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Report Cover Page

ACERA Project
1101E
Title
Sampling Interceptions for Identification
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Material Type and Status
Final Report
Summary

Background: DAFF intercepts pests, which may be regulated, and therefore actionable. The Operational Science Program (OSP) identifies the intercepted pests to determine their biosecurity status. The results of identification are recorded in the Incidents database. Not all pests are identified to the species level. A range of factors affects the amount of information available about any interception, so the Incidents database does not support statistical analysis, and DAFF cannot accurately evaluate the relative biosecurity risk posed by different pathways.

Overview: This project develops a sampling-based identification protocol which will result in identification data that supports statistical analysis.

Outcomes: The following outcomes arise from this report.

1. Overall OSP species level IDs have improved from around 25% in the mid to late 1990's to around 42% in 2012.
2. The main improvements have come from specialised training and the publication of taxonomic keys and manuals.
3. To our knowledge, no international organization has been able to solve the problem of the non-representativeness of captured specimen data.
4. We develop a candidate scheme under which all intercepted specimens are submitted to OSP, and OSP implements a stratified sampling regime to determine which specimens to identify.

Recommendations: The following recommendations arise from this report.

1. Develop a trial of the sampling approach sketched herein (p. 24).
2. Free up OSP time to invest in spending time with border programs (p. 27).
3. Streamline Incidents data entry to enable more complete data capture (p. 26).
4. Improve feedback between OSP and border inspection staff (p. 27).
5. Maintain and increase specialised training of OSP staff with external experts (p. 27).

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Sampling Interceptions for Identification.

ACERA 1101E Final Report

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Contents

Table 2: Table of definitions used throughout the text.

Term	Definition
AIMS	AIMS is the DAFF database that records the management prescriptions and outcomes for biosecurity risk management for cargo items that are accompanied by a full import declaration (FID).
Incidents	Incidents is the database that records the details of pests that are intercepted, mainly but not exclusively during DAFF intervention.
MAPS	Mail and Passenger System, a DAFF database that records the regulatory effort and outcomes for international passengers and mail.
Pest	A pest is any species, strain or biotype of plant, animal or pathogenic agent that is injurious to plants, animals, or products.
Regulated Article	A regulated article is capable of harbouring or spreading pests. An example is an orange carried by an international passenger.
Regulated Pest	A regulated pest is a pest that is deemed a biosecurity threat, and whose discovery mandates application of appropriate phytosanitary and/or sanitary measures.
VMS	The Vessel Management System is the database used by DAFF for managing the biosecurity risk of international ocean-going vessels.

1

Executive summary

Background

DAFF intercepts pests that may be regulated, and which are therefore actionable from the point of view of biosecurity policy. The Operational Science Program (OSP) identifies intercepted pests in order to determine their biosecurity status. The outcome is recorded in the Incidents database.

Ideally, DAFF data holdings would support analysis to report an estimate of the biological risk presented by regulated activities such as importation of goods and international passenger or mail activity. Such an analysis requires two datasets, namely, information about the amount of regulatory effort, as is available for example in the DAFF databases AIMS, MAPS, and VMS; and information about the biological risk of intercepted pests, such as is stored in Incidents.

However, analysis of this kind is impeded by the incompleteness of the data. Not all pests are identified to species or to the level of biosecurity status — some are not because the importer opts for treatment or other remedial action immediately, and others because of operational, technological, or scientific constraints. A variety of unreported factors affects the amount of information that is available about any interception, and the information is missing in a haphazard way. Therefore Incidents does not support statistical analysis of biological risk, and the inspectorate cannot accurately evaluate the relative biosecurity risk posed by different pathways.

Objectives

The objectives of this project were to (i) review the existing approaches to identifying intercepted pests and recording the outcome, and (ii) develop a sampling-based identification protocol, which will result in identification data that supports statistical analysis of the biological risk of pathways.

Conclusions

The following conclusions arise from this project.

1. Overall OSP species level IDs have improved from around 25% in the mid to late 1990's to around 42% in 2012. The main improvement has been as a result of specialised training but also from the publication of specific taxonomic keys and manuals both by internal and external experts.
2. To our knowledge, no international organization has been able to solve the problem of the non-representativeness of captured specimen data.

3. We developed a candidate scheme under which all intercepted specimens are submitted to OSP, and OSP implements a stratified sampling regime to determine which specimens to identify.

The candidate scheme may be briefly summarized as follows. Upon interception of a pest,

1. the pest is submitted to OSP, where
2. it will be screened to determine whether the pest is a show-stopper — that is, one whose discovery presents a significant risk (e.g., khapra beetle);
3. those pests that are not identified as show-stoppers will then be divided into two groups, namely,

   (a) mandatory id: identification required for specifying treatment, etc. — these pests will be identified as per the current standards;

   (b) optional id: identification not required (e.g., importer requests treatment without awaiting identification results) — these pests will be randomly sampled for identification. Some will be identified as per the current standards; others will be stored. Note that all pests will still be screened as per step 2 above.

Recommendations

The following recommendations arise from this project.

1. Develop a trial of the sampling approach proposed herein (p. 24).
2. Free up OSP time to invest in spending time with border programs (p. 27).
3. Streamline Incidents data entry to encourage and enable more complete data capture (p. 26).
4. Develop better feedback mechanisms between OSP and border inspection staff (p. 27).
5. Maintain and increase specialised training of OSP staff with external experts (p. 27).

2

Introduction

DAFF identifies pests detected on incoming goods. The identification is carried out by entomologists and plant pathologists in DAFF's Operational Science Program (OSP). The identification is performed for two main reasons: primarily to determine if the detection is a regulated pest so that appropriate phytosanitary and/or sanitary measures can be applied, and secondly, to become better informed about the nature of the risks of various import activities. Accurate identification is essential for decision-making in biosecurity (Maynard and Nowell, 2009).

The collection of specimens and the level of identification of pests that are detected by inspectors depend to a great extent on operational considerations. Sufficient work is done to determine the appropriate measures required to mitigate any biosecurity risk encountered, and to justify whether the consignment required treatment. This may not include identifying the pest to the species level, or even formally determining whether the pest is a biosecurity risk. Live plants also require ID reports for phytosanitary reporting purposes, and fumigation failures require IDs and risk statements in order to justify the de-listing of overseas fumigation companies.

