African Swine Fever - potential biological warfare threat

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Abstract

African Swine Fever (ASF) is a viral infection which causes acute disease in domestic pigs and wild boars. Although the virus does not cause disease in humans, the impact it has on the economy, especially through trade and farming, is substantial and causes more than one billion EUR yearly losses in Eastern Europe and dozens of billions globally. Thus, ASF is a possible biological weapon, due to: ease of infectious material collection; its extremely high virulence; multiple transmission route mechanisms; no treatment and no vaccine; its high resistance to inactivation and devastating impact on pork production.

In our theoretical model, a single person (a “lone wolf”) without any special training in microbiology or financial support could release and disseminate ASF virus to a disease free territory. In contrast to other biological weapons, such as Bacillus anthracis or Variola virus (the respective causative agents of anthrax and smallpox), a terrorist could access the virus easily, e.g. by collecting infectious materials from wild boar carcasses. Sample preparation is simple and does not require any sophisticated laboratory equipment. Recent development of portable ASF virus detection kits in mid-2019 in China and possibility to anonymously test samples in accredited laboratories (e.g. in Ukraine) increased feasibility of attack, because until now material diagnosis was the weakest point in possible intentional introduction protocols. Such a contaminated material could easily be used for infection of swine or wild boars in a new disease-free territory and seed a new outbreak.

We conclude that rising awareness about the ease of an intentional ASF introduction to a disease-free region (via bioterrorism) is an important element of security strengthening and recommend the use of modeling approach for risk assessment as well its experimental validation of the international ASF dissemination.

This analysis does not include external confidential attachment that contains a secret information (possible infection introduction protocols with demonstrated case studies), when unauthorized disclosure of the information could cause damage to the national and international security.

Introduction (threat, vulnerability and consequence of ASF)

ASF "is probably the most serious animal disease the world has had for a long time, if not ever" said Dirk Pfeifer, a veterinary epidemiologist at the City University of Hong Kong (Normile, 2019). Virus is propagating from East to West of Europe (with an average[1] velocity of 250 km/year by long range "jumps" and around 20km/year by "local diffusion" (Iglesias, et. al., 2019)) since 2007 (since 2014 in the first NATO/ EU -member countries), and even faster (550 km/year[1]) in Eastern Asia (OiE, 2019C). Until now, the full complexity of the processes of ASF spread in general and human role played in it in particular has not been fully revealed. Experience shows that eradication is very difficult and, in some conditions, even almost impossible in a region already affected (OiE, 2019C), so arrival of the virus to a disease-free region may lead to devastation of pork production, pork being a cheap and efficient source of proteins especially in Central/Eastern European diet. There is no treatment and no vaccine available yet, and it has a great impact, as it is non-dangerous to humans (not a zoonosis) (Cwynar, et al., 2019). To illustrate the impact, only in Poland and Estonia, after introduction in 2014, due to restrictions up to 90% (in the whole Estonia (Nurmoja, et el., 2019) and in some regions of Poland like Podlasie Voivodship (Dziennik Ustaw, 2019)) pig production in mainly small farms was banned or stopped. In Ukraine, national pig population decreased almost twice since ASF introduction in 2012 (FAPA, 2018), (Gospodarz, 2017). ASF is an emerging epidemiological threat relevant from the perspective of public health in the sense of ONE Health (Narrod, et al., 2012), for which computational risk assessment models have been proposed (Jarynowski, Belik, 2019A). After its introduction as a new very virulent strain in 2007 it caused (Bloomberg, 2018):

- Millions of culled animals yearly (currently hundreds of millions since 2018 (ABC, 2019));
- Dozens of billions of euros losses yearly (in Poland 100 million EUR direct (Tygodnik Rolniczy, 2019), (Dziennik Ustaw, 2019) and around 300 million EUR indirect costs) [Fig. 1];
- A possible introduction to the USA could cost 20 billion EUR only in first year (ABC, 2019));
- Complicated restrictions, varying from day to day (e.g. zones and biosecurity in EU (European Commission, 2014), or China);
- Conflict between governments and societies (Chenais, et al., 2019).

[1] Taking into account the distance from the first European outbreak near Poti, Georgia in 2007 to the latest outbreak in Belgium/Cambodia in the middle of 2019.

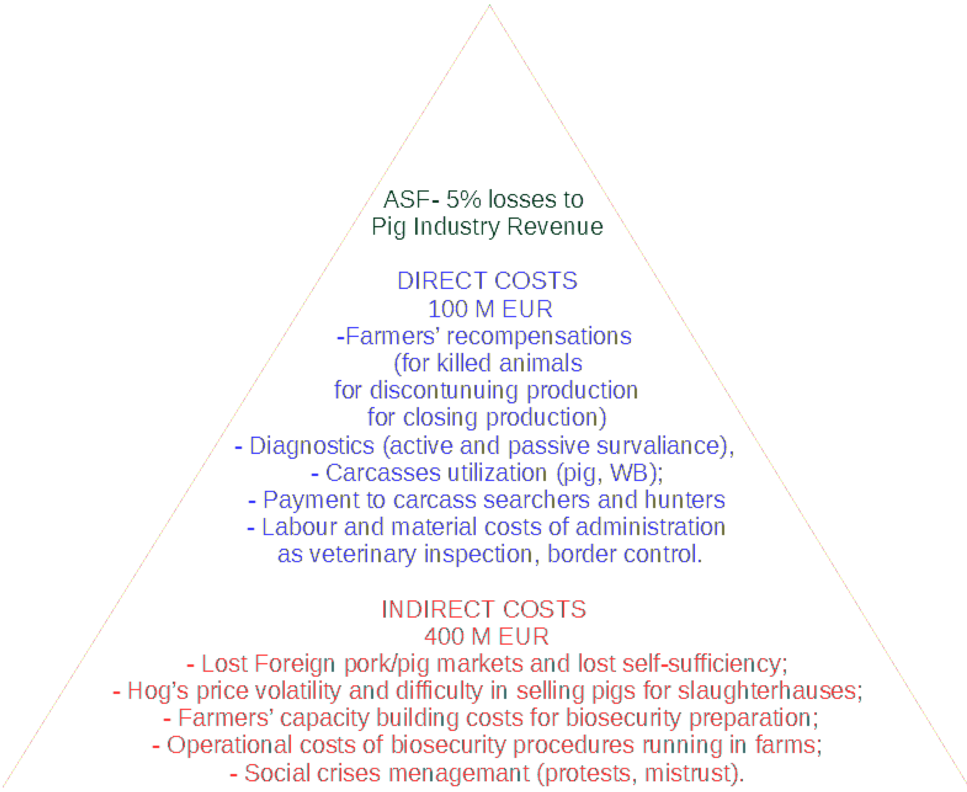

Fig. 1) ASF-related costs structure on the example of Poland.

Public health and military authorities should study basics of ASF threat, also because it is possible that ASF virus might be used in a biological attack. The intentional release of germs (Bertrandt, 2007) can not only kill livestock or wild animals, but might cause more economically important indirect impact. New kinds of biological weapons which fall outside of traditional doctrine of some rogue state possessing them (e.g. as during Cold War era) can be easily released alongside inadequate societal preparedness (Maclntyre, 2018). Pork is a key component for many of dishes in various national cuisines (Magazyn Kuchnia, 2019) (more than 50kg yearly consumption per capita in most of European countries (AHDB, 2017)) and made up to 60% meat consumption (Oh, 2011) in China (before the ASF introduction in 2018). During only 10 months of the outbreak since August 2018, China (all of 33 mainland provinces have been already affected (OIE, 2019C)) lost up to 200 million pigs (Reuters, 2019) due to ASF disease or ASF-triggered restrictions. Since April 2019 pork is no longer the most widely consumed meat in the world and the leadership was overtaken by poultry with a global share of 35% (FAO, 2019A). Moreover, the perspective seems to deteriorate because the disease is affecting the international trade (opening and closing of borders) and supply/demand (causing huge spatiotemporal variation of hogs price per kg as 0.5 – 4.5 EUR in China in 2019), having serious socio-economic impact (Rabobank, 2019), (AgroPolska, 2019). Some countries in Europe are also suffering from the shortage of drugs in the middle of 2019 (TVN24, 2019), and some of these medicaments are produced by mainly Chinese companies. Deliveries had been halted due to, among others, work stoppages in Chinese factories (Polskie Radio, 2019), that produce pharmaceuticals from porcine ingredients (Vilanova, 2019). In this paper, we are going to present a theoretical scenario of potential intentional dissemination of ASF virus in epidemiological perspective and discuss a possible public health decision making response and preparedness.

