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SHORT COMMUNICATION

Exploring the hurdles that remain for control of African swine fever in smallholder farming settings

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Abstract

To honour the 100 years anniversary of the first publication about African swine fever (ASF) a webinar with a particular focus on disease control in the smallholder sector was organized. This article is based on the webinar, summarizing the early history of ASF research, reflecting on the current global disease situation and bringing forward some suggestions that could contribute towards achieving control of ASF.

The first description of ASF by R. Eustace Montgomery in 1921 laid the foundations for what we know about the disease today. Subsequent research confirmed its association with warthogs and soft ticks of the *Ornithodoros moubata* complex. During the latter half of the 21st century, exponential growth of pig production in Africa has led to a change in the ASF-epidemiology pattern. It is now dominated by a cycle involving domestic pigs and pork with virus spread driven by people. In 2007, a global ASF epidemic started, reaching large parts of Europe, Asia and the Americas. In Europe, this epidemic has primarily affected wild boar. In Asia, wild boar, smallholders and industrialized pig farms have been affected with impact on local, national and international pig value chains. Globally and historically, domestic pigs in smallholder settings are most frequently affected and the main driver of ASF virus transmission. Awaiting a safe and efficacious vaccine, we need to continue focus on other measures, such as biosecurity, for controlling the disease. However, smallholders face specific challenges linked to poverty and other structural factors in implementing biosecurity measures that can prevent spread. Improving biosecurity in the smallholder sector thus remains an important tool for preventing and controlling ASF. In this regard, interdisciplinary research can help to find new ways to promote safe practices, facilitate understanding and embrace smallholders' perspectives, engage stakeholders and adjust prevention and control policies to improve implementation.

KEYWORDS
ASF, disease control, epidemic, pigs, prevention, subsistence farming

1 | INTRODUCTION

African swine fever (ASF) was first described from what is today the Republic of Kenya (Kenya) by R. Eustace Montgomery in 1921 (Montgomery, 1921). His publication includes an impressive number of clinical trials which were recently described and contrasted against what has been scientifically evidenced today by Penrith et al. (2021). Montgomery's iconic publication includes the statement '…*under the conditions at present existing the disease is one that can in large measures be avoided*'. We would argue that the essence of this statement, that we have enough technical knowledge to prevent the disease in domestic pigs, holds true also today. Despite that, control has seldom been achieved, especially in smallholder settings (Brown et al., 2018; Penrith & Kivaria, 2022; Penrith et al., 2021). In situations of chronic poverty, which is the reality for many smallholders across the world, a low level of investment in pig farming leads to low biosecurity, which in turn leads to a high risk for getting and spreading ASF and other pig diseases, resulting in low and insecure income and disease induced poverty traps (Ebata, MacGregor, Loevinsohn, Win, & Tucker, 2020; Perry & Grace, 2009). Poverty as such is thus both a consequence of ASF outbreaks and an important reason why smallholders fail to implement preventive and control measures (Aliro et al., 2022; Chenais et al., 2021; Ebata, MacGregor, Loevinsohn, & Win, 2020).

2 | MATERIAL AND METHODS

With the objective to honour the 100 years anniversary of the first publication about ASF and to explore what is actually hindering ASF control in smallholder settings today, a webinar was organized by the Global African Swine Fever Research Alliance (GARA) and the Swedish International Agriculture Networking Initiative (SIANI) on the 8 December 2021.[1] The webinar gathered around 400 participants from six continents representing academia and the private and public sectors at different levels, including policy makers. This article summarizes the presentations and the discussion during the webinar based on notes from the speakers and the facilitators. The article includes a résumé of the early history of ASF research, reflections on the current global disease situation, and suggestions for solutions that could contribute towards finally fulfilling Montgomery's statement regarding control of ASF.