Two levels of decision making are performed with respect to identification, after interception. First, a decision is made by the inspectors whether or not to collect and submit specimens. This decision is often based on standard procedures, and is clear-cut for those border activities where the commodities are clearly defined, such as fresh fruit produce. For such pathways, work instructions are relatively straightforward. However, variations are possible in some pathways. For example, if the consignment is being fumigated anyway, then officers will not necessarily submit samples that reflect the diversity of taxa unless there is an imperative to do so. Other pathways, such as air passengers, do not lead to straightforward procedures, because the types and volumes of commodities encountered are unpredictable.

Second, a decision is made by DAFF as to how to best deploy diagnostic resources. This decision requires determining which intercepted pests are likely to be of quarantine concern and what level of identification is needed to clarify the pest's status.

The problem when interpreting data about intercepted pests is that the subset of specimens that is collected and identified cannot be considered a random sample of the pests approaching the border (see, for example, McCullough et al., 2006, p. 613). A more systematic collection of data about arriving pests and diseases would enable inference to be made about the magnitude and type of threats. Sampling theory provides a useful framework for obtaining useful information when measurement of the full population, that is, fully identifying every pest detected, is impractical.

As an example of the problem, consider the need to submit a frog for identification after it has been detected. Regardless of where it is found, in a passenger's shoe or in a container of oranges, we are all agreed: it shouldn't be there. But, why do we need to identify it? After all, if we euthanaise the frog and check that there aren't any more frogs, then the biosecurity risk is mitigated. Yet, there are a number of situations where it could be worthwhile identifying the frog. Suppose that the passenger found the frog when unpacking at home. It might be prudent to check that it isn't a local frog. It may be important to identify the frog in order to assess the importance of the pathway. Alternatively, the frog may be submitted for identification simply out of interest because it is a type that the inspector hasn't seen before, or it seems to be intercepted more often. As another reason, we might want to work out the pathway by which the frog entered the container, which may led to adjustment of biosecurity measures, and knowing the species is likely to help with this issue. Finally we may wish to learn what kinds of pests the frogs might act as a vector for.

Currently, there is no single set of decision rules about the need to identify pests. Consequently, the data have haphazard gaps arising from inconsistent detection methodologies and variable submission of specimens. Estimates of the pest approach rate derived from these data are likely to be biased. For example, DAFF records can provide a reasonable count of the number of times frogs have been intercepted, assuming consistent reporting. But if, say, a group interested in vertebrate pests were to ask a questions about a particular frog species, we can say for sure that it has been detected, but we cannot say for sure that it has not been intercepted. Advice on how often and from where it has been intercepted is biased because of the haphazard way specimens are sent to be identified, among other causes.

This report looks at ways this problem can be overcome. The purpose of this project is to develop a sampling strategy that would promote the identification to a species level of a nominated proportion of pests and diseases detected during inspection so that inferences about the nature of the risks of various importation activities can be made. These strategies will be presented in a subsequent report.

The rest of this report is structured as follows. The next chapter provides an overview of the processes of specimen identification for a range of border activities undertaken at several locations: Brisbane, Melbourne, Perth, and Sydney. Chapter 4 develops simple statistical summaries of the 2012 identification data. Chapter 5 provides a brief overview of specimen interception, handling processes and identification for a number of international jurisdictions that we approached. The final chapter discusses a possible solution and the problems with implementing it.

3

DAFF Process

3.1 Introduction

This chapter reviews the structures and processes that surround the identification of regulated pests detected by DAFF Biosecurity. It is the outcome of numerous interviews of DAFF Biosecurity personnel in Canberra, Brisbane, Sydney, Perth, and Melbourne.

3.2 The Need to Submit Specimens for Identification

We examined two types of border activities for which the identification of intercepted pests have quite different imperatives and outcomes: Cargo (fresh produce only) and Passengers/Mail. Other activities that we did not survey include break-bulk, machinery and timber.

In the inspection of fresh produce, *interception* refers to the discovery of a potential regulated pest during inspection of all or a sample of the consignment (ISPM5; FAO, 2007). The question is: what should be done with the consignment when pests are intercepted? To answer this, OSP tries to identify the specimen to determine whether or not it represents a biosecurity risk. If there is clear evidence that the specimen does not represent a biosecurity risk — for example, because it is of a taxon that is is not a regulated pest (i.e., is of no quarantine concern) — then no further action may be necessary. Otherwise, the importer is asked to choose between various options, usually including treatment, re-exportation, or destruction. However, the importer may decide not to await identification, and may opt for treatment immediately. Given the commercial imperative to move cargo as rapidly as possible and hence to clear consignments quickly, many consignments are treated without the identification of the pest. In this case there is no operational biosecurity imperative to identify the risk further, and consequently, while records show that a pest was detected, the identity will not necessarily be known. OSP will still identify the pests as far possible, albeit some time after the goods have been treated and released. This can be an issue if the pest would have been one who's identification would have led to treatment at a non-standard rate (e.g., khapra beetle, or internal feeders in fruit) but training of officers has made this a relatively rare occurrence. Identification of specimens is particularly valuable for those consignments that have a formal import risk assessment (IRA), as the identified specimens can be compared against the species of concern arising from the IRA.

In contrast, in the inspection of the luggage of international passengers, or mail articles, interception refers to the detection of a regulated article during inspection. The distinction is that a regulated article is capable of harbouring or spreading pests, rather than necessarily being a pest itself (FAO, 2007). For example, fresh fruit may be found. Although the fruit may not represent an obvious quarantine risk in itself, depending on the status of the plant, it may be carrying a regulated pest. Hence it will be confiscated and destroyed due to the potential biosecurity risks that are associated with these hosts. The biosecurity risk is assumed to be handled by this decision; if there are no other similar items detected, then no further decision needs to be made. There is no operational imperative to identify the risk further (even if pests are detected on the regulated article), and the practical considerations of clearing passengers and declared items quickly do not readily enable the sample collection and data entry needed for identification.

3.2.1 Cargo

Specimen identification within the Cargo environment plays two roles: tactical, in terms of identifying and then forming a response to an immediate threat, and strategic, in terms of providing information on the biological risks associated with a commodity which can inform pest risk assessments that lead to adjustment to phytosanitary measures.

All pests and diseases intercepted by Cargo should be submitted for identification; that is, OSP does not encourage inspecting officers to make a decision on the pest status of the organism. This prescription is for reporting purposes, as well as a good training aid (positive feedback on what they have detected) etc.

