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RESEARCH ARTICLE

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Novel biotechnologies for eradicating wasps: seeking Māori studies students' perspectives with Q method

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ABSTRACT

Aligned with the New Zealand government's 'Predator-Free 2050' target for Aotearoa New Zealand, National Science Challenge: Our Biological Heritage supports research into five distinct 'novel biotechnological controls' of exotic wasps. A framing question within this project is which controls are considered 'socially acceptable' and thus suitable for further development to control and potentially eradicate introduced wasps? How can the public answer this question without first engaging with complex technologies? Can they develop and express an informed view that still reflects their 'gut' reactions and unique positions? To model and explore the views of an 'informed public', university students in Māori studies engaged in reflection, writing and mapping activities; choice and ranking exercises; Q Method; and focus group interviews. Amongst the interviewees, Q Method analysis distinguished three 'factors', describing unique viewpoints: those who see the *potential* of biotechnologies, those who are in *doubt* about them and those in a position of *trust* in scientists. Overall, the group see potential in new biotechnologies for wasps but are wary of political, economic and social decision-making mechanisms.

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Introduction

Aotearoa New Zealand (A-NZ) is a large island land mass with a unique ecology and biosphere. Human discovery, settlement and occupation by East Polynesians in 1350AD, followed by European settlers in the late 1700s, have had a deleterious impact on many endemic species and many exotic species that came with humans are predators. These species include Polynesian introductions of the kiore, and European introductions of animals such as deer, Black rat, Norwegian ship rat, possums and stoats. Many of these predators that flourish in NZ's ecosystem can dramatically reduce populations of A-NZ's native flora and fauna (eg Towns et al. 2006; King 2017). The management of these predator or pest species for the sake of natives, especially birds, is widely supported by the public (Russell 2014).

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The community-rooted Predator-Free 2050 (PF2050) goal was a government initiative launched in 2016, with the aim to eradicate rats, possums and stoats from A-NZ. The ambition of the project ethos has been lauded by some as A-NZ's 'moon shot', an opportunity to bring natives such as kiwi back into abundance, and a way to connect and support existing efforts to protect threatened species (Russell et al. 2015; Norton et al. 2016; Owens 2017). To achieve the PF2050 goal, new, effective and socially acceptable methods of pest control are likely to be needed (Goldson et al. 2015). Researchers have been working toward targeted, next-generation biotechnological controls as potentially 'game-changing' pest control techniques (Piaggio et al. 2016; Dearden et al. 2017). Limiting the ability of species to mate, breed and spread may be seen as more humane than killing, and is an option offered by biotechnologies. These technological advances thus potentially open up a new kind of conversation in pest control.

Social perceptions, however, of biotechnologies such as genetic modification have historically not been overly positive. In 2004, the Royal Commission on Genetic Modification (RCGM) effectively advocated that NZ 'proceed with caution' on these technologies. But this ran counter to religious, spiritual and cultural concerns, and a strong backlash occurred from amongst academic and public communities alike. This included opposition from Māori to the technology (Baker 2012), but also to the way the debate was conducted and decisions made (Hutchings 2004). This aligns with the views of people in other indigenous contexts (Harry et al. 2000). As co-signatories to the Treaty of Waitangi, along with the Crown, Māori have mechanisms through which to negotiate with the New Zealand government along its governance and decision-making practices. These precede the much-discussed notion of a Social Licence to Operate (Ruckstuhl et al. 2014) although key principles in Social License, such as trust (Edwards and Trafford 2016), are critical to public support and engagement. Public engagement in conversations on emerging pest control technologies is a priority of the National Science Challenge: Our Biological Heritage theme. In the allocation of funding these challenges are recognised as 'at least as much an economic and social challenge as a biological one' (Russell, Innes et al. 2015). The actual mechanisms for social engagement are evolving (Hindmarsh and Du Plessis 2008), and as the key challenge for the future, need much work to tease out who and how to engage, and how to communicate and inform.