ASF Epidemiology

ASF is currently a number one threat in veterinary epidemiology (epizoology) and the whole agricultural sector in EU (RMF, 2018) and USA (Vet online, 2019C) as well as one of the highest priorities globally (OiE, 2019B), (FAO, 2019B). The main challenge for risk assessment and prediction of ASF is spreading lies due to the lack of adequate understanding of human role in this process (Belik, et al., 2011). ASF was first described in Kenya in 1921 and traditionally it has been confined to the African continent. There were only three introductions, from Africa to Europe: ~1950, ~1980 (e.g. all pigs in the Netherlands were culled), since 2007 current outbreak started in Georgia. The disease is endemic in Central/South Africa and Sardinia, however the most virulent genotype II comes from Caucasus through Eastern Europe and Siberia, then propagates over China and South Korea and it has recently been observed in ASEAN countries as Vietnam, Cambodia, Thailand, Philippines as well as focally in Belgium (Cwynar, et al., 2019), (OiE, 2019C). There are a few disease registries collecting notifications on ASF, such as OiE (The World Organization for Animal Health), FAO (The Food and Agriculture Organization of UN), ProMED, EFSA (European Food Safety Authority)/ ECDC (European Centre for Disease Prevention and Control). However, there are various practices about outbreak notifying and Belarus, despite being affected (Cwynar, et al., 2019), (GlobalMeat, 2018) continues to deny any ASF outbreak (white spot on Fig. 6).

The transmission process is very complex; however, we identify 3 main factors (OiE, 2019A), (EFSA, 2015):

- Wild Boars (WB) can be a host and a biological vector in the form of carcasses, meat and hunting target;
- Swine or domestic pig (denoted pig later on) can be a host and a vector as a living animal or pork product;
- Human (denoted hum. later on) can a be mechanical vector;
- Potential tick vector from *Ornithodorine* family has been described.

Biosecurity in the context of ASF is a strategy to decrease risks of ASF introduction to farm or region and is an important element of veterinary infection prevention (Pejsak, 2017). However, perception and compliance with biosecurity among farmers differ significantly between countries in accordance with their organizational statuses and attitudes. Cultural and behavioral habits of people (which seem to be main factor for the spread of disease (EFSA, 2015)) differ substantially (Dors, et al., 2018). In Eastern Europe fast propagation was mainly due to noncompliance with restrictions (farmers did not care about biosecurity or traded with infected pork for profits (Depner, 2018)) and the same reason could drive the spread of ASF in South-East Asia.

Infectious materials in animal-animal transmission route are: blood, nasal swabs, rectal swabs, vagina swabs, faeces and tissues (OIE, 2019A). Virus remains viable and there is a possibility of long-term stability in some uncooked or undercooked meat products (e.g. up to 6 months in smoked ham (FAO 2013)). ASFV can survive for sustained periods and maintain its infectivity in various environmental conditions such as extreme pH and temperature (Niederwerder, 2019). The diagnostic tool of choice is genetic analysis such as PCR. However, access to laboratories equipped with PCR-equipment and supplies for ASF-primers and arrays is limited (e.g. in Poland till 2018 only one lab could officially perform ASF genetic analysis (Veterinary Inspectorate, 2019). However, now even portable tests are already on the market in China since 2019 (Jie, 2019). More available serological tests (antigen detected from tissue smears or sections by staining e.g. with ELISA) are characterized with low specificity (high false negative results) due to death of animal before developing antibodies (preacute form of disease (OiE, 2019A)). There are mobile versions of these serological tests (Gallardo, 2013) used for example in Africa, Sardine (Cappai, et al., 2018) or China (RingBio, 2019) which could be applied in the field conditions, and PCR test are currently being developed in China (Jie, 2019), (Miao, et at., 2019). However, terrorists may abuse some facilities of already working public or private accredited laboratories in countries which allow for non-registered ASFV molecular diagnosis for private/"scientific" reasons. One can identify possible infection routes (EFSA, 2018), (FAO, 2013):

- WB and pig nose-nose and other (pig) contacts in farm;
- Feeding on carcasses (pig, but WB are not showing cannibalism in normal conditions and feed on other WB only if access to food/proteins is limited (EFSA, 2017));
- Swills/Food scraps/Meat rest-overs and faecal-oral (pig-WB via hum and pig-pig via hum who are feeding animals with contaminated swills);
- Fomites and contaminated environment (pig directly or indirectly via hum);
- Pork supply chain (pig-pig via hum).

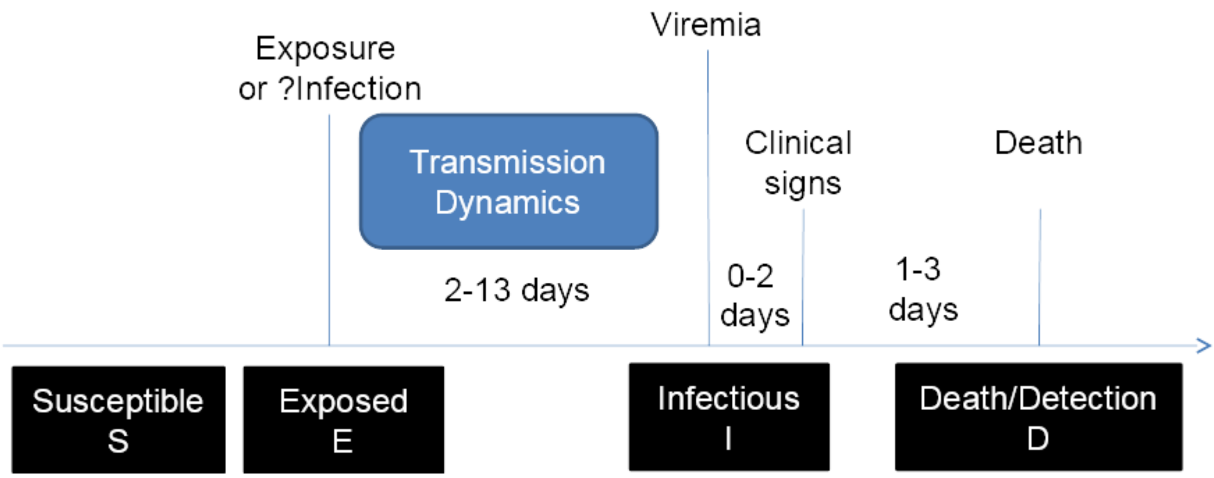

Fig. 2) Pathogenesis of ASF (the presented notation will be used later on)