The cargo inspection environment is diverse, with very different kinds of inspection depending on the operations: tailgate, fresh produce, Unaccompanied Personal Effects (UPE), timber, machinery, break-bulk, etc. The extent of inspection intensity ranges from a tailgate inspection of a shipping container through to several years of screening in post-entry quarantine for high-risk nursery stock.

While our coverage of cargo operations was far from comprehensive, for context we briefly summarize our observations of the inspections of a handful of different cargo lines. We observed inspections of green drinking coconuts, taro and kiwifruit (each with 600 units, including 60 inspected under a magi-lamp); tropical aquarium fish and truffles (both 100%); and cut flowers (1–10 cartons imported $\rightarrow$ 2 cartons inspected, 11–20 $\rightarrow$ 3, 21–50 $\rightarrow$ 5, $> 51 \rightarrow 7$). The sampling approach followed the standards prescribed by ISPM 31 (FAO, 2008) in each case.

The treatment decision depends on having evidence of active infestation. For example, borer holes in timber indicate pest activity, but they might be old and abandoned or the borers might be dead as a result of a treatment. Such an observation would not necessarily demand treatment.

In any case, the action upon the interception of a potential pest was uniform across the surveyed lines: store a specimen in a suitable medium, record relevant details, submit the specimen to the OSP and place a hold on the cargo. There are a few exceptions to this sequence. For example, upon the interception of giant African snails, consignments are ordered in for treatment immediately because the officer will be confident in the identity of and the risk presented by the pest.

A complication for pest identification within the cargo environment is that some importers will consolidate products, or even parts of products, from a wide range of sources. For example, a furniture manufacturer might collect timber from various sources, and prepare and ship the products from a different location. The manifest will state that the product originates in the location from which it was sent, but the components of the product come from a wide array of places that may be of higher risk, as well as increasing the potential for cross contamination. This process complicates identification because it is no longer always possible to establish where the product originated.

3.2.2 Passengers & Mail

We interviewed border inspectors at Brisbane, Sydney, and Melbourne international airports. In each case, our goal was to determine the practice of and attitudes towards the submission of specimens for the identification of intercepted pests and diseases. Inspectors inspect certain items of passenger baggage and mail using a range of different tools: x-ray, detector dogs, and manual inspection.

During the development of this project, Passengers & Mail implemented Risk-Based Intervention (RBI) strategy which resulted in a refocusing of inspection effort towards higher-risk pathways in Cargo. Consequently, comparatively few interceptions are being sent to OSP for ID (probably only about 60% of what was being submitted 18 months ago) from the passengers and mail programs. Numerous explanations are possible, but the most plausible one is that the officers are inspecting less because they are only required to look for high-risk material.

The submission of specimens for identification is much more variable in Passengers and Mail than in the Cargo environment; submission of specimens varies from region to region, and sometimes within regions. Often the trigger for submitting pests was personal initiative; it would be submitted for identification if the pest looked interesting, and if there was time. Skill sets and training may also play a role; it is reasonable to believe that those with biology qualifications will make more submissions than other inspectors. The high degree of personal initiative in the decision to submit the specimen suggests the possibility that any observed variation within and between regions may reflect training and culture as much as the approach rate of pests.

Submission to Incidents is performed using templates that are custom built into the Mail and Passenger System (MAPS) database. Recording the details of a submission to Incidents from MAPS is slow, and this is a disincentive to making a submission when the passenger queues are long. Furthermore, some of the input fields are cumbersome, for example, part of the documentation of the submission relies on a commodity search from a closed set of keywords. Often the appropriate conveyance or commodity cannot be found, so the officer is forced to make an approximation, which further undermines the perceived value of the process.

It was clear from our interviews that there was not a uniform understanding of what kinds of specimens OSP would like to have submitted. It was felt that some filtering by inspectors should be performed, for example, we heard that OSP did not want to see book-lice (psocids), because they are very common and not a threat. However, screening for invertebrate pests is challenging, and screening for plant pathogens at the border inspection point is practically impossible given the current set up and resources available (this includes knowledge, reference material, equipment, and support documentation resources). This is because screening for plant pathogens requires equipment and training beyond that which is readily available at the inspection point.

The Passengers and Mail environment is different to the Cargo environment. For the most part, once the pest has been intercepted, the identified risk is assumed to be mitigated, since the detection of a pest would result in a more thorough inspection and the intercepted item would be treated or discarded appropriately. Hence there would seem to be less tactical motivation for a species-level identification of an intercepted specimen in Passengers and Mail. Nevertheless, identification can give significant information on what is moving and assist in developing strategies to minimize the risk.

Finally, there was clear variation in the levels of skills, training, and experience of the border inspectors in the selection of specimens intercepted for diagnosis and recording.

3.3 Identification

Specimen identification is mostly undertaken by OSP staff. The outcome of the identification is recorded in a database called Incidents (see Section 3.3.3). As noted above, the need for identification differs between programs: in Cargo the decision on appropriate actions usually waits on the outcome of identification; this is rarely the case in Passengers and Mail.

It is important to note that when identification determines whether treatment is necessary, there may be significant imperative to do it quickly owing to importer needs (e.g., shelf-life of goods). This means that often identification is only carried out in sufficient detail to determine whether there is a quarantine risk or not. Identification to the species level may not be done immediately because risk can be determined by identification at a higher taxon level. A side-effect of the pressure on identifications is that importers do not want to wait for the identification, and so potentially many cosmopolitan pests may be treated due to commercial pressure for the movement of goods.

The identification resources within OSP are split into two streams: plant pathology and entomology, which cover plant pathogen pests and invertebrate pests (and occasionally non-mammalian vertebrate pests) respectively. Invertebrate pests are usually detected at the organism level, whereas plant pathogen pests are usually detected as symptoms rather than the causal agent, hence further steps are often required to detect/determine the causal agent. Many specimens cannot be identified to species level for the reasons outlined below.

OSP has improved its IDs to species level over recent years and this appears to correlate with specialised training that has been undertaken with external experts. Thrips are the most notable example. Specialised training was delivered in 1997, 2001 and again in 2010. In 1995 OSP were identifying 46% of thrips to species level; by 2000 this was up to 53%; by 2004 it reached 65% and in 2012 it averaged 78% (excluding Central East Region).

