick 'Yes':

Yes	No

1. Please write your country/territory name

2. Contact email and name for follow-up questions (if you do not require privacy)

3. Please note your organisation

Wild pigs in your country/territory

4. Please indicate the pig species that are present within your country/territory

- If 'No pigs' are present please end survey here, thank you.

Species	Tick if present
Wild boar or feral pig *(Sus scrofa)*	
Sulawesi babirusa *(Babyrousa celebensis)*	
Hairy babirusa *(Babyrousa babyrussa)*	
Togian Islands babirusa *(Babyrousa togeanensis)*	
Bearded pig *(Sus barbatus)*	
Javan warty pig, Bawean warty pig *(Sus verrucosus)*	
Sulawesi warty pig *(Sus celebensis)*	
Philippine warty pig *(Sus philippensis)*	
Mindoro (Oliver's) warty pig *(Sus oliveri)*	
Palawan bearded pig *(Sus ahoenobarbus)*	
Visayan warty pig *(Sus cebifrons)*	
Pygmy hog *(Porcula salvania)*	
No pigs	
Other (species not listed – please name)	

5. **For the relevant species present in your country/territory, please fill out the corresponding information:**

- An example row is presented in the table below for *Sus scrofa* (feral pigs) in Australia for reference.

Repeat the information for every species that is present.

Species (complete for the species present within the country)	Has ASF been detected in that species?	Is the species protected for conservation?	Are there conservation breeding efforts?	Minimum density of that species (pigs/square km)	Maximum density of that species (pigs/square km)	Approximate % of country where the species is found
Example row for Wild boar or feral pig *(Sus scrofa)* **in Australia**	**No**	**No**	**No**	**0.1 pigs/km²**	**20 pigs/km²**	**40%**
Wild boar or feral pig *(Sus scrofa)*						
Sulawesi babirusa *(Babyrousa celebensis)*						
Hairy babirusa *(Babyrousa babyrussa)*						
Togian Islands babirusa *(Babyrousa togeanensis)*						
Bearded pig *(Sus barbatus)*						
Javan warty pig, Bawean warty pig *(Sus verrucosus)*						
Sulawesi warty pig *(Sus celebensis)*						
Philippine warty pig *(Sus philippensis)*						
Mindoro (Oliver's) warty pig *(Sus oliveri)*						
Palawan bearded pig *(Sus ahoenobarbus)*						
Visayan warty pig *(Sus cebifrons)*						
Pygmy hog *(Porcula salvania)*						
Other (species not listed – please name and complete the table)						

6. **Where are wild *Sus scrofa* or other endemic Suidae found in your country/territory?**

Locations wild pigs can be found	Tick if relevant	Species
Natural areas (e.g. national parks)		
Agricultural areas (e.g. farming/crops/livestock)		
Semi-rural (e.g. villages)		
Urbanised areas (e.g. main towns/city areas)		
Other instances (specify below)		

If other instances, please specify below:

Farming domestic pigs and harvesting wild pigs

7. **Are domestic pigs (*Sus scrofa)* farmed within your country/territory? (If 'No', go to Q8).**

Yes	No	Unsure

(i) If yes, please indicate the type of farming methods conducted within your country/territory:

Farming method	Tick if relevant	Approximate proportion of national production from each category (%)
Large-scale production (>500 sows or >4,000 fatteners)		
Medium-scale production (5–500 sows or 20–4,000 fatteners)		
Small-scale production (1–2 sows or 1–20 fatteners)		
• Free range/scavenging (unrestrained)		
• Semi-intensive (confined within large area)		
• Intensive (confined to a pig pen)		
• Integrated (with fish farming)		
• Other (specify below)		

If other methods, please explain in further detail:

8. **Do parts of the human population in your country/territory use wild pigs for specific purposes (e.g. hunt for cultural or dietary)? (If 'No', go to Q9.)**

Yes	No	Unsure

(i) If yes, please indicate the purposes for wild pig use:

Wild pig use	Tick if relevant	Relevant species
Food (diet/consumption)		
Food (ceremonial occasions)		
Hunting/sport		
Feed for farm animals		
Dowries		
Hierarchy ranking		
Rituals (sacrifice, worship, taboo)		
Payment/monetary reasons		
Other (specify below)		

If other purposes, please explain in further detail:

Transmission of ASF in domestic and wild pigs

9. **Has ASF been transmitted between wild pigs and domestic pigs in your country/territory? (If 'No', go to Q11.)**

Yes	No	Unsure

(i) If yes, has this transmission been between:

Sus scrofa	Tick if relevant	
Domestic pigs to wild pigs		
Wild pigs to wild pigs		
Wild pigs to domestic pigs		
Unsure		
Other wild pigs		**Species relevant**
Domestic pigs to other wild Suidae		
Other wild Suidae to other wild Suidae		
Other wild Suidae to domestic pigs		
Unsure		

(ii) If transmission is occurring, how is it occurring at the wild pig and domestic interface?

