Quarantine and Biosecurity: An Entomologist's Perspective

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Biosecurity helps us control what we let into Australia and what we keep out. Getting the balance right requires constant vigilance. Dung beetles, honeybees and biocontrol agents show us why.

We each are likely to see biosecurity, its opportunities and challenges, through our own personal and professional experiences. For many, securing our biodiversity and protecting our health is little more than the visible hand of quarantine that greets visitors and returning nationals at our international airports.

Australia stands proud in its record of informing travellers about the dangers to our economy, health and environment if unwanted pests, weeds and diseases enter our island nation. Without doubt this constant vigilance and cooperation by the general public has kept us free of many harmful exotic organisms.

However, as a retired biologist I see deeper biosecurity issues – some where our score card is excellent, and others where attention is warranted. Not surprisingly, these issues are shaped by three aspects of my professional background: as a chief of a CSIRO Division (Entomology), as the Commonwealth Visitor for the Weeds Cooperative Research Centre (CRC) and as chairman of the Honeybee R&D Council.

Wearing these three hats has allowed me to see the good and the bad of quarantine practices, and the consequent impacts on biosecurity for better and worse. The common thread has been insects, and how these abundant creatures – ones we have and don't have – affect many facets of modern society.

An Ongoing Balancing Act

Within CSIRO my responsibilities included the National Insect Collection of 12 million specimens representing the enormous number of native insect species in Australia. Collecting, cataloguing, naming and understanding the biology of this vast fauna was the responsibility of taxonomists and ecologists in the Division of Entomology, working with entomologists in museums, state departments and universities.

Our insect fauna has, over evolutionary time, contributed to Australia's rich, diverse and unique biota. Insects have even shaped aspects of our physical environment such as our soils. For instance, the large Oecophorid moth family, with over 5000 species, has co-evolved with our eucalypts and continues to play a key role in nutrient cycling and soil formation. Other standout groups include termites, weevils, native dung beetles, butterflies, dragonflies and many dipteran and hymenopteran families, along with "honorary" insects such as mites and spiders. Australia's isolated island status enabled the evolution of our distinctive biota.

Despite the unique biota, agriculture in Australia, since the arrival of Europeans, has been dependent on exotic plant and animal species from across the globe. Since European settlement we have introduced many species deliberately for food and fibre, such as sheep, cattle, horses, goats, pigs, camels, wheat, cotton

and clovers. Only very few native species, such as kangaroos and macadamias, are included in our menu.

Numerous other foreign species obtained "entry permits" for cultural or aesthetic reasons, including rabbits, cats, dogs, foxes and a wide range of flowering plants. Some deliberate introductions had no redeeming features, such as the cane toad; others brought mixed blessings. The latter include feral pests – rabbits, cats, pigs, goats and camels – or weed species like camphor laurel, lantana, morning glory, Paterson's curse, and a wide range of tropical pasture weeds.

Some introductions were accidental (earthworms) or incidental (honeybees) but have proved beneficial. Earthworm species, imported with potted plants from Europe have played a valuable role across the continent in bolstering soil fertility from a very low base. The European honeybee, *Apis mellifera*, was introduced around 1820 as a source of food sweetener (honey). Since its early and widespread establishment in managed hives, and as feral colonies largely in tree hollows, it has proved to be our most valuable imported insect. Honeybees provide pollination services to a wide range of exotic crops worth more than $4 billion per year.

Our need to import exotic plants and animals, or at least improved genetic stock, will always continue if we wish our primary producers to remain profitable and sustainable. Likewise there will be ongoing demands to introduce natural enemies to control environmental weeds and feral pests. We cannot expect any change to the continuing demand for importation of ornamental plants and animal species for cultural purposes.

A key aspect of biosecurity and quarantine is about getting the balance right: preserving our native plants and animals but also assisting agriculture, the environment and the aspirations of a modern society. One highly successful example of importing a group of exotic species to restore the balance in our pastures and rangelands is the Australian Dung Beetle Program (see box, p.8).

Top marks must go to all the research agencies and the regulatory organisations that collaborated over the past 40 years to address the ecological imbalance caused by the dung of large exotic herbivores, without a single breakdown in quarantine and biosecurity.