A similar trend is present with mites, although there has not been specialized training for mites, and the overall percentage identified to species level is much smaller (e.g., 5.3% in 1995 to 6.5% in 2004 and around 9% in 2012). This is because there are a very large number of mite taxa, including many undescribed species, and also because immatures are the most commonly intercepted stages, and immatures can't be identified past order/family on most occasions.

Overall OSP species level IDs have gone from around 25% in the mid to late 1990's to around 42% in 2012. The main improvement has been as a result of specialised training but also from the publication of specific taxonomic keys and manuals both by internal and external experts.

3.3.1 Entomology

Insect identifications to species level are often difficult or even impossible because:

1. there is not enough time,
2. the species are poorly known or undescribed (ie. new to science),
3. the pest specimen is immature,
4. country of origin and/or host commodity information is unknown or incorrect,
5. rearing immature specimens is difficult and often risky from a biosecurity perspective,
6. molecular techniques for most insects are primitive or non-existent,
7. appropriate taxonomic resources, reference collections, or skills are unavailable,
8. the provenance of the host material is uncertain,
9. the pest specimens are the wrong sex or wrong caste, or
10. the specimen is damaged — e.g. squashed, deteriorated, lost body parts or worn body parts.

OSP staff estimated that 30–35% of specimens can be identified to species level for entomology with current resourcing, and that with the best resources available, this could probably reach 40–45%. Most DAFF regions have one or two OSP entomologists. Entomological taxonomic specialists usually focus on one taxon or a few taxa, e.g., thrips. To provide some context: there are 60,000 named/described species of weevil and probably as many as 300,000 yet to be described, and weevils are only one group of an estimated million or more species of beetles in the world; however the vast majority are of low biosecurity significance, like most insects.

Plant pest measures are guided by the International Phytosanitary Measures under the international plant protection convention as frequently the biology, identity, and impact of plant pests is relatively unknown; whereas diseases and parasites of vertebrate animals are managed via protocols for individual pests as they are relatively well known, hence the diagnostics and response mechanisms are more clearly defined.

3.3.2 Plant Pathology

The gold standard for assessment of the biosecurity risk would be to inoculate the host plant with the disease, but that is very rarely practical. Identification of plant pathogens is difficult because:

1. there is not enough time;
2. the causative agents of diseases are undescribed or poorly characterized;
3. fungal structures required for ID based on morphology alone (e.g., spores and other reproductive structures) are often not present. In this case either the fungus needs to be cultured to obtain these structures (not all fungi are culturable and of those that are, some require many months or have specific requirements for sporulation) or molecular methods must be used to complete the ID. Not all OSP labs are equipped with molecular capabilities and, as a relatively new ID technique, molecular diagnostics is limited to those organisms for which information has been lodged in molecular databases;
4. viruses and bacteria are often not able to be diagnosed based on morphological characters, and viewing this characters is not simple given their microscopic size;
5. disease symptoms that are seen can be the result of a complex of causative agents and conditions;
6. there are difficulties in culturing causative agents and there are risks associated with containment of deliberately cultivating undetermined plant pathogens;
7. plant pathologies are often ecosystems, not a single species, in which case the analyst must try to identify the most significant causative agent in the complex of species or varieties presented;
8. similar symptoms can be caused by both biotic and abiotic causes; and
9. host information is missing or incorrect — which is required to diagnose/understand likely causative agent/s.

3.3.3 Incidents Database

Incidents is the name of the database that holds the details of intercepted specimens for DAFF. Incidents has been in use since about 2003; the previous system was called *Pest and Disease Information* database (PDI). Incidents is distributed in that data can be uploaded and accessed from any DAFF regional office; PDI was centralized, and specimen data were input by a dedicated officer based in Canberra.

Impressions of Incidents and PDI vary. PDI was built at a time when databases were rudimentary, and linespeeds were comparatively slow. The centralized nature of PDI encouraged a high level of consistency and permitted tight quality control of data inputs and outputs. On the other hand, Incidents is inconsistent in entry of information and can be slow for data entry; in one region we heard estimates of 20 minutes for recording an entry by a non-specialist over a slow computer link. Data entry for Incidents is seen by inspectors as competing with other activities. Incidents has limitations, one being that if the inspector can't find the right response for a field, then they will be forced to guess. For example, if the commodity is ceramic tiles and the entry term is unavailable, there is a problem as 'tiles' do not have a commodity code. PDI had a dedicated data entry officer, so this problem was not as common as it enabled appropriate and consistent interpretation of the data for entry.

The quality of data stored in Incidents has also been questioned: a survey in February 2011 identified that half of the sampled entries had at least one error. Incidents does not have a detailed internal reporting module so a report has to be run through the back-end of the system using Hyperion. PDI had an inbuilt detailed reporting functionality which was useful for OSP in particular, but also allowed quick reliable reports to be generated for stakeholders, including overseas and state counterparts. The reports generated from Incidents data are unreliable at best and an OSP staff member usually has to spend a significant amount of time cleaning the data before it can be used.

Indirectly, the difficulty of entering data into Incidents has an impact on the amount of specimens being submitted for identification, particularly in the Passengers and Mail Program. There are other issues that have a higher priority than struggle with computer access.

4

Identification: 2012 activity

In this chapter we provide a brief statistical summary of the Incidents database for 2012. We note that cautious interpretation of some of the following information is needed, because of the uncertain nature of the design of the underlying data collection.

The database comprises 26549 entries for 2012, from 8070 unique AIMS quarantine entries. The month-to-month count is presented in Figure 4.1. A regional split covering a number of statistics is presented in Table 4.1. The quicker time to identification for fresh products, imported food, and nursery stock reflects the need for quicker handling of these commodities.