Plenty of experiments already conducted *in vitro/in vivo* and field observation suggest that disease infectivity is relatively low (which has an impact on potential warfare use), however multiple transmission routes could still cause rapid propagation in totally susceptible population in a "wave" character (Cwynar, et al., 2019). Infection probability and infectious dose differ between various routes of infection. Our current knowledge about ASFV etiology and pathogenesis increased substantially due to EU overall observation (EFSA, 2017), (EFSA, 2018). Contact infectious route based on UK experiments (Guinat, et al., 2014), (Guinat, et al., 2016) in quasi natural farm conditions shows infectivity intra 0.91/day and inter 0.31/day with R_0 (epidemic reproduction rate (Jarynowski, 2011) estimation: around 1.5 (Nielsen, 2017). Inoculation (S-I ~10 days) and injection (E-I ~ 5 days) experiments form The Netherlands and Denmark (de Carvalho Ferreira, et al. 2012), (Olesen, et al., 2017), (Olesen, et al., 2018) suggest 3 day- maximal time period for environmental transmissions, dose dependence in feeding route. German experiments (Pietschmann, et al. 2015) show effect of feeding on carcasses (high infection probability and short incubation period). Longer incubation (S-I ~15 days) period and non-zero recovery probability was suggested in a Spanish experiment

(Gallardo, et al., 2018) and Estonian field observation (Shulz, et. el., 2019). Posterior field studies in Latvian farm outbreak investigation (Lamberga, et al, 2018) and in Russian Federation allow for the calculation of basic reproduction rate: interfarm R_0 <2, intrafirm R_0>3, (Guinat, et al., 2018), (FAO, 2018). Infection probability per social nose-nose contact seems to be in 10-30% range (Shulz, et el., 2019). However, feeding on carcasses and infections from environment are main drivers of propagation (Iglesias, et al., 2019) and they differ significantly among locations (e.g. Europe, Asia), hosts (WB or pigs), etc. There are satisfactory within- or between-farms pigs models (Halasa, et al., 2018) or (Pfeiffer, et al., 2008), and wild boars ecological models (Thulke, et al., 2011), (Taylor, et al.,2019). However, the human factor is rarely integrated in these models (Jarynowski, Belik, 2019A). In conclusion, ASFV infectivity per direct contact is low [Fig. 2] and R_0 does not exceeds 1 significantly (barrier value), but it is easy to transmit by many additional non-direct routes (via eating virus-laden pork or feed, via contaminated farmering/hunting equipment, via flies (Olesen, et al., 2018) or drinking contaminated water (Niederwerder, et al., 2019)). On average, each gram of tissue (e.g. spleen) can contain 10^12 viruses and 1ml of blood (a single drop) can contain 10^8 viruses from infected pig/WB. 50% infectious dose (ID50) (Zimmerman, et al., 2019) for oral track for dry feed is around 10^4 (viruses), but for the liquid feed it is much smaller –10^2. Injective ID50 is even smaller – 10^1 (Niederwerder, et al., 2019). So a single drop of blood could be used to infect 50 million animals (Bloomberg, 2019) without deploying cell line reproduction and other sophisticated virological techniques.

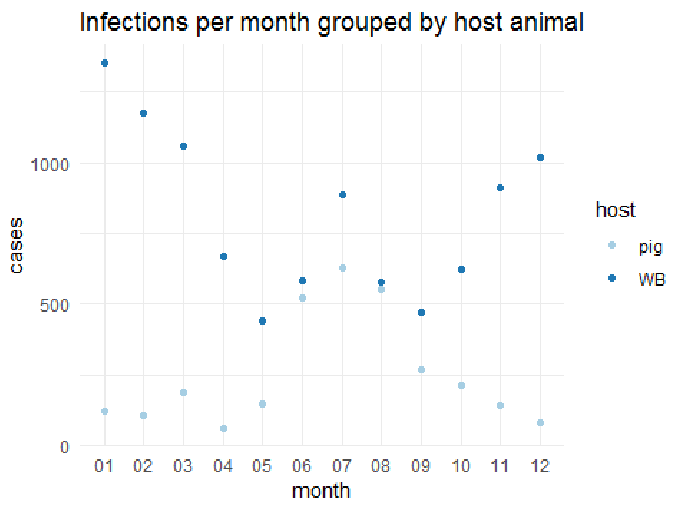

Fig. 3) No. of new cases monthly (crude incidence) with characteristic seasonality for both WB and pigs.

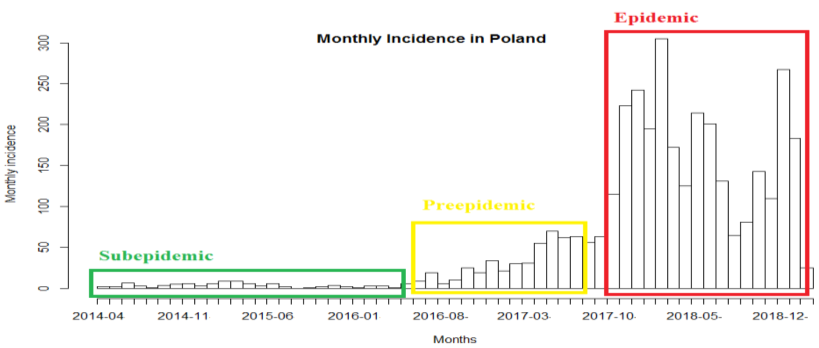

Fig. 4) Time series of no. Of new cases monthly (crude incidence) in Poland with characteristic seasonality and 3 regimes of the spread: “subepidemic”, “preepidemic” and “epidemic”.

Incidence rates were significantly different depending on the month of infection detection [Fig. 3, 4]. The highest incidence rates for domestic pigs were recorded in summer (June, July, August) and small increase is observed in summer and also in winter for WB. However, seasonality in WB could be biased by many factors, such as hunting insensitivity. A summer peak[Fig. 3, 4] in the incidence in pigs could be explained by many factors: intensive workload and workers’ movement due to harvesting season; farmers’ habits with regard to attending forest for recreation (e.g. relax, berry and mushroom picking), role of mechanical vector, i.e. flies (Olesen, et. al., 2018) or ticks in warmer regions (Vial, et al., 2018).

The virus can circulate in domestic pigs only (e.g. China), among wild boar populations only (Belgium, the Czech Republic – already eradicated (OiE, 2019D)) and coexist in both populations (e.g. Poland, Ukraine, Russian Federation). The carcasses and pork products play a role of a long term reservoir of the virus.

There are 2-3 main possible corridors of ASF propagation to Western Europe [Fig. 5, 6] due to environmental and climatic conditions (IBI, 2018), (Veterinary Inspectorate, 2017):

- North path goes via Baltic states and North European Plain;
- South-central path goes via Ukraine and Hungarian plateau and Danube valley (and later to Po valley);
- South path via Moldovan (Galați) corridor to Eastern Balkans.

