'To Hazard or Not to Hazard, That is the Question': How Unknowns in Science Affect the Identification of Hazards in an Import Risk Analysis

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ABSTRACT

The process of hazard identification, in the context of an import risk analysis (IRA), involves the recognition of disease agents and pests that could be associated with trade in a commodity. For a pathogen to be classified as a potential hazard the following criteria should be met. The pathogenic agent should be: 1) appropriate to the imported commodity; 2) capable of producing adverse consequences in the importing country; 3) likely to be present in the exporting country; and 4) exotic to the importing country, or, if present, be subjected to mandatory control or eradication measures. Hazard identification is, in essence, a decision-making process resulting in the classification of a pathogen as 'a hazard' or 'not a hazard'. A pathogenic agent determined not to be a hazard is not considered further in an IRA. In this regard, the analysis must be transparent by providing clear reasons for the exclusion or the inclusion of a pathogen. However, it is often the case that the data available on a pathogen is incomplete or inconclusive, yet value judgements (and justifications) must still be made by analysts as to whether the above criteria are met. This paper discusses various solutions to tackling uncertainty and lack of knowledge in the identification of potential hazards, using Australia's current import risk analysis on non-viable bivalve mollusc as a practical example.

INTRODUCTION

Hazard identification - the scientific process of recognising pathogenic agents that may be introduced with the importation of a commodity - is a dichotomous process. A pathogenic agent is either classified as a 'hazard' or 'not a hazard', based on certain criteria. A pathogenic agent that is determined 'not a hazard' is not considered further in an import risk analysis (IRA). Those agents identified as 'hazards' are further analysed to determine more precisely the probability of establishment in the importing country and the resulting impacts, i.e., the overall 'risk'.

According to the *OIE Code* (OIE, 2000a), for a pathogenic agent to be identified as a potential hazard, it should comply with all of the following criteria:

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- the pathogenic agent should be appropriate to the animal species to be imported, or from which the commodity is derived;
- the pathogenic agent could produce adverse consequences in the importing country;
- the pathogenic agent may be present in the exporting country; and
- the pathogenic agent should not be present in the importing country. If present, the pathogenic agent should be associated with a notifiable disease, or should be subject to control or eradication measures.

In keeping with international obligations, the analysis should be transparent. Scientifically justifiable reasons must be given so that the exporting country is provided with clear and documented reasons for inclusion of an agent as a hazard in an IRA. In this regard, the quality and confidence of the decision is reliant on the scientific information on which it is based. For example, information on host range, geographic distribution, taxonomic affinities between related species/strains and the pathogenicity of an agent are fundamental to applying the above criteria; yet with regard to many aquatic animal pathogens, these aspects remain poorly understood.

This paper will discuss how these matters are dealt with in the practical conduct of an IRA, where decisions must be made and justified (consistent with international obligations) in spite of the unavailability of relevant scientific information. Biosecurity Australia communicates the information and opinions regarding hazards in a Technical Issues Paper. The Technical Issues Paper for Australia's IRA on non-viable bivalve molluscs has recently been released for stakeholder comment (Biosecurity Australia, 2002) and is used here as a practical example.

WELL RESEARCHED VS POORLY RESEARCHED PATHOGENIC AGENTS

Where a disease agent is well researched, hazard criteria may be readily applied. For example, *Haplosporidium nelsoni*, the aetiological agent of MSX disease in Eastern oysters (*Crassostrea virginica*), has attracted significant research effort over the past few decades and continues to do so. The pathogen has not been recorded from Australia; is known to cause mass mortalities of *C. virginica* on the East Coast of North America; naïve hosts are susceptible to disease; historical evidence suggests that the disease has spread via stock translocations (Burreson *et al*., 2000) and the disease continues to spread into new geographic areas (ProMED-mail, 2002). On this basis, *H. nelsoni* has been considered a hazard in Biosecurity Australia's non-viable bivalve mollusc IRA.