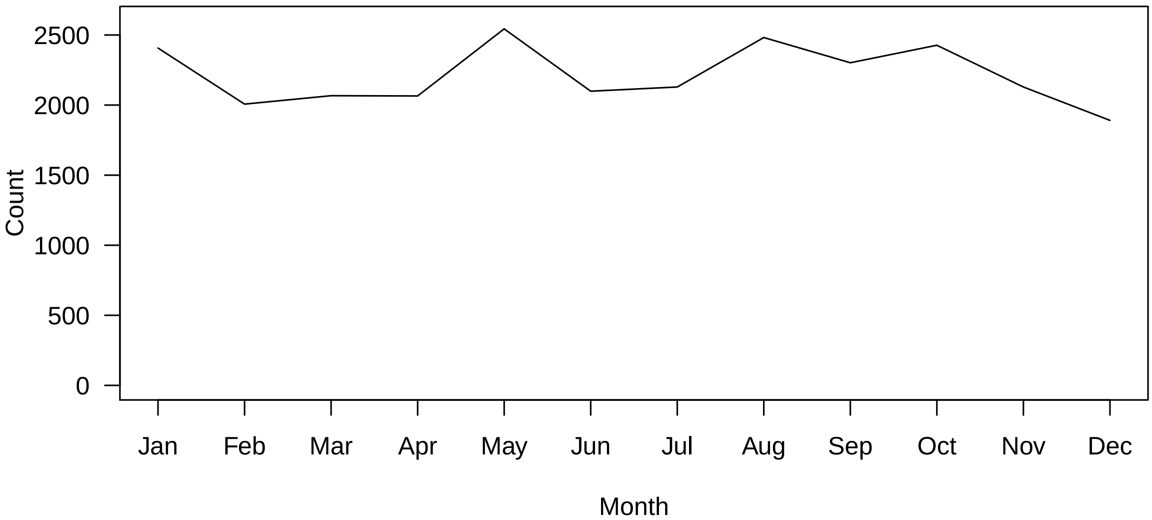

Figure 4.1: Monthly entry count for 2012 Incidents database.

We use the following definitions.

- Time to identify is the number of days between the incident date and the identification date.
- Unidentified records are those records that had blanks for all of class, order, family, genus, species, and subspecies.
- Biosecurity Risk are those records where the "present in Australia" flag is neither Yes nor Not Applicable.

Our data analysis showed that 17.8% of the pests have no identification information recorded.

Table 4.1: Summary by program and region. The Risk column and row refer to the percentage of identified pests that are considered a biosecurity threat. TTI is the average number of days taken to identify the pest, by program.

Program	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Total	Risk	TTI
Airports	0	331	80	1348	60	0	520	202	2541	69.8	9.695
Detector Dogs	0	2	0	0	0	0	0	0	2	100.0	
Export Grain	0	1	0	5	0	0	0	10	16	43.8	0.616
Export Horticulture	0	0	0	38	0	0	0	0	38	57.9	16.101
Fresh Produce	14	5470	5	607	25	0	579	160	6860	78.3	1.230
Import Clearance	38	3071	254	3758	475	92	2340	4146	14174	68.0	5.606
Imported Foods	0	17	0	2	2	0	0	2	23	65.2	2.330
Live Animal Export	0	1	2	0	0	0	0	0	3	100.0	25.367
Live Animal Import	0	86	0	2	0	0	19	18	125	69.6	2.412
Mail	0	485	0	36	0	0	195	13	729	65.0	6.340
NAQS	0	0	0	32	0	0	0	0	32	56.2	12.265
Nursery Stock PEQ	6	124	0	462	19	1	6	256	874	85.8	2.756
Seaports	1	79	126	387	164	16	144	215	1132	58.0	11.978
Total	59	9667	467	6677	745	109	3803	5022	26549		
Risk	66.1	79.2	82.4	63.4	70.5	62.4	69.4	65.2			

However, 88 records had no identification information recorded but had a flag of Yes for the variable “Present in Australia”.

5

International Review

Part of the brief for this project was to obtain information about the extent to which other countries identified intercepted pests and diseases. To this end, we sent a standard questionnaire (described below) to representatives of international phytosanitary organizations. The representatives were personal colleagues of the authors and attendees of the Quarantine Regulator's Workshop run by DAFF and held in May, 2011, in Kuala Lumpur.

The questions were designed to determine what actions the organizations take to identify intercepted biota under two different circumstances: when detected in cargo, and when detected in the luggage of an international passenger. The questions asked were: if an item of potential biosecurity risk is found (1) in cargo, or (2) in the personal effects of an international passenger, then

1. is an attempt made to identify the species of the risk?
2. if so, is it performed by the inspector or some other party? and
3. is this identification always performed? and if not,
4. what are the circumstances in which it would not be performed?

Questionnaires were sent to representatives of 23 countries. Responses to the questions were received from 11 countries and are summarized in this chapter. Overall there was a wide range of responses — everything from don't ID at all, through get the inspectors to do the IDs, to all specimens sent to specialist scientists.

5.1 Australia

For convenience, this section paraphrases the more detailed description given in the previous section. The inspection of goods and people at the border is conducted by two authorities, the Australian Customs and Border Protection Service (Customs) and DAFF Biosecurity. Items of biosecurity concern (whether declared or detected by Customs) are referred to DAFF.

Cargo

When pests are detected in cargo, the importer has the option of having the consignment treated immediately or waiting until specimens sent to Departmental entomologist and/or plant pathologist have been identified to a sufficient level to determine if treatment is required. For some pests, external experts will also be consulted. In addition, any inspector can submit specimens for identification.

International Passenger

Most pests detected in airport passengers' luggage are not identified. The main exception to this would be when legal proceedings are expected to be taken against the passenger. Again, any inspector can submit specimens for identification, typically when a serious pest or disease is a possibility or when it is something the inspector has not previously seen.

5.2 Canada

Inspections of goods and people in Canada are conducted by two authorities, the Canada Border Services Agency (CBSA) and the Canadian Food Inspection Agency (CFIA).

CBSA is the inspection authority at the border. It is responsible for screening imports of all types and referring any with specific phytosanitary requirements to CFIA for review of documents, inspection, release, or detention. For the most part, it is not considered necessary to identify all pests which are found on the packing material since regulatory action is taken in all cases directly at the border. Nonetheless, CBSA inspectors do have the option of submitting specimens to CFIA for identification.

When a plant or animal species that may pose a biosecurity threat to Canada is detected in a commercial shipment or in the possession of a traveller, the goods may be refused entry into Canada or referred to the CFIA, Environment Canada (EC) or both for further inspection by certified veterinarians, and/or plant or animal specialists depending on the type of good and which legislation applies. The CFIA and/or EC will then provide a recommendation to the CBSA to either refuse or authorize the entry of the species into Canada.

