GETTING AHEAD OF THE GAME: PREPARING FOR NOVEL INCURSIONS

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ABSTRACT

The invasion curve highlights the importance of prevention and quick eradication in preventing establishment of new populations. Surveillance programs aim to prevent new animal pests from arriving in Australia through early detection of stowaways and illegal imports. Detecting new animal pests in the wild following release or escape can be difficult as there is often little local knowledge of their behaviours. To be prepared for these events, toolkits are being developed, applying best practice management techniques refined on established vertebrate pests, to aid in quick detection and capture to prevent establishment following an incursion of these novel pests.

Behavioural information of how species use their micro-environment, shelter preferences, diet and feeding can help to identify techniques to enhance their subsequent detection and capture. While some techniques may be applicable for multiple species there may be key differences which influence how they are applied. Detailed review and examination of behaviours and detection programs in the native range of these species can also highlight critical knowledge gaps. It is important to identify and explore these gaps both prior (to improve the probability of detection and capture) or post incursion (to assess impacts on ecosystems and how the species use the Australian landscapes). Here, I will use several exotic species as examples to describe the approaches undertaken to identify behavioural attributes that can be exploited to enhance detection and capture of likely, high-risk species to Queensland to ‘get ahead of the curve’.

Keywords: incursion, exotic, behaviour, detection, capture.

INTRODUCTION

The benefits of preventing the establishment of a pest species over the long-term cost of managing the impacts of that pest species are well documented. In Australia, the estimated costs to agriculture from established pest animals and weeds are in the order of $5.2 Billion per year (Hafi *et al*. 2023). Pest animals in Queensland are estimated to cost the agricultural sector over $340 Million per year (Hafi *et al*. 2023).

An ever increasingly used tool to highlight the benefits of early intervention in pest management is the invasion curve (Figure 1). This curve demonstrates that the longer the time that a species is present, the greater the area infested, and the control cost, will be. The best situation for Australia’s environment and agricultural sectors is to prevent pest species entering the country, and surveillance programs at border control aim to achieve this. There is, however, increasing pressure on border programs due to illegal trafficking in exotic species and stowaways across transport systems. The illegal live animal trade is considerable and often follows species being allowed in legal trade in certain jurisdictions, for example almost all smuggled species into Australia are found in the legal US pet market and there is an average 5.6-year lag between a species appearing in the US trade and its subsequent detection in Australia (Stringham *et al*. 2021).

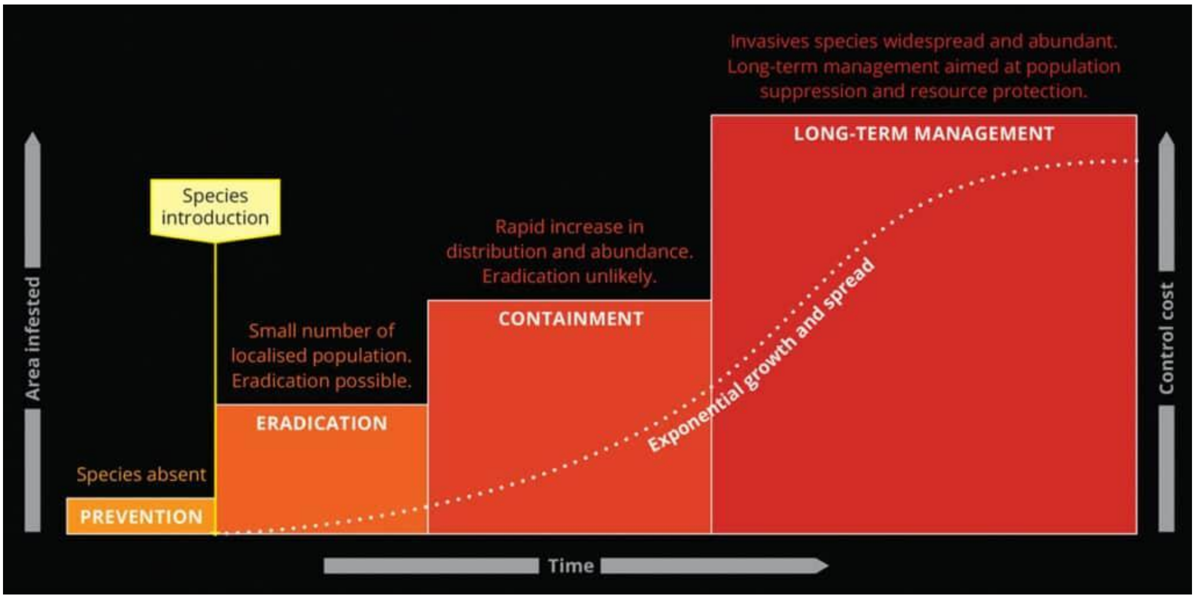

Figure 1. The invasion curve highlighting increasing costs of control as the species moves beyond the opportunity for eradication and into long-term management (from Invasive Species Council 2022).

