How do plant toxins lead to mixed diets?

Karen Marsh[1], Bill Foley[1], Ian Wallis[1] and Stuart McLean[2]

[1]School of Botany and Zoology, Australian National University
[2]School of Pharmacy, University of Tasmania
Email: karen.marsh@anu.edu.au

In 1974 Freeland and Janzen proposed that saturation of individual detoxification pathways by plant toxins forced mammalian herbivores to consume a variety of foods. A mixed diet would allow the detoxification load to be spread across multiple detoxification pathways, increasing the total amount of food that could be eaten. Despite its having been widely cited, there is little direct evidence supporting this theory. We have studied the detoxification mechanisms employed by common brushtail possums, *Trichosurus vulpecula*, to investigate whether feeding limitations and diet mixing in this species are a response to detoxification limitations.

We reasoned that if detoxification rates limited how much brushtail possums eat, they should eat more if detoxification rates increased. Possums require the amino acid glycine to detoxify benzoate. Thus, we created two scenarios, slow and fast detoxification of benzoate, by supplying diets containing either benzoate alone or benzoate and glycine (Fig. 1). Detoxification constraints appeared to govern the feeding decisions of brushtail possums, as the amount they ate was not influenced by benzoate if glycine was in the food, but was reduced when benzoate concentrations increased in the absence of glycine (Fig. 2).

We predicted that possums would eat a greater total amount of food when presented with a choice between toxins that utilised different pathways than when presented with no choice or with a choice between toxins that utilised the same pathway. Brushtail possums offered a single toxin ate significantly less than when offered a non-toxic diet (Fig. 3). When offered a choice of toxins that used different detoxification pathways (1,8-cineole and benzoate or *p*-cymene and benzoate), possums mixed their diets and ate more than they did of the single-toxin diets (Fig. 3). Possums offered a choice of toxins that used the same pathway (1,8-cineole and *p*-cymene) ate no more than they did of the single-toxin diets (Fig. 3).

Our study showed that detoxification constraints do affect feeding by common brushtail possums. Possums ate more benzoate when the rate at which they could detoxify it increased and ate more when they were able to assemble mixed diets that spread the detoxification load over more than one pathway.

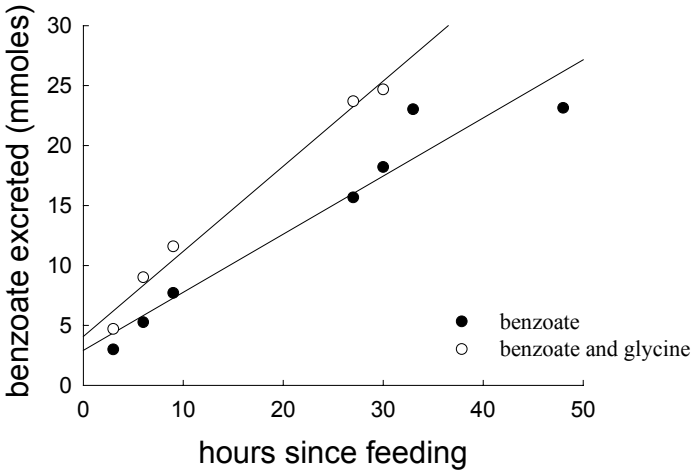

Figure 1. Eight common brushtail possums were fed 40 mmol of benzoate with and without glycine. This graph is the excretion curves for one possum, although all were similar. Possums excreted benzoate more quickly when they were given glycine.

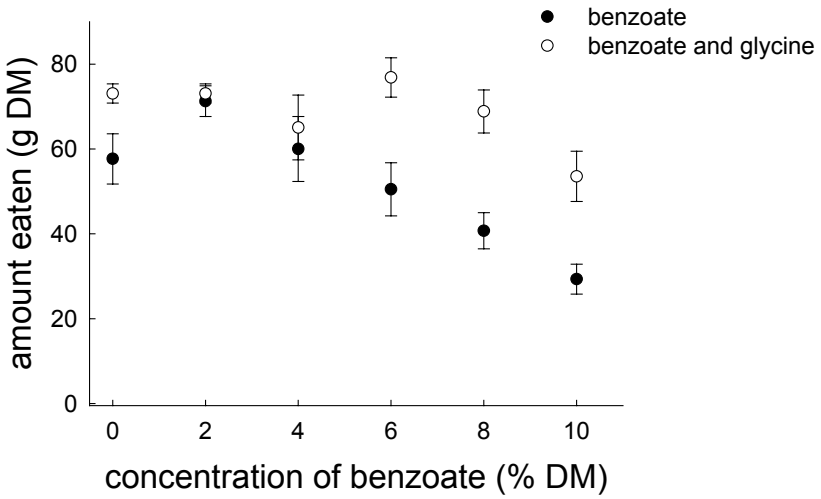

Figure 2. Six brushtail possums were offered six concentrations of benzoate with and without glycine. Mean amounts eaten decreased as concentrations of benzoate increased, unless glycine was present. Error bars indicate 1 s.e.

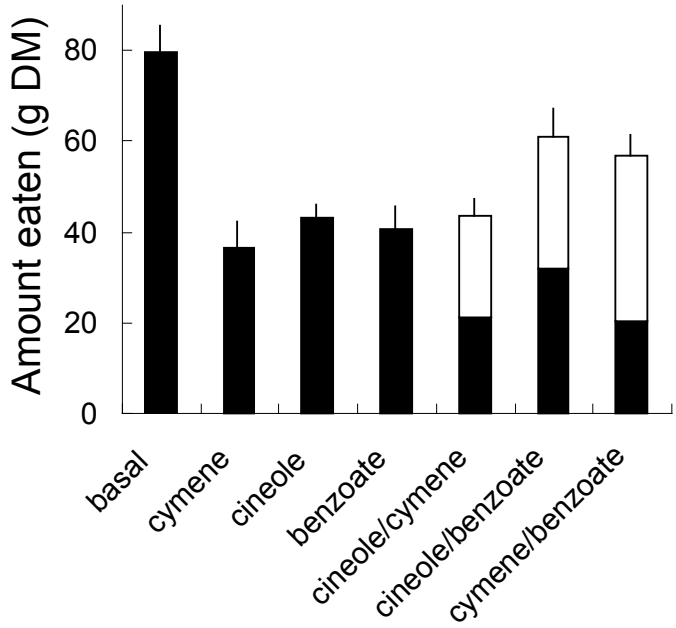

Figure 3. Seven brushtail possums were offered three individual toxins as well as choices between pairs of toxins. The same detoxification pathway is used to detoxify cineole and cymene, while a separate pathway is used for benzoate. Diet mixing allowed possums to eat more, provided that the toxins were detoxified along different pathways. Mixing a diet with cineole and cymene was no better than eating a single toxin. Bars indicate mean amounts eaten, error bars show 1 s.e.