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Review

Emergence of African Swine Fever in Poland (2014–2021). Successes and Failures in Disease Eradication

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Abstract: African swine fever (ASF) in Poland has been a major concern for pig production for the last seven years. The main constrains in ASF eradication in Poland are due to the high density of wild boar in ASF-affected areas of the country. Other factors, responsible for long-distance ASF spread to new regions of the country, are mainly related to human-mediated activity and lack of awareness of the potential disease threat to pig production. In the case of pig holdings, the only effective measure of ASF prevention is strict implementation of biosecurity rules. Despite many efforts to implement these measures, the disease occurred in a number of voivodeships, poviats and counties of Poland, primarily in eastern Poland; however, starting from 2019, also in the western part of the country. Further recommendations to eradicate ASF in Poland or at least to minimize the economic loss caused by ASF in pig production include effective wild boar population management strategies along with the implementation of strict biosecurity measures. The observations from the last seven years of ASF epizootic in Poland clearly indicate that the disease could not have been effectively controlled in wild boar population and could only be restricted in domestic pig population following severe biosecurity rules. As for ASF spread control in wild boar population, the measures applied in other EU countries include active wild boar carcass search and disposal along with sanitary and reduction hunting. These measures have also been shown non-effective. The only solution for future sustainable pig production in Poland seems to be strict collaboration between pig producers, veterinary inspection, and hunting associations.

Keywords: African swine fever; wild boar; pig production; eradication measures; biosecurity

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1. Introduction

The first outbreak of African swine fever (ASF) in wild boar was found in Poland on 14 February 2014, approximately 10 km from the border with Belarus, near the town Grzybowszczyzna (Sokólski county, Podlaskie voivodeship), where dead wild boar was collected frozen from the river which may indicate that the infected wild boar were present in the identified area earlier than expected [1,2]. The wild boar carcass was excavated from the ice and the samples were sent to the National Veterinary Institute-National Research Institute (NVRI) in Pulawy (Poland). After routine diagnostic tests, the presence of ASF virus (ASFV) genetic material was found in internal organs and blood of dead wild boar. It appeared that the first ASF wild boar outbreak in Poland occurred due to direct disease spread from the Republic of Belarus [1,2].

2. Current ASF Situation in Poland

From February 2014 until this day (30 July 2021), over 12,764 outbreaks of ASF in wild boar and 400 outbreaks of this disease in domestic pigs have been confirmed in Poland [3–5]. Unfortunately, despite the measures implemented for ASF eradication, the number of outbreaks in wild boar and domestic pigs is increasing dynamically, which has been evident particularly during the last two years [1–5]. Similarly, the increasing number of ASF outbreaks in domestic pigs has been confirmed. Regarding the structure of pig production, the majority of non-commercial and backyard pig holdings are located in the eastern part of Poland, while big commercial pig holdings are mainly concentrated in the west of the country (Lubuskie and Wielkopolskie voivodeships). In terms of wild boar population multiplicity and density, the current number of wild boar is close to 67 thousand heads. The highest density of wild boar is observed in western Poland because of afforestation and environmental conditions.

The first ASF outbreak among domestic pigs in 2021 has been confirmed in Lubuskie voivodeship in a large commercial pig holding keeping almost 16,000 swine, while the second outbreak occurred at the end of May 2021 in a commercial pig holding keeping 3373 pigs in Wielkopolskie voivodship [3]. Then, surprisingly, an additional 34 outbreaks emerged in different parts of the country. The majority of new outbreaks in domestic pigs occurred in an area adjacent to previous outbreaks in wild boar.

With some exceptions, including recent ASF outbreak in March 2021, the ASF seasonality in domestic pig population in Poland and Central Europe usually falls between June and the end of September [5,6–8]. Where wild boar population is concerned, the highest number of ASF outbreaks in wild boar is identified in spring and summer. Since there is no effective vaccine against ASF, the eradication measures focus on limitation of wild boar population along with strict implementation of biosecurity rules by the owners of pig holdings.