New incursions of exotic species require quick action to detect and remove the individuals before any opportunity of establishment. However, there is often limited local knowledge of that species which can hinder control activities. For example, when red-eared slider turtles (REST - *Trachemys scripta elegans*) were first detected in Queensland, capture attempts used techniques traditionally used for Australian freshwater turtle species. These included the use of seine nets and draining water bodies to expose and recover individuals (O'Keeffe 2005). These techniques were discovered to be unsuitable for locating and capturing REST as they burrow deep into the silt on the bottom of the water body and cannot reliably be found (O'Keeffe 2005). While eradication of those populations detected in Queensland was achieved, it required development of new strategies (trapping around waterways during draining, using fyke nets, and training detector dogs to locate nests) to locate and capture REST which delayed the operations and increased risk of establishment (O'Keeffe 2005). It also required the development of new monitoring tools, that are still being refined some 20 years post first detection (Harriott 2024), to prove eradication and to monitor new reported sightings of REST.

To be better informed and prepared prior to incursions by vertebrate species, toolkits are being developed to aid quick detection and capture of exotic individuals before establishment. These toolkits review and examine detection and capture methods in the species home range and in exotic regions of establishment to assess success and practicalities for use in Queensland. The toolkits also examine life history traits of the species, such as breeding, diet and food acquisition, and shelter and micro-habitat preferences to provide strategies to increase detection and capture likelihoods. Using climate matching models, the toolkits also examine establishment risk and regions in Queensland that are most similar to the native range of the species to highlight areas where focussed attention should be directed if the species is reported. Finally, the toolkits identify gaps in knowledge related to detection and capture of the species and provide recommendations to fill those gaps.

ESTABLISHMENT RISK AND REGIONS OF SUITABILITY

The risk of an exotic vertebrate species establishing in Australia can be determined using an establishment risk score that assesses several categories including climatic suitability, history of establishment in other non-native ranges, taxonomic class, and generalist or specialist diet and habitat use (Bomford 2008). For example, Northern palm squirrels (*Funambulus pennantii*) score high for climate suitability and exotic established populations, and they are mammals with a generalist diet and thrive in disturbed habitats leading to an Establishment Risk Score of 'Extreme".

The climate match score shows the suitability of environment for the potential incursive species and can be mapped to show the regions of highest suitability (Figure 2). For example, African pygmy hedgehogs (*Atelerix albiventris*) and Tokay geckos (*Gecko gecko*) would be well suited to northern Queensland while American corn snakes (*Pantherophis guttatus*) are most suited to southern and central Queensland and Northern palm squirrels are most suited to all areas except east coastal regions.

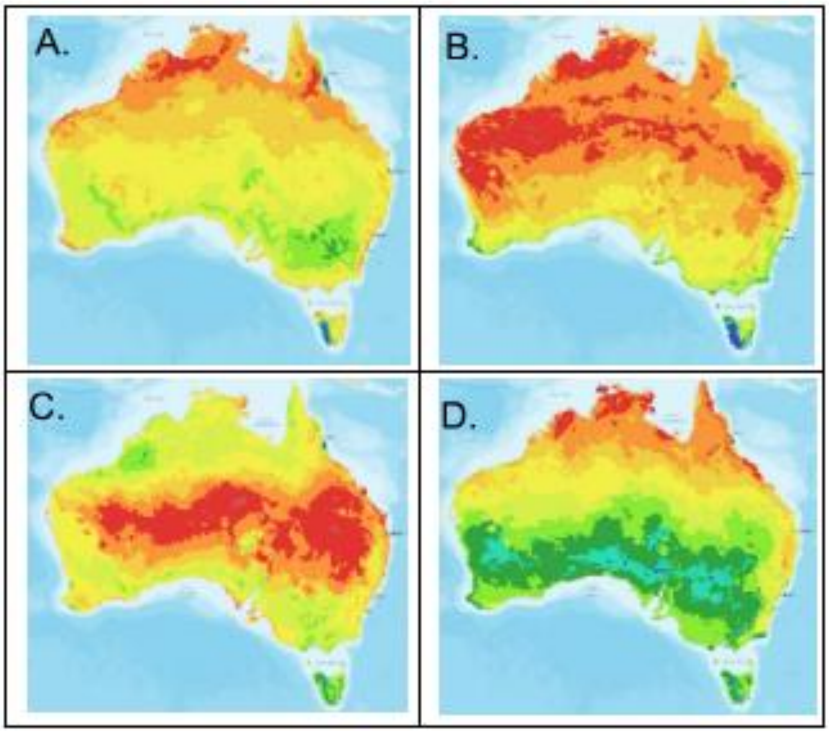

Figure 2. Climatch maps for: **A.** African pygmy hedgehog, **B.** Northern palm squirrel, **C.** American corn snake, **D.** Tokay gecko. Orange and red colours show regions of highest suitability while blue and green show regions of lowest suitability.