3 | RESULTS AND DISCUSSION

3.1 | The past: one hundred years of ASF research in Africa

ASF first came to the attention of R. Eustace Montgomery, at the time a pathologist at the Muguga Veterinary Research Centre in Kenya in 1910. The disease caused the pigs of European settlers to show severe clinical signs and resulted in a high case fatality rate. Investigations over the next decade culminated in a comprehensive description of the disease that was published in 1921 and laid the foundations for everything that we know about the disease today (Montgomery, 1921; Penrith, Kivaria, et al., 2021). Subsequent research confirmed that the disease was caused by a filterable agent and associated with the presence of wild African porcine species that were impervious to the effects of the disease and did not transmit it directly to domestic pigs. Montgomery further showed that the infectious agent could persist for a long time in organic material but was destroyed by heating for 10 min at 60°C. Although classical swine fever (CSF) sera obtained from Europe did not neutralize the virus, acceptance that ASF was not a virulent form of CSF only became general in the late 1940s. By that time the disease had been identified in South Africa, Angola, Malawi, Zambia and the Democratic Republic of Congo (Gago da Camara, 1933; Saliki et al., 1985; Steyn, 1932; Turnbull, 1932; Wilkinson et al., 1988). Early research included attempts to immunize pigs with hyperimmune sera from recovered pigs and attenuated virus, the latter causing chronic forms of disease with a prolonged carrier state. By the end of the 1980s a sylvatic cycle between warthogs and soft ticks of the *Ornithodoros moubata* complex that lived in the warthogs' burrows had been described, with virus circulation occurring between the ticks and neonatal warthogs that develop a sufficient level of viraemia to infect other ticks that fed on them (Thomson, 1985). Transmission to domestic pigs was explained by finding that the tick nymphs, sometimes in large numbers, travelled on warthogs (Horak et al., 1988) and could be dropped in areas frequented by pigs. During the same period a cycle between domestic pigs and related ticks inhabiting their shelters was discovered in a highly endemic area of Malawi (Haresnape & Mamu, 1986). A single experimental study on bushpigs indicated limited transmission to domestic pigs during the acute stage of infection (Anderson et al., 1998).

Introductions of ASF virus (ASFV) into Portugal in 1957 and again in 1960, the latter followed by endemic establishment on the Iberian Peninsula and spread to several other countries within Europe and to the Americas during the 1970s and 1980s, spurred research that resulted in better understanding of the virus and improved diagnostics (Manso Ribeiro & Rosa Azevedo, 1961a; Manso Ribeiro & Rosa Azevedo, 1961b). The first introduction into West Africa also occurred in this period, followed by another in 1996 involving several other countries further east (Brown et al., 2018). Molecular research using restriction fragment length polymorphism to compare viruses from Europe and Africa revealed the diversity of the African viruses, and led to the classification of genotypes based on the p72 protein (Bastos et al., 2003), with 24 genotypes currently identified, all of which are present in eastern and southern Africa where the warthog-tick cycle occurs. Today, ASF in Africa is dominated by a cycle involving domestic pigs, pork and fomites, and this cycle is driven by human activity (Penrith et al., 2019).

3.2 | The present: from endemic circulation in Sub-Saharan Africa to a global epidemic

After the first major outbreaks of ASF outside Africa had been brought under control in the 1990s, the disease distribution was with the