3. ASF-Affected Area Enlargement in Poland

The ASF-affected area in Poland expands dynamically, similarly to the emergence of new ASF outbreaks in wild boar and domestic pigs [1,2,5,8] (Figures 1 and 2).

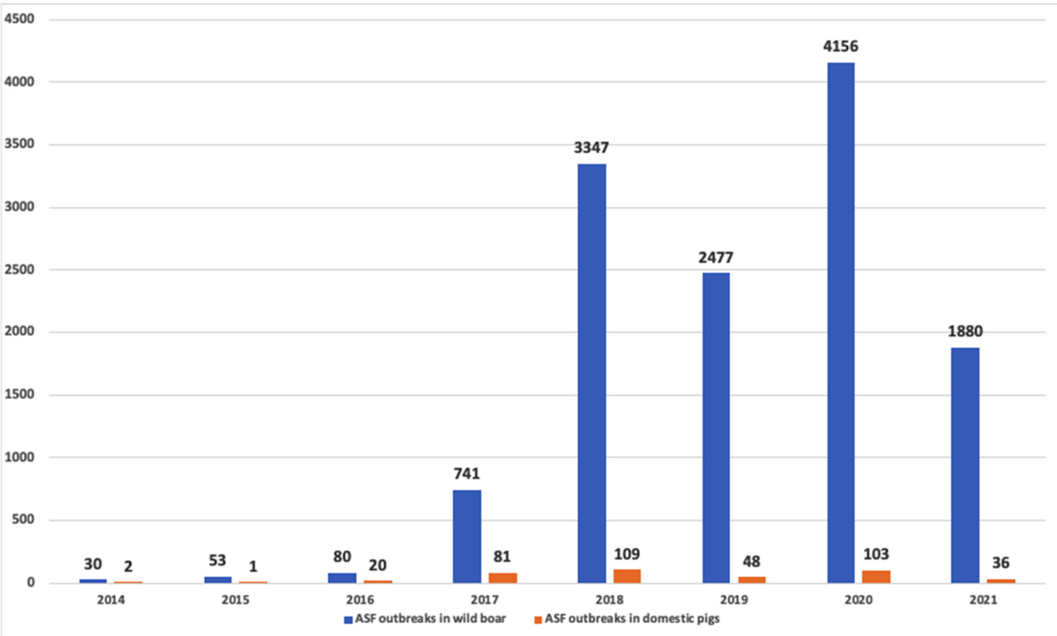


Figure 1. African swine fever in Poland 2014–2021. The number of ASF outbreaks in wild boar and domestic pigs. Source: General Veterinary Inspectorate: https://bip.wetgiw.gov.pl/asf/mapa/ (accessed on 30 July 2021).