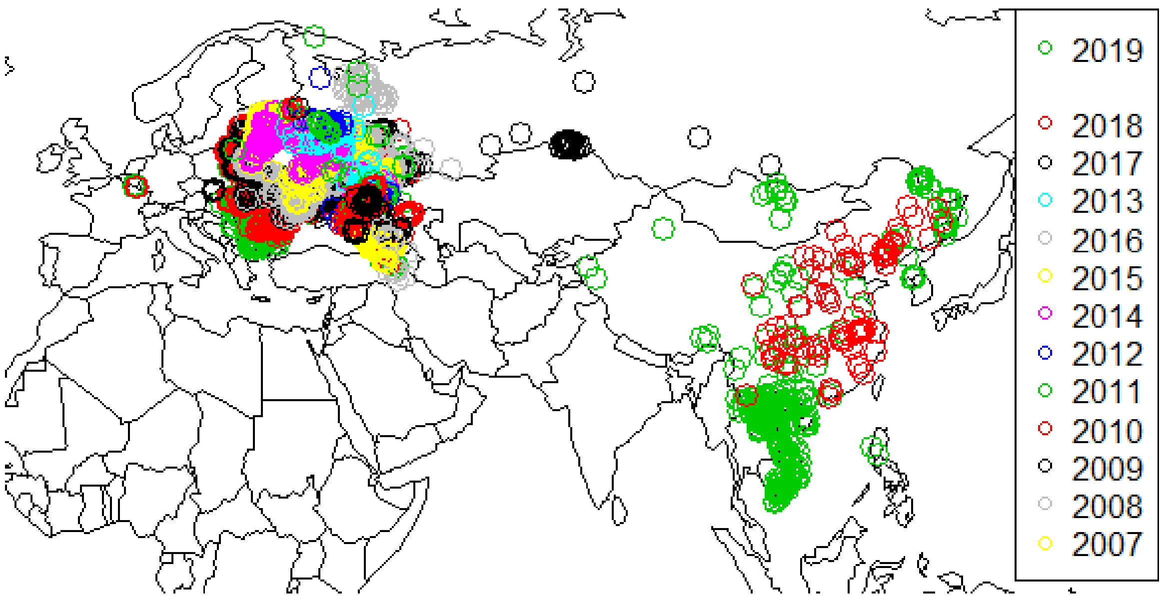

Fig. 5) Clustering of ASF infection notification in geographical space of pandemic Caucasian Genotype II[2] (Notifications till October 2019). Distinguished Northern (Baltic States and Poland),South – central

[2] Non-pandemic strains are endemic in central and south Africa and on Sardinia

(Ukraine trough Hungary and Slovakia), and Southern (Ukraine to Eastern Balkan States) branches in Europe. (colors – years)

There are significant differences between regions which can lead to different propagation scenarios. The main factor for long-term disease sustainability and endemicity is wild boar population. Lack or low WB density in Carpathian Mountains implies that propagation probably has been happening via jumps (such as illegal pork products trade) and along Danube valley (Bartosiak, 2019).

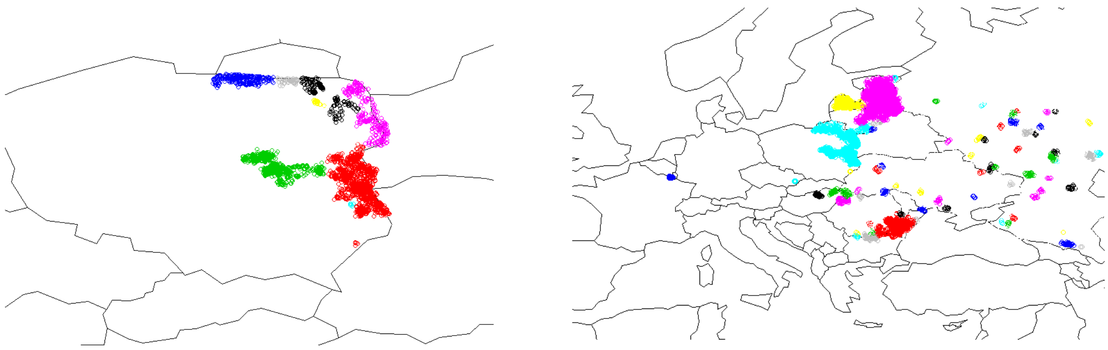

Fig. 6) DBSCAN (Density-based spatial clustering) clustering of infection notification in Poland and Europe (notifications till September 2019)

Besides Caucasus, Southern Europe and South East Asia, there are soft ticks (as Ornithodoros does not exist in most of Northern/Central Europe) which can be a vector of ASF virus (Vial, et al., 2018). In China and the United States pork production chain is less modular (Jayaram, Vickery, 2018) and is more interconnected than in Europe (it could impose a very fast spread, as all 33 Chinese mainland provinces have been affected in less than one year (OiE, 2019C)).

Poland, Hungary and Romania at the front of the wave in Europe, while for example in Baltic States the disease entered an endemic phase (e.g. characterized by a high prevalence of seroconverted living animals due to increased recovery rates states (Shulz, et al., 2019)). Around 30% of the territory of Poland has been affected (in the middle of 2019) and first signs of endemicity were observed in Podlaskie voivodship (Pejsak, Truszczyński, 2019).

The recent eradication of a focal introduction into the Czech Republic (OiE, 2019D) reveals that effective mitigation strategies and optimal protocols for control measures in timing and zoning are available (OiE, 2019B). We observed 2 sites in Poland near Kraśnik and near Łomża without secondary cases, so low contagiousness of the disease with a high mortality rate could lead to natural outbreak extinction in the very early phase of epizootic. However, the expansion of the virus as a wave is still not under control in Europe and Asia (disease transmission to ASEAN countries one by one in 2019). Recent observations in Russia (Iglesias, et al., 2018), Ukraine and Baltic states (Shulz, et al., 2019) suggest a mild form of endemicity of ASF in wild boar population in Europe in next decades, but, in the long term, adjusted biosecurity standards and surveillance could significantly reduce the cost and burden of disease in domestic pigs.

Social conflicting and fear layer

Low biosecurity levels and illegal trade of pigs and pork products is the main reason for rapid propagation in EU neighboring countries and China/Vietnam. ASF has already slightly changed food consumer behavior in Ukraine (shrinking of more than 30% of pork consumption (Pigprogress, 2019B) and dramatically in China by pork consumption reduction (Reuters, 2019A). Big release of Belgian pork on EU market and shortage of pork in China due to ASF caused rapid and unpredicted fluctuation of hog's price (e.g. 1.1 - 1.8 EUR per kg in Poland (Wiadomości Handlowe, 2019)). The intensive fight against ASF in European Union is significantly transforming regulations and ethics, triggering protests of various groups of interest such as farmers, hunters and ecologists (animal right activists). New biosecurity laws and standards (with possible unsatisfactory compliance by small farmers) are resulting in a backlash of farmers against governmental bodies. Many small producers, who could not comply with new biosecurity rules must close their farms or change the production profile or become agricultural workers, often abroad (Pigprogress, 2018). New protest movements are appearing with following social agents: pig breeders' organizations, animal welfare organizations, hunters' organizations and veterinary organizations. ASF in not a zoonosis, so it is not dangerous to people, so many citizens or even infectious disease doctors in affected countries "disregard in dealing with this infection" (LSM.lv, 2014). The genome for the ASF virus is stable, meaning that reasortation and mutations could not easily jump the species barrier (LSM.lv, 2014).

Polish Media example

Public awareness about ASF is low, mainly due to the fact of ASF not being a human disease [Fig. 7, 8]. The topic of ASF in Poland in the media practically did not exist since the emergence of the disease in 2014 until the first outbreaks in pig farms in the summer of 2016. Moreover, the arrival of ASF in Greater Poland (national hub of pig production) may cause social protests on an unprecedented scale in thepost-Soviet Poland .