Māori perspectives are broad-ranging meaning they are likely to represent a broad range of possible social positions. For instance, research with Māori communities found 7 uniquely identifiable positions on biotechnology (Te Momo 2007). Māori concerns about biotechnology seem mostly rooted in an explicit tikanga basis (Satterfield et al. 2005) or sovereignty-related concerns such as biocolonialism and health of the land (Hutchings 2004). Health benefits are often cited as a reason for accepting biotechnology research and outcomes. Perception studies have sought feedback from a range of people (Satterfield et al. 2005) or targeted particular cohorts, for instance, Māori scientists (Haar 2003), members of the Kai Tahu tribe (Roberts and Fairweather 2004) and mothers (Te Momo 2007). Particular technologies explored have been in health research (Hudson et al. 2010), nanotechnology (Munshi et al. 2016), future food (Hutchings et al. 2012) and gene editing (Mead 2018) to name a few. Many Māori-led studies are actively shifting debates away from 'problem-research-solution-apply' perspective-seeking approaches by exploring and applying Māori norms, values and frameworks (for instance see Mead 2003; Hudson et al. 2007; Baker 2012). Research has also explored processes by which participant's perspectives can be valued (such as Cram et al. 2009; Hudson et al. 2012). Through this work, participants become active participants in the co-(re)construction of new ways to look at these issues, as well as the reflection on and reporting of their own perspectives. Our study adds a specific focus on wasp control using biotechnologies, with Māori studies students. Furthermore, we use a method that acknowledges and articulates these previous debates, asserting the specificity and relevance of Māori views to biotechnology debates, while allowing participants to have, form and express their own ideas and perspectives.

While mammals take the PF2050 limelight, common wasps (*vespula vulgaris*) and German wasps (*V. germanica*) have a massive impact on native insects and birds, especially in honey dew beech forest (Lester et al. 2013). The biomass of wasps in the Nelson Lakes region, at peak wasp abundance, was calculated to be higher than that of combined biomass of all birds, stoats, rats and possums in the area. German wasps were first noted in Hamilton in 1946. Common wasps became abundant in New Zealand during the 1970s and were well established and widespread upon identification. With no natural predators, social wasps quickly gained a strong foothold in Aotearoa's ecosystem (Lester and Beggs 2019). Nuisance value aside, their stings are life-threatening to those allergic to wasp venom. Their economic impact on New Zealand industries has been estimated at $133 million/year (MacIntyre and Hellstrom 2015). Control campaigns have been highly successful in mobilising public support and crowd-funding. In the Nelson and Taranaki regions 'Wasp Wipeout' has raised money for the use of the toxic bait Vespex®. Deployed in elevated bait stations during the larvae-feeding stage of the season, this bait and toxin combination is highly targeted and an effective treatment that kills entire wasp nests. This kill is achieved by wasps themselves transporting Vespex® to the nest as food and poisoning offspring in the larval stage.

This research is part of a National Science Challenge: Our Biological Heritage project that investigates five different 'novel biotechnologies' (see Table 1). These are emerging biotechnologies under development that have the potential to control and possibly eradicate exotic social wasps from Aotearoa NZ. The mission statement for the project seeks 'socially acceptable' next-generation technologies that are targeted and affordable. As such the project is designed to be multi-disciplinary, including experimental research led by science specialists linking to social science research on perspectives. Kāhui Māori is a governance and advisory body of Māori researchers who oversee how research design and execution adhere to Vision Mātauranga (VM) principles (Ministry of Research Science and Technology 2007). Oversight by members of Te Kāhui, the multidisciplinary Māori Advisory Board, encourages and supports researchers to seek connections with Māori, iwi and Māori entities, find ways that Māori perspectives can be heard and taken seriously, and support and value mātauranga Māori. Kāhui Māori's influence increases the likelihood that the research will be trans-disciplinary, of value to public stakeholders and that it will connect to policy and governance change.

As a way to explore the likelihood of new biotechnological control methods being accepted, the research seeks opinions on 'pests' generally, wasps in particular, existing control methods, novel biotechnological controls, and the social and political context that both enable and constrain the conversations. These questions required developing and using a wide array of methodologies that were consistent with kaupapa Māori positioning. Q Method can give particular insight when there is a multitude of perspectives.