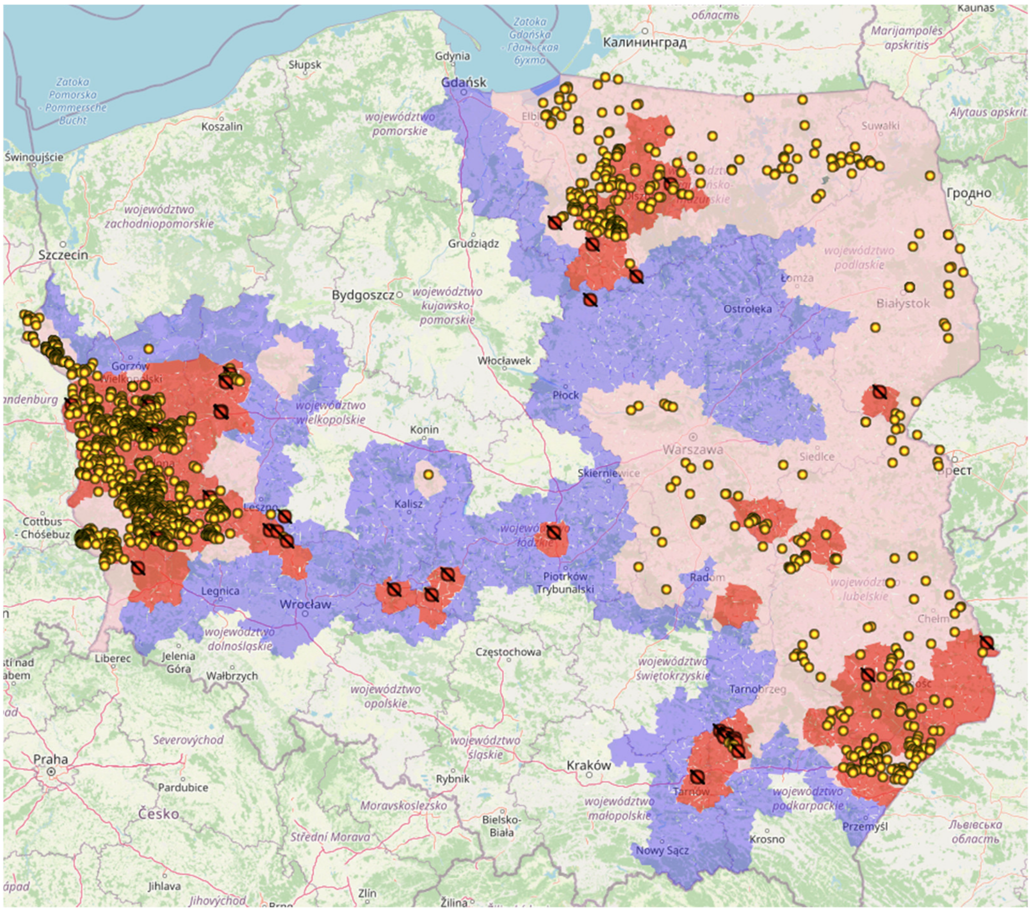


Figure 2. Current epidemiological situation regarding the emergence of ASF in Poland. The ASF-affected areas, in particular voivodeships, are indicated. The yellow points indicate wild boar ASF outbreaks in 2021, while red-crossed circles outline ASF outbreaks in domestic pigs. Source: General Veterinary Inspectorate: https://bip.wetgiw.gov.pl/asf/mapa/ (accessed on 30 July 2021). The colors of ASF-restricted zones I, II and III are consistent with the European Commission Regulation (EU) 2021/605 implemented on 7 April 2021.

Currently, ASF is present in 11 voivodships, namely: Podlaskie, Lubelskie, Mazowieckie, Łódzkie, Warmińsko-Mazurskie, Zachodniopomorskie, Wielkopolskie, Lubuskie, Dolnośląskie, Małopolskie and Podkarpackie (Figure 2). The recent estimation of wild boar density states that it is lower than 0.5 wild boar per square kilometer. However, the wild boar number estimation could have been erroneous. The forested territory in Poland is estimated at 9.2 millions of hectares which is equal to 30 percent afforestation of the whole country. The current population of domestic pigs reached over 11.4 million heads in 2020 [3]. ASF has been expanding in Poland every year [8–10]. Initially, ASF was spreading mainly in the east of the country—along the eastern border [2]. The speed of ASF spread in wild boar population was initially relatively low and ranged from 10 to 12 km per year in the western and southern directions [2,5]. In 2016, the disease was transferred by humans for a longer distance to the Moniecki county within the Podlaskie voivodeship [1,4]. The probable source of virus transfer was the illegal burial of pigs from nonconfirmed ASF outbreaks and subsequent infections in wild boar [4,8]. Similarly, the human factor was also a direct cause of ASFV introduction in 2017 to the area of the Mazowieckie voivodeship, near Warsaw and Piaseczno [3,5,8]. In the latter case, the distance over which the ASFV has been transferred, reached over 120 km. Finally, in 2018, the ASF was identified in another region of the Warmińsko-Mazurskie voivodeship, where the virus has been introduced by an infected wild boar probably from the Kaliningrad Oblast (Russia) [3,4]. Russian veterinary authorities previously reported the presence of ASF in wild boar population [11,12].