An adult of the Paterson's curse root weevil, *Mogulones geographicus*, on a Paterson's curse flower. The weevil is a biological control agent of Paterson's curse. Image credit: CSIRO Entomology

Of course, we should continue to recognise and remedy the serious habitat loss of native biota caused by extensive land clearing and replacement of native pastures for modern agriculture and food security.

Weeds and Biosecurity Loopholes

While exotic plant species underpin Australian agriculture and provide enormous enjoyment to garden lovers, the presence of other exotic plants tells a different story. Some plants grow where we don't want them to, and often in abundance. In pastures, weedy plants such as Paterson's curse and St John's wort replace useful animal fodder and can even be toxic; in crops, they reduce yield and add to production costs; in natural habitats, weeds can displace native plants, with flow-on effects for native fauna.

According to the World Wildlife Fund (WWF; http://www.wwf.org.au):

> Weeds cost Australia an average of $4 billion a year and cause large production losses in the beef, wool and wheat industries. This equates to $1 lost out of every $7 Australia's farmers earn in exports. The cost has doubled in just 20 years and is likely to increase.
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> Weeds have also caused the extinction of at least four native species and continue to endanger many

threatened species, endangered ecosystems and World Heritage areas. They are the second biggest threat to Australia's ecosystems and wildlife, and over the next several years are expected to become the number one immediate threat to nature.

Many exotic weeds are weedy because they lack the natural enemies that reduce their competitiveness in their native habitats. Selective introduction of natural enemies, including insects, mites and fungi, by CSIRO and state departments has proved to be a valuable strategy in controlling many weeds. Lack of significant downsides to the importation and release of a diverse collection of natural enemies for reducing the nation's weed burden is further tribute to the safety and effectiveness of Australia's quarantine procedures.

The emerging impact on feral bee colonies of the small hive beetle, the latest honeybee pest to breach Australia's quarantine barrier, is beginning to have detectable impacts on the free pollination services provided by feral bees.

Against this rosy background it may come as a surprise to learn that our importation policies have had serious loopholes. As recently as 2007 it was legal to import over 4000 known agricultural and environmental weeds not yet found in Australia. This was the surprising conclusion in *Front Door Wide Open to Weeds*, a study undertaken by the University of Western Australia and the CRC for Australian Weed Management.

Important lessons can be learned from the way in which the problem was identified and the role of "virtual institutions" like the Weeds CRC and non-government agencies like WWF in remedying the problem.

The source of this biosecurity risk was a loophole in Australia's border control protocols. The Permitted Seeds List allowed entry of 2916 genera, which included thousands of known weedy plant species. As noted by WWF: "These plants were not required to undergo any kind of weed risk assessment and could be imported into Australia without impediment".

Although the federal government recognised the problem, little was done to remedy the situation. Probably nothing would have happened until the Weeds CRC used its influence to pressure the government to close the loophole.

The irony of the situation is that the Weeds CRC was itself a virtual institution, a collaborative network whose partners were real institutions, including CSIRO divisions, state departments, universities, federal government agencies and industry. It is a case where the whole is greater than the sum of its parts. The Weeds CRC could, and did, use its moral authority and collective knowledge to force a reluctant and self-protecting bureaucracy into action, much to the chagrin of the federal government. The loophole has since been closed.

However, the story does not have a happy ending. The death knell for the Weeds CRC was sounded when the Howard government terminated "public good" CRCs on the misguided notion that they were not "good investments", despite robust economic studies indicating impressive returns. Before the most recent election the incoming Rudd government promised a return to "public good" CRCs and committed $10 million for a Weeds CRC.

The Rudd government made good on both promises – well, sort of. It instructed its Department of Agriculture to find the $10 million from existing programs. Miffed bureaucrats found the funds by terminating other programs, including some excellent performers, so Peter robbed Paul.

However, they failed to release the funds to continue the Weeds CRC. Instead, they established a competitive grants scheme for weeds R&D, administered by themselves.

There is now no CRC focused on weeds research. The outcome is widely regarded as a disaster.

The Weeds CRC, which gave excellent service to Australia since 1995, ceased to exist in June 2008. Consequently, weeds research and biosecurity has returned to the dark ages preceding the establishment of the CRC in 1995. Australia remains capable of great initiatives, and equally capable of destroying them with impunity.