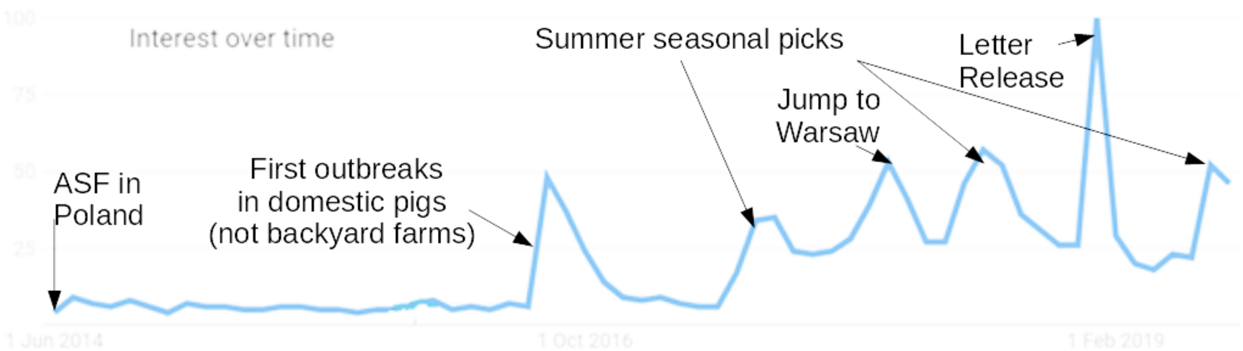

Fig. 7) Google query search trends with scientists' letter release on 9.01.2019 (NaukadlaPrzyrody, 2019) on WB depopulation (ASF phrase in Poland)

Only the presentation of the problem on wild boars and ASF in the open letter of Polish scientists in January 2019 (Conservation, 2019) started a cascade of interest, so the level of attention towards the issue differs over time. Poland has taken drastic but likely ineffective measures (disregarding the science) and massively increased culling of wild boar (Vicente, 2019).

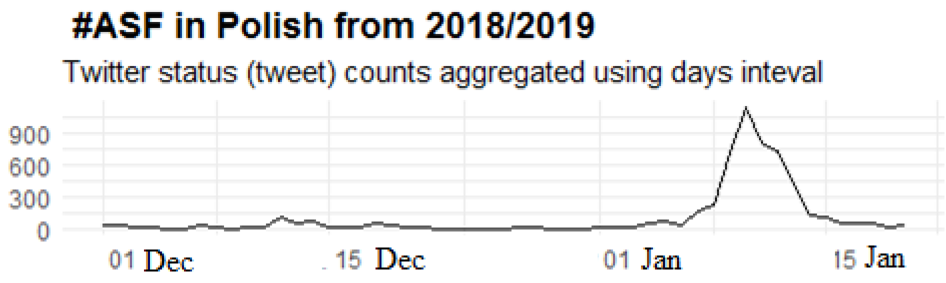

Fig. 8) Daily tweets counts in Polish with scientists' letter release (ASF in Poland)

We have preliminary defined the main agents in Polish media:

- Farmers represented mainly by the Agrounia organization active in social media (e.g. Facebook), which organizes mass protests both in the mild form of happenings (e.g. "throwing meat") as well as hard ones - road blocking.
- Animal rights' defenders, protest movement without an indicated main player, active especially on Twitter and having influencers such as bloggers or streamers. They operate mainly in the area of digital space (e.g. protest letters) and to a little extent in a particularly engaging ways (e.g. blocking hunting and demonstrations).
- Hunters and environmental / veterinary services, movements involved cognitively in the ASF problem, but entangled in conflict often against their will (like hunters implementing government-determined contingents, or underfunded veterinary services that have more responsibilities due to ASF). They organize themselves mainly on all social media platforms like Facebook, Twitter or closed online forums.

It is possible to observe the communication dynamics and the conflict relations between movements. Some farmers blamed veterinary inspection for ASF propagation and even claim that National Veterinary Institute uses it for business purposes which is could be illustrated by the phrase used by farmers: "Pejsak (the most recognized swine veterinarian), Jurgiel (minister of agriculture), two mates, they will cause the end of Polish economy"[3]. Indeed, National Veterinary Institute charged farmers with a higher cost for ASF diagnosis than Friedrich-Loeffler-Institute (National Authority for Animal Diseases) in Germany did (Lubelskie24, 2018) and only recently reduced the cost to less than 20 EUR. Small farmers blamed big international farming corporations (Agrounia, 2019) e.g. Smithfield Foods and Pini Pologne, which can easily meet biosecurity standards and increase production. Misunderstanding of ASF epidemiology among farmers (Agrounia, 2019) and inefficient state response (Vicente, et al., 2019) is leading to polarization between farmers and the state. There is a lot of controversy of possible routes of introduction of the disease to Poland and many farmers believe in a rumor that the first (and few others) infected dead wild boar case in Poland on the border with Belarus was intentionally introduced by "the enemies of Polish economy" (SE, 2018). The possible appearance of political consultancy[4] or foreign intelligence in social media, which could polarize society (Duvanova, et al., 2016), were observed because Twitter accounts, already classified as potentially suspicious (Oko, 2019) were also propagating anti-government content which fueled

[3] Polish original: "Pejsak, Jurgiel, 2 bratanki, koniec Polskiej Gospodarki"
[4] like Cambridge Analytica Ltd. or other

animal right movement [Fig. 9 – yellow colored]. However, ASF had a small effect only on European Parliamentary Election 2019, where the number of notifications correlates negatively with % of votes (adjusted for pig density confounding effect) for currently ruling party in Poland (IBI, 2019B).

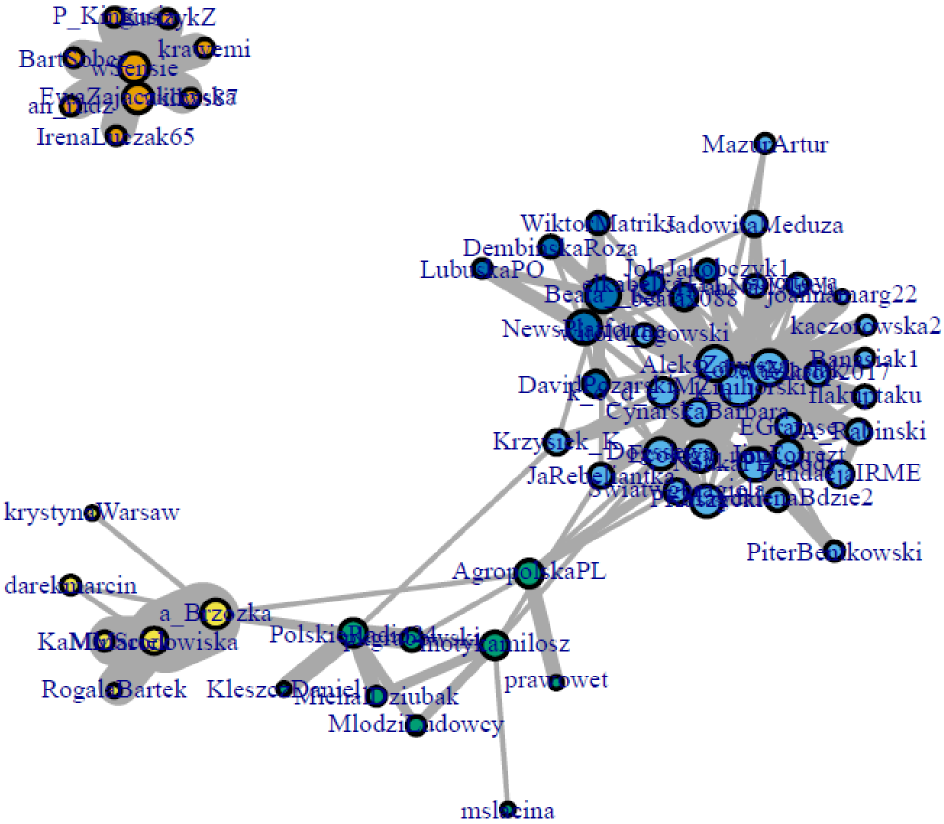

Fig. 9) Network built on 5285 retweets with #ASF with Polish language tagged from 19.12.2018 to 18.01.2019. Nodes are Twitter accounts (threshold for node>10 tweets), link is a retweet. Right wing politicians (orange), Mass media (blue), Animal rights activists (yellow), Farmers representatives (green)

Risk assessment for ASF introduction

Analyzing possible introduction mechanisms is crucial for understanding the spread of the disease , especially because it was recently observed in China and Belgium far away from previously affected regions. Authorities of many countries have started active preparations (WashingtonPost, 2019) in response to the threat that ASF can be introduced to a new territory via (Żuber, 2012), (Elbers, Knutsson, 2013):

- Natural introductions (e.g. WB transmission on the border between countries, which is for example the most likely path from Russia/Belarus to Baltic States (Cwynar, et al., 2019));
- Accidental introductions (e.g. the most likely introduction to Czech Republic via contaminated discharged pork products brought by a Ukrainian hospital worker or waste from trucks in a logistic center (OiE, 2017));
- Intentional disease introductions.