4. Human-Mediated ASF Spread in Poland

It is probable that the human factor was the main cause of eight ASF outbreak occurrences identified in 2018 during the summer in Cieszanów commune of the Podkarpackie voivodeship [3,8]. The conducted epizootic investigation revealed that ASFV-infected wild boar were found in the area located approximately 90 km away from these outbreaks in domestic pigs. Human activity was undoubtedly the cause of the first ASF wild boar outbreak in the western part of Poland, on the territory of Lubuskie voivodeship, which has been identified in November 2019 with a dead wild boar killed in a road accident [3,8]. The above-mentioned dead wild boar was found more than 300 km from the nearest ASF outbreaks in wild boar or domestic pigs in central Poland [8]. Additionally, there are some speculations concerning the first identified wild boar outbreak in western Poland which occurred in the previously ASF-free area. Similarly to the above-mentioned cases, it is extremely difficult and rather impossible to prove some rumors of ASFV introduction to western Poland by seasonal employees from the eastern part of Europe where ASF occurs endemically [8,10]. However, in terms of epidemiological investigation and explanation, the most problematic occurrences include four ASF outbreaks found in 2021 in domestic pigs in Łódzkie voivodeship in central Poland or a single outbreak in Małopolskie voivodeship (southern Poland). These incursions may indicate illegal human activity including trade of unregistered and ASFV-infected pigs.

According to literature resources from Russia which described the epidemiological situation between 2012 and 2013, one of the theories of ASF emergence along the international communication roads was dumping out food-waste containing ASFV-contaminated sausages by truck drivers in transit [11]. Of course, it is possible to transfer the virus through contaminated pig meat, as has been shown in the case of Czech Republic [4,13]. However, the more likely scenario takes into account the long-distance transfer of wild boar or pig carcasses from an unknown origin. An additional factor which impedes the understanding of ASF spread and the undertaking of successful measures of its eradication is the relatively low infectious dose of the ASFV necessary to cause clinical ASF among swine [14–16]. These findings are supported by data published by Probst et al. [17], as well as recent inputs in ASF epidemiology by Walczak et al. [16]. These results showed that to cause the clinical form of ASF in susceptible pigs, only a few infectious virus particles are required. In the context of ASF course in wild boar, recent studies conducted by Rodríguez-Bertos et al. [18] and Sánchez-Cordón et al. [19] expand the current knowledge state regarding ASF pathogenesis and epidemiology in free-ranging wild boar.

5. ASF Emergence vs. Wild Boar Density and Environmental Structure

The very first wild boar outbreaks of ASF in western Poland were identified in locations near the forests or brakes. The ASF outbreaks in wild boar have been confirmed mainly in wild boar that were found dead or road-killed [3,8]. The probable reason for the identification of many ASF outbreaks in a short time was the high degree of afforestation in the area of Lubuskie voivodeship as well as the relatively high density of wild boar which contrasts with the official data indicating density at the level from 0.27 to 0.52 of wild boar per square kilometer [8]. In spite of the introduction of preventive measures, including construction of fences, application of fragrance repellents, and wild boar trapping, the ASFV moved to the neighboring regions reaching the Dolnośląskie and Wielkopolskie voivodeships. Taking into account the preventive measures of ASF eradication in wild boar population in Belgium, Czech Republic, or South Korea, it can be concluded that a 1.5 m high single fence setup cannot be fully effective [6,7,20,21]. The satisfactory results of limiting ASFV spread among the infected wild boar can be achieved by the application of multiple (triple) fences with parallel electric fences [20,21].