European Honeybees, Biosecurity and Food Security

When honeybees were introduced to the Australian colonies around 1820, the role of pollen in plant reproduction was just being appreciated. The role of honeybees in moving

Varroa mite. Image credit: Denis Anderson, CSIRO

pollen between plants was even less so. Over the past 200 years this exotic species, *A. mellifera*, has changed from a supplier of a sweetener to a primary crop pollinator. Some important crops – including almonds, avocado, blueberry, cucumber, rockmelon, sunflower, watermelon and zucchini – are fully dependent on honeybee pollination. Some very high value crops like canola, cotton and pasture clovers can increase yields 10–20% with honeybee pollination. When all the sums are done, the gross value of crops that involve honeybee pollination exceeds $2 billion, and some put the figure above $4 billion.

Both wild colonies (feral bees) and managed hives contribute pollination services. Feral bees provide the service for free but they need to be sufficiently close and abundant when a crop or pasture is flowering to do a good job. "A single honeybee colony can cumulatively fly and transport pollen up to 450,000 kilometres every day carrying out up to 67.5 million potential

pollinations, being a fundamentally important step during food production," according to Dr Boris Baer of the University of Western Australia's Collaborative Initiative for Bee Research (CIBER).

Beekeepers often provide hives for pollination in exchange for a honey crop. Increasingly, beekeepers are offering a paid pollination service, earning over $50 per hive for several weeks service. Around 100,000 hives are needed each August just for the annual almond crop. Projected demands of 350,000 hives for the almond crop indicate that there soon may be insufficient managed hives to meet industry needs. Eastern Australia only has around 500,000 managed hives.

The emerging impact on feral bee colonies of the small hive beetle, the latest honeybee pest to breach Australia's quarantine barrier, is beginning to have detectable impacts on the free pollination services provided by feral bees. The rapid spread of the small hive beetle along the eastern seaboard of Australia since its arrival around 2000 – probably from the USA into the Richmond district west of Sydney – is believed to be responsible for lower numbers of feral bees in gardens, crops and small orchids in these warmer moister regions. The beetle is also causing devastation in managed hives along the eastern seaboard.

Thus, for nearly 200 years feral bees and managed bees maintained by commercial and amateur beekeepers have met the pollination needs of Australia's primary industries and the wider community. However, the small hive beetle is a harbinger of even worse times ahead. We face the likely entry of a devastating mite, *Varroa destructor*, which has spread around the world in recent decades, with Australia one of the very few places left for it to colonise. In Europe, the USA and New Zealand, varroa mite has virtually eliminated feral colonies and been responsible for a major decline in managed hives. In the USA, managed hives have declined from 6 million to 2.4 million in the past 50 years, with the process accelerating in the past four years. Productive hives are abandoned and the workers just vanish. It's called colony collapse disorder. Pesticides, exotic diseases, overworked bees and varroa mite have caused the decline. Varroa mite is widely implicated in colony collapse disorder, not as the sole cause

Dung Down Under: Exotic Beetles Are Welcome Guests

Our native dung beetle fauna comprises 335 described species, with more to be described. For the most part they process marsupial dung, characterised by small dry pellets. A few native species can process the larger and moister cattle and horse dung. These species, like *Onthophagus atrox*, are thought to be relicts from ancient times when much larger herbivores roamed the countryside.

During the 1950s and 60s an entomologist, Dr George Bornemissza, noted a paucity of dung beetles in cattle and horse dung compared to his native Hungary. He argued that the introduction of select dung beetle species from Europe, and especially Africa, could address the problems caused by dung accumulation - pasture fouling, explosions of dung-breeding fly species such as the ubiquitous bush fly and disease transmission.

Between 1968 and 1986, 43 exotic dung beetle species were introduced from Africa and Europe by CSIRO, and 23 have successfully established in a wide range of habitats across mainland Australia and Tasmania. This herculean task was completed without introducing any animal disease, such as swine fever or foot-and-mouth virus, which were endemic in countries from which some beetles were sourced. No introduced species has become a pest, and no detectable harm has been inflicted on the native dung beetle fauna. More than 20 state and federal agencies were involved in the Dung Beetle Program, and all cooperated well to ensure that no unintended negative effects flowed from this ambitious program.