Thus, ASF is a possible biological weapon (Szopa, et al., 2018), due to:

- ease of contagious material collection;
- difficulty to secure many farming sites and forest areas (soft targets (Dugdale, 2005));
- its extremely high virulence;
- multiple transmission route mechanisms;
- its high resistance to inactivation;
- no vaccine and treatment;
- difficulty in post disposal investigation and low treatability due to slow "evolutionary clock" of virus genome (Mazur, et al., 2019);
- devastating impact on pork production.

However, bioterrorism event does not exist in reviewed European national surveillance systems (in contrast to US or Australia for example). In American risk assessment review, bioterrorism is ranked as a fourth most important introduction path of ASF (Brown & Bevins, 2018) and authorities recognize ASF as the main threat in agriculture (Vet Online, 2019C). Thus, United States public administration tries to be prepared for a terrorist introducing such a foreign high-risk animal disease as ASF by formulating surveillance and contingency plan (Gordon, 1986). In Australia, sabotage risk was also examined (Ausvetplan, 2016). Western European authorities seem to underestimate the potential role of bioterrorism in ASF introduction and this issue does not exist e.g. in German (FLI, 2019), British (Defra, 2018), Polish (NIK, 2018), (MRiRW, 2017) official preparedness plans and possibly in other Western European countries. What most of national risk assessments have in common is that probability of introducing ASF by legal trade is almost neglectable (Mur, et al., 2012), (Lu (Y), et al., 2019), so most of attention is focused on illegal human behavior and failing to adhere to restrictions. Focal introductions of ASF are considered to be human-mediated, however, the main interest special groups are usually limited only to:

- hunters because of wild boar hunting tourism;
- truck drivers because they travel long distances throughout Europe and gastarbeiters from affected areas who may inadvertently discard infected meat products.

There are many pro-active approaches like TV spots or leaflets (like Netherlands (NVWA.nl, 2018)), active surveillance on the border (UK, Australia and Japan are permanently collecting positive samples from fitosanitary border controls (Guardian, 2019)).

OIE classification of release (or entry) by exposure routes (Defra, 2018):

- Legal trade in live animals and products of animal origin;
- Illegal trade in live animals or products of animal origin;
- Fomite transmission, transport or other identified routes.

According to current observations, ASF expansion in Europe is ongoing and a forecast for future arrival time can be proposed (Jarynowski, Belik, 2019C) with mathematical modeling and machine learning approaches, where for example the most likely arrival time to Germany is around 2023 and arrival time estimator for Polish counties is publicly available at http://interdisciplinaryresearch.eu/index.php/asf.

Disease is devastating trading networks, permeable land borders and farms with little or no ability to stop the spread in many areas of impact (Ausvetplan, 2016):

- livestock health (health of affected species, including animal welfare);
- trade and economic impact (including commercial and legal impact);
- environmental impact;
- organisational capacity;
- political impact;
- reputation and image.

In countries with high military expenditures (such as e.g. Australia, USA and Russia), bioterrorism gathers high attention (FDA, 2003), (CDC, 2008) with special attention on ASF (Selected Agents, 2019), (Australia Group, 2019), (Voronina, et. al., 2017). However, in the perception of bioterrorism threat it is difficult to distinguish information from disinformation or private opinion from official position (Novosti, 2018). Moreover, lack of bioterrorism training with veterinary/sanitary inspectors in Western Europe leads to misunderstanding of propagation paths projections. For example, Russian epidemiologists suggested 2 main corridors (Northern and Southern), which is obvious according to geography (historical European War Theaters) because of the environmental landscape (Bartosiak, 2019). Moreover, computer simulations are in agreement with such predictions (Mur, et al., 2012), (Jarynowski, Belik, 2017). On the other hand, Western European veterinarians were at least confused with such projections (and some were even suspecting intentional introduction) (Veterinary Inspectorate, 2017).

Taking the calibrated Grunow–Finke Assessment Tool (Chen, et al., 2018) and agricultural outbreak intentionality index (Sequera, 1999), (Roberge, 2015) into consideration, we conducted the risk assessment for intentional ASF introduction [Tab. 1].

Tab. 1) Calibrated Grunow–Finke Assessment Tool and agricultural outbreak intentionality index for ASF introduction in China and Belgium

Introduction	calibrated Grunow–Finke (Chen, et al., 2018)	Agricultural index (Sequera, 1999)
China	17/60 which means around 30% of terrorism likelihood	5/10 (moderate likelihood of agroterrorism)
Belgium	11/60 which means around 20% of terrorism likelihood	4.5/10 (low to moderate likelihood of agroterrorism)

However, the results should be taken with care, because the calibrated Grunow–Finke Assessment Tool was developed for human diseases. Besides risk analysis tools, the rapid surveillance methods are required to detect unnatural epidemic signals (Dembek, 2016) which should lead to security practices through innovative uses of psychology and organizational dynamics to both understand terrorists and train response teams and societies (MacIntyre, et al., 2018).

Bioterrorism and food safety

Chemical, biological, radiological and nuclear defense (CBRN defense) already constitute established protective measures in NATO and AUSCANNZUKUS military alliances (CDC, 2000). We focus on epidemiology of infectious diseases which can be used as biological warfare agents. Identification of CBRN use-related threats and potential enemies, monitoring of threats, and medical intelligence is the domain of military safety (Maciejwski, 2001) due to restoring capabilities resulting from a new type of hybrid war (EP, 2019). However, identification of ASF, sanitary procedures, and managing a crisis are covered mainly by (as veterinary) public health and public administration, so cooperative civil and military training that would bridge security with animal and public health is needed (Bertrandt, et al., 2013).

There are few classifications of potential agents, for instance one by CDC (Centers for Disease Control and Prevention in USA (CDC, 2018)):

A. Highest risk (high infectivity and mortality rates), e.g. Smallpox (Jarynowski, 2014) or Anthrax;
B. Medium risk (moderate infectivity and morbidity rates), e.g. EHEC E. Coli (Weiser, 2016);
C. Unknown risk (unknown infectivity and morbidity rate), e.g. new generic pathogens produced by CRISPR/Cas genetic modification, but also ASF itself due to availability and ease of dissemination (CDC, 2019).

On the other hand OiE used to classify up to 2018 livestock pathogens as (OiE, 2018):

A. Highest risk (the severity of the illnesses they produce and their ease of dissemination, and their high level of transmissibility): with ASFV but also FMD (Foot and Mouth Disease), CSF, Classical Swine Fever (CSF), avian influenza, etc.
B. Medium risk (moderately easy to disseminate and cause moderate diseases with low fatality rates), e. g. brucellosis, salmonella, non-living toxins (ricin and enterotoxin B).

ASFV is the same time a pathogen:

- one of the easiest to obtain (the highest threat) due to reachability of WB carcasses or contaminated pork;
- one the easiest to introduce (the highest vulnerability) due to reachability targeted farms or environmental WB;
- one of the most costly - definitely the most costly within all animal diseases - (the highest consequences) due to devastating effect to Economy (reaching 1% of GDP of affected regions).