6. An Example of ASF Expansion in Western Poland

By the end of 2020, almost 2500 outbreaks of ASF in wild boar were found in the western part of the country (2093 in the Lubuskie, 439 in Wielkopolskie and 7 in Dolnoslaskie voivodeship) [8]. Unfortunately, due to the inevitable expansion of ASF, in September 2020, the virus was confirmed for the first time in Brandenburg in Germany. The relatively high wild boar population density allowed ASF to quickly spread along the eastern border of the country [13]. The first wild boar outbreak of ASF in Germany was found about 28 km from the nearest ASF wild boar outbreak in Poland. Until 20 April 2021, 1016 ASF outbreaks were registered in Germany in two federal states (Brandenburg and Saxony) [3,13]. Until 30 July 2021, three ASF outbreaks have been found in Germany in the area adjacent to previous ASF outbreaks in wild boar. These outbreaks occurred in free-ranging or non-commercial pig holdings.

In the first quarter of 2021, the most numerous outbreaks of ASF in wild boar were found in western Poland in a relatively small area of Lubuskie voivodeship. During this period, the disease was registered in six voivodeships of our country [3,8].

The analysis of potential reasons for consistent ASF spread in wild boar population indicates that the ASFV strain which currently circulates in Europe is characterized by high virulence, which results in sudden death after infection in the vast majority of infected individuals [2,6,7]. The fever that occurs early (usually within 24 h after infection) reduces the mobility of wild boar [16,18,22–27]. As a consequence of fever of the infected wild boar, the virus shedding period is rather limited. During the experimental studies, it has been shown that the average survival time of the infected wild boar reaches an average of 4 days, then the animal dies [14–16,28]. This phenomenon is favorable in terms of the speed of disease spread. It is likely that some wild boar may survive ASFV infection and become long-term carriers of the virus. The epizootic data from Estonia and Latvia suggest that in some regions of these countries, the prevalence of sero-positive wild boars being ASF survivors ranges from 20 to 50 percent [20,23,25,27]. Despite the fact that most of ASF wild boar outbreaks in Estonia are confirmed in hunted wild boar on the basis of the presence of specific antibodies only, there is still a certain percentage of ASF outbreaks confirmed among dead wild boar with the presence of ASFV in their tissues [23–25]. Unfortunately, a similar scenario is probable in wild boar population in Poland in spite of the current percentage of sero-positive animals reaching from 1 to 2 percent [4,5]. To prevent this phenomenon, implementation of intensive and most effective measures aimed at significant reduction of the wild boar population are required. According to numerous scientific opinions of European Food Safety Agency (EFSA) from 2017 to 2019, the effective reduction of wild boar population is possible when the hunting bag per year is equal to 70% of the whole number [6,10,24,25,29].

7. Potential Ways of ASF Eradication

The data on ASF epizootics in wild boar in Poland showed that a significant number of infected individuals die before antibodies' onset [2–5]. For example, in Lubuskie voivodeship, the intensive searching performed during spring 2020 in the area over 13,800 square kilometers resulted in identification of 2505 dead wild boar with the prevalence of 84 percent of ASFV-positive animals [8]. This observation indicates that one of the most effective measures of ASF eradication is the procedure of frequent search and removal of wild boar carcasses. Previous scientific opinions claimed that dead wild boar remain an ASFV reservoir from 1 to 6 weeks after death. This time period depends on the soil humidity conditions, pH, as well as solar radiation [17,28]. The scientific data published by EFSA showed that the most important limitation of ASF spread is active search and removal of dead wild boar carcasses in the area with a radius from 50 to 100 km from the so-called "hot spots", namely the recently diagnosed ASF outbreaks in wild boar [6,10,25]. Following the above-mentioned opinions, the high increase in the number of ASF wild boar outbreaks in the affected area occurs approximately 6 months after disease spill-over.

After 30 months of the epizootic, the number of outbreaks seems to decrease gradually [4,5]. This hypothesis is confirmed by the observations made in virtually every region of Poland where ASF was found, starting from Podlaskie and Lubelskie voivodeships [4].

