Regulatory Mechanisms in Biosystems

ISSN 2519-8521 (Print)
ISSN 2520-2588 (Online)
Regul. Mech. Biosyst.

Spatio-temporal analysis of African Swine Fever in Ukraine over 2020–2024

V. V. Ukhovskyi*, L. Y. Korniienko*, M. V. Bezymennyi**, O. V. Pishchanskyi*, O. V. Matviienko*, A. V. Pyskun*, G. B. Aliekseieva*, M. I. Sushko*, M. L. Radzykhovskyi***, O. B. Ryevnivtsev***

**State Scientific and Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Expertise, Kyiv, Ukraine*
***Institute of Veterinary Medicine of the NAAS of Ukraine, Kyiv, Ukraine*
****National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine*

Article info

Received 06.07.2025
Received in revised form 15.08.2025
Accepted 18.09.2025

State Scientific and Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Expertise, Donetska st., 30, Kyiv, 03151, Ukraine.
Tel.: +38-066-789-85-19.
E-mail: uhovskiy@ukr.net

Institute of Veterinary Medicine of the NAAS of Ukraine, Donetska st., 30, Kyiv, 03151, Ukraine.
Tel.: +38-066-789-85-19.
E-mail: nomax@ukr.net

National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony st., 15, Kyiv, 03041, Ukraine.
Tel.: +38-067-725-65-07.
E-mail: nickvet@ukr.net

Ukhovskyi, V. V., Korniienko, L. Y., Bezymennyi, M. V., Pishchanskyi, O. V., Matviienko, O. V., Pyskun, A. V., Aliekseieva, G. B., Sushko, M. I., Radzykhovskyi, M. L., & Ryevnivtsev, O. B. (2025). Spatio-temporal analysis of African Swine Fever in Ukraine over 2020–2024. Regulatory Mechanisms in Biosystems, 16(4), e25163. doi:10.15421/0225163

African Swine Fever (ASF) is a highly contagious and deadly viral disease of pigs, causing devastating losses to swine production globally. Since its first detection in Ukraine in 2012, ASF has remained a critical challenge for the national pig industry, threatening both food security and economic stability. The ongoing spread of ASF in Ukraine is exacerbated by insufficient biosecurity, illegal pork circulation, and uncontrolled backyard slaughter, particularly under wartime conditions. This study provides a retrospective spatio-temporal analysis of ASF outbreaks across Ukraine during 2020–2024. Official data from regional laboratories of the State Service of Ukraine on Food Safety and Consumer Protection were collected and analyzed. Descriptive statistics, choropleth mapping, kernel density estimation, and standard deviational ellipses were applied using QGIS 3.28 to assess the dynamics, geographical distribution, and seasonal trends of confirmed ASF cases in domestic pigs and wild boars. A total of 185 outbreaks were recorded over the five-year period: 151 in domestic pigs and 34 in wild boars. The highest number of outbreaks occurred in 2024 (85), which is 9.4 times higher than in 2022 (9). Two seasonal peaks were identified: a major one in July–August and a smaller one in November. These trends suggest that the warm-season peak is likely linked to the distribution of infected pork products, while the colder months favor virus survival in the environment. Central Ukraine (particularly Kyiv, Poltava, and Kirovohrad regions), Chernihiv (Northern Ukraine) and Mykolaiv (south) regions showed the highest density of outbreaks and the largest number of slaughtered pigs, with over 98,128 head slaughtered due to ASF during the study period. The analysis confirms that ASF incidence is geographically clustered and persistent in the central part of Ukraine. The disease dynamics trends in domestic pigs closely mirror the overall trend observed in both domestic pigs and wild boars. The results highlight the importance of improving surveillance systems, enforcing backyard farm controls, and implementing risk-based biosecurity interventions. Spatial analysis tools proved highly effective for identifying high-risk zones and guiding veterinary decision-making.

Keywords: epizootic; African Swine Fever; mapping; GIS.

Introduction

African Swine Fever (ASF) is a highly contagious transboundary disease of pigs with a mortality rate of almost 100%, which practically wipes out the domestic pig population and causes significant losses to the pig industry worldwide (Ward et al., 2021; Ruedas-Torres et al., 2024). The cross-border spread of ASF is facilitated by the illegal transportation of infected pigs, trade in contaminated pork products, and the movement of transmission factors across borders. Such activities pose a significant risk of international transmission of ASF, which emphasizes the need for strict border controls and international trade rules to prevent the spread of the virus (Bellini et al., 2021; Know et al., 2025). Currently, the disease is widespread in Africa, Europe, Asia, Oceania, and the Caribbean and is a threat to the pork industry on a global scale.

Both domestic pigs and Eurasian wild boars and feral pigs (also *Sus scrofa*) are highly susceptible to the disease and are commonly involved in its spread (Koh et al., 2023; Lentz et al., 2023). Symptoms of the disease can be quite variable with the manifestation of fever, mild and severe forms of the course, and even chronic and latent infections (Sun et al., 2021; Ruedas-Torres et al., 2024). Pathological changes in both wild boars and domestic pigs differ significantly and correlate with the virulence of viruses, the dose of virus during infection, the characteristics of the immune system and the degree of resistance of the affected animal (Sánchez-Vizcaíno et al., 2015; Ruedas-Torres et al., 2024).

The transmission of the virus and the formation of latent forms of the course (the actual persistence of the virus in the body of an infected animal) differ in different geographical conditions and in different countries, as the disease continues to spread actively through food (slaughter) and environmental factors, often spreading through direct contact or consumption of virus-contaminated pig products (Liu et al., 2021; Main et al., 2022; Juszkiewicz et al., 2023).

