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CSIRO Submission 18/646

Inquiry into controlling the spread of cane toads

House of Representatives Standing Committee on the Environment and Energy

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Executive Summary

This submission provides an overview of the introduction of cane toads to Australia and goes into the efficacy of the current control measures used, as well as detailing novel methods being developed for cane toad control and mitigation. This submission in particular highlights CSIRO research historically undertaken on cane toad management as well as research CSIRO is currently engaged in to develop novel genetic tools to combat cane toads. The submission emphasises the need for novel methods of cane toad abatement to be developed because the currently available tools are:

- Costly and labour intensive
- Not effective at a landscape scale

The submission also touches on the social implications of the current abatement strategies and the work CSIRO is doing to engage with the public and learn about their attitudes towards the use of novel genetic technologies in pest eradication and conservation.

Introduction

CSIRO welcomes the opportunity to provide input to the House of Representatives Standing Committee on the Environment and Energy inquiry into controlling the spread of cane toads.

The cane toad was introduced into Australia in 1935 by the Queensland Bureau of Sugar Experiment Stations after reports of cane toads being used to control cane beetles in Hawaii and Puerto Rico. Within five years the government released over 60,000 young cane toads into Queensland. Almost 85 years later it is estimated that cane toads occupy over 1.2 million square kilometres in northern and eastern Australia (Urban *et al*, 2008).

The cane toad's ability to spread so quickly into so many different ecosystems is due to a few key characteristics. Cane toads are a very hardy species that can go long periods of time without food or water and are opportunistic feeders that can take advantage of a wide variety of food sources. They are also highly fecund, with females laying between 10,000 and 30,000 eggs in a single clutch and breeding on average twice a year. Finally, cane toads express toxins throughout their entire life cycle which are lethal when ingested. This means that cane toads have not become a staple prey source for Australian predators, so there is no significant predation to keep their population numbers in check.

Western Australia first declared the cane toad a pest in 1950, and 40 years after the introduction the first toad, a survey of the devastating impact of cane toads on Australian fauna was published by Archer and Covacevich (1975) of the Queensland Museum. This publication helped initiate efforts into cane toad eradication and control, which started in earnest in the 1980's with federal funding and establishment of a cane toad Research Management Committee (Invasive Animals CRC, 2006). In the years since, a significant amount of work has been done to understand the ecology, life cycle, population dynamics, genetics, and diseases of the cane toad (Alford, 1994; Hyatt *et al*, 1998; Lampo and De Leo, 1998; Shine, 2010; Trumbo *et al*, 2016). This knowledge is quite valuable, and has aided scientists all over the world better understand the changes in ecosystem dynamics caused by invasive species (Phillips *et al*, 2006). However, to date, no effective eradication or landscape scale population management strategies have been developed.

Research has indicated that that the threat presented by cane toads is higher now than ever. While early estimates of cane toad movement estimated that the invasion front progressed approximately 10 km a year, newer estimates put this figure closer to 55 km a year (Urban, 2008), with some evidence pointing to this increase in speed caused by genetic evolution in the toads (Phillips *et al*, 2006). Another worrying trend is the increased thermal tolerance seen in toad populations at the southernmost invasion front (Kolbe *et al*, 2010; McCann *et al*, 2014), indicating that the species is capable of evolving and spreading to habitats outside of its originally predicted range.

The spread of cane toads has had a significant impact on a wide variety of Australian ecosystems particularly during the first few years after the invasion front has come through. The long-term broad impacts of cane toads on biodiversity beyond a small number of directly affected native species has been exaggerated but native species level impacts are significant. Among the Australian natives that are directly impacted by the cane toad are quolls, goannas, multiple species of snakes, freshwater crocodiles, and native amphibians (Burnett, 1997; Catling *et al*, 1999; Crossland *et al*, 2000; Llewelyn *et al*, 2010; Shine 2010). Recovery of native populations, particularly of native amphibians, has been observed in ecosystems where long-term monitoring has been undertaken. Australia has no native toads and as such many endemic families of predators have little resistance to toad toxin. It will therefore take a long time before native species adapt to cane toads and can contribute to the suppression of their abundance. In addition, cane toads present a threat to domestic animals, especially dogs (Johnnides *et al*, 2016). While it is difficult to ascertain how many dogs are poisoned by cane toads every year, retrospective studies from veterinarian clinics in Brisbane indicate that single clinics can average between 30- 50 cases a year (Roberts *et al*, 2000; Reeves, 2004).