Table 1. In-brief explanations of the principles and applications for the five biotechnological controls under investigation.

Biotechnological control	Principle	Potential application in wasp control
Artificial Pheromones	Pheromones are chemical substances produced and released to communicate with (or affect the behaviour and physiology of) members within the same species.	Artificial pheromone could be used to lure wasps into traps, disrupt developmental cycle or mating behaviour. An artificial sex pheromone, for example, might stop males from finding and mating with queen wasps.
Trojan mites for biological control	A mite, *Pneumolaelaps niutirani*, was discovered in 2011 by a NZ researcher. Wasps nests infested with these mites were found to be generally smaller, diseased, and less aggressive than mite-free nests.	These mites could be used as a biological control agent to transmit a pathogen of wasps. Other biological control agents lay eggs in or on wasp larvae. Hatched eggs feeding on the larvae restrict wasp colony growth.
RNA Interference (RNAi)	RNA interference (RNAi) is a gene silencing mechanism triggered by providing double-stranded RNA. When ingested into insects, this RNA can lead to death or affect the viability of the target pest. RNAi is a natural cellular defence process.	Researchers have been using RNAi with a number of crop pests, for example to stop gene associated with juvenile development. This is not a 'genetic modification' of wasp DNA. It could be used to stop wasps reproducing.
Trojan female	In many populations, naturally occurring mutations occur in mutations inherited mitochondrial DNA. These mutation means females produce sterile males, without affecting the female carrying them.	Large numbers of female wasps carrying natural mitochondrial mutations could be reared and released. The idea is that a female and her daughters would produce sterile males over multiple generations, leading to a steady population decline.
Gene drive	'Gene drives' rely on the genetic modification of an organism's DNA by scientists. Gene drives dramatically promote the inheritance of a particular gene to increase its frequency in a population.	A genetically engineered trait or characteristic, such as susceptibility to disease or infertility, can be driven through several generations. Laboratory studies have shown gene drives can affect entire populations.

Note: Longer variations of these were given to participants in a 5-page primer.

The paper thus reports on a variety of findings relating to the viewpoints of intelligent lay-people with perceptive, thoughtful and culturally-informed views. While our focus is on wasps, results inform the PF2050 project and the control or eradication of other pest species.

Methodology

A Kaupapa Māori orientation on Māori-centred research

Kaupapa Māori (KM) research includes a range of methodologies that reflect, or have been repurposed to put Māori values, aspirations and decolonising principles at their centre (Smith 1999). KM takes Māori positionality as central and normal. It seeks to build up Māori. These aims and philosophies were originally nursed within the academic discipline of Education, yet the values permeate and related research practices continue to be developed in many disciplines, notably across schools of Māori Studies. In KM, reviving mātauranga and/or generating new mātauranga are likely to be central to KM research. Te reo Māori is taken for granted. The focus of KM research is designed by Māori communities and supports their aspirations. In spite of our desire for these outcomes from all our research, it is hard to argue that this project meets these latter criteria.

Thus, we argue that this project is Māori-centred, with a kaupapa Māori orientation. We are guided by the 5-category VM classification in this assertion (New Zealand's

Biological Heritage National Science Challenge 2018). The research priority emerged from the overall Challenge with Kāhui Māori sanction and is accountable to the Challenge directors. The research methods were designed and led by two Māori researchers working alongside a Pākehā researcher. We sought out and explored a method that could support the philosophies of KM. A KM orientation meant that within these restrictions, we put our participants' aspirations first. Being mindful of the burden of 'participant fatigue' and 'oversampling' that Māori in communities experience, we designed this study to build knowledge and research capability amongst ourselves and our students. Connecting students to a real world problem that they address in their studies contribute to their engagement, learning (Kuh 2008) and success. Participants were recruited by the postgraduate student and research assistant King Hunt. He provided kai (food) and koha of supermarket gift vouchers (thank you gifts) to participants, with the intention of fostering manaakitanga (hospitality). Another form of manaakitanga was in the sharing of knowledge and ideas, and in the manner of sharing. The chance to experience a new methodology was appreciated, especially by the postgraduate students.