African Swine Fever was reported in Georgia in 2007 (Rowlands et al., 2008). The disease affected domestic and wild pigs, and quickly spread to the Russian Federation, Armenia and Azerbaijan (Sánchez-Vizcaíno et al., 2015; Sargsyan et al., 2018). Later, it even affected wild boars in Iran (Rahimi et al., 2010). In 2012, the disease was first reported in Ukraine (Korniienko et al., 2023). In January 2014, the EU reported the first outbreak of ASF among wild boars in Lithuania, a northern country bordering Belarus. Since 2014, outbreaks of ASF have been reported in several Northern European countries, including Poland (Vergne et al., 2017). In 2014–2018, the pathogen was detected in Lithuania, Poland, Latvia and Estonia (Sánchez-Vizcaíno et al., 2015; Oļševskis et al., 2016; Cwynar et al., 2019; Nurmoja et al., 2020), Hungary, the Czech Republic and Romania (Cwynar et al., 2019; Ungur et al., 2021). Since 2018, the ASF virus has been detected in Asia, affecting 16 countries on the continent, including China, with devastating consequences, halving the number of pigs due to the impact of the disease and a strict extermination strategy to control it (Li & Tian, 2018). In 2019, the virus affected the pig industry in Vietnam (Le et al., 2019). In the same year, the virus was detected in Oceania, in East Timor, and in 2020 in Papua New Guinea (Barnes et al., 2020; Tran et al., 2021). Since 2021, ASF has been reported in the Caribbean (Dominican Republic, Haiti) (Jean-Pierre et al., 2022; Ruiz-Saenz et al., 2022). In early 2022, the disease was detected in Italy (Giammarioli et al., 2023; Pavone et al., 2023). In 2023, the ASF virus was confirmed in domestic pigs in Bosnia and Herzegovina, Greece and Croatia (Ruedas-Torres et al., 2024). There are no treatments for this disease, so only early diagnosis, biosecurity measures on farms, and rapid culling of infected herds help reduce the risk of transmission (Ekakoro et al., 2023; Klein et al., 2023). The knowledge of ASF is still extremely limited due to the large genome of the pathogen, its complex structure, unknown function of many genes, and the influence of various factors such as genotypic complexity, immune output mechanism, immune defense mechanism, etc. Therefore, it is necessary to strengthen the research on the pathogenesis and epidemiology of ASF to identify the pattern of genetic evolution of virulent strains, transmission characteristics and pathogenicity (Li & Zheng, 2025).

Vaccination against any infectious disease is the best strategy for the control and specific prevention of infection (Korniienko et al., 2023). However, there are still many questions about current vaccines against African Swine Fever. With the exception of Vietnam, other countries have not yet approved the use of such drugs in pigs (Ruedas-Torres et al., 2024). Experiments have shown that inactivated drugs were not sufficiently immunogenic (Goatley et al., 2020; Cadenas-Fernández et al., 2021) and did not stop the spread of the virus (Sánchez-Vizcaíno et al., 2015). It was found that live attenuated vaccines, although more effective than inactivated vaccines in terms of immunogenicity, carried the risks of forming latent forms of infection with persistence of the virus in vaccinated animals, and after the use of a live preparation, it was necessary to differentiate vaccinated from infected animals (Zhang et al., 2023; Ruedas-Torres et al., 2024).

The lack of biosecurity and biosafety measures on pig farms and the human factor are currently identified as the leading risks of active spread of this disease (Bellini et al., 2021). Therefore, the improvement of these measures, active surveillance and epizootic monitoring, with mandatory parallel control of wild boar populations, are considered by most researchers to be effective and affordable ways to prevent ASF until an effective safe vaccine is available that can provide reliable specific prevention and control of this disease worldwide (Zhang et al., 2023; Ruedas-Torres et al., 2024).

Materials and methods

The current study presents a retrospective epidemiological assessment of incidence of ASF infections in domestic and wild pigs across different regions of Ukraine between 2020 and 2024. Data were sourced from official reports provided by regional laboratories operating under the State Service of Ukraine on Food Safety and Consumer Protection (SSUFSCP), as well as from research conducted by the State Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Expertise (SRILDVSE) in Kyiv, Ukraine. Information extracted from the 1–Vet and 2–Vet reporting forms for the specified years was compiled and subjected to systematic analysis.

We compared the number of outbreaks registered in affected areas by year and animal species. We analyzed the seasonality of outbreaks and the spatial distribution of the number of animals slaughterred each year. All maps were created in QGIS 3.28 (QGIS.org, 2024. QGIS Geographic Information System. QGIS Association. www.qgis.org). Spatial layers of Ukraine's administrative boundaries were downloaded from the geoBoundaries database (www.geoboundaries.org). All spatial data were reprojected to the EPSG:3035 (ETRS89/LAEA Europe) coordinate reference system to minimize area distortion across the study region. Cases of ASF were aggregated by administrative regions (oblasts) and visualized using choropleth maps to represent the intensity of outbreaks. To standardize the visualization of case counts across regions, we applied a manual classification scheme to the annual data. This approach ensured cross-year comparability by using fixed intervals and avoiding biases inherent in automated classification methods for skewed distributions.

The Heatmap (Kernel Density Estimation, KDE) tool in QGIS was applied to visualize spatial clustering of cases across all study years. This tool converts (smoothes) a point layer into a continuous surface of point density. To ensure comparability across years, we used a fixed radius of 67 km for all KDE analyses. This value represents the arithmetic mean of optimal bandwidths calculated individually for each annual dataset (Fotheringham et al., 2000) method (page 149, equation 6.16). The output raster resolution was set to 1000 m. Other parameters were left as default.

Spatial trends in case distributions were analyzed using directional statistics: Mean centers – geographic centroids of case distributions, Standard Deviational Ellipses (SDE; 1 standard deviation) to quantify directional bias and dispersion. We calculated these statistics for each year and host type (wild/domestic pigs). Computations were performed in QGIS 3.28 using the Spatial Analyzer 0.1.4 plugin.

Results

Ukraine has been a disease-affected country with ASF since 2012 (1 outbreak area with infected domestic pigs). In 2014, 16 outbreaks were registered (4 – domestic pigs, 12 – wild boars), in 2015 – 40 (34 – domestic pigs, 5 – wild boars, 1 – infected object), in 2016 – 91 cases (84 and 7 respectively), in 2017 – 163 (119 – domestic, 38 – wild and 6 infected objects), in 2018 – 145 (93 – domestic, 39 – wild, 13 – infected objects), in 2019 – 53 (35 – domestic, 11 – wild, 7 – infected objects) (Korniienko et al., 2023). According to the analysis of the epizootic situation in 2020–2024 (Table 1, Fig. 1), a total of 185 outbreak areas were identified, of which 151 were with domestic pigs and 34 – with wild boars. In 2020, 23 outbreaks were identified in domestic pigs and 5 in wild boars (28 in total), in 2021 – 13 and 3 (16), in 2022 – 7 and 2 (9), in 2023 – 38 and 9 (47), in 2024 – 70 and 15 (85 in total). The lowest number of outbreak locations was recorded in 2022 (9 outbreaks in total), which was due to the full-scale invasion of Ukraine by Russian troops. The number of affected areas in 2024 amounted to 85, which is 9.4 times more than in 2022. The number of outbreaks among wild boars in general is 18.3% of the total number of outbreaks, by years, this percentage was 17.8% in 2020, 18.8% in 2021, 22.2% in 2022, 19.1% in 2023, and 17.6% in 2024, respectively.