Producing biological weapon usually requires advanced theoretical knowledge in the field of microbiology and technological experience in this area (Ura, et al., 2015), even in the era of do-it-yourself synthetic biology (Krzowski, et al., 2017), but it is not the case with ASFV, which can be acquired in sufficient amount directly from the environment (e.g. WB carcasses). ASFV affected meat is harmless to people, but there still are specific food safety hazards which touch developed countries, such as food terrorism (Dzwolak, 2009). In case of intentional ASF introduction, we could additionally classify it as agroterrorism with its economic motives and effects on consumers, producers and agri-food market (Bertrandt, 2007). There have been just a few such confirmed events in the history of the world agriculture (19 in 1915–2000 by according to Monterey), but many more were suspected and never fully confirmed (Kacperska, 2017). Other animal diseases as FMD and CSF also considered possible biological weapon, however, in comparison to ASF, their viral agents are much less available to obtain without a lab and there exist vaccines against them. African Swine Fever virus was suspected to be in the arsenal of Soviet bio-agents (Leitenberg, 2012), but current

Russian or North Korean facilities are undocumented and seem not to play such a significant role after Cold War anymore. ASF was suspected by USSR epizootiologists to be intentionally introduced to Cuba in 1971 (Stegniy, et al. 2015).

Agriculture in the form of, for instance, pig farming is particularly susceptible to attempts by terrorists due to difficulty of protection (Zawojska, 2011):

- wild boars are geographically dispersed in unprotected spaces which facilitates access for terrorists,
- pigs are usually concentrated in often overpopulated farms, which favors the rapid spread of infectious diseases,
- animal pathogens like ASF can be easily isolated from the environment or obtained from illegal or quasi-legal laboratories,
- ASFV is very stable and can remain infectious in meat (but also pieces of death animal) over several months (Juszkiewicz, et al., 2019);
- Front wave character of ASF makes it easier for terrorists to acquire the virus (e.g. in Poland some people make finding WB carcasses the source of income due to availability of dead animals in recently affected areas (Okrama, 2018)), detain it, and transport pathogens without jeopardizing their own health.

There are also limitations of ASF effect to economy and social conflict. Usually, the main expected result of terrorism is not a material one, but causing chaos through hysteria and fear in the affected society (Michailiuk, 2016). In ASF case there is lack of fear on a scale similar to human infectious diseases or food-borne diseases (Lue, et al., 2018). Animal diseases as ASF, which are not zoonosis, do not exist in public awareness, mass culture and media outside of group of interest (Jarynowski, et al., 2019A). However, fear could be induced by "fake news" or "mis-information" on ASF effects on human health in social media by for instance cyberattack (Kasprzyk, 2018).

ASF intentional introduction

Pork production collapse caused by terrorism might be manifested in an economic system through shifts in demand or/and supply curve (mainly via trade restriction), a variability in the price (Rabobank, 2019) as well as in the deadweight loss to the society (Zawojska, 2011). It is not possible to exactly indicate and count small groups, individual criminals and psychopaths who can plan and also commit terrorist attacks (Chomiczewski, 2003). A rational (planned) terrorist chooses an optimal introduction protocol track (confidential) which maximizes the expected utility according to his resources. An irrational (followed by ideology and not instructed by intelligence directly) terrorist could choose suboptimal track of introduction protocol (confidential), conditioned by availability and his imagination of efficiency (which could be driven by media). There are few groups of agents which could be interested in ASF introduction to a disease-free land in times of international/internal instability not seen in Europe since the end of the Cold War (EP, 2019). For example, in USA within FBI's Weapons of Mass Destruction (FBI, 2009) Directorate there exists the Biological Countermeasures bureau identifying such potential groups (Vet online, 2019A). State-supported agro/bio-attacks have declined, but other groups and lone wolfs can also be interested in using ASF as bioweapon due to the ease of use (Keredimis, et al., 2013).

Traditional Terrorist organization or intelligence agencies of conflicted countries (Macltyre, 2018)

There are organizations from countries which could profit from the introduction of ASF to some other countries due to the high economic impact of the disease (as other state-sponsored espionage and bio-warfare programs). They can choose laboratory track with the use of microbiologists and spies working undercover in the societies. For example, the so-called Islamic State - “ISIS” could use Old Testament (Deuteronomy 14, 4-5) and Quran (5:3) meaning of ‘dirty’ for pigs and hit western economy at the same time (state or quasi-state political/religious/nationalist group (Michailiuk, 2009)). Approx. 4000 people (who have joined the so-called ‘ISIS’) live currently in Europe and approx. a million refugees come to Europe yearly, so there is a strong possibility that potential terrorists are among them (Lech, 2017). Some of potential collaborators serve as technicians or scientists in both medicine or veterinary field and could be hired by terrorists. Engagement of criminal cartels and international corporate competitors may be also considered, while ASF trade restriction could cause massive economic losses to affected farming sites, but on the other hand it could greatly handicap disease-free sites. State sponsored organizations could use meat trading market (in corruption susceptible territories) or drop the infected soft ticks off the plane (in humid and hot areas) (Buzun, 2016). The states already affected can manipulate with own WB population movement, to flux infected animals to a new territory (e.g. by driving hunting). Rich organizations could sponsor animal rights defending movements, the so called “useful idiots” to block adequate sanitary state reactions (Buzun, et al., 2019).

Recent form as Lone wolfs or small organizations (Macltyre, 2018)

Some organizations and individuals (Doroszczyk, 2019) with specific interest can profit from ASF introductions (Smith, 2015). Some of their representatives could make a use of the extreme ease of ASF intentional introduction:

- vegans and vegetarians could benefit from pork production disturbance; unemployed or precariat biologists could have much more state-financed work in ecology conservation domain (domestic or foreign animal- and environmental-rights groups/individuals). For example, Animal Liberation Front have conduced to 700 criminal acts worldwide already (Vet online, 2019C). However, ecoterrorists and animal rights have been involved in violence and vandalism rather than “strict bioterrorism” (Keremidis, et al., 2013).
- fanatic Islamists or Zionists influenced by xenophobic ideology could appreciate the collapse of “dirty” pig farming according to some holy scriptures (home-grown violent religious extremists such as self-radicalized residents or foreign radical entities). Religious extremists, who have historically caused mass casualties, may be opposed to western values (Keremidis, et al., 2013);
- anti-government political party would like to benefit from massive protests and country destabilization (anarchist and anti-government extremist groups);
- mass casualty sociopaths (motivations connected with individual mentality disorders).

Conductors of such kind of acts maynot necessarily be professionals in microbiology, so ASF is an ideal germ for them due to ease of usage and availability, so that terrorists can obtain weapon agent and suitable delivery method with very limited resources (Michailiuk, 2016). Isolating and breeding ASFV derived from natural sources could make millions of people to be potential terrorists. However, possible treatability of attack from such scenarios seems not to be very feasible.

