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A MODEL FOR QUANTITATIVE ASSESSMENT OF QUARANTINE RISKS FROM INTERNATIONAL TRADE IN LIVESTOCK PRODUCTS

Roe R.T.[1], Cannon R.M.[2]

Ce document propose un modèle généralisé d'évaluation précise des risques de quarantaine dûs à l'importation de bétail et produits dérivés de bétail. Le modèle proposé surmonte les restrictions du modèle du Code pour la Santé des Animaux de l'Organisation Internationale des Epizooties concernant l'importation des animaux. Le sujet de discussion porte sur l'application et les restrictions de l'évaluation quantitative du risque. Dans beaucoup de cas l'application des techniques de mesure du risque sera limitée par l'information disponible pour établir une estimation des paramètres de base. Le risque relatif d'un agent de maladie comparé à un autre et d'importation d'un pays à un autre peut être évalué même quand le risque absolu ne peut être évalué faute d'information.

INTRODUCTION

The OIE Animal Health Code chapter on "Import Risk Analysis" contains guidelines on the conduct of risk assessments. These guidelines refer to the risk associated with the importation of a commodity in its usual commercial form as the unrestricted risk estimate. This unrestricted risk estimate (R) is calculated as the product of the probability of agent entry (*PAE*) and the probability of disease establishment (*PDE*) in the importing country:

$$R = PAE * PDE$$

The guidelines define the probability of agent entry (*PAE*) to be a function of country factors (F_1), commodity factors (F_2) and the number of animal units (n) imported by the relationship

$$PAE = 1 - (1 - F_1 * F_2)^n.$$

Care is needed in applying the OIE approach since the term *PAE* is used differently in the two equations. The first equation is applicable to the risk associated with the importation of a single animal. The second equation provides an adequate estimate of the probability of agent entry with the importation of a number of animals. However, it is possible that the agent might enter more than once and so the value for *PAE* cannot be inserted into the first equation. The unrestricted risk from the importation of n animals is given by

$$R = 1 - (1 - F_1 * F_2 * PDE)^n.$$

The development of a model for assessing the risk of agent entry and disease establishment from the importation of a number of animals, or of product derived from a number of animals, is the subject of this paper.

AN ALTERNATIVE RISK ASSESSMENT MODEL

Suppose the probability that a disease agent of quarantine concern will be introduced with the importation of product from a single animal is P_1 and the probability, given product from an infected animal is imported, that a susceptible animal will be exposed to the agent resulting in a disease outbreak is P_2. Then the probability that an agent of quarantine concern will be introduced with product from a single animal and result in a disease outbreak is $P_1.P_2$. The probability that the importation of product from one animal will not result in an outbreak of disease is $1 - P_1.P_2$. The probability that imported product from none of n animals will result in an outbreak of disease is $(1 - P_1 P_2)^n$. The probability that the importation of product from n animals will result in at least one disease outbreak is therefore:

$$1 - (1 - P_1 * P_2)^n.$$

In this model P_1 corresponds to the "probability of agent entry" and P_2 to the "probability of disease establishment in the importing country" of the OIE model, although here the probability of establishment is taken to be the probability that product from one infected animal imported into a country will result in a disease outbreak.

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[1] Australian Quarantine & Inspection Service, PO Box 858, Canberra ACT 2601, Australia
[2] Bureau of Resource Sciences, PO Box E11, Kingston ACT 2604, Australia

The risk of introduction and establishment of a particular disease from a tonne of imported product is a function of :

p, the probability that the disease is present but undetected in the source herd or flock at the time of slaughter. This is discussed later but will be influenced by:
- the incidence of the disease in the source country;
- disease control and public health inspection policy and practices in the source country; and
- the incubation period of the disease.

c, the probability, given the source herd or flock is infected at the time of slaughter, that the disease agent is present in the tissues of the dressed carcass. These **commodity factors** are dependent on the predilection sites of the disease agent but could be varied by risk management procedures such as deboning.

a, the probability, given the disease agent is present in the dressed carcass, that it will persist through storage and transport. This is influenced by **agent factors** such as the disease agent's resistance to post mortem pH changes and to physical factors such as chilling or freezing. This probability could be varied by risk management procedures such as cooking.

e, the probability, given an infected carcass is imported, that a susceptible host will be exposed to an infective dose and initiate an outbreak. Again this probability could be varied by risk management procedures such as post-arrival processing or controls on use. These **importing country factors** would be dependent on:
- the use and distribution of the imported product;
- food scraps containing an infective dose being fed to back yard or pet animals or birds or the disposal of waste on tips to which feral animals or free-flying birds have access; and
- the agent being infective per os.

n, the number of animals making up one import unit (a tonne) of the product.