Table 1
Number of ASF outbreaks in Ukraine in 2020–2024

Year	Number of ASF outbreaks		
	wild boars	domestic pigs	total
2020	5	23	28
2021	3	13	16
2022	2	7	9
2023	9	38	47
2024	15	70	85
2019–2024	34	151	185

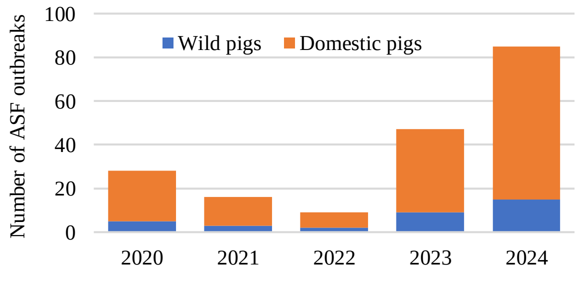

Fig. 1. Dynamics of ASF outbreaks in Ukraine in 2020–2024

Analysis of the seasonal component shows an increase in the peaks of detection of outbreak area numbers in July (Fig. 2). However, the total number of outbreaks over 5 years by month shows two peaks in the incidence (Fig. 3).

The first and highest trend was in July–August, and the second, lower peak was in November. The incidence trend among domestic pigs almost completely coincides with the combined trend (among wild and domestic pigs). However, the seasonality among wild boars repeats the trends among domestic pigs with less intensity. It is quite natural to see an increase in the incidence trend in November, when the ambient temperature drops significantly, and the cold preserves the virus, which contributes to its preservation in meat and other transmission factors. However, the highest peak in the incidence among domestic and wild pigs was in July, when the virus is inactivated in the environment after a few days, which can only be explained by the spread of the virus with pork. In this case, the Veterinary Medicine Service needs to control backyard slaughter of livestock in private households and strengthen the veterinary and sanitary examination component. According to the results of the analysis, it was found that during 2020–2024, 98,128 head of pigs were slaughtered as a result of ASF outbreaks in Ukraine (Table 2).

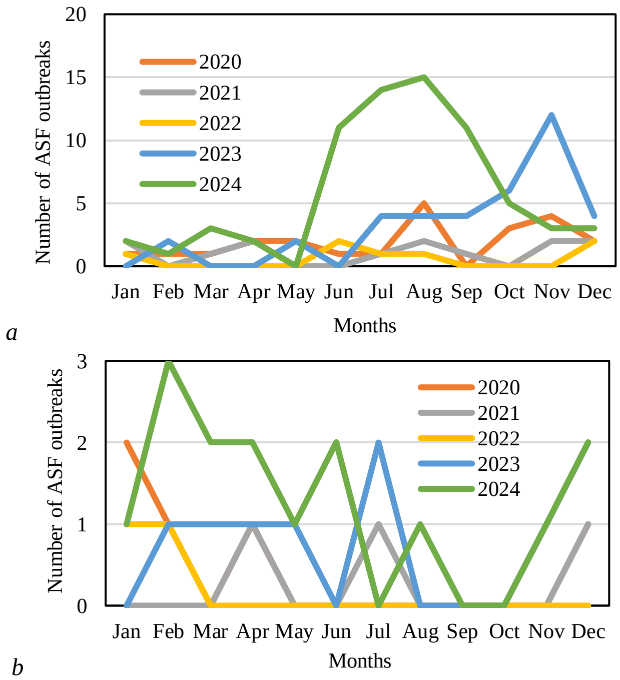

Fig. 2. Epidemic curves of ASF cases among pigs in Ukraine by month, 2020–2024: *a* – domestic pigs; *b* – wild boars

Based on the results of the data analysis, we have compiled "Maps of the distribution of the number of pigs slaughtered as a result of ASF outbreaks in Ukraine", which visualize the number of pigs (wild and domestic) slaughtered by year in different regions of Ukraine (Fig. 4).

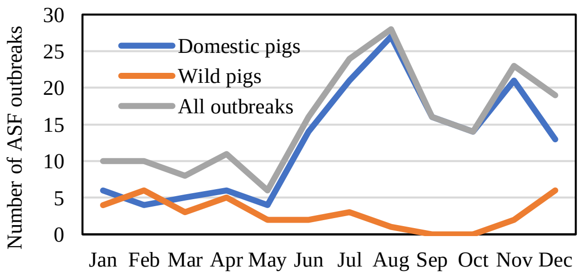

Fig. 3. Epidemic curves of ASF cases among domestic pigs and wild boars in Ukraine by month, 2020–2024

Table 2
Number of pigs slaughtered as a result of ASF outbreaks in Ukraine in 2020–2024

Year	Number of ASF outbreaks		
	wild boars	domestic pigs	total
2020	143	5,490	5,633
2021	3	25,281	25,284
2022	3	248	251
2023	63	4,746	4,809
2024	132	62,019	62,151
2019–2024	344	97,784	98,128

As shown on Figure 4, the largest number of slaughtered pigs as a result of ASF outbreaks was observed in the central part of Ukraine. A significant number of them were from Kyiv, Sumy, Chernihiv, Kirovohrad and Kherson regions. The general trend during the analyzed period was a 284-fold preponderance in the number of slaughtered domestic pigs over wild boars. The vast majority of pigs slaughtered in 2020–2024 were recorded in the central part of Ukraine (Fig. 5).

Based on the results of the data analysis, we also compiled "Maps of the distribution of ASF outbreaks in wild and domestic animals in Ukraine", which visualize the number of ASF outbreaks by region of Ukraine using different color intensities of each region (Fig. 6).

The analysis of the spatial and temporal distribution of ASF cases in Ukraine in 2020–2024 shows that in 2020, ASF cases were widespread throughout Ukraine, with the highest concentration in the central and northern regions. In 6 regions (Lviv, Zakarpattia, Khmelnytskyi, Cherkasy, Kharkiv and Luhansk), no ASF outbreaks were recorded in 2020. In 2021, the number of ASF outbreaks decreased significantly from 28 outbreaks in 2020 to 16 outbreaks in 2021 (a decrease of 42.9%), with the main concentration in Southern and Central Ukraine, with the highest number of outbreaks in Kherson, Mykolaiv and Chernivtsi regions. In 2022, the downward trend in ASF outbreaks continued. Thus, the number of outbreaks decreased from 16 outbreaks in 2021 to 9 outbreaks in 2022 (a decrease of 43.7%). The highest number of outbreaks was recorded in Chernihiv and Mykolaiv regions. In our opinion, this significant decrease in the number of outbreaks was due to underdiagnosis of the disease, as a result of the outbreak of active hostilities in Ukraine in 2022. In 2023, there was a rapid increase in the number of ASF outbreaks in Ukraine, by 422.2% compared to the previous year, with a concentration of cases in the central and northern part of Ukraine (the largest number of outbreaks was recorded in Kyiv and Kirovohrad regions). In 2024, the trend towards an increase in the number of ASF outbreaks in Ukraine continued, by 80.8% compared to the previous year, with 85 outbreaks. The highest concentration of such cases was observed in the central part of Ukraine, with a significant concentration of outbreaks in Kyiv, Poltava, Kirovohrad and Mykolaiv regions.