Cane toads affect multiple industries (tourism, agriculture etc.), however the impacts have not been high enough for broad industry investment, therefore cane toad management and eradication attempts have generally been publicly funded. Research suggests that if the impacts caused by cane toads are to be properly biologically controlled, new technologies need to be developed which can operate at the continental scale (Shanmuganathan *et al*, 2010; Tingley *et al*, 2017).

Since the 1970's CSIRO has been undertaking cane toad management research including; options for viral and genetic biological control (Thresher and Bax 2006; Shanmuganathan *et al*, 2010; Pallister *et al*, 2011), understanding cane toad diseases (Hyatt *et al*., 1998), potential geographic distribution (Sutherst *et al*, 1996), and toxicology (Halliday *et al*, 2009). In the 2000s CSIRO undertook highly novel research into one such approach attempting to develop a genetically modified virus capable of infecting cane toad tadpoles and interfering with their ability to metamorphose into adults in a species-specific manner, but was ultimately unsuccessful due to technical difficulties in the viral gene delivery (Pallister *et al*., 2011).

Currently CSIRO is applying its expertise in genetic technologies at the Australian Animal Health Laboratory to explore novel pathways to a new control measure (conditioned taste aversion in native predators) that links with and strengthens existing impact management strategies. Public attitudes towards using such genetic tools in a conservation application are an ongoing and a fundamental part of this work. If acceptable to the public (particularly with indigenous land owners) and successful in the laboratory, then regulatory approvals would be sought for field trials. This could be the first step on a pathway to develop additional genetic control measures not only to protect native species but also to reduce population numbers of cane toads both in endemic affected regions and at the invasion front.

CSIRO response to the Terms of Reference (ToR)

a) the effectiveness of control measures to limit the spread of cane toads in Australia.

CSIRO is not directly involved in the field management of cane toads in tropical Australia. A number of control measures are in effect and all are reported to have some degree of effectiveness. These include:

Manual removal – effective locally but is resource intensive, with other reviews concluding that money is better spent on other mitigation strategies (Invasive Animals CRC, 2006).
Adult trapping – effective in targeted areas (Tingley *et al*., 2017) but limited in more remote locations as traps have to be monitored regularly.
Tadpole trapping –more effective and less labour intensive than adult trapping (Tingley *et al*., 2017), however is still confined to areas where people are.
Fencing of water resources- fencing can provide some impact, however it is often considered prohibitively expensive (Invasive Animals CRC, 2006). Fencing also can prevent native animal’s access to water resources, which can have further negative impacts on the environment.

Many of these measures are labour intensive and, while they can be effective at a local level, they are not able to contain toads at a landscape scale. With that said many of these activities such as manual removal are often managed by local communities and volunteers and provide opportunities for community engagement and help raise awareness of different threats facing our environment. Thus it is important to also factor in the social impacts of different control measures when assessing their overall utility.

Other methods that CSIRO has explored but not implemented in the field include:

- <u>Viral biocontrol</u> – CSIRO has undertaken a significant amount of work to identify a viral biocontrol agent for the cane toad (Shanmuganathan *et al*, 2010). While multiple viruses that infect cane toads have been discovered (Hyatt *et al*., 1998), no suitable, species specific candidates have been identified (Invasive Animals CRC, 2006). Recent advances in next generation sequencing technology have enabled the discovery of several previously unknown viruses in healthy Australian cane toads (Russo *et al*., 2018), however unless some degree of virulence can be demonstrated, the potential of such endemic viruses as successful viral biocontrol agents appears low.
- <u>Sterile male technology</u> – this technology involves making tetraploid (animals with 4 sets of each chromosome instead of 2) males, which then are released and mate with females to produce non-viable triploid offspring (e.g. Thresher and Bax, 2006). It was presented in the mid 2000’s as a possible solution, but never implemented at the time due to technical hurdles related to early embryo manipulation, which is critical to making artificial tetraploids. Due to CSIRO’s current work into genetic technologies more information is being gained about handling and manipulating early cane toad embryos, and those insights could help make this a feasible strategy.

Emerging methods that are still being developed or are in the early stages of field trials by CSIRO and other research providers:

- <u>eDNA sampling</u> – This allows for the presence and population density of cane toads in a body of water to be determined using environmental DNA (Tingley *et al*, 2017). While it is not a direct eradication strategy it is an important new tool for tracking cane toad populations and could be used to determine the efficacy of population control strategies.
- <u>Automated call detectors</u>- This allows for tracking where cane toads are on the invasion front, and importantly locates where they are breeding (Tingley *et al*, 2017). Cane toads participate in mass

breeding a few times a year where all the breeding age cane toads in an area will amass in a body of water and mate. Knowing when and where mating is taking place is a critical tool for deploying population control strategies like tadpole traps.