The main reason for the significant decrease of the wild boar population is the death of the majority of animals from ASFV; the hunting of wild boar in the ASF-affected regions seems to have a minor impact on wild boar population decrease. It is worthwhile to be mentioned that poorly organized wild boar hunting actions within the ASF-affected area may worsen the epizootic situation, including causing a faster spread of ASF [6,15]. The reports of EFSA on this particular issue have been repeatedly revised in response to the changing situation in the Baltic States and Poland [6,7,10,24,25]. The possibility to organize intensive hunting actions within the recent ASF "hot spots" should be excluded for a period of at least 2–3 months. The main efforts in such a situation should be focused on carcass removal and disposal. Unfortunately, the thesis of high ASFV pathogenicity eliminating infected wild boar population is not completely plausible. This view was presented a few years ago [2,7], however, it is worth remembering that an episode of any infectious animal disease cannot be directly related to all animal diseases. Therefore, the programs that have been effective for the eradication of classical swine fever (CSF), foot-and-mouth disease (FMD) or Aujeszky's disease (AD) should be reviewed again.

Currently, it is believed that due to the presence of individual boars which survive ASFV infection, the virus may persist at low titers within the contaminated environment for a long period of time [17,26,29–33]. This phenomenon is observed in Poland, mainly in the eastern part of the country. According to previous reports from EFSA [6,10], it is not possible to exclude the possibility of the disease recurrence in an area free from ASF for at least 24 months from the last outbreaks in wild boar. This theory works well in practice, especially in the Podlaskie voivodeship in Poland, but also in some regions of Estonia and Latvia [23,27]. Meanwhile, infections by oral route with a low dose of the virus occur mainly in wild boar after direct contact with remains of dead wild boar due to ASF [4,16,32]. From the epidemiological point of view, the asymptomatic ASFV carrier in wild boar poses a special threat in terms of disease persistence for many years without awareness of the fact. Bearing this in mind, the eradication of ASF in wild boar population without the use of an effective vaccine will become practically impossible and probably we will struggle with the epizootic similarly to Sardinia for over 30 years [33]. Of course, pig breeding in Sardinia differs from the standards in other European countries, due to populations raised in an illegal free-ranging way—the so-called 'brado pigs'. This significantly stimulates the circulation of the virus in the environment between the infected wild boar and domestic pigs.

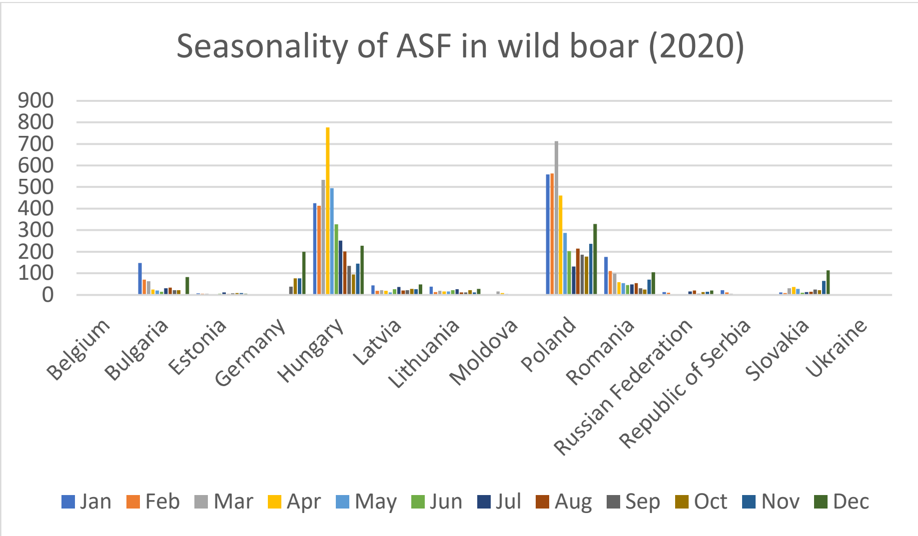
According to the current opinion of EFSA experts, the areas where the population of wild boar are almost absent are referred to as the "white zones" (personal communication). Currently, one of the priorities of EFSA is to develop a model for the generation of these zones, which occurred in France and Luxembourg in the regions bordering Belgium, and has led to the inhibition of the further expansion of this disease and the eradication of the epizootic in Belgium. The strategy of "fencing" the new ASF wild boar outbreaks initiated in western Poland and is a part of the efforts related to the eradication of the disease [5,8].