Transmission	**Tick if relevant**		
	Sus scrofa	**Other wild pigs (specify species to the right if relevant)**	
Direct contact (pig to pig)			
Direct contact with dead pig carcasses			
Scavenging of food/waste from domestic pig farms			
Indirect contact (i.e. via human interactions or fomites)			
Spread via effluent from domestic piggery			
Spread via pig products (e.g. pork)			
Vectors (if present)			
Other (specify below)			

If 'other' transmission pathways present, please explain in further detail below:

10. Do you have any suggestions on how this transmission could be better controlled?

Control of ASF in wild pigs

11. **Are there any control or prevention strategies currently being used for ASF in wild pigs in your country/ territory? (If 'No', go to Q12.)**

Yes	No	Unsure

(i) If yes, please indicate the control measures for ASF that are used in wild pigs, noting if they are successful:

Control/ prevention strategy	Tick if relevant	Species	Successful (Y or N)	If unsuccessful, specify why
Fencing				
Zoning*				
Biosecurity**				
Surveillance				
Carcass disposal				
Vector control				
Culling/population control				
Border quarantine				
Other (specify below)				

* Zoning: identifying geographical areas/boundaries where specific control strategies (i.e. culling within a certain area) are to be carried out.

** Biosecurity: implementation of specific strategies within countries to eliminate/reduce the incursion of the disease (i.e. strict import conditions).

If other strategies used, please explain in further detail below:

(ii) If culling or population control is conducted, how is this performed and which species are targeted?

Culling method	Y	Species (specify target species)	N
• Shooting on the ground (e.g. hunting)			
• Aerial shooting (e.g. from a helicopter)			
• Trapping			
• Poison baiting			
• Snaring			
• Fertility control			
• Other (please specify):			

(iii) If surveillance is conducted, please indicate the strategies used:

Surveillance strategy	Y	Species (specify target species)	N
• Pig carcass searching			
• Random/frequent testing of wild pig			
• Looking for signs of pig mortality or morbidity			
• Other (please specify):			

12. Do you have a managed hunting system or season for wild pigs within your country/territory? (If 'No', go to Q13.)

Yes	No	Unsure

(i) Please indicate the strategies that are relevant:

Pig management strategies	Yes	No	Unsure
A specific hunting period			
Pigs hunted for game			
Pigs hunted for food			
There is a quota/limit when hunting			
There is a target species or demographic of pig hunted (e.g. females)			
Does illegal hunting occur?			
Other (please specify below)			

Please explain in further detail below any additional information on management strategies:

(ii) Please indicate reasons for wild pig management:

Reasons for wild pig management	Yes	No	Unsure
Prevention of crop damage by wild pigs			
Prevention of potential traffic incidents			
Prevention of invasion to urban areas			
Disease control			
Other (please specify below)			

Please explain in further detail below any additional information on management strategies:

Maintenance of ASF in wild pigs in your country/territory (if absent, go to Q17)

13. How long has ASF been in wild *Sus scrofa* populations?

- Write the number of months (e.g. 6 means it has been present in wild pigs for 6 months)

14. Do you consider wild *Sus scrofa* to be epidemiologically important in outbreaks in domestic pigs?

Yes	No	Unsure

15. How long has ASF been in other species of wild Suidae?

- Write the number of months (e.g. 6 means it has been present in **other species of wild Suidae** for 6 months)

16. Do you consider other species of wild Suidae to be epidemiologically important in outbreaks in domestic pigs?

Yes	Species	No	Unsure

Regulations/legislations

17. Do you have regulations or legislation to:

(i) Protect wild pigs for conservation reasons?

Yes (specify below)	No	Unsure

(ii) Control ASF in wild pigs?

Yes (specify below)	No	Unsure

(iii) Regulate hunting in wild pigs?

Yes (specify below)	No	Unsure

18. If relevant, please specify any additional laws or regulations associated with wild pigs and/or domestic pigs for ASF prevention:

Follow-up research

- Knowing the relevant distribution of domestic and wild pigs within a country/territory provides valuable information in assessing the transmission and risk of ASF.
- For future research a case study may be conducted to assist in this important area. If you would like to be involved or provide data for this research, please indicate 'Yes' and contact will be made.

Yes	No

End of survey

We thank you for your time spent taking this survey. Your response is very appreciated.

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