RISK ASSESSMENT FOR IMPORTING AND KEEPING EXOTIC VERTEBRATES

MARY BOMFORD, and **QUENTIN HART**, Pest Animal Unit, Bureau of Resource Sciences, P. O. Box E11, Kingston, ACT, 2604, Australia.

ABSTRACT: Exotic animals can establish wild populations that may cause serious adverse economic and environmental impacts. In Australia, there are a number of species currently kept in captivity that would pose such threats were they to escape and establish. Paradoxically, there is a push to allow freer trade in animals between countries for recreational and commercial purposes. This paper considers approaches to assess and manage these risks, including the application of ecological theory to estimate the probability of escape, establishment, eradication, and harmful impact. Although some potential forms of impact are obvious, particularly for species that are pests in their natural or introduced range, others may be less so because species may change their behavior or ecology in new environments, and interact in unpredictable ways with resident plant and animal species. This uncertainty creates a need to leave a wide margin for error when assessing the risk of harmful impact.

KEY WORDS: exotic species, risk assessment

Proc. 18th Vertebr. Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. 1998.

INTRODUCTION

Australia is a geographically isolated continent with a rich diversity of indigenous flora and fauna. The diversity of flora and fauna was even greater 200 years ago before European settlement and consequent habitat modification and ecosystem imbalance through the introduction of new species.

The development of agriculture in Australia relied on the introduction of many exotic agricultural plant and animal species—some of which subsequently established widespread wild populations and became pests including goats, pigs, and a wide range of weed species. European rabbits (*Oryctolagus cuniculus*) were brought in with the first European settlers for food, fur and skins and have subsequently become Australia's most widespread and significant pest animal (ABS 1996). The rate of spread of the rabbit in Australia was the fastest of any colonizing mammal anywhere in the world—advancing at up to 100 kilometers per year in the rangelands. The scale of the impact of the rabbit in Australia is considered to be unique in the history of wild animal introductions (Williams et al. 1995).

Other exotic species which have subsequently become pests were brought in as companion animals (e.g., cats), for sporting purposes (e.g., the European red fox—*Vulpes vulpes*), or simply to make Australia seem more "European" (e.g., the European starling—*Sturnus vulgaris*). Other species were, ironically, brought in to control existing pests and became pests themselves (e.g., the cane toad—*Bufo marinus*)(ABS 1996).

The result is a suite of introduced species—about 20 mammals, 30 birds, 20 freshwater fish, several amphibians, 500 invertebrates and 1,500 plants—which are pests of agriculture and/or the environment (ABS 1996). Hindsight provides the opportunity to prevent additions to this extensive inventory of pests. Risk assessment provides a mechanism.

Risk assessment processes for importing and keeping exotic vertebrates have an important role to play in reducing the likelihood of new species establishing and causing adverse impacts in Australia.

THE RISK

Species' translocations are proceeding at an unprecedented rate around the world and have the potential to cause adverse impacts to agricultural, environmental, and urban systems. There is a risk that new imported species, or exotic species that are currently kept in private collections and zoos, could escape and become pests. For example, the Somali dwarf mongoose (*Helogale undulata rufula*) is a small colonial carnivore that has significant potential to inflict damage to Australian wildlife if a wild population established. Yet a breeding colony of this species is kept in an open enclosure in an Australian zoo.

Ferrets have established wild populations in New Zealand and have had highly detrimental effects on wildlife. Yet ferrets can be kept without any permits or restrictions in Australia, and a wild population has now established in the Australian island state of Tasmania.

The forms of adverse impact that an established population of an escaped exotic animal could cause include:

- reduction of agricultural productivity (competition with grazing stock for feed and water, damage to horticultural crops, predation on stock, land degradation)
- environmental damage (competition with native species for food, water, and shelter
- spread of parasites or diseases
- attack, harassment, or annoyance threat to the community, particularly in the urban environment
- structural damage
- cost and collateral impact of control measures

THE BENEFIT

Exotic species can bring many benefits to agricultural production, recreation, tourism, scientific and medical research, international conservation efforts, and education. Many of Australia's agricultural and recreational industries are based on introduced animals and there is ongoing demand to import new species and genotypes.

A number of zoos in Australia are involved in coordinated breeding programs for endangered species, both for release programs and to maintain the genetic integrity of zoo populations. The display of such species also serves to educate the public about environmental and biodiversity issues.

THE ISSUES

Key issues relating to assessing the risk of importing and keeping exotic vertebrates are:

- What is an acceptable level of risk relative to potential benefits for the import and keeping of exotic species?
- How can we minimize risk exposure (i.e., controlling the number and type of exotic species imported in the country) and manage the risk that we accept (i.e., management of the species that are introduced)?
- What criteria can be used to assess the potential costs and benefits of importing and keeping exotic species in Australia?

