Contrasting seasonality of African swine fever outbreaks and its drivers

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A B S T R A C T

The seasonality of African swine fever (ASF) outbreaks in domestic pigs differs between temperate and subtropical/tropical regions. We hypothesise that variations in the importance of wild boar-to-farm and farm-to-farm transmission routes shape these contrasting patterns, and we emphasise the implications for effective ASF control.

African swine fever (ASF) is a devastating viral disease that has affected many of the world's domestic pig and wild boar populations, rapidly spreading from sub-Saharan Africa to Europe, Asia, and the Americas (FAO, 2022). The co-circulation of the ASF virus (ASFV) in domestic pigs and wild boars exposes farms to a continued risk of ASFV introduction via both wild boar-to-farm and farm-to-farm transmission (Guinat et al., 2016). Yet, the effective control of ASFV in domestic pigs requires understanding the relative contributions of these two transmission routes to viral incursions on farms.

We present the contrasting seasonal patterns of ASF outbreaks on farms between different climatic zones. Based on this, we discuss how these patterns could result from variations in the dominant transmission route, highlight major uncertainties about the underlying epidemiological and ecological drivers, and suggest how further research could address these knowledge gaps.

The reported number of ASFV-infected herds show pronounced seasonality in Europe and temperate regions of Asia (Fig. 1A), with peaks in summer/autumn. It is unlikely that these summer/autumn peaks could be solely attributed to seasonal changes in pig production. Higher pig production would be expected to lead to more frequent movements of pigs, personnel, and vehicles—resulting in increased contacts with potentially contaminated pig value chain actors and environmental sources. However, pig production in Europe, where ASFV has been circulating for the longest time outside sub-Saharan Africa, and China did not increase during the summer and autumn (Fig. S1). In the Republic of Korea, pig production peaks in summer (Fig. S1), and farm-to-farm transmission has been suggested to have played a role in the country's first epidemic in 2019 (Yoo et al., 2021). However, since 2020, farm outbreaks in the country have remained too sporadic (with a median of 116 days between successively reported farm outbreaks) to conclude that farm-to-farm transmission alone drove the observed seasonal patterns.

These observations raise the possibility that ASFV transmission dynamics in wild boar populations has contributed to these summer/autumn peaks in ASF incidence on farms in temperate regions. In fact, wild boars engage in seasonal reproduction in temperate regions, mostly mating in winter and farrowing in spring, although due to mild winters, this seasonality in the reproduction cycle is less clear than it used to be (Pascual-Rico et al., 2022). The associated changes in social group size, structures, and behaviours could result in seasonal transmission among wild boars, thereby posing a seasonally varying risk of ASFV introduction to farms, as is the case for some other infectious diseases (Plowright et al., 2016). Furthermore, human and wild boar activities are likely to increase during crop harvesting seasons over the summer, further promoting spillover risk. This risk may be further increased by the higher abundance of hematophagous insects in summer, although their role in ASFV transmission outside Africa warrants further investigation (Guinat et al., 2016).

It must be noted that this alternative hypothesis does not seem to be supported by ASF incidence patterns observed in wild boars, considering that they show peaks mostly in winter (Fig. 1B). However, these observations could be strongly biased by seasonal variations in surveillance efforts due to wild boar hunting in temperate regions occurring mainly in winter (Schulz et al., 2022). Reflecting this, ASFV transmission dynamics in wild boars and its seasonal impact on viral incursions on farms are still poorly understood as most studies investigating the interface between wild boars and domestic pigs are based only on ASFV incidence in wild boars, without explicitly accounting for variations in surveillance efforts (Hayes et al., 2021). Furthermore, the occurrence of ASF outbreaks on farms can be influenced by diverse local factors, leading to variations within climatic zones and across years. For instance, in 2022, in Romania, ASF outbreaks among small-scale farms (i.e. fewer than 100 pigs) peaked in both summer and winter, while other European Union Member States continued to experience distinct peaks during the summer, regardless of farm size (European Food Safety Authority et al., 2023).

In subtropical/tropical Asian regions, reported farm cases show less pronounced seasonality (Fig. 1C). First, wild boar breeding in these regions is often protracted or occurs throughout the year (Indian River Lagoon Species Inventory), suggesting that wild boar population dynamics and, consequently, ASFV transmission dynamics in these populations and the risk they pose to farms may differ compared to