Since 2000, a series of evaluations addressing the abundance and distribution of introduced dung beetles has been conducted. These have led to the cropping and redistribution of species to optimise dung burial, and to identifying gaps that could be filled by further introductions. During 2009, 27 state and federal agencies approved the introduction of a further two species of dung beetle from Europe. New Zealand is also assessing, with assistance from Australian researchers, the Australian introductions with the intention of importing suitable species to deal with the same imbalance caused in New Zealand pastures by cattle dung.

Edwards, Penny 2007. *Introduced Dung Beetles in Australia 1967–2007. Current status and future directions.* This publication is accessible on the Landcare Australia website (http://www.landcareonline.com.au). Search on 'dung beetles'.

Seed of bitou bush accidentally entered Australia near Newcastle, NSW, in 1908 in dry shipping ballast from South Africa. It was spread for dune stabilisation between 1946 and 1968 by the Soil Conservation Service of NSW. Bitou bush was also used for rehabilitation of coastal dunes after mining for rutile and zircon. Bitou bush subsequently invaded surrounding bushland, displacing native flora. So far, 10 biocontrol agents have been safely introduced to reduce its weediness. The seed fly, *Mesoclanis polana* (inset), now widely established along the eastern seaboard north of Bega, NSW, is capable of greatly reducing seed production, a key component of the plant's weediness. Image credits: Penny Edwards (main image) and Royce Holtkamp (inset)

but as a tipping point when combined with the multiple sources of stress on the modern bee hive.

Australia is now bracing itself for the entry of varroa mite in an undetected swarm of honeybees, hitching a ride by ship from New Zealand or another nearby country. Recent research shows that the varroa mite threat has compounded: in Papua New Guinea a second species, *Varroa jacobsoni*, has switched from its traditional host, the Asian honeybee *A. cerana*, to *A. mellifera*.

This recent evolutionary event greatly enhances the risk of a debilitating invasion by either or both *Varroa* species. In both instances, the mite would require live honeybees as carriers, and now either *A. mellifera* or *A. cerana* would suffice.

A recent federal Parliamentary committee released a report, *More than Honey* (http://www.aph.gov.au/House/committee/pir/honeybee/report.htm), which emphasised the

Introduced dung beetles reduce pasture pollution, fly numbers and improve nutrient recycling.
Image credit: Willem van Aken and CSIRO

strategic importance of honeybees for pollination services. But it also revealed serious weaknesses in the nation's quarantine arrangements. Like the proverbial parson's egg, some aspects are good, others not so good. In 2001 the Howard government sold Sydney's Quarantine and Inspection Services (AQIS) Eastern Creek quarantine facilities for a pittance with a lease-back arrangement that terminates by 2015. The facilities included the only honeybee quarantine facilities for Australia. No arrangements are in place for replacement facilities. General operation of the AQIS facility is also under review following the outbreak of equine influenza. This triggered two major quarantine reviews whose recommendations are far-reaching but have yet to be implemented.

The *More than Honey* report was scathing in its assessment of the sequence of events surrounding the entry, detection and subsequent handling of the Asian honeybee *A. cerana* following its detection in the port of Cairns in May 2007. Offspring colonies from the Cairns incursion are still being found in January 2010, so the quarantine breach has yet to run its full course. Fortunately, the original swarm did not carry varroa mite or other parasites. The incursion did serve as a salient and timely reminder that Australia is not adequately prepared to deal with an invasion of varroa mite, other mites or other unwanted honeybee species such as *A. cerana*. One thing is certain: Australia is better prepared to respond to a quarantine breach in terms of the more clearly defined roles of state and federal agencies.

Australia can be proud of its quarantine record but there are some impressive failures like equine influenza and the *A. cerana* saga, and some indefensible decisions such as the closure of quarantine stations in the mistaken belief that quarantine services could be privatised. Maybe they can for cats, dogs and possibly horses, but certainly not for honeybees.

The biosecurity challenge increases with globalisation and human population growth, but the funds to protect our biodiversity, to ensure sustainability of primary production and to safeguard human and animal health continue to diminish. Greater awareness of problems, especially by tomorrow's decision-makers, is a key step in getting the priorities right.