The task of hazard identification becomes difficult when making decisions on pathogens where gaps exist in the knowledge available. Lack of knowledge on a disease agent may be due to the pathogen not attracting a great deal of research interest or research support. In general, the knowledge available on bivalve mollusc diseases largely reflects the importance of bivalve aquaculture in various regions and the availability of expertise to diagnose or study disease. In Africa, the former Union of the Soviet Socialist Republics, Asia and Central and South America, the health status of bivalves is almost totally unknown or unreported. In addition to this, many aspects of some bivalve diseases remain poorly understood despite concerted research efforts. For example, despite several decades of active research, the complete lifecycle of the protozoan parasites belonging to the genera *Haplosporidium* and

Marteilia remain unknown. The inability to conduct experimental infections in the laboratory prevents studies on the range of hosts that may be potentially susceptible to these pathogens.

Information available on disease agents that are well researched does, however, allow for valued assumptions to be made when considering related disease agents that have not attracted a great deal of research interest. The following case history is provided. *Haplosporidium nelsoni* is known to infect Eastern oysters and Pacific oysters (*Crassostrea gigas*). While the pathogen is highly pathogenic to Eastern oysters, it has only been recorded at very low prevalence in *C. gigas* and has little apparent effect on this host. All available evidence suggests that *H. nelsoni* was introduced to the East Coast of the United States via stock translocations of *C. gigas* from Asia, where the pathogen switched hosts into the naïve Eastern oyster species in which it is pathogenic (Burreson *et al*., 2000). On this basis, it was considered justifiable in the *Technical Issues Paper* to consider all *Haplosporidium* species to have similar characteristics and therefore be potentially pathogenic to naïve bivalve species in Australia (thereby meeting hazard criterion 2), even in cases where the Haplosporidium species is not reported to cause disease. Thus, *Haplosporidium tapetis* in clams in Europe is considered a hazard, even though the pathogen has not been reported to cause serious disease (Chagot *et al*., 1987; Figueras *et al*., 1992).

ERRING ON THE SIDE OF CAUTION

Interpretations and parallels that are drawn from relevant circumstances and experiences are certainly valuable in allowing analysts to make decisions in the absence of information. However, the confidence that can be placed on these assumptions must be determined. This is true for any scientific process. For example, data presented in scientific papers are accompanied by error bars, indicating the level of confidence that can be placed on the knowledge gained. Uncertainty in knowledge becomes all the more crucial where the consequence of a decision arising from that information may be significant, such as the introduction of a disease. As such, suitably cautious interpretations have to be made. If the missing information is critical and the consequences severe, then one should err on the side of caution until further information is made available.

For example, *Bonamia exitiosus* occurs in dredge oysters in New Zealand (Hine, 2001). A species of *Bonamia* also causes significant problems in Australian flat oyster populations and it has long been presumed that the two are the same species, although definitive taxonomic studies have not established this. If the two *Bonamia*'s are considered to be the same species, *B. exitiosus* cannot be considered a hazard as it does not meet criterion 4. However, recent evidence has revealed some differences in the histopathology of the New Zealand and Australian *Bonamia*'s (J. Handlinger, pers. comm.). Therefore, if one was to err on the side of caution, B. exitiosus should be considered a hazard that is separate from the Australian species until studies have confirmed that they are the same.

The practice of applying conservative judgment is a subjective procedure, however, it is one that a country is allowed to do in keeping with international rights and obligations. The degree to which a country chooses to err on the side of caution is a reflection of the level of biosecurity that country chooses to apply to trade. The IRA process and methodology remain unchanged, but decisions must meet safeguards that are put in place to ensure that negative

trade affects are minimised (e.g., the *SPS Agreement*[1] condition that refers to consistency in risk management).

Reasonable decisions and poodles in bananas

In justifying erring on the side of caution, judgements must be reasonable and not extremist. The cartoon by Gary Larson provides a comical reminder of what is unreasonable in making decisions (Fig. 1). Certainly a country exporting bananas would consider it unreasonable for an importing country to list poodles as a hazard in a banana IRA.