ASF introduction control

Intentional ASF introduction, however unlikely, must be considered due to the easiness in comparison to other threats. Current counterterrorism focuses on small groups and lone wolves, so forecasting (Najbebauer, et al., 2008) and thwarting of bioterrorist acts is increasingly more difficult because of irrational psychological factors, but also more urgent, since terrorists have easier access to pathogens like ASF and do-it-yourself biological tools (EC, 2019). Obligatory sanitary inspections on the border should be conducted across suspected individuals traveling from affected areas (e.g. similar to Israel policy). However, interventions with the highest impact and lowest cost should be prioritized and public health early warning systems should assess this issue (Kasprzyk, et al., 2010). Active surveillance like SIGMA Animal Disease Data Model could strengthen European control (EFSA, 2019). Possible counterterrorism could indlude:

- Monitoring over recent development of mobile universal genetics analysers (whose cost starts from 1500 EUR) with possibility to include ASF amplifier on the panel/arrays (not available on the market global market yet – however tested in China, but a few US and European startups have been also working on it);
- Training emergency management and veterinary public health staff in the so called "Animal Health Joint Criminal and Epidemiological Investigations Workshop" and promoting concept of ASF as an economic threat (USDA, 2019), (Veterinary Institute, 2018);
- Monitoring intensive search for WB carcasses in front wave countries requested by strangers (currently mainly Poland, Ukraine and Hungary);
- Assessing several possible smuggling channels in EU (e.g. from Poland to Germany);
- Monitoring the flow of air passengers and selective sanitary inspection according to biological and technological materials (mainly Ukraine, Belarus, Russia in Europe and China, Vietnam and Cambogia in South East Asia);
- Identifying high risk areas – possible targets (e.g. high pig density and forest density);
- Warning veterinarians and local authorities in high risk areas of possible threats of ASF and how to protect herds (Vet online, 2019B);
- Training veterinarian and police/military special agents in common outbreak investigations (Veterinary Institute, 2018), (Vet online, 2019B);
- Advising farmers on informing public administration about any attempt for unauthorized access, suspicious activity or criminal action in their pig farms in potential target territories (Vet online, 2019B);
- Surveillance of entering to forest by image processing and machine learning approaches in potential target territories for unusual behaviour, activities, etc.;
- Securing pig carcasses from being stolen during massive outbreak (Agrointel.ro, 2019);
- Monitoring veterinarian and microbiologist job market for suspicious advertisements;
- Monitoring private and public institutions which allow for paid ASFV molecular diagnosis;
- Monitoring of veterinary and forestry authorities for proper quarantine/restriction measures introduction in ASF-suspected and ASF outbreak zones (to avoid infectious material releases);
- Monitoring activity in legal Internet with artificial intelligence about digital trace (Najgebauer, et al., 2008) according to patterns (searching and queries on ASF diagnosis, WB habitat etc.) (Helbing, 2016);

- Monitoring and improving understanding of topological and dynamic structure of whole food chain (Weisser, et al., 2016), (Lu, et al., 2019);
- Active surveillance in surrounding area if a new ASF case is suspected or shortly after its confirmation due to possible simultaneous spread from non-single seeds of infection (Schirdewahn, et al., 2017).

Procedures prepared after disease identification donot differ between intentional and non-intentional introduction and can be found in many guidelines for ASF specific (Ausvetplan, 2016) or general emergency operations in the face of biological hazard (Trzos, et al., 2017). Collaboration between farmers (biosecurity standards), governmental institutions (veterinary inspection) and hunting associations (WB depopulation) can lead to a significant decrease of the disease impact (Cwynar, et al., 2019).

Conclusions

Permanently ASF-affected countries have lost international pigs and pork market position by relaying more and more on import and even changed their consumption habits (e.g. less than one year of ASF in China probably will cause more problems in "country of Dragons" than trade war with USA (Globalresearch, 2019)). According to Sub-Committee on Security and Defence of European Parliament "Repeated attacks by both State and non-state actors (...), reminds that (…) the European Union is far from being immune to CBRN threats" (EP, 2019). "ASF can be understood as a biological weapon (…) equivalent to bioterrorism[5], said Russian Chief Veterinary Officer - S. Dankvert (Rosselkhoznadzor, 2013). We conclude that rising awareness about the easiness of ASF introduction to a disease-free region (e.g. via bioterrorism/agroterrorism) is an important element of security strengthening. New challenges in public health security such as lone wolf engagement can no longer be addressed within the isolated ivory tower of veterinary medicine, but require cross-disciplinary solutions from other fields (such as e.g. One Health Initiative). The implementation of that change should lead to focus on pathogens, which can be freely available outside professional laboratories and could become a weapon within do-it-yourself biology like ASFV (MacIntyre, et al., 2018). Thereby, the ease of using ASF with the commercial materials only in one's kitchen should be counteracted by hazard monitoring system. Before ASFV, it was extremely difficult for potential terrorists to produce/purchase/steal a strain with given properties, and even "do-it-yourself" synthetic biology (Krzowski, 2017) is far more advanced technologically in comparison with the ease of performing intentional ASF-spread. Billions EUR losses to the targeted economy could be easily achieved with ASFV - "a weapon of mass destruction for the poor" by even single determined person, who is intelligent enough to understand scientific papers or published information in the Internet and skilled enough to apply knowledge in practice.

In particular, despite significant research efforts, analysis and modelling of ASF notification events, and its spatiotemporal epidemiology due to human role are hardly considered, although they are crucial for understanding of the ASF spread. In our opinion, ASF is the only non-zoonotic animal disease, which should be considered in a very short list of biological weapons. Collaboration between veterinary/sanitary and civil/military inspection must be enhanced as well as various experiences

[5] "К АЧС надо относиться как к биологическому оружию, которое несет неотвратимые экономические последствия (…) приравнять к биотерроризму"

such simulation practice must be exchanged (Bertrandt, et al., 2013) for optimal solution finding for such an interdisciplinary problem. Eradication is extremely difficult in WB (Depner, 2018) and difficult in farms (Pejsak, 2017) in a region already affected, so ASF will definitely affect food supply chain of a new country (Kielan, 2019), (Bertrandt, 2009). Intentional introduction could happen on various scales: of a single county (e.g. from Eastern to Western Poland); intracontinental (e.g. from Eastern to Western Europe); intercontinental (e.g. from China to USA). However, an adequate counter-terrorism practice would be very difficult to prepare and to accept by societies.

In this paper, we intend to share our own reflections from infectious disease/epidemiological (epizootic) point of view. Long term persistence in the environment and virus stability (ease of collection of infectious materials), and high case fatality rate, relatively low contagiousness but many infectious routes with no possible treatment and vaccination (difficulty to control it) make the virus (Chanais, et al., 2019) a potential biological warfare.

We show a theoretical model of using ASF as a biological weapon (with feasibility analysis for various potential paths) and an accessible epidemiological analysis with an accent on the indirect costs of the disease (such as trade restriction and conflicting societies). The main idea is to present a protocol for the collection (from carcasses, pork products or culture) / processing (blood, tissue, body pieces preparation) / infecting (injection or feeding WB/pigs) with infectious material. We have identified potential categories of terrorists to be sophisticated intelligence, small organizations and lone wolves. We proposed a few possible dissemination case studies, which do not need to be well prepared and expensive to archive relatively high success rate.

Described ASF introduction problem should be carefully revisited due to new circumstances since a cheap, sensitive and specific portable ASF-detection kit was developed in the middle 2019 in China (Miao, et al., 2019), for proper risk assessment and guidelines preparation for training the public health providers in emergency response in still disease-free territories. Technically, we suggest: building risk maps; supporting biosurveillance, biosafety and biosecurity; monitoring technology development and related radical ideation (GlobalDefence, 2018) in order to develop a plan for decision-makers in a crisis situation (Trzos, et al., 2017). Delaying the introduction time by these measures is also relevant, while the race to develop a vaccine (Barasona, et al., 2018), (Reuters, 2019B) or treatment continues, especially in world leading biotechnological research centres like the most affected country - China (Reuters, 2019C), (Mallapaty, 2019). However, no spectacular breakthrough has observed yet (PigSite, 2019), so in the next few years' perspective, we could only consider preventive measures (AgrarHeute, 2019), (Scientist, 2019). Compliance to biosecurity rules seems to be the main and relatively effective measure to control disease in already affected regions in the long run (Depner, 2018), (Reuters, 2019D).

Most probable and most effective introduction protocols and case studies (appendix of this analysis not attached in this manuscript and available only after authorisation) should be confidential with limited access of authorized bodies, because disclosure of this information could be used to plan an attack without the need of one's own conceptualization (Ludwiczak, 2005).

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