This paper describes the regulation of exotic animal imports in Australia and outlines the risk assessment approach developed by Bomford (1991) that is currently used in Australia.

REGULATION OF EXOTIC ANIMAL IMPORT AND KEEPING IN AUSTRALIA

Legislative control over the import of exotic animals is held jointly by the peak Federal environmental agency—Environment Australia and the Australian Quarantine and Inspection Service (AQIS). Both organizations rely on advice on the "pest potential" of species from a national Vertebrate Pests Committee (VPC) whose members represent relevant State and Federal government agencies.

Until 1991, VPC, Environment Australia, and AQIS had no framework or guidelines for assessing the risks associated with the import and keeping of potential vertebrate pest species in Australia. Risk assessments were made in a fairly subjective way and were difficult to justify if political pressure was brought to bear to alter a decision.

Bomford's 1991 model was developed on the premise that the import and keeping of exotic vertebrates should be subject to a balanced and rigorous risk assessment, taking into account both potential benefits and harmful impacts, and using all available scientific theory and information on the biology of the species being assessed. It should be emphasized that, given the uncertainty of the assessment due to incomplete information, it is a predictive model rather than an absolute measure of risk. Thus, a conservative approach should be adopted along the lines of the precautionary principle: "the absence of evidence of risk does not equate to the evidence of absence of risk" (Moller and Barret 1996).

It is likely that community demands and international obligations under WTO agreements concerning free trade will result in increasing numbers of species being imported into and kept in Australia.

Thus, there is a need to develop transparent, evidence-based risk assessment processes to increase decision-making objectivity and reduce the influence of social, economic, and political pressures. Risk assessment processes should be developed in conjunction with interest groups to achieve transparency and enhance compliance, although the assessment itself should be entirely independent of these groups. Interest groups should pay for the application of the risk assessment process in accordance with the user-pays principle (AQIS 1991).

Rigorous risk assessment processes do not necessarily hamper free trade. Experience in Australia with weed risk assessment has shown that more scientific risk assessment models have the potential to prevent the entry of a greater proportion of high risk species while at the same time freeing up trade at the lower risk end to the extent that more plants could be imported (Walton and Ellis 1997).

Freer trade may also reduce risk by reducing illicit trading. For example, the Australian Quarantine and Inspection Service ended a ban on avian imports in 1989 to reduce the incentive to smuggle birds and eggs into Australia and, therefore, reduce the likelihood of introducing exotic avian diseases (Wilson 1988).

It is essential to get the risk assessment process right at the import stage, because once permission is given to allow a species into the country, it is extremely difficult to reverse it. Animal confiscations and increased keeping restrictions are often politically unpalatable and strongly resisted by keeper groups. Unfortunately, Australia is already faced with the situation where high risk species (e.g., Indian ringneck—*Psittacula krameri krameri*, monk parrot—*Myiopsitta monachus*, and red-eared terrapin—*Pseudemys scripta*) entered the country before the current, more rigorous risk assessment processes, and some of these are now widespread through small private collections.

THE CURRENT RISK ASSESSMENT PROCESS

Ecological theory relating to each of the component processes associated with exotic species introductions are considered by the current risk assessment model used in Australia. The component processes are the probability of:

- an exotic species escaping
- the escapees establishing a wild population
- the escapees or established population being eradicated
- harm associated with the three former factors outweighing the potential benefits associated with the species being imported

Probability of Escape

Clearly, some species possess attributes that enhance their ability to escape. Security of premises and keeping restrictions can be used to manage this risk. However, no physical barriers are completely proof against:

- natural disasters such as floods, cyclones, fires and earthquakes
- willful removal by animal liberation groups or illegal traders
- vandalism, terrorism, civil unrest or war

There are numerous examples of exotic species being released during natural disasters. For example, a flock of yellow-headed Amazon parrots (*Amazona ochrocephala*) was released by a California aviculturist when fire

threatened his collection, resulting in the establishment of an exotic population (Long 1981; Nilsson 1981).

Probability of an Escaped Population Becoming Established

There is a large body of scientific theory on the factors that affect establishment, including analyses of previous successful and unsuccessful introductions. This information was used in Bomford's (1991) model to draw generalizations about factors that affect the probability of establishment. These include:

Escape conditions:

- timing of escape—especially season
- number of animals escaped—critical threshold usually about 20 individuals
- sex of animals escaped—single sex collections reduce the risk of establishment
- condition of escaped animals—particularly their health, sex and reproductive status
- source of escaped animals—wild caught from expanding populations most successful

Environmental factors:

- bioclimatic distance—Nix and Wapshere (1986) found bioclimatic distance, which is a measure of climatic similarity between the sites of origin and release based on rainfall and temperature, accounted for 80 to 90% of the variance in success of introductions of birds into Australia
- site—factors conducive to establishment include: the availability of habitat near the release site that meets the species' physiological and ecological needs, disturbed habitats, and absence of competitors or predators