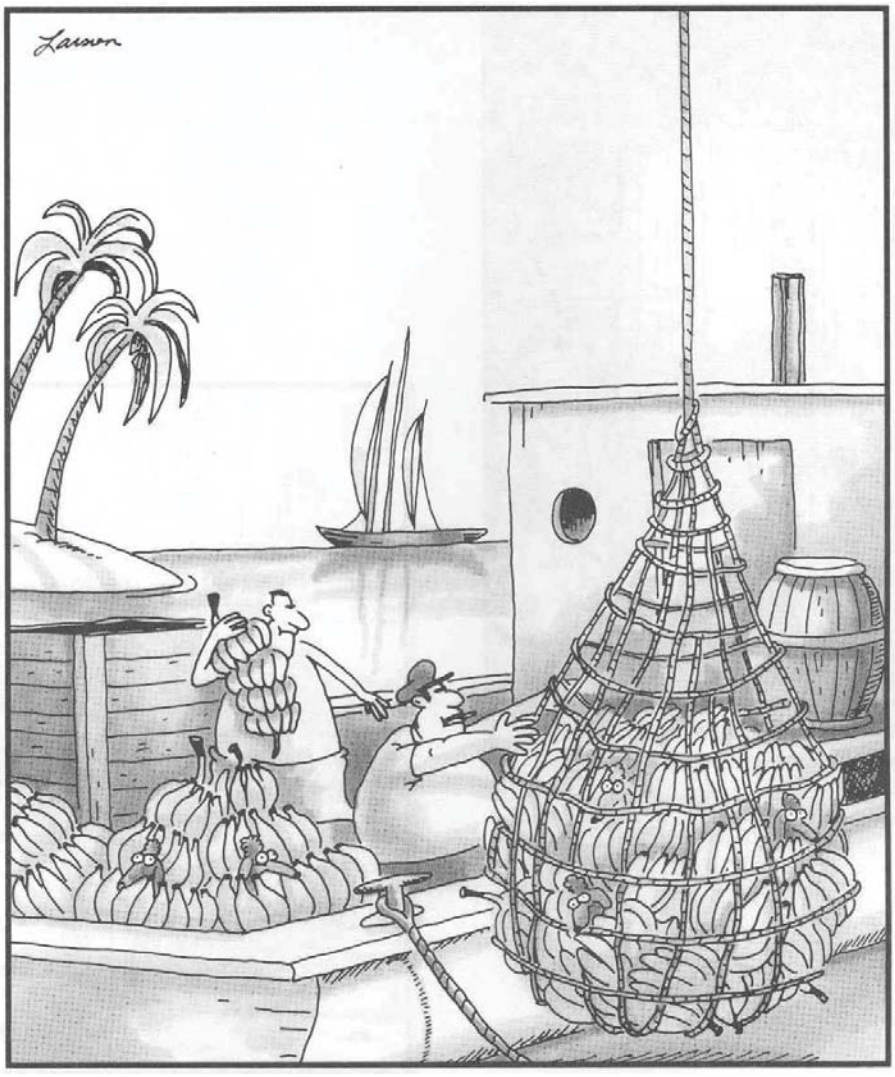

Figure 1. How poodles first came to North America

[1] WTO Agreement on the Application of Sanitary and Phytosanitary Measures

Humour aside, pest or disease issues have the potential to be used as trade barriers. The WTO *SPS Agreement* provides the legal framework to prevent member countries from using disease agents as trade barriers, where protective measures put in place by an importing country must be based on scientific assessment according to international standards and techniques. However, in some cases, the inconclusive or incomplete nature of the scientific information on which a decision may be made makes the issue of 'reasonable' or ' unreasonable' difficult to establish until further scientific research can resolve the issue.