The general trend during the observation period was the persistence of a consistently high incidence rate in the central regions of the country, while the western and eastern regions showed consistently lower incidence rates. The analysis of the spatial and temporal distribution of ASF outbreaks by estimating the core density in 2020 – 2024 demonstrates trends in the intensity of the epizootic process and the presence of hot spots in Ukraine (Fig. 7). Areas with the highest density of ASF cases are highlighted in more intense color, and areas with the lowest density are highlighted in less intense color.

In 2020, the kernel density assessment indicates a high concentration of ASF outbreaks in the Central and Northern Ukraine. The highest densities are observed in Sumy, Kyiv, Chernihiv, Vinnytsia and Dnipro regions, where the coloration is the most intense. The Southern and Eastern regions show a lower density of cases, with the least intense coloration. In 2021, the pattern of ASF case density changed. The highest density was observed in the Southern region and part of the Eastern region (Chernivtsi oblast). In most of the Western region and in the Northern and Eastern regions, only single outbreaks of ASF were recorded. In 2022, only two clusters of ASF among domestic pigs were recorded: one in Sumy region and one in Mykolaiv region. In the Western and Eastern regions, no outbreaks of ASF were reported.

In 2023, the number of ASF outbreaks increased significantly (compared to 2022), with two clusters of the disease recorded: in the Northern region in Chernihiv and Kyiv oblasts, and another cluster in the Central region – Kirovohrad oblast. Only single outbreaks of this disease were recorded in the Western and Eastern regions. In 2024, the upward trend continued with a high concentration of cases in the Central, Northern, Southern and part of the Western (Ivano-Frankivsk and Chernivtsi) regions, with Kyiv and Poltava regions showing the highest density of cases. An assessment of the density of the ASF outbreak core in Ukraine for the entire period from 2020 to 2024 shows consistently high levels of epizootic intensity in the Central and Northern regions. The heatmap represents the combined density distribution across all study years, with color intensity corresponding to case concentration (warmer colors indicate higher density) (Fig. 8).

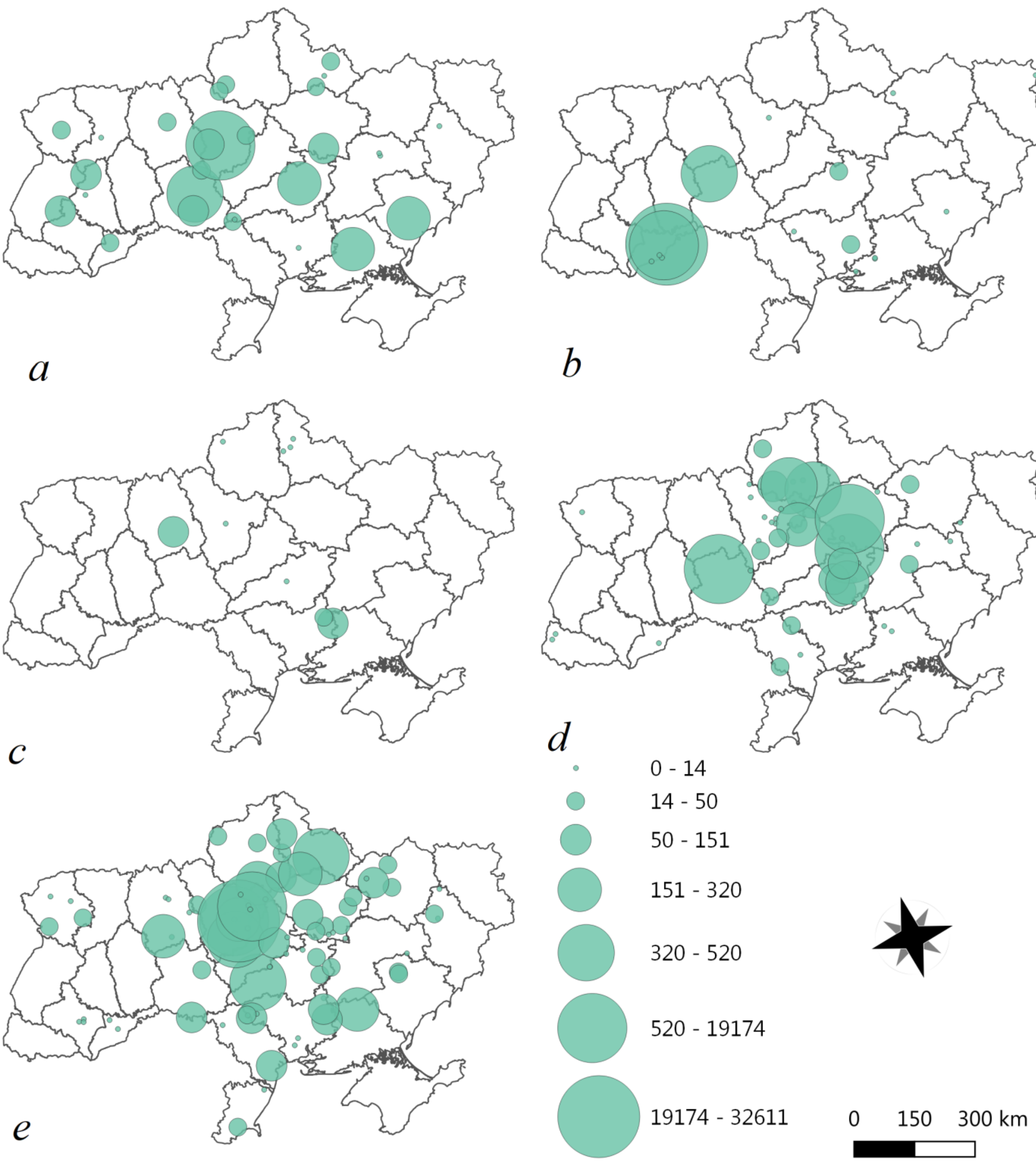

Fig. 4. Maps of the distribution of the number of pigs slaughtered as a result of ASF outbreaks: *a* – 2020; *b* – 2021; *c* – 2022; *d* – 2023; *e* – 2024