Community attitude:

- likelihood of the public reporting escapes which would allow early detection, capture, and eradication
- likelihood of the public feeding and sheltering escapees which would increase probability of establishment

Species attributes:

- distribution—species that are widespread and abundant in their natural range, and/or have a history of establishing exotic populations represent a higher risk
- physiology—species that have the ability to tolerate a wide habitat and climatic variability and have a high reproductive rate (early sexual maturity, large clutch/litter size, high breeding frequency, short gestation and opportunistic breeding) represent a higher risk
- diet—dietary generalists and opportunists are more successful than specialists, and herbivores are more successful than carnivores or omnivores
- behavior—characteristics increasing the risk of establishment include: commensalism with people or ability to live in modified environments, ability to seek out habitats suitable for survival, vagility (ability to change domicile over time), non-migratory, and/or flocking or herding behavior
- phenotype and genotype—high variability increases the potential for rapid adaptive radiation

Although the species attributes that favor establishment are represented in the exotic species which have established wild populations in Australia, there are many exceptions. There has been little research to identify or quantify the relative significance of these attributes or how they might interact—so the theory is far from robust or definitive.

The degree of certainty in assessing the likelihood that a species could establish a new environment is limited, particularly by:

- the large number of factors that influence success, including a high element of chance
- inadequate information on the ecology, physiology and behavior of most species, and the cost and long-term nature of research needed to obtain these data
- unpredictability with which species may change their ecology, behavior, phenotype or genotype in new environments, especially where there are different foods and fewer predators, competitors and diseases

The existence of escape contingency plans that enhance early detection and capture/eradication influences the probability of establishment, and may be taken into account in the risk assessment process.

Probability of an Escaped Population Being Eradicated

Once a population is established, eradication chances are likely to be low or non-existent due to high costs, lack of political will and, for many species, the extreme difficulty of the task. There are no cases of an established mainland pest population ever being eradicated on any continent. It is, therefore, critical that there are contingency plans and associated resources for early detection and eradication of newly escaped individuals or small localized populations that become established.

Species attributes that affect the chances of early detection and eradication include visibility, habitat preferences, behavior, and susceptibility to trapping or poisoning.

The feasibility of eradication will also depend on community attitudes towards the species involved and the control measures used.

Probability of Net Adverse Impact

For an assessment of potential environmental and agricultural damage, it is necessary to predict probable population densities and distributions.

Analysis of trends in past introductions enable generalizations about taxa and species attributes that cause environmental or agricultural damage.

Ebenhard (1988) reviewed the literature on introductions of exotic vertebrates worldwide and found that 40% of mammal introductions have been linked to some ecological impacts on populations of native plants or animals, mainly through predation, competition, or habitat damage. Ebenhard found of the 49 recorded introduced predatory mammal species, 20 are reported as having caused one or more indigenous populations to decline in abundance or become extinct.

In comparison, Ebenhard found only 5% of bird introductions have been associated with ecological impacts, but considered this may be a great

underestimate. The main effects of introduced birds are as competitors with native species and as vectors or reservoirs of disease. These effects are hard to demonstrate and poorly documented. Exotics may also hybridize with native species corrupting their gene pool. Waterfowl are particularly susceptible to this problem.

Estimated adverse impact is weighed against estimated potential benefits. As indicated previously, potential benefits may be significant and justify some risk of harm.

APPLICATION OF THE RISK ASSESSMENT MODEL

The VPC currently lists exotic species in one of five categories:

Category 1 - entry and keeping prohibited
Category 2 - restricted to high security collections
Category 3 - other collections
Category 4 - entry and keeping unrestricted
Category 5 - pests already widespread

Applications are made to VPC by public and private zoos and individual keepers to downgrade category listing for species that they want to import, or species that are already in Australia but that they want to keep in a lower security collection.

Because pest species do not respect state borders, it is essential that uniform risk assessment processes operate within all states of a country. In Australia this is effectively achieved through the national VPC, although individual states are currently able to allow a species to be downgraded one category level from the national recommendation.

The risk assessment model developed by Bomford (1991) is used to determine whether the benefits of recategorization applications outweigh the risks.

Although there has been a trend towards more quantitative risk assessment models in the last decade, most biological risk assessments are going to be semi-quantitative at best due to incomplete information. One advantage of semi-quantitative or quantitative risk assessment is that they allow sensitivity analyses to determine the most critical points of risk or risk factors. At the same time, quantitative risk assessments may be misleading if they suggest a level of accuracy which is not supported by available data (Nunn 1997).