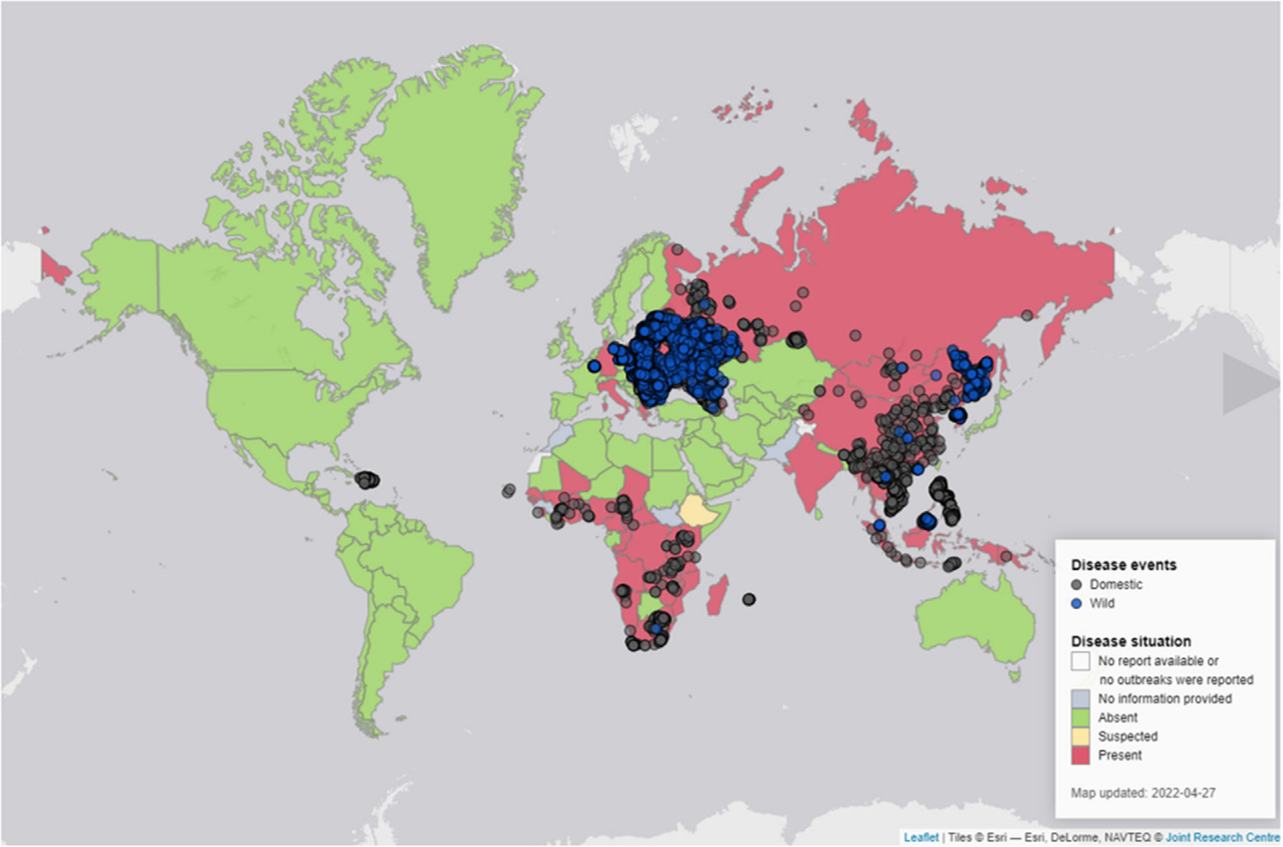

FIGURE 1 Reported cases and disease outbreaks of ASF as reported to the OIE early warning system from 2005 to 2021. *Source*: World Animal Health Information System (https://wahis.oie.int/). Map: African Swine Fever disease profile, European Food Safety Agency

exception of the Italian island of Sardinia again limited to the African continent. As a consequence, the perceived threat of ASF, and thus the interest, gradually declined within the international community. At the same time pig production in Africa increased almost exponentially because of an increasing demand for affordable protein by a growing middle class (Mulumba-Mfumu et al., 2019; Penrith, 2020). The growth of the pig sector occurred mainly in smallholder settings characterized by low-input-low-output and low biosecurity. In this environment, ASFV thrived, and the growth of the pig sector was accompanied by an increase in reports of outbreaks in endemically infected countries as well as by the introduction of ASFV into historically ASFV-free countries on the continent (Penrith et al., 2013). With this in mind and given what was known already at the time of Montgomery about the characteristics of ASF, it seems reasonable to claim that what then happened was predictable: ASFV managed to again escape the African continent. The genotype II virus arrived in the Black Sea port of Poti in Georgia in 2007 (Rowlands et al., 2008), a region which was not prepared to control the situation and the virus was able to spread. As a direct consequence, we today have a global epidemic and more ASFV in the world than ever before (Figure 1). Since its introduction to Georgia, the virus has spread to large parts of Europe (Sauter-Louis et al., 2021; Viltrop et al., 2021), Asia (Mighell & Ward, 2021) and the Americas (Gonzales et al., 2021). In Europe this current epidemic has primarily affected wild boar, with some exceptions in the eastern parts. As in domestic pigs, ASFV infection in wild boar results in severe clinical disease with high case fatality rates (Blome et al., 2013; Rodríguez-Bertos et al., 2020; Sánchez-Cordón et al., 2021). Disease control in wild boar populations has proved especially difficult and so far only two countries, Belgium and the Czech republic, have managed to eradicate the disease (Miteva et al., 2020). Globally and historically, however, domestic pigs in smallholder settings are most frequently affected and the main driver of ASFV transmission (Costard et al., 2013; Costard et al., 2009; Penrith et al., 2019).