For example, the potential for Pacific oysters to carry *Bonamia* sp. infection has been highlighted by some countries as a concern with regard to trade of *C. gigas* from *Bonamia* endemic regions. In considering the importation of Pacific oysters from Tasmania, the European Commission considered that, among other issues, "*the possible role of carrier of Bonamia sp. has not been evaluated for Crassostrea gigas*." (DG(SANCO)/1289/2000). However, *Bonamia* species have only been recorded from *Ostrea* and *Tiostrea* oyster species. Is this a "poodles in bananas" situation? *Bonamia* species have never been recorded from Pacific oysters; however, whether *C. gigas* is refractory to infection has not been conclusively resolved through targeted experimental studies. Certainly, the ability for Pacific oysters to carry other protozoans such as *H. nelsoni* in low and unnoticeable numbers raises a cautionary tale, but is it reasonable to extend this assumption to other parasite groups? *Haplosporidium* species and *Bonamia* species, while both belonging to the Phylum Haplosporidia, are different enough that extending parallels between the groups may be unjustified. For example, they show different modes of transmission (*Haplosporidium* species have indirect lifecycles, Bonamia species have direct lifecycles) and stages of development (*Haplosporidium* species produce spores, *Bonamia* species do not).

Exceptions to the rule

In developing guidelines in the *Technical Issues Paper* to take into account instances where information is lacking, it was sometimes the case that in considering the hazard status of a particular pathogen these strategies or guidelines conflicted. For example, where a disease or pathogen had not been reported in over a decade, it was considered that no adverse consequences could be identified and that there was little justification to list that pathogen as a hazard. On this basis, the disease Marteiliosis of Calico scallops was not considered a hazard, given that the *Marteilia* species responsible for the mortalities has not been reported from the coast of Florida since 1988 (Moyer *et al*., 1993). However, following the recommendations in the OIE Diagnostic Manual for Aquatic Animal Diseases (2000b), a guideline was also determined in the *Technical Issues Pape*r for *Marteilia* species, where it was considered that until more is known these parasite groups, their presence in any bivalve should be regarded as potentially serious.

Given that active surveys have not been conducted in recent years, it is possible that the pathogen is still present in scallop populations off the coast of Florida in low and unnoticeable numbers. It is also possible that the scallop mortalities in 1988 were an isolated event as a result of introduction of the disease from Europe, but that the pathogen failed to establish in Florida waters, perhaps due to the absence of a suitable alternate host. In this case, is it overly cautious to consider that this pathogen be listed as a hazard or is it reasonable?

Dealing with new information

While it is true that the knowledge available on bivalve mollusc diseases worldwide is lacking, research conducted by many laboratories in Europe, North America and Australasia have revealed significant findings over the past few years. New parasite species and diseases have become apparent, taxonomic conundrums have been resolved and new hosts and geographic ranges have been recorded. In this regard, the IRA process must be dynamic and able to account for new information as it arises. In many cases, new information has been generated through the advent of new technologies, such as molecular techniques. For example, the existence of the Paramyxean parasite *Marteilia maurini*, separate from *Marteilia refringens* (aetiological agent of Abers disease), has been debateable. Recently, gene analysis has confirmed that the two parasites are separate species with different levels of pathogenicity in different hosts (Le Roux *et al*., 2001).

DNA analysis has, however, highlighted some regulatory challenges. The relatedness of *Perkinsus* species worldwide has proven difficult to determine and has presented much confusion in the assessment of these pathogens with respect to stock movements. Gene analysis was undertaken to address this and it was found that *Perkinsus olseni* from Australia, *Perkinsus atlanticus* from Europe and *Perkinsus* sp. from Australia, Asia and NZ are likely to be the same species complex *Perkinsus olseni/atlanticus* (Robledo *et al*., 2000; Murrell *et al*., 2002). Consequently, *P. olseni/atlanticus* does not fulfil hazard criterion 4, given the wide geographical distribution of the pathogen and its presence in Australia. However, grouping species on the basis of genetic information has been questioned by some workers on the basis that it is possible that a particular gene region targeted may not be informative to species level. Is this a case of valid concern regarding the suitability of a particular scientific method and the confidence that can be placed on it, or is it a hesitance in accepting new information when making decisions in areas where the consequences may be severe (i.e., introduction of a new disease strain)[2]?