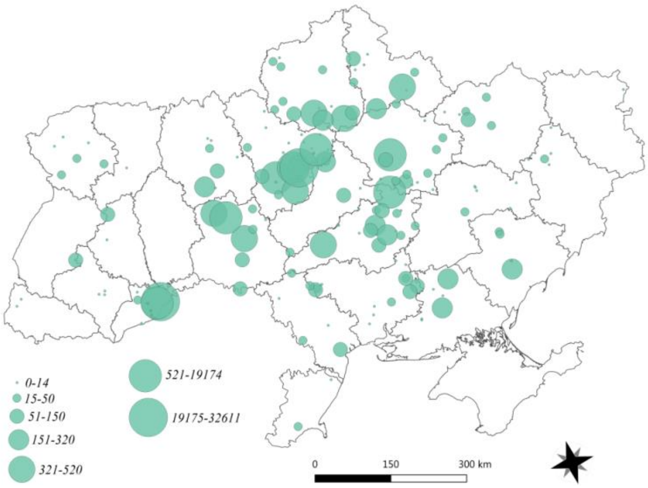

Fig. 5. Maps of the distribution of the number of pigs slaughtered as a result of ASF outbreaks in 2020–2024

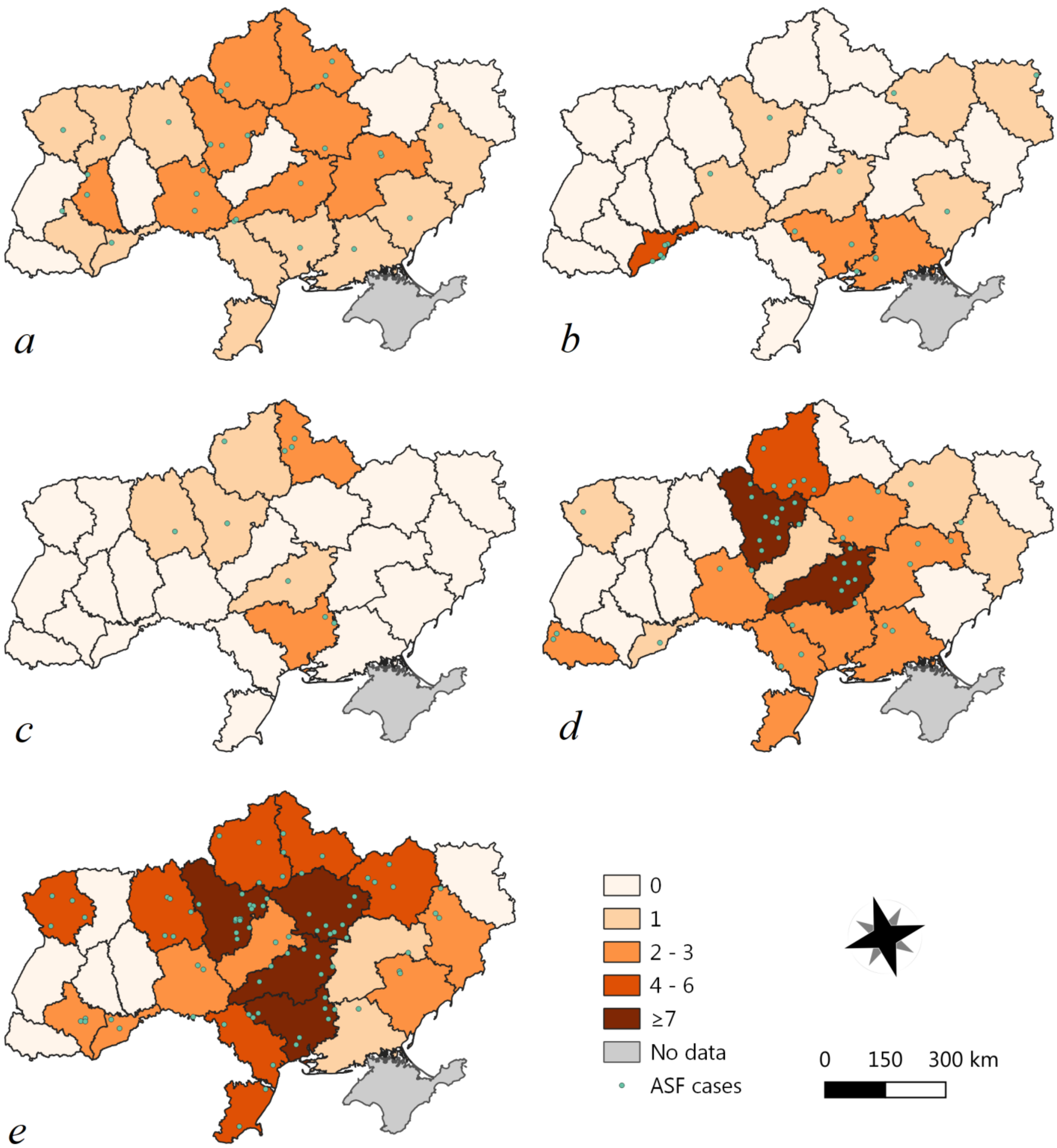

Fig. 6. Maps of the distribution of cases of ASF (2020–2024 years): *a* – 2020; *b* – 2021; *c* – 2022; *d* – 2023; *e* – 2024

The highest density of cases across all study years is concentrated in Kyiv, Poltava, Kirovohrad, Mykolaiv, and Kherson regions. The Southern and Western regions show lower incidence rates, although in 2021 some increase in case density was observed in the Western region (Chernivtsi oblast). The largest number of outbreaks during analyzed period was detected in Kyiv (33), Mykolaiv (17), Kirovohrad (17), Poltava (14), and Chernihiv (13) regions. A somewhat smaller number – in Vinnytsia (9), Chernivtsi (9), Sumy (8), and Odesa (8) regions.

The distribution of ASF cases in Ukraine is demonstrated using standard deviation ellipses for the whole analyzed period over five years. Each ellipse represents the directional distribution of ASF cases for a given year and covers approximately 68% of cases for each animal species. The ellipses demonstrate where most cases are concentrated, their spatial orientation and the breadth of spread (Fig. 9).

The analysis revealed differences between wild boars and domestic pigs by year of observation. Thus, the spatial distribution of cases in wild boars is shifted to the northwest compared to domestic pigs, which may be explained by the predominant range of wild boars in Ukraine. In 2020, cases among wild pigs were concentrated mainly in the northwest, while cases among domestic pigs were scattered throughout the country. In 2021, there was one case among wild boars in Kherson region, which shifted the overall distribution to the south. In 2022, due to low data intake, cases were distributed along the north-south axis, with only two cases in wild boars in Kyiv and Chernihiv regions. In 2023, 2024, the distribution of outbreaks among these animals was more scattered from west to east, while in domestic pigs most cases were reported in the center of the country. In general, the analysis shows that over the past five years, ASF cases have been concentrated mainly in the Central, Northern and Southern regions of Ukraine, with an increase of the incidence in the central region (Fig. 10).

