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Model for ranking freshwater fish farms according to their risk of infection and illustration for viral haemorrhagic septicaemia

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ABSTRACT

We developed a model to calculate a quantitative risk score for individual aquaculture sites. The score indicates the risk of the site being infected with a specific fish pathogen (viral haemorrhagic septicaemia virus (VHSV); infectious haematopoietic necrosis virus, Koi herpes virus), and is intended to be used for risk ranking sites to support surveillance for demonstration of zone or member state freedom from these pathogens. The inputs to the model include a range of quantitative and qualitative estimates of risk factors organised into five risk themes (1) Live fish and egg movements; (2) Exposure via water; (3) On-site processing; (4) Short-distance mechanical transmission; (5) Distance-independent mechanical transmission. The calculated risk score for an individual aquaculture site is a value between zero and one and is intended to indicate the risk of a site relative to the risk of other sites (thereby allowing ranking). The model was applied to evaluate 76 rainbow trout farms in 3 countries (42 from England, 32 from Italy and 2 from Switzerland) with the aim to establish their risk of being infected with VHSV. Risk scores for farms in England and Italy showed great variation, clearly enabling ranking. Scores ranged from 0.002 to 0.254 (mean score 0.080) in England and 0.011 to 0.778 (mean of 0.130) for Italy, reflecting the diversity of infection status of farms in these countries. Requirements for broader application of the model are discussed. Cost efficient farm data collection is important to realise the benefits from a risk-based approach.

1. Introduction

An environment where animals can be grown with a low risk of losses due to the occurrence of animal diseases is beneficial for agri- and aqua-culture and eventually benefits society as a whole. Competent authorities (CAs) take

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a role in achieving and maintaining a high animal health status through a range of activities, including surveillance. In times of limited resources, there is an increased need to develop cost saving surveillance methods.

A recent review of risk-based methods for fish and terrestrial animal disease surveillance (Oidtmann et al., 2013) found that although risk-based surveillance (RBS) approaches are applied in the design or assessment of a number of terrestrial animal diseases, there are few examples of risk-based approaches applied to aquatic animals (Oidtmann et al., 2009, 2011c; Kleingeld, 2010; Diserens et al., 2013), or scenario tree modelling approaches for the evaluation of surveillance systems (Oidtmann et al., 2008; Lyngstad et al., 2011).

The European Council Directive 2006/88/EC (Anon, 2006) on aquatic animal health requires that risk-based animal health surveillance is applied to aquaculture production businesses (APBs) in the EU. The frequency of inspections should take account of the likelihood that the fish farm may contract and spread disease, thus the risk must be assessed for each APB. Five disease categories (not to be confused with risk categories) for countries, zones or compartments are defined by the Directive: Category I—approved pathogen-free status; Category II—not declared disease-free, but subject to a surveillance programme to achieve disease-free status; Category III—infection status is unknown; Category IV—subject to an eradication programme, and Category V—where some farms (but not necessarily all) are known to be infected. Since there are multiple notifiable fish diseases, a single APB may be in multiple disease categories (e.g. in Category I for viral haemorrhagic septicaemia (VHS), and Category IV for infectious haematopoietic necrosis (IHN)). The Directive requires that a risk-based approach is used for both disease surveillance (article 10 of the Directive) and compliance inspections (article 7) for all disease categories. This paper presents a quantitative model to rank fish farms based on the likelihood of disease introduction. The model can calculate the risk of introduction for both freshwater salmonid and cyprinid pathogens. Parameter estimates for 3 freshwater fish diseases listed by European Council Directive 2006/88/EC, VHS, IHN, and Koi herpes virus disease (KHD) were obtained through an expert consultation (Oidtmann et al., in press). We also present the application of the model for VHS, in three geographic regions. VHS was chosen for this case study as it is one of the most important viral diseases of freshwater farmed rainbow trout (*Oncorhynchus mykiss*) in Europe (Smail, 1999), and is responsible for estimated annual production losses of 20–30% (Baruchelli et al., 1990). VHS virus (VHSV) is a rhabdovirus, genus Novirhabdovirus, and four genotypes of VHSV are recognised based on nucleic acid sequencing (OIE, 2012), which are broadly associated with geographic location. In Europe, the disease became of relevance with expanding rainbow trout aquaculture. Historically, VHSV genotype Ia was detected in most EU member states (MS). VHS is listed in EU legislation (Anon, 2006) and EU MS can, through surveillance and biosecurity measures, demonstrate freedom and restrict imports of live susceptible fish species to regions with the same health status. VHS is absent from the UK and a number of geographic zones throughout the EU. Denmark recently succeeded with the eradication of the disease from most of its territory (Anonymous, 2013; Bang Jensen et al., in press). The expected benefits of freedom from the virus include, a more productive and less disrupted (due to absence of disease control measures) rainbow trout aquaculture, and access to wider markets. VHSV remains a continued threat to trout production in Europe. Recent notifications of VHSV detection in EU MS are shown in Fig. 1.

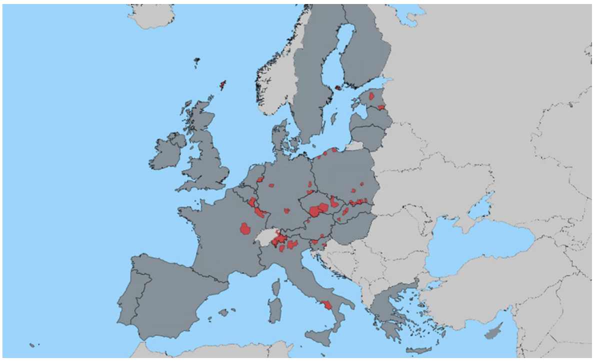

Fig. 1. Viral haemorrhagic septicaemia virus (VHSV) in Europe: Areas shown in red were reported as infected with VHSV by EU member states (EU MS) to the Animal Disease Notification System (ADNS; http://ec.europa.eu/food/animal/diseases/adns/adns_en.htm) during time period 1.1.2010–19/03/2013. ADNS is a notification system designed to register and document the evolution of the situation of important infectious animal diseases in EU MS.

We previously presented a model for risk ranking of farms for pathogen introduction and spread for freshwater salmonid fish farms (Oidtmann et al., 2011c). The model presented here develops this methodology further by revising its structure, extending its application to a broader range of fish diseases, using parameter estimates derived from a wider expert consultation exercise, and having a stochastic functionality.

2. Materials and methods

2.1. The model

The purpose of the model is to calculate a risk score for individual aquaculture sites. The score indicates the risk of the site being infected with a specific fish pathogen (VHSV, IHN virus (IHNV), Koi herpes virus (KHV)), and is intended to be used for risk ranking sites to support surveillance for demonstration of zone or member state freedom from these diseases. The model inputs include a range of quantitative and qualitative estimates of risk factors organised into five risk themes: (A) Live fish and egg movements; (B) Exposure via water; (C) On-site processing; (D) Short-distance mechanical transmission; (E) Distance-independent mechanical transmission (Table 1). The estimates are based on location (relative to potential sources), pathogen introduction pathways, and biosecurity practices of the farm site being assessed. Farm data are based on site records and site inspection.

For each theme, a risk score between zero and one is calculated as described in Appendix A. The final risk score