Since its introduction to China in 2018, ASFV has spread across many parts of Asia. As a result, many countries are now dealing with what could be considered endemic infection either in wild boar or domestic pigs, or in both (Dixon et al., 2020; Kedkovid et al., 2020; Woonwong et al., 2020). The epidemiological features of ASF in the region are closely linked to particular characteristics of each local pig farming and pork food context (Barnes et al., 2020; Bernardes & Peña et al., 2020; Hunter et al., 2021). In the low- and middle-income countries (LMIC), extensive trade in live pigs and pork makes it very difficult to implement hygiene practices that are able to effectively inactivate environmental ASFV contamination (Mighell & Ward, 2021; Normile, 2019). Wu et al. (2020) emphasized that successful prevention, control and eradication of ASF in China would not be possible without an effective vaccine. In the absence of an effective vaccine, reduction in ASF spread would require significant improvement in biosecurity at farm level and across the value chain (Liu et al., 2021; Penrith, Bastos, & Chenais, 2021). Experiences from Africa and Europe show that this will be particularly difficult to achieve in the smallholder value chains (EFSA Panel on Animal Health & Welfare et al., 2019; Penrith, 2020). To indicate the significance of the task of implementing biosecurity in smallholder systems in Asia, in 2016 China had over 41 million farms with less than 100 pigs representing 98% of all pig farms, and there were 4572 farms with at least 10,000 pigs representing 0.01% of all farms (Source: National Bureau of Statistics in China). There are indications that the devastating effects of ASF and the control measures has changed the industry structure with a reduction in the number of small farms (Liu et al., 2021).

ASF outbreak response methods used by veterinary authorities in Asia typically involve whole herd culling and trade restrictions of affected or at-risk farms (Li et al., 2022; Liu et al., 2021). These control measures often result in major losses of income to all actors along the pork value chain (Cooper et al., 2021; Nguyen-Thi et al., 2021). The response by the different actors to the measures varies significantly between countries and roles in the pork value chain. Farmers may decide to discontinue pig production and switch to producing other food animals, such as poultry or even wild animal species (Woonwong et al., 2020). If they decide to continue with pig production, there is anecdotal evidence that some choose to use non-approved or illegal ASF vaccines. A recent publication indicates the presence of new variants of ASFV genotype II in China, which in infection experiments using low infection doses were shown to result in mild disease with persistent infection (Sun, Zhang, et al., 2021). These strains may be due to natural variation or the use of non-approved vaccines. Another publication reports the detection of ASFV genotype I in China, causing mild and chronic disease (Sun, Huang, et al., 2021). The molecular characteristics of the virus were highly similar to two isolates reported from Portugal in 1968 and 1988, strongly suggesting the use of non-approved vaccines. Live vaccines have proved to give homologous protection against disease in vivo and in vitro but have unfortunately not been safe in terms of reverting to wild forms causing mild and chronic forms of the disease (Barasona et al., 2019; Blome et al., 2020; Muñoz-Pérez et al., 2021; Viltrop et al., 2021).

Another response strategy to ASF adopted by some pig farms in areas with endemic infection is intensive within-herd diagnostic surveillance based on PCR testing, aimed at detecting any introduction of virus as early as possible, and to then perform selective culling of PCR positive pigs (Yao, 2020). This strategy requires significant financial investment into staff and technology and is therefore most likely only applicable in very large pig farms.

3.3 | The future: sustainable, safe and inclusive smallholder pig farming

As pointed out, prevention and control of ASF can be achieved through implementing basic biosecurity measures (Montgomery, 1921; Penrith, Kivaria, et al., 2021). However, smallholders are known to face challenges in employing on-farm biosecurity, avoiding feeding uncooked swill, and appropriately disposing of dead or infected animals (Aliro et al., 2022; Chenais et al., 2017). To improve feasibility, acceptance and implementation of preventive biosecurity measures and disease control it is central to embrace smallholders' perspectives and priorities. This includes co-creation of custom-made biosecurity solutions as well as finding ways to address the disease and to talk about it that are acceptable, comprehended and doable for smallholders (Barnes, Alvaran, et al., 2020; Setiawan et al., 2018).