However, there are no doubts that due to the higher number of ASF outbreaks in wild boar population and the presence of new infections in many regions of the country, the risk of direct or indirect transmission of ASFV from wild boars to pig production may continuously increase [4]. The main efforts are focused on implementation on strict biosecurity rules in pig farms to prevent ASFV spread from virus-contaminated areas [21,30]. In spite of continuous ASFV spread in wild boar, this goal is reliable taking into account the current experience of the Czech Republic, Belgium, Estonia, Hungary and so far, of Germany, where biosecurity standards have been strictly implemented [13,21].

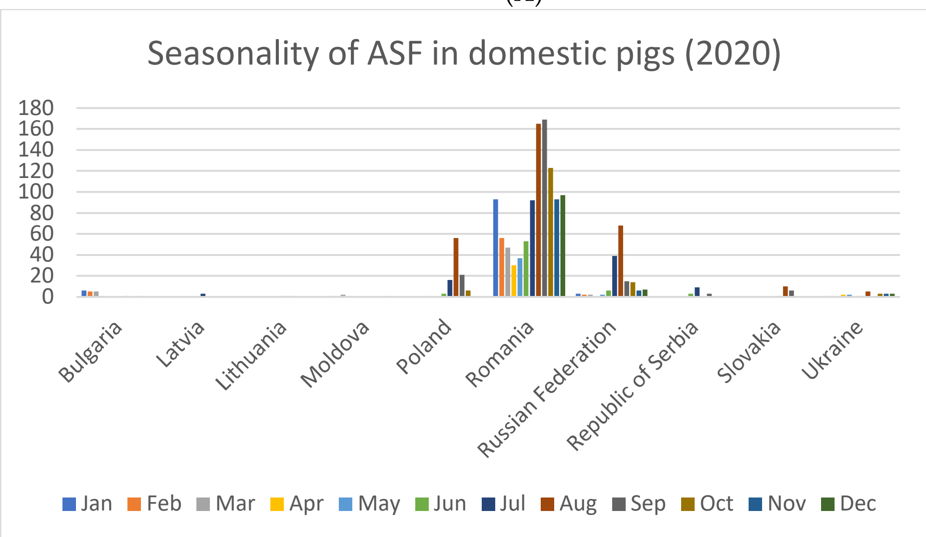
8. Potential Sources of ASF in Pig Production

According to the available, but not fully comprehensive investigations of the epizootic situation in the country, the most frequent source and factor of ASFV introduction to pig herds was human activity [2,4–8]. This factor was the direct cause of ASF outbreaks in domestic pigs which emerged during the first two years of epizootic [1,2]. Other potential sources of ASF were purchasing the infected piglets or infected pigs during the incubation period of the disease, swill feeding, or through ASFV-contaminated equipment, vehicles or crops. In 2015–2016, there were also cases in ASF outbreaks indicating direct contact of pigs with virus-contaminated tissues of dead wild boar. During the years 2017–2020, the probable source of the disease was the virus-contaminated green forage, hay or straw [4,5,8].

The data on the number of ASF domestic pig outbreaks detected in Poland and other European countries in 2020 (Figure 3A,B) indicate that we are not able to cope not only with disease control in wild boar population but also among domestic pigs. This situation is different in other EU countries that have been affected in the same period as Poland (e.g., Lithuania, Latvia and Estonia) [7,23–27].



(**A**)



(**B**)

Figure 3. The occurrence and seasonality (monthly) of ASF outbreaks in wild boar (**A**) and ASF outbreaks (**B**) in domestic pigs in 2020. Source: General Veterinary Inspectorate: https://bip.wetgiw.gov.pl/asf/mapa/ (accessed on 30 July 2021).

In addition, during 2020, there were only a few single outbreaks of ASF among domestic pigs in Lithuania and Latvia, while in Estonia, no outbreaks have been notified since 2018 [3,8].