The ellipses of standard deviations for ASF cases among wild and domestic pigs for the period from 2020 to 2024 (Fig. 10) show that the main center of ASF cases among domestic pigs is located in the Central regions of Ukraine, including Poltava, Kyiv and Kirovohrad regions. This ellipse also includes part of the Southern regions, indicating a wide territorial spread of ASF. At the same time, there is a more Northwestern location of ASF cases among wild boars, mostly centered in the Northern region.

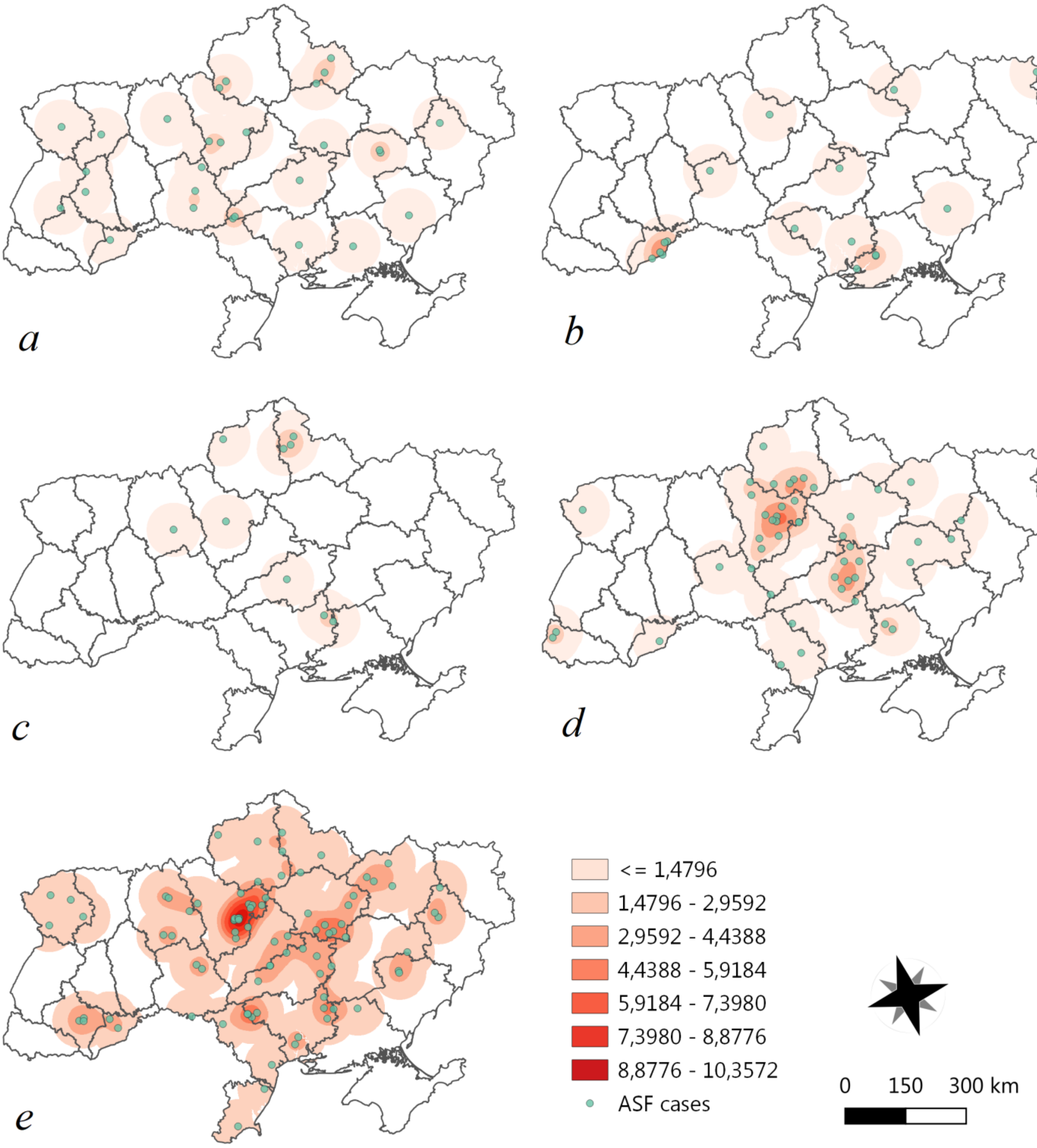

Fig. 7. Kernel density estimation of ASF cases in 2020–2024 years: *a* – 2020; *b* – 2021; *c* – 2022; *d* – 2023; *e* – 2024

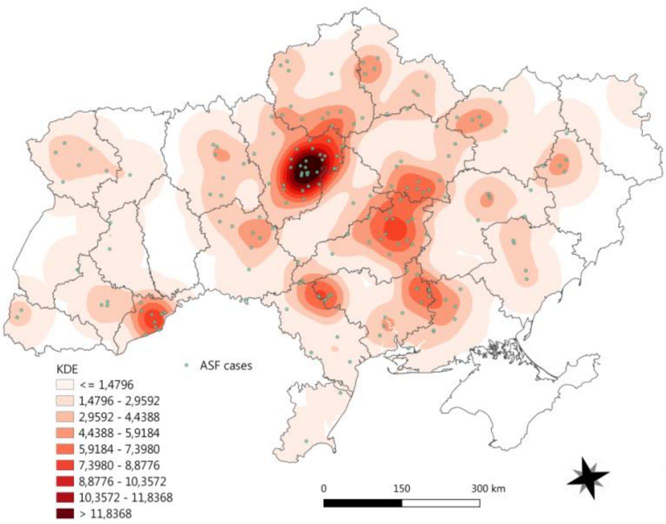

Fig. 8. Kernel density estimation of aggregated ASF cases (2020–2024)

