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Developing a national framework for Dingo trophic regulation research in Australia: Outcomes of a national workshop.

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Introduction

There has been speculation about whether the Dingo (*Canis lupus dingo*) plays an important role in maintaining ecosystem function through top-down trophic regulation. The lack of focused research prompted the organization of a workshop attended by Dingo researchers and managers from across Australia in October 2005 (Dickman *et al.* 2006). Workshop attendees recognized the benefits of improving both the strategic direction and integration of research ideas and results. This led to a second workshop: Towards a National Agenda for Dingo Trophic Regulation Research, held on the 26th November, 2007 in Perth, Western Australia. Attendees sought to develop a framework, based on Visser (2007) and outlined here, for Dingo research in Australia to ensure that future experiments address gaps in our knowledge and minimize repetition among studies.

A possible framework for future Dingo research

Workshop attendees divided the Australian continent into four broad bioclimatic zones following Hobbs and McIntyre (2005) (see Fig. 1) as the trophic roles that the Dingo plays are likely to vary across these zones. This is because: (i) assemblages of native and exotic prey species differ between zones; (ii) an exotic mesopredator possibly affected by the Dingo (the Red Fox *Vulpes vulpes*) occurs in some zones only; and (iii) Dingo management regimes vary widely across the continent. For each bioclimatic zone, a model of interactions was constructed with links within the trophic web (Fig. 1). Workshop attendees discussed past and current research to identify which interactions had been studied, and which required further research. This broad review, which has been submitted for peer review elsewhere, revealed that most hypotheses on Dingo-trophic regulation have not been tested adequately, with research focusing largely on the possible effects of the Dingo on exotic mesopredators and prey. The following is a summary of the key research needs in each of the four bioclimatic zones as discussed at the workshop.

The northern zone

The impacts of the Dingo on cattle in this zone have been explored indirectly through dietary studies (see review in Corbett 1995), but more research into the direct effect of the Dingo on cattle and livestock production is needed (Fig. 1). Current research on the effects of feral Pig (*Sus scrofa*) on rainforest vegetation (Wet Tropics CRC) could be expanded to examine the interaction between the Dingo, feral Pig, cattle and vegetation in both rainforests and savannahs.

Previous research has suggested a positive correlation between the presence of the Dingo and the persistence of small mammal populations (see review in Johnson *et al.* 2007); however, the mechanism driving this pattern is unclear. Limited research has also suggested a negative impact of predation by feral Cat (*Felis catus*) on small mammals, but the overall effect of this predator on biodiversity has yet to be addressed in this bioclimatic zone. Ways to tease out the unstudied interactions (Fig. 1) include: (i) manipulation of Dingo populations by baiting; (ii) manipulation of cattle numbers; (iii) manipulation of fire regimes (whilst monitoring effects on biodiversity); and (iv) manipulation of feral Pig numbers (whilst monitoring cattle attack incidents). To be interpretable, replicated manipulations need to be conducted on cattle stations with and without Dingo. As this zone is subject to changing fire regimes and shifts in rainfall seasonality, experiments should be conducted ideally under varied conditions.

The arid zone

Most current research on Dingo trophic regulation is being carried out in arid central regions, perhaps due to the relative ease of disentangling trophic interactions in these less complex and less productive environments. There are also

Figure 1. Model of major trophic interactions between the Dingo, mesopredators and prey within each of four bioclimatic zones in Australia. Arrows indicate the status of research on the interactions.

several areas in arid central and north-western Australia where there has been little or no control of the Dingo and there is an extensive reserve system; these factors provide opportunities to study interactions and manipulate populations away from the effects of cattle grazing (Fig. 1).

In parts of this region, the Dingo, feral Cat and Fox occur sympatrically where the Rabbit (*Oryctolagus cuniculus*) is abundant. This situation changes dramatically where the Rabbit is absent and prey scarce. Then, Dingo predation on other predators may provide respite for small and medium-sized native animals such as Bilbies (*Macrotis lagotis*) (Southgate *et al.* 2007) and hopping-mice (Letnic *et al.* 2009). Research has highlighted the effect of the Dingo on large herbivores such as Emu (*Dromaius novaehollandiae*) and macropods by sampling populations either side of the Dingo fence. The Dingo is also a regionally important predator of the (herbivorous) Rabbit, particularly where the Fox and feral Cat occur at lower densities.