Moving forward, the first goal of the fight against ASF should be to prevent outbreaks of the disease in domestic pigs in order to recognize Poland as an ASF-free country in the pig population [12,21,22,32,33]. Supporting this thesis, the EFSA scientific opinions claim that biosecurity measures including solid fencing on pig farms are the most important factors to avoid ASF emergence in pig production [12,34,35].

During the last 7 years of ASF epizootics in Poland, there were some speculations regarding the possibility of ASFV transmission by stable flies (*Stomoxys* sp.), mosquitoes or insects from the *Tabnidae* family [36]. However, the studies conducted by the National Reference Laboratory for ASF at the National Veterinary Research Institute in Pulawy revealed only marginal contamination of the surface of flies and other insects by the genetic material of ASFV. Thus, there is no proof that these insects are the main reason for the spread of ASF in Poland among domestic pigs, or between the population of infected wild boar and domestic pigs. Similarly, the studies conducted in ASF outbreaks in Romania or in Lithuania confirm that the aforementioned insect species cannot be the main vector of ASFV transmission [21,32,34].

9. Further Perspectives of ASF Eradication and Protection of Pig Herds

It is essential to make all pig producers aware that the only way to prevent further ASF outbreaks in domestic pigs is strict implementation of the biosecurity rules in all categories of pig production. Since there is no effective vaccine against ASF, efforts aimed at introducing biosecurity measures should be a priority. The future recognition of Poland as an ASF-free country in domestic pigs should be the aim of all stakeholders including pig producers, veterinary inspection and hunting associations. An important element of the eradication program is the earliest possible detection of the disease in ASFV-infected herds. The ASF-suspicion should be raised by the pig producer, who supervises these animals daily. The extraordinary behavior of the pigs may indicate the very first clinical signs of ASF in pigs. Therefore, such information should be continuously disseminated among pig producers and veterinarians.

On the other hand, the authorities are responsible to implement the most effective administrative measures in order to prevent disease emergence facilitating its future eradication. This task, in turn, can be accomplished only by the aforementioned effective limitation of the wild boar population as well as quick removal and disposal of dead wild boars from the environment.

10. Conclusions

The real chances to limit further ASF spread among wild boar by vaccination strategy are rather negligible and should not be taken into account in the next 10 years [37–39]. Recent reports from the United States of America (USA) shed light on a potential ASF vaccine development, but there is still no information on the potential possibility to meet all the restrictions of the safe and protective vaccine including the implementation of the Differentiating Infected from Vaccinated Animals (DIVA) strategy [39]. The other strategy, undertaken by Barasona et al. [40], showed the successful application of non-hemadsorbing isolate from Latvia as an efficient orally-delivered vaccine for wild boar against virulent Arm07 strain of ASFV. Only the joint and intensive work of international research teams with experience in advanced genetic engineering methods and many clinical trials on a representative number of pigs may guarantee the development of an effective vaccine against ASF in the future.

For these reasons, there is no doubt that the wild boar will remain the main reservoir of ASFV for many years in a number of ASF-affected countries including Poland, Romania or probably, Hungary and Serbia. It seems that the current model of wild boar population control is not effective enough and does not give a chance to eradicate ASFV from wild boar population. Without a rapid and comprehensive change of ASF eradication measures, the number of ASF-affected regions will consistently increase, creating a growing risk of virus transmission from wild boar to domestic pigs.

In conclusion, it is worthwhile to recall that Poland was one of the countries striving in the World Organization for Animal Health (OIE) to be a country with ASF in wild boar population but ASF-free in domestic pigs. In turn, the OIE adopted a legal regulation in May 2017 which claims that an ASF-free country is the country free from the disease for at least 12 consecutive months in the pig population. A few of the countries have taken advantage of this legal path, but unfortunately, this does not apply to Poland. Finally, the recently published EFSA data indicate that a definitive separation of ASF incidence in the wild boar and pig populations is not possible.

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