Space-time dynamics of African Swine Fever spread in the Philippines

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Introduction
African Swine Fever (ASF) is a highly contagious viral disease that affects both domestic pigs and wild boars. There is no known cure for ASF, infected pigs must be depopulated or culled to prevent disease spread. While ASF is not harmful to humans, it is an important transboundary animal disease that spreads through direct or indirect contact with infected pigs, contaminated feed, and other pork-related materials.

In July 2019 the Philippines reported its first case of ASF in Rizal province near Manila. Since then, the virus has spread into other provinces. The ASF outbreak resulted in the culling of over 300,000 pigs, decreasing the pig population by 20.8% in 2021, and impacting vulnerable consumers. Despite ASFV being transmitted through susceptible populations of the Philippines for more than three years, key aspects of the epidemiological dynamics of disease spread in the country are yet to be elucidated. The objective of the manuscript here was to conduct a comprehensive assessment of the spatial and temporal dynamics of the ASF epidemic in the Philippines. The study focused on understanding the spread of ASFV in both space and time scales, identifying potential risk factors, and developing strategies to control the outbreak and enhance early detection in the future.

Methods
Data on farm outbreaks officially reported to the government of the Philippines between August 16, 2019 and July 20, 2022 were made available by the International Training Center on Pig Husbandry (ITCPH), Agricultural Training Institute, Department of Agriculture of the Philippines. Recorded data, for each farm outbreak included event ID, administrative level (region, province, municipality, and barangay), and date of reporting. Outbreaks are defined as at least one ASF case identified on a farm. In total, 19,697 farm-outbreaks were then used and analyzed after data cleaning. In addition to the descriptive statistics the epidemic curve was built, and a biannual (6-month) scale was used to describe the fluctuations in the first and second half of each year. In order to investigate if there was a specific pattern in the occurrence of ASF outbreaks on farms, a seasonal index (Si) was calculated for each month. A space-time permutation model was used to evaluate the clustering of ASF outbreak cases in both space and time and to identify the geographic regions and time periods of potential clusters with significantly higher ASF incidents in comparison to surrounding areas.

Results
The highest number of outbreaks were reported in the second semester of 2020 (n=5486 outbreaks), representing 27.85% of all reported cases throughout the 3-year study period. The Si was highest in August (Si=1.79) and September (Si=1.67) and lowest in May (Si=0.48), reinforcing the conclusion that the epidemic was most severe over the second half of the years. The distribution of all reported ASF outbreaks was spatially clustered as suggested by the results of the Global Moran's I test (Moran's Index=0.1186; p<0.0001). The space-time scan analysis identified five significant (p<0.01) clusters. The directional test in five space-time clusters were all statistically significant (p<0.01) and indicated different directions of ASF spread at the local level.

The present study is the first to assess the epidemiological dynamics of ASF spread in the Philippines. The results presented here will help inform the implementation of control activities in the country, and increase awareness and understanding of disease spread, which is of interest to the international veterinary community. The higher incidence of ASF outbreaks observed in the second semester of each year may be attributed to various factors. Notably, the period of highest disease incidence coincides with the rainy (or monsoon) season, which typically occurs between June and November. There is a significant relationship between ASF outbreaks and the amount of precipitation. These results suggest that higher humidity levels may contribute to the higher occurrence of ASF outbreaks in certain times of the year. Flooding can lead to the dispersal of carcasses and subsequent contamination via ASF leaching into the ground. Based on the seasonal index results and the characteristics of the disease pattern, it can be inferred that the lower temperatures and humidity of the cool dry season (December-February) is less favorable for the spread of ASF. Additionally, the hot dry season (March-May) could potentially result in a lower occurrence of ASF outbreaks.

The results of the space-time cluster analysis showed that the disease was concentrated in the northern part of the country, with Manila as the initial outbreak location. Target surveillance and biosecurity measures may be needed in these high-risk clustering areas to mitigate the impact of the disease. A closely connected network of swine and swine-related products may have facilitated disease spread. Veterinarians with field ASF experience in the Philippines indicate that, during the second half of the year, particularly during the third quarter coinciding with the start of the academic year, smallholders tend to sell pigs to fund education. However, because a reduction in the price of pigs is also typically seen at this time of the year, movements in search of the best prices are common throughout the country. The increased human activity can result in more frequent movement of animals and pork-related products, which may contribute to the spread of ASF. As a result, the seasonal pattern observed in our analysis in the Philippines may also be explained, at least in part, by this social phenomenon.

Conclusion
In conclusion, our research offers valuable insights into the dynamics of ASF outbreaks over a 3-year period. Our analysis shows a clear seasonal pattern with higher frequencies occurring from August to October and lower frequencies from April to May. In terms of space, the disease was more severe in the Northern island of Luzon, particularly during the second half of the year. These spatial and temporal patterns can inform disease prevention and control efforts in the future, and help authorities prepare for and mitigate the impact of potential ASF outbreaks.

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