[O40] PARTICIPATORY RISK MAPPING OF AFRICAN SWINE FEVER IN EUROPE – SPATIOTEMPORAL ELICITATION OF EXPERT OPINION

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Summary
African swine fever (ASF) is an internationally spreading viral pig disease with a massive socio-economic impact. Accurate identification of regions with a high risk of ASF introduction is critical for efficient allocation of resources to prevent disease occurrence. Our knowledge of risk factors that inform spatial disease estimates is incomplete, complex and uncertain, thus limiting rational approaches to discerning high-risk regions through strictly statistical or logical means alone. Therefore, we developed a novel participatory mapping system (Participatory risk mapping network for animal diseases, PRMNAD) that exploits efficient cognitive decision-making processes, known as heuristics.

During a study that applied PRMNAD to ASF in wild boar, users were asked to evaluate map-based risk information and the monthly ASF-disease status in Europe, to then choose currently ASF-free regions that were in their opinion at high risk of reporting the disease during the next month. At the end of each assessment period, user selections were validated against the true disease status that emerged.

We found that person-based PRMNAD selection of ASF high-risk regions outperformed an entirely random or distance-to-disease informed selection model, suggesting that PRMNAD considers indeed additional potential disease risk classifiers.

PRMNAD explores regionally and timely explicit disease classification methods at the interface of social sciences and epidemiology. PRMNAD provides accessible expert opinion, facilitates the identification of disease risk factors and examines efficient heuristic disease spread classification strategies to inform modelling of complex animal disease spread.

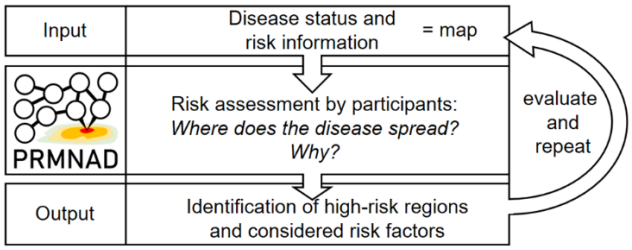
Introduction
Since its re-incursion on the European continent in 2007, ASF has continuously spread in an unprecedented manner. Each year the disease has moved along for kilometres and invaded previously disease-free territories (1,2). This worrying situation requires frequent and instantaneous decision-making by local authorities and stakeholders to implement adequate and efficient ASF control. These decisions have to be made in regards to resource allocation for surveillance efforts and implementation of prevention and control measures, such as fencing or searching and removal of wild boar carcasses. Detailed anticipation of ASF spread in the near future forms the basis of risk-based disease management. Assessing the risk of disease dissemination in a spatially and timely explicit manner would allow the design of efficient control strategies that could be tailored to a locally relevant context.

To assess future ASF spread and to determine currently disease-free regions that are at high-risk of ASF incursion a comprehensive knowledge of ASF risk factors is essential. ASF susceptible European wild boar are a mobile and dispersed wildlife species that play an important role in the short distance dissemination and persistence of ASF in Europe (3,4,5). Therefore, in areas where wild boar are present, risk factors related to their biology and behaviour need to be considered for the assessment of ASF spread. Many additional, potential ASF risk factors have been considered previously, including disease aspects of the environment, host, animated or unanimated vectors and risk factors in relation to the pathogen itself (6,7,8,9,10,11). Yet, our knowledge of complex ASF risk factors is imprecise and incomplete, making it difficult to apply to a local disease context in a timely and spatially explicit manner (10). Similarly, in the absence of reliable risk factor information, utilising a conventional process of systematic expert opinion elicitation to determine the regional disease risk status for ASF would involve complex and time-consuming processes (12).

Here, a ‘Participatory risk mapping network for animal diseases’ (PRMNAD) is presented to rate applicable risk factor information and facilitate local disease management decision-making by capturing individual, spatio-temporal risk assessments from persons with expertise in disease-related knowledge areas. In this study, PRMNAD was applied to examine the currently ongoing spread of ASF in wild boar in Europe.

Materials and Methods
PRMNAD used spatially- and timely-explicit case report data to map the disease status of pre-defined 10 x 10 km grid regions. A grid cell was considered diseased, if a case was reported within it. The regional disease status was then combined with potential disease risk information to create an interactive map that was presented to PRMNAD users for selecting regions with a high risk of ASF occurrence. Figure 1 provides a schematic illustration of the PRMNAD system.

Figure 1. Concept of the Participatory risk mapping network for animal diseases (PRMNAD).



The users of the system recorded their selected high-risk regions and important underlying disease risk factors that they had considered for each selected region. The study was conducted in monthly time steps or assessment cycles. At the beginning of each month, disease and risk information was updated on the map and the map subsequently provided to the users for selection of high-risk regions and reporting of relevant associated risk factors. By the end of the month, user predictions were compared with the truly emerging disease status. During user recruitment, information about the professional background and experiences of the users was collected by questionnaire. Overall, the study period covered 19 months.

The map-based risk assessment tool for this study was implemented in the statistical programming language R, version 3.6.3 (13) with the 'sf' (14), 'tmap' (15) and 'leaflet' packages (16). The disease status was created with ASF case reports from the Animal Disease Information System (ADIS) of the European Union and the World Animal Health Information System (WAHIS) of the World Organisation for Animal Health (OIE). Potential disease risk information was identified by literature review (11). The required information was organised in selectable layers of the mapping tool, by combining customised geospatial land cover information from CORINE Land Cover (17), OpenStreetMap (18) and GlobCover 2.3 (19), based on the 10 km reference grid of the European Environmental Agency.

To assess the performance of PRMNAD in comparison to stochastic disease spread prediction, a model was constructed to simulate the PRMNAD system and help examine strategic selection mechanisms applied by human PRMNAD users.

Results
During the study period, 21 active participants validly contributed 931 individual regional risk assessments for the occurrence of ASF in wild boar to PRMNAD. Expertise of the participating users collectively covered veterinary medicine, epidemiology, geospatial analysis, networks, parasitology, wild boar biology and machine learning, with the majority having prior experiences working with ASF. The users reported that they spent around 1 to 2 min on their decision to select a single high-risk region.

Of the 931 validly predicted high-risk regions, ASF wild boar cases were reported the following month in 173 (0.185) regions. Users reported nearness to disease and forest connectedness as some of the most frequently considered risk factors for their decision-making.

Examination of PRMNAD performance with a stochastic model revealed that person-based PRMNAD selection of ASF high-risk regions outperformed an entirely random selection model by about 163-fold (geometric mean (GM), range 20 – 358-fold) and a distance-to-disease informed model still by about 26-fold (GM, range 3 – 51-fold).

Discussion
PRMNAD integrates spatio-temporal animal disease reporting data with potential risk factor information through an interactive mapping format to facilitate participatory evaluation of disease spread risks. Here we developed and demonstrated the PRMNAD concept and examined the current ASF epidemic in Europe during a 19-month study in 2020 and 2021.

We show how PRMNAD could be widely implemented to access and report spatially explicit expert opinion, but also how PRMNAD creates opportunities to rate and examine disease risk factors and disease spread prediction strategies for the complementation of conventional statistical or stochastic disease modelling.

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Acknowledgement

The authors thank all participants of this risk mapping study for lending their time and expertise to conduct monthly risk assessments, and for providing valuable feedback to help improve and develop the risk-mapping tool. Landcover data from the European Space Agency and the ESA Globcover Project 2005 led by MEDIAS France/POSTEL were used. Some map data is copyrighted to OpenStreetMap contributors and available from https://www.openstreetmap.org. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773701.