3.3.1 | Systemic and structural factors shape disease control decisions

In the light of the need to change farmer practices to reach disease control, behavioural models such as the Health Belief Model and the Theory of Planned Behaviour are often used by epidemiologists to understand farmer behaviour, design interventions aiming to influence individual practices, or to explain success or failure in biosecurity implementation (Ritter et al., 2017). These models assume that determinants of behaviour are correlated with individuals' perceptions of disease risks or prevention and control benefits, and that these perceptions are largely based on the information individuals possess (Conner & Sparks, 2005). In other words, they emphasize the individual and rational nature of disease control decision making. As a result, recommendations based on these models tend to focus on attempts to 'change minds' by sharing information or communicating the benefits of prevention and control actions (Dolan et al., 2010; Kelly & Barker, 2016). The Theory of Planned Behaviour further points at peoples' attitude towards diseases as a key component that influences behaviour (Sniehotta et al., 2014). However, there is ample evidence that knowledge and attitudes are significantly shaped by the unique socio-cultural, economic and political environments where people operate their farms (MacGregor & Waldman, 2017; Thys et al., 2016; Zvonareva et al., 2018). Several studies have recently exemplified this disconnect between knowledge and behaviour (Caudell et al., 2022; Kiambi et al., 2021; Mangesho et al., 2021). Caudell et al. (2022) specifically found that farmers' knowledge of and attitudes towards antimicrobials and biosecurity did not predict their practices, underlining the need to 'change contexts' in addition to 'changing minds' (Dolan et al., 2010). In another example, a Swedish study on farmers' use of antibiotics in dairy farming shows that agricultural support structures, regulation and market possibilities are more important drivers of farmers' use of antibiotics than knowledge (Fischer et al., 2019). Achieving behavioural changes of individual farmers thus requires addressing the structural and systemic factors that shape the contexts in which farmers act (Rose et al., 2018). With regard to smallholder farming, key systemic factors include access to low-interest loans that allow farmers to invest in biosecurity and health of their pigs, and improved access to veterinary advice and care (Ebata, MacGregor, Loevinsohn, & Win, 2020). In LMICs, access to animal health and extension services is often limited, especially for poor smallholders (Aliro et al., 2022; Arvidsson et al., 2022; Ilukor et al., 2015). In such settings community animal health workers (a category of service providers that are not strictly defined and that can include lay people that are trained and supervised by public veterinary authorities as well as those with no supervision and very limited or no basic training) and lay people considered as local experts are important, accessible and locally trusted sources of information and veterinary healthcare for farmers (Ilukor et al., 2015). These service providers understand local practices and are respected locally; therefore, they can act as important bridges between formal and local systems (Arvidsson et al., 2022). This role is currently limited or even undermined by the fact that they frequently are not given adequate training and support, and as a result have limited knowledge about ASF and other animal disease. The result is that farmers might be unintentionally misinformed by these trusted messengers or reject guidance provided by official sources of information that are not trusted. This reinforces the vicious cycle of disease outbreaks stimulating and being stimulated by poverty-induced constraints. Supporting, strengthening, and building the capacity of community animal health workers could be part of a solution promoting sustainable and bio secure smallholder pig farming. Further, many LMICs pig value chains lack economic incentives for healthy animals as there are no product tracing or labelling connected to higher consumer prices for products from animals with a certified health status. In addition to promoting epidemiologically safe behaviours through economic incentives that span the entire pig value chains, policies on land use, access to feed and low-interest credit need to be reviewed (Ebata, MacGregor, Loevinsohn, Win, & Tucker, 2020). Unless these factors are addressed by policies, individual behaviours will not change.

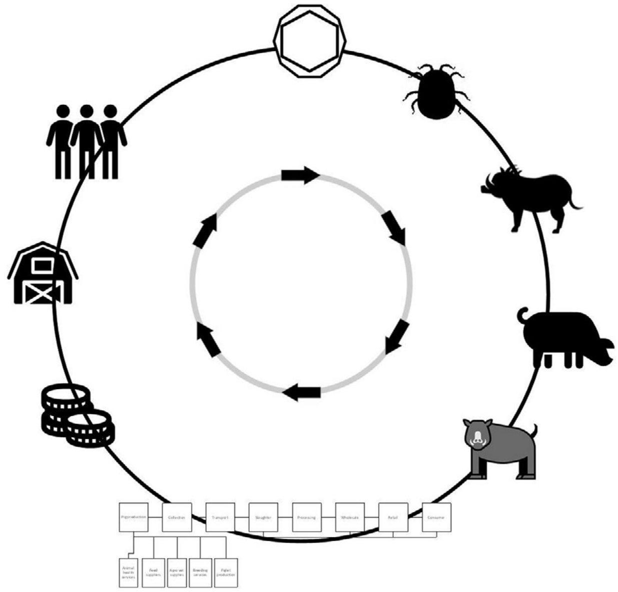

FIGURE 2 To achieve control of ASF separate knowledge of epidemiologically important factors such as (clockwise from the top) the virus, the arachnoid host, the vertebrate hosts, the value chains, the economic, societal and cultural reality of pig-keeping, as well as the people keeping pigs is not enough. This needs to be complemented by inter- and trans-disciplinary research studying how these factors are entangled with each other and with disease control

3.3.2 | ASF in smallholder farming in Europe – time for a change

Smallholder, backyard pig farming is an important component of the cultures, traditional ways of life and agricultural livelihoods across the globe, including in rural areas of Central and Eastern Europe (Hunter et al., 2021; Rapsomanikis, 2015; Van Praag et al., 1982). Despite the small number of animals per farm and the low importance for international trade, smallholder farms play an important role in the local ASF epidemiology, and the disease transmission in these informal systems influences the disease status of a country.