- Targeted water resource reduction- Cane toads rely on water sources for both survival and breeding. While cane toads can survive for long periods of time without water (through a process known as estivation, which is somewhat similar to hibernation) they must have water for breeding and for tadpoles to develop in. By studying cane toad breeding habitat selection scientists could develop a better understanding of what makes an ideal cane toad breeding ground, and thus block cane toads from these area or modify the landscape/ habitat such that it is no longer suitable for breeding (Tingley *et al*, 2017).
- Reduced fitness breeding- Genetic studies comparing established cane toad populations to populations at the invasion front have found that invasion front cane toads, or "fast" toads, are adapted for faster spread into new areas (Phillips *et al*., 2006). By transplanting "sedentary" cane toads from established populations to the invasion front for breeding the "sedentary" toads will breed with the "fast" toads. The resulting progeny from a "fast" toad and "sedentary" toad mating would in theory spread slower since it would have an equal mix of "fast' and "sedentary" genes. If done on a large scale this could slow the spread of cane toads into new areas.
- Conditioned taste aversion: Conditioned taste aversion is a harm mitigation strategy that aims to "teach" native Australian predators to avoid cane toads, thus mitigating some of the impacts cane toads have on the environment (O'Donnell *et al*, 2010). The system works by feeding predator species with ground up cane toad meat that is mixed with an emetic (a non-lethal substance that induces vomiting) which causes the animals to get sick, but does not cause any lasting negative health problems. In some circumstances this conditioning has been shown to be effective at increasing the avoidance of some predator species to cane toads. Preliminary field trials by government and NGO's in WA for conditioned taste aversion are on-going.
- Exotic lungworm as a potential biocontrol agent: The exotic lungworm (*Rhabdias pseudosphaerocephala*) was accidently introduced with cane toads as part of the original releases. Lungworm densities in toads are lower at the invasion front than in established populations. It has been proposed that native frogs could be used to spread the lungworm at the invasion front to reduce cane toad fitness (Pizzatto *et al*, 2012).
- Gene editing and genetic engineering: In recent years new tools have emerged in the field of molecular genetics that allow scientists to make very small, even single base pair, changes to the genome, a process now known as gene editing. In addition, tools to make larger changes including inserting novel genes into the genome have also advanced. CSIRO has developed capabilities in this field (e.g. Thresher and Bax, 2006) and is currently working on developing methods for gene editing and genome engineering in the cane toad. The first aim is to target genes in the toxin production pathway to generate "low toxin" cane toads that can be used for conditioned taste aversion (studies have shown predators respond better to conditioned taste aversion when live prey is used as opposed to ground up meat). The second aim is to engineer toads with reduced reproductive capability by deleting or repressing genes that are critical for fertilization in the cane toad.

b) additional support for cane toad population control measures.

The control measures currently available all play an important role in controlling cane toad populations, however they only provide transient and/or localised benefits since cane toads reproduce prolifically, quickly repopulating depleted areas and rapidly adapting to new environments (Invasive Animals CRC, 2006). This indicates the need for new approaches aiming at the development of tools and strategies that can address the problem at a landscape scale.

Novel genetic control measures have been and are being developed for a number of pest animal species such as carp (Thresher *et al*, 2014), mosquitoes (Adalja *et al*, 2016), and rodents (Leitschuh *et al*, 2018) and the Cane Toad genome, a prerequisite for any such approaches to proceed, has now been published (Edwards *et al*., 2018). As these genetic control measures are further assembled and tested it is likely that opportunities will arise to consider similar methodologies for cane toad population control. To do this will require the development of genetic modification systems for the cane toad. CSIRO's current research strategy around cane toad control is based on exploring these methodologies.

Other critical components of CSIRO's strategy in this area focus on risk assessment and gauging public sentiment with respect to the use of genetic tools to address critical conservation problems (Hayes *et al*, 2018). A key facet of this is engagement with communities directly impacted by cane toads, particularly the traditional land owners whose cultural heritage is being eroded by the loss of significant native species. CSIRO is committed to a completely transparent approach to gene technology development and also works very closely with regulators and end-users throughout the development of such approaches under agreed international principles (Emerson *et al*, 2017).

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