Expiry dates on scientific information

Scientific methods are constantly improving and changing. A high resolution microscope and a molecular diagnostic method may reveal the presence of a pathogen unable to be observed using older equipment and methodologies. Alternatively, the same process may be able to discount the presence of a disease agent where a mortality event has occurred. With regard to molluscs, the cause of mortalities is often uncertain. It is sometimes the case that either no infective agent is identified or the role of an identified organism is not proven causal to mortalities. In these cases, other factors such as heat stress or acid water conditions may be responsible.

In previous years, some poorly defined mortality events of bivalve molluscs were recorded in the literature under a new disease name. In these cases, an analyst must consider these 'diseases' as a potential hazard. In the *Technical Issues Paper* for the non-viable bivalve

[2] *Perkinsus olseni/atlanticus* appears to behave differently in different countries. The pathogen has not been recorded from European abalone species. Yet in Australia, the pathogen causes severe pathological effects in abalone populations and has been linked to mortalities (Lester, 1986), although this may be due to the different conditions in which the pathogen lives rather than different strains with different levels of pathogenicity.

mollusc IRA, 'diseases' that were recorded in the literature and that were considered relevant to the above situation were grouped together in a category named 'poorly described diseases'. These 'diseases' were considered not to be hazards if there were no indications of an infectious nature from the epidemiology, and/or an adverse impact in Australia could be identified based on the available scientific information. However, in the event that new information comes to light confirming the presence of an aetiological agent, that information would be incorporated into the IRA.

The unknown disease agents

One of the biggest criticisms of the IRA process is that hazard identification is restricted to dealing only with identifiable and known disease agents. As mentioned previously, the disease status of bivalve molluscs in many geographic regions is poorly understood. Further, undiagnosed mass mortalities of cultured bivalve molluscs occur each year worldwide and it is likely that serious diseases will emerge in other bivalve groups and species as intensive culture expands. In an attempt to account for this in the bivalve mollusc *Technical Issues Paper*, a general category for undefined mass mortality events has been considered. While this category cannot, and should not, be stated as a "hazard" (in that hazard criteria cannot be applied), Biosecurity Australia is examining the feasibility of linking such events to identified hazards that demonstrate, for example, a similar epizootiology, and that have undergone risk assessment. Where other criteria are relevant, for example the host species of concern is also present in the importing country, management strategies developed for the similarly-behaving known disease may then be applied in the interim until the mass mortality event is defined or described.

CONCLUSION

Import risk analysis, including the hazard identification stage, is a science-based process. Analysts must make decisions that are supported by sufficient scientific information, based on scientific principles and that are objective, defensible and transparent. Where information is incomplete or lacking, strategies or guidelines can be developed so that appropriate professional judgements can be applied. In dealing with new information, the process must be a dynamic one. It may be the case that new information may contradict with previously held beliefs. "Hazards" may become "not hazards" or *vice versa*. Further to this, the issues relating to whether or not it is reasonable to err on the side of caution in making valued assumptions or accepting new information must be addressed.

It must be emphasised, however, that hazard identification is just one stage in the risk analysis process. Erring on the side of caution at this stage of the IRA is often less important in terms of the outcome because a detailed evaluation on a pathogenic agent is made in the risk assessment phase. However, in order to make the process manageable, pathogens can be (and should be) omitted from the IRA if sufficient information and expert judgments deem it justifiable. The validity of such a decision rides on the importance of peer review and feedback through stakeholder comment.

The reality is that unknowns in science will always exist, but the job still has to be done. To quote Dr Carl Sagan (1997) in his novel *The Demon-Haunted World – Science as a Candle in the Dark* – "Science is far from a perfect instrument of knowledge. It's just the best we have."

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