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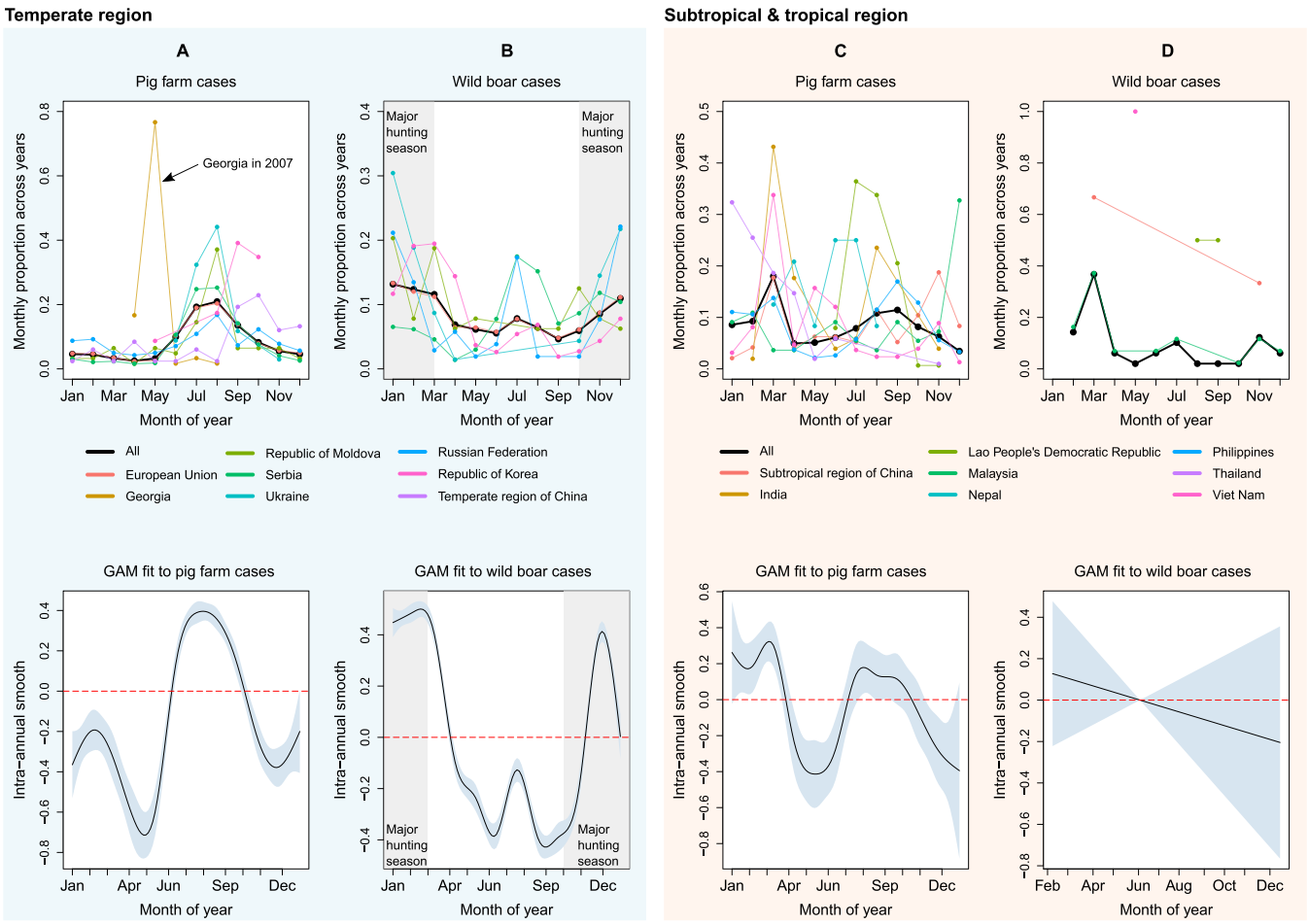

Fig. 1. The seasonal trend in ASF pig farm and wild boar cases by climatic zone. The plots on the first row show the proportion of ASF cases (y-axis) over month of year (x-axis), with different colours representing different countries or regions. Black points and lines represent the seasonal trend averaged over countries or regions with the same climatic zone. The plots on the second row show intra-annual smooth term estimates (y-axis) over month of year (x-axis) obtained by fitting a generalised additive model to incidence data by week of year. The analysis of the seasonal trend is based on FAO EMPRES Global Animal Disease Information System (EMPRES-i) data [downloaded September 24, 2022]. Only countries with more than 50 domestic pig farm cases before Sep 24, 2022, including those within the EU, are included to show the seasonal trend in countries where domestic pig farms are likely to have been exposed to a continuous risk of ASFV introduction. ASF cases in the countries of the EU are grouped, considering that ASF surveillance/control regulations are relatively more homogeneous within the EU compared with other countries. Conversely, ASF cases in China are separated by climatic zone, given that the country's land spans different climatic zones.

temperate climatic regions. In addition, if pig production varies seasonally, as observed for poultry production in some of those regions (Delabouglise et al., 2017), it could promote farm-to-farm viral transmission during high production periods. However, discerning the relative contribution of different transmission routes is expected to be more challenging in those regions considering the often limited availability of epidemiological and ecological data, especially of ASF surveillance data pertaining to wild boars (Fig. 1D) and farms (Vergne et al., 2020).

In conclusion, seasonal trends in farm outbreaks and their differences between climatic zones highlight the need to better understand the interface between wild boars and domestic pigs. To achieve this, it is crucial to assess ASFV transmission dynamics in wild boars and its potential associations with viral incursions on farms, taking into account wild boar ecology and variations in surveillance efforts. Furthermore, while these seasonal patterns differ between climatic zones, there are also variations within each zone and across years. These likely result from heterogeneous epidemiological contexts, emphasising the importance of characterising local pig value chains and understanding the way in which they may influence the observed seasonality in ASF outbreaks. Conducting such research would help quantify the relative contributions of wild boar-to-farm and farm-to-farm transmission routes to ASFV farm outbreaks, thus guiding optimal ASFV prevention and control strategies. These are challenging but important tasks.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.epidem.2023.100703.

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