While it is generally accepted that control of ASF in feral pigs requires a tailored and locally adapted approach, there is no such flexibility in the regime concerning domestic pigs in the European legislation today, although differences in the epidemiology have been observed in different production systems (EFSA Panel on Animal Health & Welfare et al., 2019). We argue here that to be effective, the legal framework for animal health interventions must take into account not only the biology of the pathogen and host species but also production systems so that appropriate, feasible and targeted disease control and eradication strategies can be developed (Figure 2). It appears that compliance would be improved if the animal health legislation were amended to include a gradual and more context-adapted approach to disease control (Busch et al., 2021). In the case of non-commercial farms, derogations from the general EU-regulations should be considered to protect traditional, self-sustaining agriculture and to ensure survival of traditional farming practices that express the cultural identity of many rural people. For larger farms, there is likewise an urgent need to independently evaluate the approach of testing and partial culling within infected farms. If epidemiologically effective it may provide a socially and sustainably more acceptable alternative to whole herd culling. In summary, although we need to adapt biosecurity measures to local people's realities, change efforts are mainly needed at the level of national and global politics and economy.

4 | FINAL REMARKS

The holy grail of an effective, safe, cheap, thermostable vaccine for oral administration has not yet been found, even if science has advanced quickly in the past decade (Penrith, Bastos, et al., 2021). History teaches us that we need to be very careful with live vaccines to avoid the spread of low virulent ASFV strains causing mild symptoms complicating diagnosis and control (Gavier-Widén et al., 2020; Lentzos et al., 2022). At the same time, so far only live vaccines have proven effective (Blome et al., 2020). In the continued absence of vaccines with all desired qualities, we need to focus on other measures for controlling the disease. The objectives and the level of investment into national ASF policies vary significantly between countries. In some, the aim is eradication of the virus and in others, it is primarily maintaining pork price at a level, which is acceptable to most consumers. In countries with presence of the sylvatic cycle, eradication of infection from the endemic area can never be achieved, but at the same time its contribution to ASF in domestic pigs is small (Penrith et al., 2019). It is human activities such as trade in pigs and pork that drive the infection and export the disease also in these areas. Eradication of the infection in domestic pigs is therefore achievable even in the presence of the sylvatic cycle, although it will be a long-term project involving community engagement and public-private partnerships to enable the implementation of basic biosecurity measures by even the poorest farmers and value chain actors to prevent outbreaks of ASF (Penrith, Bastos, et al., 2021).

Montgomery pioneered ASF research, and through the past century we have continued his tradition through research into epidemiology, virology, pathology and immunology. We can now conclude that ASF in domestic pigs is not only a viral, but also or perhaps even mainly, a societal problem, and that it is the smallholder sector that would benefit most from advances in the social and cultural aspects of the disease and disease control. We need to urgently invest more in interdisciplinary research including different disciplines of social sciences to find new ways to promote practices that will save livelihoods and economies. Interdisciplinary research, cross-cultural dialogue and participatory methods have been suggested as approaches that facilitate understanding and embracing of smallholders' perspectives in research (Barnett et al., 2020; Ebata, Hodge, et al., 2020; Tasker, 2020). Behavioural science offers ASF prevention and control actors the opportunity to investigate drivers of risky behaviours, identify barriers to the adoption of risk-reductive measures and design and test interventions. Social science can help us study the context around disease control decisions, and participatory approaches can be increasingly employed to understand and engage stakeholders in their specific scenarios, and to adjust prevention and control policies to their perspectives, thus improving implementation.

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CONFLICT OF INTEREST

The authors confirm that no conflict of interests prevail.

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ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as this is a review article with no original research data.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available at https://www.youtube.com/watch?v=5nNWYePT4-0.

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ENDNOTE

[1] https://www.youtube.com/watch?v=5nNWYePT4-0

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