Cargo

As an example in the commercial stream, if an item is a potential biosecurity risk under the Health of Animals Act and Regulations or the Plant Protection Act and Regulations and is also a species that is controlled under CITES, then the shipment is referred to both the CFIA and EC. The latter department (EC) will attempt to identify the species under circumstances where the species is unknown. The CFIA may or may not identify the species; it may just be seized without species identification. An item may be refused entry without knowing exactly what species it is. For example, the CBSA is responsible for conducting inspections of Wood Packaging Material (WPM). In the case of a live pest being found in WPM, the shipment is treated or refused entry and the pest specimens collected and submitted to the CFIA laboratory for taxonomic identification.

If EC or CFIA inspectors cannot identify the species, the specimen(s) may be sent to their respective forensic laboratory for further identification. In some cases, identification of a species is not always performed. For example, if a shipment of firewood is imported without the required permits and documentation, it will be directly refused entry and the species will not be identified.

International Passenger

Generally, in the traveller stream, if an item of potential biosecurity risk is found on an international passenger, generally no attempt is made to identify the species or the risk and the goods are refused entry into Canada. However, in the case that further inspection and/or consultation for investigation purposes with the CFIA and/or EC is required, the goods may be referred to the CFIA and/or EC for further inspection or sent to either a CFIA or EC forensic laboratory for species identification. Where an undocumented live bird, for example, is discovered on a traveller, it will likely be referred for identification by EC inspectors.

5.3 Hong Kong

An attempt will always be made to identify the intercepted species by the inspector; the identification is confirmed by a professional-grade officer.

5.4 Japan

An attempt will always be made to identify the intercepted species by the inspector. If the inspector is unable to identify the species then the item is sent to an identification team, of which there are about 20. If the team is unable to identify the species then the item is sent to one of two special missions at Yokohama and Kobe. Importation of the goods is not permitted until identification is complete or a treatment such as fumigation is requested and applied.

5.5 Malaysia

Cargo

An attempt will always be made to identify the intercepted species by the inspector; most inspectors have basic training in identification. If the inspector is unable to identify the species then the item is sent to the central laboratory for identification. Interceptions are reported regularly to the National Plant Protection Organization (NPPO).

International Passenger

Infested items and items without suitable documentation are confiscated and destroyed.

5.6 New Zealand

Cargo

The inspector screens the pest/disease to establish whether or not identification is called for. Identification is carried out for certain combinations of suspected pest or disease and commodity. There are some commodities and some pest types for which identification of associated pests is considered unnecessary; the importer is allowed to choose between identify, treat, reship, or destroy. There are some pest types for which identification is always sought.

International Passenger

As above. There are some pest types for which identification is always sought, and some that are simply destroyed.

5.7 People's Republic of China

China has 35 entry and exit Inspection and Quarantine Bureaus distributed across all provinces for the management of entry and exit quarantine inspections at all ports. Each Bureau has a technical centre.

If a pest is intercepted at an entry port, the pest will be sent to the technical centre for identification. If the pest cannot be identified, or the pest is identified to be a pest with quarantine importance, then the specimens will be sent to the Chinese Academy of Inspection and Quarantine for further identification or confirmation. Sometimes the specimens have to be sent to the Institute of Zoology of the Chinese Academy of Sciences or other universities for further identification and confirmation. When the intercepted pest cannot be identified locally, or is identified to be a quarantine pest, the goods associated with the intercepted pest will be treated under the supervision of the local Bureau.

5.8 Peru

Intercepted pests are always sent to the official diagnosis laboratory. Sometimes the pest cannot be identified to a species level. If there is some risk then action is taken. Identification to species level is not performed when the pest is identified as belonging to a family or genus that does not represent a quarantine risk.

5.9 Russian Federation

All consignments of plants and plant products are subject to phytosanitary quarantine inspection at the point of entry into Russia. Identification of the species of the risk is carried out by the authorized duly-qualified phytosanitary inspector at the point of entry. If the identification can not be made there, then the samples are sent to the quarantine test laboratories of the Federal Service for Veterinary and Phytosanitary Surveillance for analysis and identification by the authorized duly-qualified phytosanitary inspectors.

5.10 Singapore

Intercepted pests are identified by the inspector and sent to the diagnostic laboratory for identification. Identification is always attempted, but may stop if the pest is beyond the capacity of the laboratory, is unextractable, or unrecognizable.

5.11 Sri Lanka

Cargo

Mostly pests are destroyed, owing to a lack of specialists in the relevant fields. When attempts for identification are made, the specimen is directed to the operation division of the National Plant Quarantine Service (NPQS) from where it is sent to the relevant division (Entomology, Pathology, Weed Science, etc.) for identification. However on specific instances where the biosecurity risk is high, such as seed potato importation, extra precautions are taken where both visual and laboratory investigation are undertaken to determine the species.

International Passenger

Pests are very seldom identified. Intercepted material is confiscated and destroyed. If an identification is attempted then it is undertaken at NPQS.

5.12 United Kingdom

Cargo

Cargo is monitored and inspected by the Plant Health and Seeds Inspectorate and they submit samples of any suspect pest or disease which are then submitted to the Food and Environment Research Agency laboratory.

Inspectors are trained to make a provisional diagnosis but all samples are then submitted to the central laboratory which will carry out a formal diagnosis. The only times when a full diagnosis is not completed is where for some reason the condition of the sample prevents this (juvenile inspect pest dies or pathogen cannot be cultured).

International Passenger

HM Customs perform controls on passengers. If they find suspect plant material they would then contact the Plant Health and Seeds Inspectorate who would inspect and if necessary submit a sample of any pest or disease.

5.13 United States of America

The identification process depends on the pathway.

Cargo

In those cases where a plant material in cargo is found infested with a fungus, the pathologist will make slide mounts of the submitted sample and search for fruiting bodies (spores) of the organism. If only vegetative mycelia are found (no spores present), the disease is considered non-actionable due to lack of identifying structures. If spores are found, the pathologist is usually able to identify the disease down to at least the genus level. Then action can be called based on whether or not the there are pathogenic species in that genus not already established or widespread in the United States. If the genus has only non-pathogenic members (*Rhizopus* — common bread mold for example), then the disease is considered non-actionable. More sophisticated means of identifying organisms by chemical tests are under development; these can also be used for detecting bacterial and viral diseases, but morphological methods of identification where slide mounts are used to identify fruiting structures is the most common practice.