The Bomford (1991) model is qualitative because it was considered that with current levels of knowledge, numerical models would give a misleading impression of objectivity, and would probably have a low level of accuracy. VPC is currently considering the possibility of quantifying the model. One way of doing this would be to consider the animals that have been introduced to Australia in the past and compare the attributes of those that have established compared to those which have not. Of those that have established, the attributes of species that have become widespread and/or caused damage can be considered. In this way, numerical values can be applied to species attributes depending on the degree to which they are likely to confer higher risks of escape, establishment and damage. The model might then be tested against future introductions and refined as appropriate. However, no model will be absolute, due to the influence of chance factors—particularly environmental conditions at the time of escape.

The current model used by AQIS to assess the weed potential of imported plant material is semi-quantitative. It overcomes some of the problems of using quantitative models by including a large number of questions (49), and a character that reduces the effect of assessor subjectivity by reducing the weighting of any one question on the final score. The model does not require that all questions are answered, recognizing that information on a particular species may be incomplete (Walton and Ellis 1997).

An example of the application of the exotic species risk assessment process used in Australia is the recent rejection of an application to import the rock hyrax (*Procavia capensis*). The rock hyrax is a rodent that is considered hard to contain and has a number of features that indicate a high risk of rapid establishment and spread and the possibility of agricultural and environmental damage, including:

- small, fast-moving and secretive—making early detection and eradication to prevent establishment difficult
- high reproduction and dispersal rates and opportunistic feeders giving a high probability of establishment
- potential for large distribution and abundance of an established population, coupled with opportunistic feeding behavior providing a high probability of environmental and agricultural damage

Given that there were few benefits to be realized from importing these species, the decision to reject the import proposal was clear-cut.

A less clear-cut case where an import application was rejected was for the blackbuck antelope (*Antilope cervicapra*) in 1990. This species has the potential to be both a pest and a new commercial livestock species. It has attributes that would make it relatively easy to eradicate escaped individuals or a small localized population. These include its preference for open habitat, low dispersal rate, low rate of increase, and herding behavior. However, the blackbuck's appealing appearance could cause public resistance to control by shooting or poisoning and would reduce the probability of eradication of an escaped or established population. The Bomford (1991) model took into account all of this information and the application was rejected.

Linked to the recategorization process are assessments for "Approved Collection Status" (ACS) to allow a particular institution to keep a species. This takes into account the security, credentials and financial viability of the proponent organization. It also takes into account how conducive the surrounding environment is likely to be to establishment of the proposed species.

An example of the need for the ACS process is the situation of Tipperary Sanctuary in the Northern Territory of Australia. This was established in the 1980s by a wealthy English businessman who wished to keep a wide range of rare species in a remote location surrounded by bushland and subject to monsoonal rain and cyclones. Despite the fact that the surrounding environment and remoteness would make detection and eradication of escaped animals difficult, the Sanctuary was approved and a few years later had 1,500 animals in a 1,000 hectare area.

The Sanctuary contained a number of exotic ungulates, despite the fact that at about this time there was a campaign in the region to eradicate unmanaged ungulates (including feral horses and donkeys and water buffalos) to help eliminate brucellosis and tuberculosis from stock. Adding to the threat, the Sanctuary encountered financial difficulties in 1990 to the extent that there were problems in providing food for the animals and it would have been difficult to find alternative homes for the animals at short notice. The peak zoo body in Australia has since developed a contingency plan for relocation of any unwanted animals.

Although VPC has a reasonably close relationship with the larger zoos and wildlife parks in Australia, the status of animals held in the large number of smaller collections is less certain. Many species—particularly birds—have been imported into Australia under previous, less rigorous risk assessment processes. The large recreational avicultural industry in Australia also provides a market for illegal smuggling. It is difficult to manage such a diffuse menagerie of animals with regard to knowing what animals are kept, how they are kept, and if there have been transfers or escapes. Thus, private collections pose one of the greatest risks and the biggest challenge of risk management of exotic vertebrates.

CONCLUSIONS

General principles of risk assessment include:

- models need to be scientific and evidence-based—more quantitative models can increase objectivity if adequate information is available to support this approach
- there is some risk associated with all exotic animal imports—scientific risk assessment processes allow the free trade:risk balance to be optimized
- the degree of certainty in assessing whether a species could establish in a new environment and inflict damage is greatly limited by a lack of data and the ecological theory—be conservative if data inadequate
- models should be continuously evaluated for predictive accuracy and modified as better information becomes available
- new models can be used to conduct retrospective analyses on exotic species being kept on the basis of previous assessment processes
- detailed contingency plans for early detection and eradication of newly escaped individuals or localized established populations reduce the risk and could be taken into account in the risk assessment process
- because there can be no guarantee that escape can be prevented or eradication will be possible, species considered to pose a high risk should be prohibited even if they represent significant potential benefit.

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