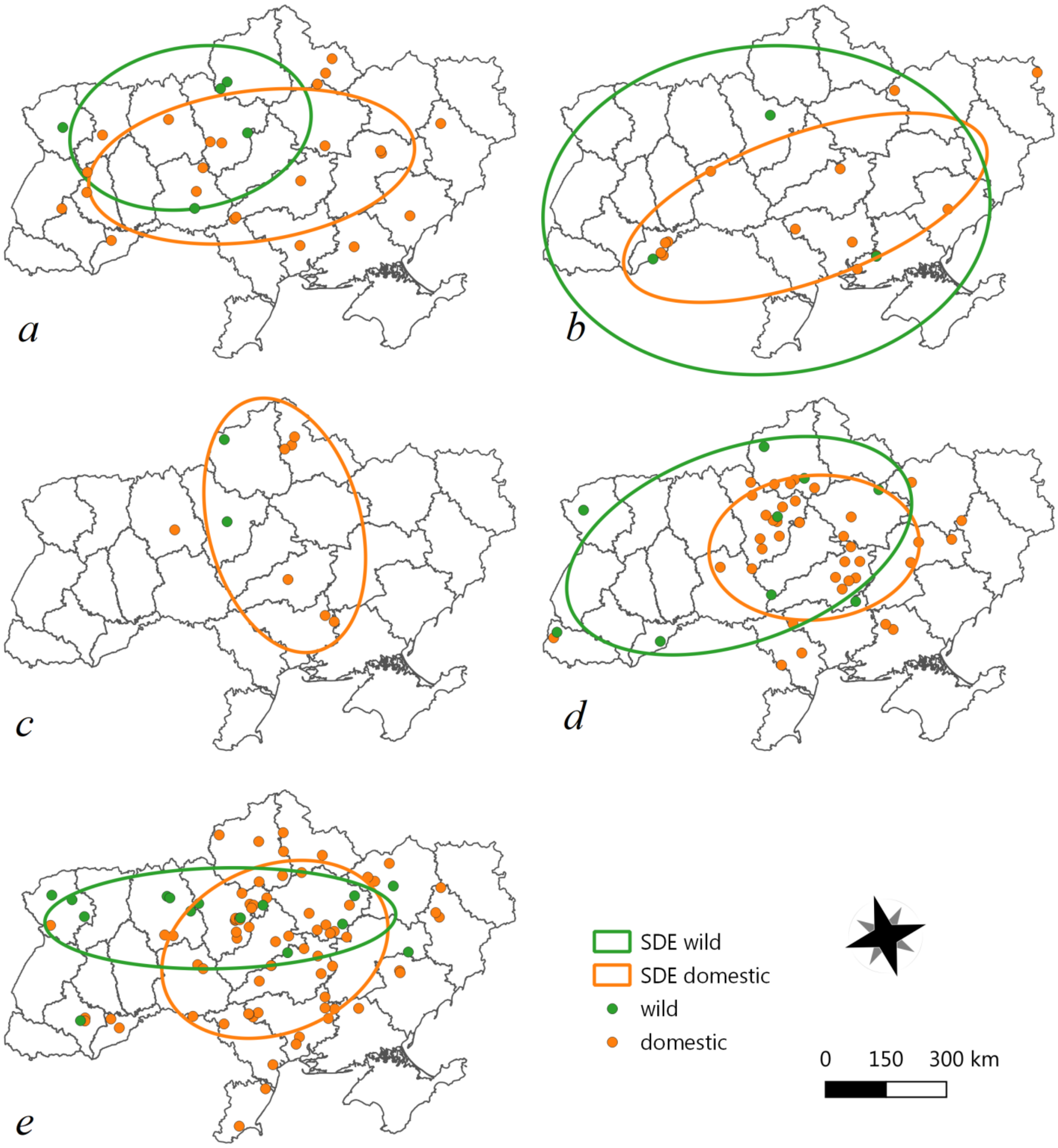

Fig. 9. Ellipse of standard deviations of ASF cases in 2020–2024:
green ellipse – standard deviations among wild pigs; orange ellipse – standard deviations among domestic pigs;
green dot – ASF cases among wild pigs; orange dot – ASF cases among domestic pigs; *a* – 2020; *b* – 2021; *c* – 2022; *d* – 2023; *e* – 2024

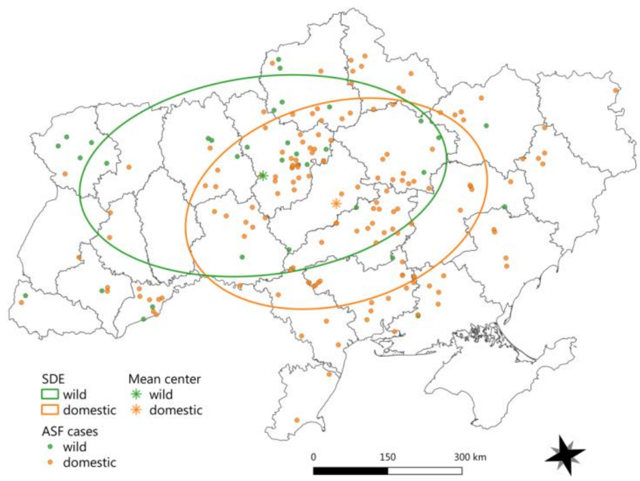

Fig. 10. Ellipse of standard deviations of ASF cases in 2020–2024:
green ellipse – standard deviations among wild boars; orange ellipse – standard deviations among domestic pigs;
green dot – the mean center of ASF cases among wild boars; orange dot – the mean center of ASF cases among domestic pigs

Discussion

Pork accounts for one third of the total amount of meat consumed by humans (Ruedas-Torres et al., 2024). However, the ASF problem is significantly worsening the food security situation in many regions. In a quarter of a century, the disease has spread to almost all continents and continues to spread. Today, even American researchers are calculating the possible losses and the likely spread of the disease in their country (Sykes et al., 2023). Ukraine has been affected by ASF since 2012, and over the past 5 years, 185 outbreaks of the disease have been detected on its territory, including 151 outbreaks among domestic pigs and 34 among wild boars.

The Eurasian wild boar is a native wild species in most of Europe (including Ukraine), Asia and North Africa, and according to data of the many researchers, its population has been increasing recently (García-Jiménez et al., 2013; Ruedas-Torres et al., 2024), and it has also been successfully introduced to the other continents and islands (Newsome et al., 2024). The close interaction and interchange between livestock and wildlife in European countries, and the completely unsatisfactory biosecurity measures, contribute to the fact that this species is becoming an important participant in the internal cycle of the pathogen circulation. In recent years, this situation has been observed in the countries of Transcaucasia, the Russian Federation and Europe (Gogin et al., 2013; Sánchez-Vizcaíno et al., 2013; Ruedas-Torres et al., 2024).

Meat or meat products contaminated with the pathogen are transmission factors and are also a potential risk factor for the introduction of ASF into the herd. Additional risk factors may include contaminated vehicles transporting pigs or carcasses, feed or bedding originating from areas accessed by wild boars, and the possibility that farm workers or other persons visiting the farm have participated in hunting or otherwise been involved in activities related to wild boars (Lamberga et al., 2020).