International Passenger

Interceptions from plant materials in passenger baggage that involve mites, insects and the like are listed as routine interceptions and forwarded to entomologists. This means final identification is considered non-critical towards the movement of foreign plant materials into United States commerce and gives the entomologist more time to study the morphological features of an organism in an effort to identify it to the most specific level. If an area identifier (entomologist) is incapable of identifying the specimen due to lack of familiarity with the intercepted material or lack of distinguishable morphological features, the specimen may be forwarded to specialists at the Smithsonian for further study. Any final determinations made by the specialist are then passed along to staff at the National Identification Service (NIS) where it is decided whether or not the specimen is reportable or non-reportable. Immature stages of insects (larvae, maggots, nymphs and the like) as well as female mites lack enough distinguishable features to classify these organisms beyond the genus level. As with plant diseases, morphological features are the key to making identifications for the majority of these organisms. Improvements are being made in using DNA markers where distinguishable features are not always present, but these tests are not available for the bulk of the organisms intercepted.

6

Solution Sketch

6.1 Introduction

We now sketch the broad ideas of a potential solution to the problem. Our goal is to provide a basis for further discussion, rather than to lock down a solution.

Briefly, our goal is to be able to estimate the number of regulated pests that are approaching the border, the number of different types of regulated pests, and levels of contamination by unregulated pests, which may indicate other problems. In an ideal world, every intercepted pest would be identified to species level, and confirmed as either regulated or not regulated, but as explained earlier in this report, this simply isn't possible, and is unlikely to ever be possible. The challenge then is to provide a statistical framework for handling the process of identification so that the information obtained from the identification efforts is as valuable as possible.

It is important for us to keep two things in mind. First, although species identification could be useful for a range of reasons, for example the biology of the organism provides knowledge of how to manage the goods associated with the pest, the principal goal is to determine whether or not the pest is regulated. Second, when we write informally about determining whether the pest is regulated or not, we really mean determine that the pest is not regulated: the baseline assumption is that all intercepted pests are regulated, and that the purpose of the OSP identification efforts is to establish that the pests are not regulated. The inability to identify the pest to a suitable level leads to the conclusion that it is *not* known to be *not* present in Australia, and therefore it must be considered a threat.

We can split the reasons for being unable to identify whether a pest is regulated or not into two broad classes: not enough information and not enough time. Some intercepted pests cannot be identified as regulated or not regulated regardless of how much time is available. It is reasonable to treat these pests as regulated pests, following the precautionary principle[1]. The other intercepted pests could be identified as regulated or not if enough time were available. With these pests, the amount of resources dedicated to their identification will affect whether or not they are classified as regulated, and hence also affect the perceived biosecurity risk of the pathway upon which they have arrived. We focus on the second group of intercepted pests.

6.2 Sketch

In many fields, we are able to learn from incomplete information by using a sampling approach for collecting the information. That is, if we want to know about a process or a population but we can't afford to measure the whole thing, then we draw a sample from it. If the sample is

[1]The *precautionary principle* or precautionary approach states if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on those taking the action. `http://en.wikipedia.org/wiki/Precautionary_principle`, accessed 13/Jan/2013.

collected the right way, then we can draw useful conclusions from it about the population or process. The 600-unit sample used for phytosanitary inspection of consignments of some fresh fruits is a good example. We wish to ensure that the contamination rate of the consignment is below a given level but we cannot afford to inspect every item, so we randomly inspect 600 units.

We believe that some kind of sampling approach will provide a natural solution to the challenge of identification under constrained resources. The essential element will be that at least some intercepted pests must be selected for identification randomly, and that the probability of selection must be known. The following protocol may not present a substantial variation on the current approach as realised in some regions.

Broadly speaking, we envisage the following kind of scheme. Upon interception of a pest,

1. the pest is submitted to OSP, where
2. it will be screened to determine whether the pest is a show-stopper — that is, one whose discovery presents a significant risk (e.g., khapra beetle);
3. pests that are not show-stoppers will then be divided into two groups, namely,
   (a) mandatory id: identification required for specifying treatment, etc. — these pests will be identified as per the current standards;
   (b) optional id: identification not required (e.g., importer requests treatment without awaiting identification results) — these pests will be randomly sampled for identification. Some will be identified as per the current standards; others will be stored. Note that all pests will still be screened as per step 2 above.

We have learned that, as might be expected, specimen submission has been most effective when the connections between border inspectors and the OSP are actively fostered, for example by OSP staff spending time with the inspectors on a regular basis. This attention can serve numerous roles; for example, the inspectors are given direct evidence of the importance of their work and the importance of specimen identification, and the OSP staff are able to monitor DAFF's interaction with the pathway more closely by observing the activities, and provide clarity and reminders around policy.

6.3 Estimating Relative Rates for Pathways

We want to be able to compare pathways by estimating the relative rate at which consignments of each pathway are contaminated by regulated pests. The problem, as outlined before, is that not every pest that is intercepted is sent for identification, and even then, may not be in a suitable state to permit full identification or may not be subjected to identification. Consequently, any estimate of the approach rate of regulated pests that is derived from the Incidents database may be negatively biased.

A counter-vailing source of positive bias is that if the pest is not identified as being not regulated, then it is assumed to be regulated. This is a practical position for the inspectorate to take. We will therefore assume that all specimens that are subjected to identification are successfully identified as being regulated or not, because any pests that are not identified as being not regulated will be assumed to be regulated. A further extension could be made to record whether the specimen is positively identified as being regulated or not identified, and therefore assumed to be regulated, however we do not consider this case here.

We now construct a simple mathematical model for this system. Suppose that n is the number of regulated pests intercepted on a pathway. For the n pests, only an unknown fraction s have specimens submitted for identification and only an unknown fraction i of the specimens are subjected to identification by OSP as being regulated or not. Therefore under the current system the data stored in Incidents lets us estimate the product of these quantities, namely nsi, when what we want to know is n.

Both s and i will vary between pathways because of the variation in types of commodities involved coupled with the fact that different types of pests are typical to different commodities, and some pests being more fragile or more likely to be at a stage that makes identification more difficult. Therefore, in order to obtain an estimate of n, we need to estimate s and i.