A model can thus be constructed of the risk of one or more disease outbreaks from the importation of a tonne of animal product as

$$RISK = 1 - [1 - (p.c.a.e)]^n.$$

In turn the probability, *p*, defined above, is a function of
- the probability that a herd/flock is infected;
- the proportion of infected herds/flocks in which the disease is not detected prior to turn-off; and
- the proportion of animals in the herd/flock that are infected at the time of slaughter.

The method of estimating p will depend on the data available, but in general will be along the lines:

$$p = (o/t).(i/d).f$$

where

- *o* - expected number of disease outbreaks in the source country per year;
- *t* - number of slaughter lots turned-off per year either obtained directly or estimated by dividing the annual turn-off by the average slaughter lot size;
- *i* - number of days animals are infectious prior to detection of an outbreak;
- *d* - average turn-off age in days; and
- *f* - prevalence of disease in an infected herd/flock prior to detection.

Where more than one disease is identified as being of quarantine concern, the risk of disease introduction with the importation of an animal product can be calculated for each disease as r_1, r_2, ... r_i and the overall quarantine risk with importations of that product from the country is then

$$R_A = 1 - (1-r_1)(1-r_2).....(1-r_i).$$

If these individual disease risks are very small this can be taken as

$$R_A = r_1 + r_2 + ... + r_i.$$

The proportion of animals in an infected herd/flock that are infected will largely be influenced by the epidemiological behaviour of the disease under consideration, but may also be affected by country factors, such as the likelihood of the disease being detected at an early stage before the animals are slaughtered.

The probability of exposure and disease establishment will be influenced by the use and distribution of the imported product, which will be independent of the disease of quarantine concern under consideration, and also on epidemiological characteristics of the disease, such as the survival of the agent and its infectivity by oral exposure.

The volume of imports of product, if permitted, would be determined by the terms of trade and is difficult to forecast. The risk is most conveniently calculated in terms of the risk per unit of importation, such as per tonne of imported animal product. Where this risk is low, the quarantine risk increases linearly with increasing volumes of imports.

DISCUSSION

There are a number of limitations that act to constrain the application of quantitative methods in quarantine risk analysis. In particular, data limitations are likely to be encountered in areas such as:

- level of agents of quarantine concern in the tissues of naturally infected hosts;
- persistence of these agents in tissues during processing and storage of the product; and
- infective dose-response by oral exposure of susceptible species.

One approach to uncertainty in relation to factors relevant to estimation of quarantine risk with a particular importation has been the use of probabilistic models. This approach has been aided by the availability of software packages, such as @RISK (Palisade Corp.) and Crystal Ball (Decisioneering Inc.), for stochastic modeling of risk. Probabilistic models are an appropriate way of taking account of variation in input factors where information is available to permit some estimate to be made of the distribution of the parameter. However, they are not able to compensate for an absence of knowledge about the level or distribution of a factor. The construction of a probabilistic model that uses a series of triangular distributions encompassing a wide range between the possible maximum and minimum values will result in a very broad range of possible outcomes which is of no more value to the quarantine decision maker than advice based on a well conducted qualitative assessment of the risk. The use of probabilistic models to deal with uncertainty may mask the real effect of variability that may exist in some input parameters.

In the absence of data on which to base an estimate of the distribution of risk factors, it is suggested a more appropriate approach is to use a deterministic model. Repeating the assessment, using a range of values around the estimated likely value of an uncertain parameter, the sensitivity of the analysis outcome to the parameter can be determined. Where the outcome is insensitive to variation in an uncertain parameter, the quarantine decision maker can have confidence in the results of the analysis. However, where the outcome of the analysis is sensitive to the assumed possible range of an uncertain parameter a conservative approach should be taken until work is done to further elucidate the distribution of the particular parameter. Having conducted a preliminary assessment using a deterministic model a further assessment using a probabilistic model could then be done when further data has been obtained on which to base the probability distributions of parameters to which the model has been shown to be particularly sensitive.

Even where the risk of introduction and establishment of a disease agent of quarantine concern can be quantified, a quantitative risk assessment does not provide an answer to the question of whether or not importations should be permitted. There is still a need to determine whether the assessed level of risk is acceptable. The "acceptable risk" will vary between diseases of quarantine concern depending on the consequences of their entry and establishment. Factors such as the likelihood of spread of the disease from the initial outbreak, potential impact of the disease in terms of both the economic and environmental consequences and the ease of eradication of the disease once established should also be considered in deciding whether importation of the particular animal or animal product should be permitted and the risk management strategies that should be adopted.