The analysis of the seasonal component for the period 2020–2024, in our case, showed that the peaks of outbreaks during the analyzed period were observed in July (the highest peak) and November (the lowest peak). The rapid spread of the virus in the warm season (the virus does not like heat, and cold preserves it) indicates that the virus is spreading in the country with contaminated pork and pork products. It is clear that if this pathogen enters the domestic pig population, it can be easily transmitted to susceptible animals through direct contact (Gaudreault et al., 2020). After all, the virus is transmitted through contaminated factors of inanimate nature, through biological fluids (including blood), feces, through carcasses or pork obtained from infected individuals, thus spreading the pathogen by indirect means (Guinat et al., 2016, 2018). The uncontrolled and illegal movement of live pigs or pork products also contributes to the emergence of new outbreaks of this infection on all continents (Penrith et al., 2013; Zhou et al., 2018) and in our country.

We analyzed the spatial and temporal distribution of ASF incidence over 5 years in Ukraine. By studying the spatial and temporal patterns of ASF incidence, we identified the most disadvantaged regions with a high risk of infection. According to our findings, the spatial and temporal pattern of ASF distribution was highly clustered, with the highest risk of disease located in Central Ukraine. The results of the cluster analysis allow us to allocate animal health resources with an increase in the latter in regions where ASF clustering is observed. Our study emphasizes the significant impact of the biosecurity system on farms and the seasonal spread of the ASF pathogen, which is mainly associated with the distribution of infected pork. The most disadvantaged regions with ASF are Kyiv, Poltava, Kirovohrad, Vinnytsia (central regions), Mykolaiv, Odesa (south), Chernihiv, Sumy (north), and Chernivtsi (west). Thus, we can see that the disease is widespread in all regions of our country, although the central regions, where a significant number of domestic pigs are located, dominate in terms of the number of cases. The maps of ASF case distribution that we have reproduced as a result of this work have shown significant potential for raising awareness of veterinary professionals and planning effective preventive measures to combat ASF. These maps also play a leading role in the tracking cases and strategically directing the actions of veterinary professionals in the most affected regions.

The territory of our country has been disease-affected for ASF for more than 12 years. According to FAO experts, the density of wild boars does not affect the manifestation of the epizootic among domestic pigs if it is less than 0.4 head per 1 km^2 of area (Korniienko et al., 2023), but even in 2012 in our country it was only 0.1 per 1 km^2. Subsequently (including as a result of the ASF epidemic), the number of wild boars has significantly decreased. Therefore, biosafety and biosecurity of pig farms in Ukraine is still a problem. Currently in Ukraine, biosecurity is mainly aimed at commercial farms; however, even private farms of pig owners, who also have access to agricultural markets, should be included in biosecurity programs. Although non-commercial farms are often a dead end in terms of the spread of pathogens, private households that sell pigs and pork on local or regional markets play an active role in the spread of the disease (Liu et al., 2021). It is the insufficient level of biosecurity of small households, or rather, indirect contact with virus-contaminated objects or the environment, that contributes to the spread of this disease in European countries (Boklund et al., 2018). This course of events is absolutely repeatable in the domestic pig industry. A high level of farm biosecurity is considered to be the most important tool for preventing the introduction of ASF on farms (Bellini et al., 2017). Scientists analyzed data on ASF cases in 2018 in Europe in the pig and wild boar populations to calculate the risk of primary infection, and identified three potential ways: legal trade in live pigs; legal trade in pork products; movement of wild boars (Taylor et al., 2020). The first two routes of infection mentioned by the author are active in Ukraine. It is also recognized that pigs raised in open air, in pens, and those pigs that have access to outdoor areas of farms may have contact with wild boars. This type of pig production is not only typical for most small farms in Europe, but also for Ukraine, and it is here that one of the weakest links in the biosecurity chain is problematic and the biggest risk factor for ASF infection. Farms with low biosecurity, high density of wild boars and the presence of vectors are considered the most dangerous combinations for the spread and persistence of ASF in households with low biosecurity (Depner et al., 2017; Nielsen et al., 2019). However, as we have already noted, Ukraine has a low density of wild boars, so this way is possible only with a high density of the latter, but this component is absent in Ukraine.

Prevention is the most effective approach to avoid the emergence and spread of ASF in countries where the disease has not yet been reported. Monitoring at the level of domestic pigs and wild boar populations is the leading measure to prevent the disease, and a large number of countries on many continents have now implemented surveillance plans appropriate to the epizootic situation. Potentially, the ASF virus can be introduced into safe areas through legal and illegal movement of livestock and pork products, as well as through infected wild boars (Mur et al., 2012). To control the disease within an infected country, reliable diagnostics, improved biosecurity of pig farms, destruction of infected pigs, and strict control and restrictions on the movement of pigs/transmission factors are introduced. However, researchers are now talking about the pandemic nature of the disease, and control and eradication measures are not very effective (Muñoz-Pérez et al., 2021). The development of effective and safe vaccines will be a crucial factor in the fight against ASF (Arias et al., 2018). Strict control and quarantine should take place in the customs departments of international airports, shipping terminals, and railway stations to prevent passengers from other countries from importing any pork products (Liu et al., 2021). The causative agent of ASFV is not simple, it has many determinants of virulence and ways to bypass the pig's immune system. So far, all the functions of the latter proteins, as well as their role in the immune response, have not been fully revealed. Additional studies are also needed to correlate immune protection with individual proteins. Currently, many drugs are vaccine candidates under development. The drugs must be safe and effective, DIVA-diagnostics (differentiation of vaccinated animals from infected animals) must be developed, and vaccines must be integrated into reliable disease control and eradication programs. However, a safe and reliable vaccine for the prevention of this disease in pigs is not yet available (Ruedas-Torres et al., 2024).

Conclusions

Outbreaks of ASF have been registered in the different regions of Ukraine since 2012. Over 2020–2024, 185 outbreaks were detected in the country, including 151 (81.7%) among domestic pigs and 34 (18.3%) among wild boars. During this period, the most active ASF epizootic process was manifested in Kyiv, Poltava, Kirovohrad (Central Ukraine), Chernihiv (Northern Ukraine) and Mykolaiv (Southern Ukraine) regions. A somewhat lower density of cases is represented by clusters in Vinnytsia, Zhytomyr, Sumy, Kharkiv, and Chernivtsi regions. The analysis of the seasonality of the disease over 5 analyzed years by month showed two peaks in the incidence. The first and highest trend occurred in July–August, and the second, lower peak, occurred in November. The incidence trend among domestic pigs almost completely coincides with the combined trend (among wild boars and domestic pigs).

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