USING BEHAVIOURS AND LIFE-HISTORY TRAITS TO INFORM DETECTION AND CAPTURE

All species have different requirements to survive and reproduce. These traits for high-risk exotic species are often adaptable and generalist in nature allowing them to thrive in a wide range of habitats. Feral pigs, for example, can subsist on a diet ranging from grains and fruits to insects and meat. This has allowed them to establish populations throughout Queensland and means that toxic baits and trapping cannot use standard food lures across the landscape. Further understanding of the animals' behaviour is required to maximise encounter rates with baits and traps (e.g. using lures that incorporate the food most being eaten in that area, such as grain rather than meat when grain crops are being damaged, and taking advantage of pig behaviour around dams by trapping on the inflow side). Similarly, African pygmy hedgehogs' diet consists of a wide range of insects, as well as worms, snails and slugs, frogs, snakes, lizards, small mammals, eggs and young of ground nesting birds, fruit, nuts, fungi and roots (Haltenorth and Diller 1988; Okaeme and Osakwe 1988). With such diverse feeding options, luring hedgehogs into traps can be difficult as they can find other food rather than enter a trap. Corn snakes, however, feed only on small mammals and the eggs and young of tree nesting birds (Rush *et al*. 2014) providing an opportunity to use eggs or mouse scent as lures in ground and arboreal traps (Stapleton 2005; Engerman *et al*. 2018; Christy 2019). Live prey has been used as a lure (e.g. live mice) for trapping invasive brown tree snakes, *Boiga irregularis*, in Guam (Engerman *et al.* 2018), but is probably not needed for American corn snakes as they hunt using chemical cues rather than visual cues and so live prey does not cause an increase in predatory behaviour (Vice *et al*. 2005). Similarly, African pygmy hedgehogs use smell and hearing to hunt and have relatively poor eyesight so visual attractants (such as feathers that have been used to attract feral cats to traps, e.g. Paton *et al*. 2024) would not be useful (Kingdon 1974). There has been very little research into trapping these species and this is a knowledge gap that needs to be explored to increase our capacity to handle future incursions.

Another tool often used to detect animals are remote activated camera traps. The usefulness of these devices will differ depending on the behaviours and traits of the animals. American corn snakes are ectotherms so aren't always detected by remote cameras. They are also primarily nocturnal and hunt over ground and in trees. Camera traps would therefore need to be set either directed at the ground or secured in trees and to take images using time-lapse rather than motion-sensor, meaning they have limited application. Larger bodied snakes, however, such as Burmese pythons (*Python bivittatus*) have a higher detection likelihood on remote cameras, especially in the near infra-red spectrum, than corn snakes (Vaco-Castano *et al* 2019). Northern palm squirrels are diurnal and spend time both on the ground and in trees foraging. Camera traps would be a useful tool for detection, but careful consideration on placement would be required. African pygmy hedgehogs are nocturnal and ground-dwelling and so detection can be improved using thermal cameras (Bearman-Brown *et al*. 2020).

Knowledge of how species use their environment can also aid in detection and capture. African pygmy hedgehogs prefer to shelter under bushes, in rock crevasses or termitaries, in buildings, or holes in the ground (Haltenorth and Dibbler 1988). Active searches and trap placements can take these details into account when searching for individuals in the wild. American corn snakes shelter during the day in underground harbours making detection difficult, however, artificial shelters (e.g. metal sheets, wooden boards) established where sightings have been reported can increase detections as the snakes use them as sheltering locations (Bird *et al*. 2015).

Reproductive requirements can also be exploited to enhance detection and capture. REST leave the water to dig nests into the ground in grassed areas near the waterbody. Nesting periods provide opportunities for catching turtles by hand or trapping the turtles as they leave or return to the water using barrier fencing and pitfall traps (e.g. Tucker 1997). Detector dogs have also been used to locate REST nests (O'Keeffe 2005) allowing removal of eggs before hatching (and have been used to locate and hand catch invasive European hedgehogs, *Erinaceus europaeus* on the Uist Islands; Thompson and Ferguson 2017). The Tokay gecko uses a distinct advertisement call to attract mates (Tang *et al*. 2001), which could potentially be used to aid detection using acoustic recorders.

CONCLUSIONS

By investigating the behaviours and life-history traits of species with high-risk of incursion and establishment in Queensland, we can find techniques to increase detection and capture rates by exploiting those traits (Table 1). This will allow a quick response to reports of new species in the wild without needing to trial techniques until we stumble onto the best methods that work. Being prepared for new species puts us ahead of the invasion curve to prevent incursions leading to establishment.

Table 1. Usefulness of detection and capture tools for four species of high-risk incursion species. Shaded cells are the best tools for capture.

Species	Camera traps	Spot and catch	Trap	Other
Pygmy hedgehog	Yes, nocturnal	Yes, thermal	Limited	Detector dog
Corn snake	Limited	Yes, crepuscule	Yes, lured	Artificial shelters
Palm squirrel	Yes, diurnal	No	Yes, lured	Nest box trap
Tokay gecko	Limited	Yes, spotlight	Yes	Acoustic trap

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