One recommendation of this report is that s should be 1, which would simplify the problem. If the data in Incidents were to include the reason for sampling and the likelihood of the sample being submitted for identification, then we can estimate n. For example the value for submission rate s (which is constant for the pathway) stored in the database might be

- 1: rules say everything is submitted (our recommendation)
- 1/7: for a weekly bug day
- $2/(22 \times 16)$: for a 2-hour bug collection, once per month (22 working days of 16 hours)
- Unknown: for the inspector wanted to know
- Unknown: submission depends on the whim of the importer

Furthermore, if the likelihood of the specimen being subjected to identification by OSP, i, were known because a suitable stratified design were used as laid out previously, and also suitable records were kept by the OSP, then we could estimate n as $\sum 1/(s \times i)$. Pests that may be show-stoppers or whose identity is required for prescribing treatment on the particular pathway will have $i = 1$, because they will be identified, and pests for which identification is optional will have i equal to the nominated sampling rate, which is yet to be determined.

6.4 Discussion

We emphasize that the only joint condition under which a pest will be eligible for not being identified is both (i) if, during screening, it is not identified as being a significant risk, and (ii) if identification is not required for biosecurity response. Examples of the latter condition include the importer electing immediate treatment, and passenger items being confiscated and the risk being contained.

Tactically, all intercepted pests will be treated as though they were regulated unless they are identified as being not regulated. So, pests that are not identified due to not being randomly selected, will still be treated as though they were regulated from the point of view of the biosecurity handling of the consignment. However, from the strategic point of view of improving the estimate of the pathway risk, the regulated status of the unidentified pests will be inferred from the outcomes of identifying the pests that are randomly selected.

For non-commodity items like passengers, mail and non-plant product cargo, most pests and diseases can be considered as 'hitch-hikers'. In general, we have only a fairly vague knowledge of where the products originated. The value of knowing precisely what has been found is probably of lesser value than the fact that something was found, and on what, and how it was being carried. Leaving aside those interceptions that might lead to a court case, a strategy that sends a proportion of pest detected for a full identification or a thorough investigation of risk material seized would seem to be consistent with DAFF's risk–return policy. Being able to specifically say what has been found on occasions is extremely useful when discussing inspection strategies and the like with stakeholders. Finally, whatever scheme is proposed, it is important to emphasize that any inspector may submit any pests found for identification, regardless of the reason.

For commodities that are plant products, the situation is different. An immediate difference is that we have a fairly precise idea of the source of the items. There will be specific pests and diseases for a product, as well as pests and diseases that have a wider range of hosts. Many of these products will have had an import risk assessment done to determine what steps are needed to mitigate any risks. Identification of all pests found would seem essential, from the point of view of determining the treatment as well as supporting or changing our ideas on what pests and diseases are present on a particular product from a particular source. As mentioned, treatment will often be chosen by the importer on the detection of a pest, and such consignments in practice have no need for identifications to be done. However, from an information point of view, identifications are important. If all pests found cannot be identified because of lack of resources, some systematic sampling of a proportion that would otherwise not be sent for identification would be useful.

6.4.1 Bug Day

In the past, AQIS used a sampling strategy to reduce the submission load of intercepted specimens in some pathways. The strategy was referred to as Bug Day, and in short required specimens to be submitted to OSP from the border only on certain days of the week. Although theoretically sound, Bug Day suffered from operationalization problems that limited its utility and undermined the reliability of the estimates that arose from it. Similar to the approach suggested here, Bug Day used a sampling approach, but it was implemented by border staff instead of by the OSP. Hence, the border staff felt that specimen identification and by association, specimen interception, was being devalued. The approach recommended here specifies that the OSP will perform the sampling and that all specimens should be submitted from the border to the OSP.

6.4.2 Snapshot Surveys

A further potential extension of the sampling is that in the passengers and mail pathways, useful estimates of the actual risk presented by certain classes of deemed risk and high-risk goods could be made using periodic snapshots. For example, sometimes citrus items are intercepted in these pathways. If there is no visible sign of pest then the items are destroyed. Instead, periodically, such items could be referred to OSP for more detailed examination to assess the risk of, e.g., citrus canker. Note that such an approach differs from Bug Day as outlined above because here, pests will still always be submitted to OSP, and under the protocol under discussion, periodically, so will potential vectors.

6.4.3 Implementation

We have brushed over the very important question of implementation, because it is likely that the details will vary from region to region. We still need to decide who will do the screening and the sampling, and how that will be carried out, what safeguards will be required, and so on. Each region will need to be supported in developing the infrastructure for an increased specimen submission burden, as each region has specific opportunities and constraints. We think that it will be best if OSP performs the screening and the sampling, that is, all intercepted specimens must be submitted to OSP.

6.4.4 Data Entry

We have learned that one (perhaps the most) significant impediment for inspectors to submit a specimen to OSP is the time involved, especially with regard to data entry. Depending on the location, correctly entering the data to the database can take 20–30 minutes. Streamlining the paperwork associated with recording a submission would be worthwhile regardless of implementing a more systematic submission and identification scheme because it should result in better data being collected. Obviously some data can only be captured at the source, but the minimum extra would only need to be a specimen number. Perhaps the specimen numbers could be on pre-printed stickers that are attached to the specimen and recorded in the database.

The sample number must have check digits in it so that mis-keying can be detected. Previously, PDI used paper forms that were submitted to a single data-entry person, which was much more convenient from the point of view of the border officer. Specific recommendations for streamlining the data capture are beyond the scope of this project, however, DAFF staff reported that general slowness of data recording had a significant impact on data capture.

6.4.5 Inspection Effectiveness

We have made a general assumption in the report that all inspections are currently performed adequately/effectively to detect the pests on the pathway. This is not necessarily the case, and adds a further layer of unknown pest-specific variation to the problem. The variation is a consequence of some pests being much easier to find, and different pathways being vectors for different pests.

6.4.6 Incidents

From a statistical point of view, the Incidents database needs to be able to record the reason that the sample was submitted, in order to compute the submission rate. It would be well worthwhile resolving the problems discussed in this report before there is any redevelopment of the database.

6.4.7 OSP

Our interviews made clear that border inspection staff, particularly at the airports, would appreciate and benefit from greater involvement from OSP. This involvement could be as simple as occasional visits of an hour or two duration, being available for ad-hoc questions and to discuss interceptions. We recommend that DAFF consider such an investment of OSP time. Furthermore, inspection staff felt that more direct feedback on the outcome of an identification would be useful. Different regions seem to handle this feedback differently.

As noted earlier, OSP has improved its IDs to species level over recent years and this appears to correlate with specialised training that has been undertaken with external experts. Such undertakings should be sustained and supported. This training provides at least two benefits, namely (i) improved ability to identify pests, and (ii) the building and maintenance of professional networks to draw upon for future identification assistance.

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