As in northern Australia, some work has focused on the effects of Dingo on cattle (Eldridge *et al.* 2002) and on the abundance and behaviour of the Cat and Fox (see Pavey *et al.* 2008).

Possible ways to quantify unstudied interactions within this zone include: broad-scale manipulation of Rabbit populations with calici or myxoma virus; control of water availability; manipulation of fire regimes; and reintroduction of the Dingo into reserves. Importantly, the arid zone represents the northern range limit for two major interactive species, the Fox and Rabbit. The climatic threshold where the

Rabbit drops out is likely to have a major influence on interactions within the model. The current limit of the Rabbit's distribution may provide an ideal opportunity to disentangle interactions between these species and predators such as the Dingo and feral Cat, and native herbivores, such as kangaroos and smaller prey species. The reliance on artificial watering points by many species in arid regions means that comparative studies may be needed between wet and dry times. Manipulation of access to water during dry times would also aid in understanding interactions between predators. Alternatively, because vegetation and prey populations respond rapidly to rainfall, manipulations of the Dingo, Foxes or Cat, could take advantage of the state of the environment; the most dramatic results from predator manipulations could be expected a year or more after heavy rain when prey populations were collapsing and predator populations still rising.

The semi-arid rangelands

The Dingo has been reduced to only scattered populations in the semi-arid rangelands due to conflict with sheep grazing (Johnson *et al.* 2007). There is also increased Dingo-feral dog hybridization compared with Dingo populations in the north-west of the continent (Newsome & Corbett 1985). Workshop attendees believed that the only place where higher densities of the Dingo may be found in this bioclimatic zone is on the outside of the New South Wales-Queensland Dingo fence or in Western Australia.

Known interactions in the rangelands include the effects of macropods, Rabbit and sheep on vegetation, Fox and Cat on Rabbit, Dingo on Rabbit and macropods, and Dingo on sheep and cattle (Fig. 1). Possible ways to examine unstudied interactions within this system include: introducing the Dingo to reserves; the use of Dingo surrogates (such as Dingo urine) to test herbivore and mesopredator responses; manipulation of Rabbit populations by poisoning and manipulation of kangaroo numbers (possibly where they are already regularly controlled). If guardian dogs are found to be effective in protecting sheep flocks, controlled reintroductions of the Dingo could be made more broadly into the rangeland environment and the effects studied on small vertebrates, kangaroos, mesopredators and vegetation (Dickman *et al.* 2009).

The temperate forests

In the higher productivity temperate forests and woodlands, vegetation structure replaces water as the major variable influencing Dingo trophic interactions. Dense vegetation may make it easier for the Fox and feral Cat to avoid direct confrontations with the Dingo, but more information is needed on the movement and behaviour of the Dingo in forest habitats.

In more mesic areas, including the rangelands and temperate forests, manipulation of Dingo numbers through baiting is not feasible because of the confounding effect on Fox populations and low Dingo numbers. Due to continuous baiting and other control measures designed to reduce stock losses, populations of Dingo, Dingo hybrids or wild dogs may not be large enough to have trophic or other effects on the Fox or feral Cat, although there is evidence for limitation of the Fox by the Dingo (Johnson & VanDerWal 2009).

Some interactions are similar to those in the semi-arid zone and include the effects of macropods, Rabbit and sheep on vegetation, the effects of the Fox and feral Cat on the Rabbit, and the effect of the Dingo on sheep and macropods (Fig. 1). However, the presence of a mid-sized native carnivore, the Spotted-tailed Quoll (*Dasyurus maculatus*) in this system adds a further dimension to trophic interactions. The interactions between introduced carnivores (feral Cat and Fox) and Spotted-tailed Quoll have been studied to some extent (Glen & Dickman 2005), but little is known about interactions between Spotted-tailed Quoll and Dingo.

Interactions within this system could be explored using isolated but intact Dingo populations; manipulation of fire regimes; and incorporation of research goals into current state programs such as Fox baiting (Fig. 1).

Conclusion

The workshop showed that, despite a substantial amount of literature (e.g. Glen & Dickman 2005; Glen *et al.* 2007; Johnson *et al.* 2007), too little remains known about the trophic interactions of Australia's apex predator. Attendees believed that accurate scientific data must underpin the development of a coherent Dingo conservation policy, and that a coordinated network of researchers able to work within the suggested framework should be established.

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