Our mixed-methods approach blended face-to-face interaction with the inclusion of quantitative ranking exercises. This study is just the second to explore how Q Method fits with the ideologies of kaupapa Māori research (Sheed 2014; Sheed and McDonald 2017). Q Method deals in subjectivities, allowing for diverse perspectives to emerge. The presentation of statements that have been carefully chosen to represent multiple voices promotes reflection and discussion on topics that may not otherwise arise. Absolute numbers are less significant compared to overall pattern comparison. Q Method will be explained further below and with that further discussion on Q Method's support of kaupapa Māori research principles.

Māori studies as a centre for discussion

In Māori studies courses at Te Kawa a Māui, Victoria University of Wellington, students engage at the intersection of disciplines, such as Western capitalism, science and mātauranga. For instance, in MAOR301 Tā te Māori Whakahaere Rauemi / Māori Resource Management students examine the ways Māori manage resources in relation to the restrictions of Crown legislation and local government policy. In MAOR202 Te Pūtaiao Māori / Māori Science, students examine mātauranga (Māori knowledge), its scientific nature and its connection with Western science. In MAOR302 Te Pūmoto o te Tangata Whenua, o te Taiao / Indigenous Knowledge(s) and Science in Global Contexts students explore how different Indigenous knowledges work alongside, with or against Western science. In these courses, Mercier introduced and designed short modules on biotechnology in Aotearoa. This included a lecture by entomologist Lester on the impact of common and German wasps on Aotearoa flora and fauna. Lester described the 'novel biotechnological controls of pest wasps' under investigation by the collaborating scientists. Lester expressed no particular preference of one biotechnology over another, spent equal time explaining each biotechnology, and also covered traditional methods of wasp nest eradication. Mercier designed assignments which (a) probed students own experiences of wasps, geolocating their accounts using Google Earth or map screengrabs (b) asked students to choose a biotechnological control, research and summarise it, and (c) considered their chosen technology from a Māori perspective that draws upon any one of a number of social, political, cultural, spiritual and ethical concerns. All of the MAOR courses value and apply tikanga, Māori and Indigenous perspectives, and Mercier expected that these would weigh heavily in students' considerations of the biotechnologies. The weighting of these assessments varied from 4% to 25%. Students were then recruited from these courses for focus groups. Ethics approval for focus groups was granted by Victoria University of Wellington's Human Ethics Committee (#24885).

Students enrolled in BIOL132, an online course, also covers pest wasps. An optional survey and invitation to take part in focus groups drew 4 survey attempts and no focus group responses, out of 50 students enrolled.

Participants

The Māori studies students learning about wasps and biotechnological controls constitute an informed but generally not science-trained audience. To avoid coercion, research student King Hunt recruited participants by emailing an invitation and information sheet to students of MAOR202 (2015 & 2017), MAOR301 (2016) and MAOR302 (2016 & 2017). Mercier was not made aware of who participated until after the trimester's grades had been entered.

Of the 16 who were willing to be involved, 1 was interviewed individually and 12 were split evenly into four focus groups, for a total of 13 participants. Five were female and eight male. Six were mature students (over 40 years of age, or with children). This represents a more male, and more mature cohort than generally seen in Māori studies. 5 participants were at postgraduate and 8 at a senior undergraduate level. All participants were familiar with Māori studies discourse, comfortable in kaupapa Māori settings, and had at least a listening fluency in te reo Māori. The participants represent a broad range of iwi (tribes), some are active leaders in student politics, and some have connections to and/or leadership roles in their home communities. 11 primarily identified as Māori and two as non-Māori. Participants were emailed a 5-page 'primer' on the five biotechnological controls prior to the meeting. The 2-h focus groups were conducted on campus during trimester breaks in 2017.

Students were first asked questions about their course learnings on wasp biotechnological controls. They then completed three ranking exercises in order of increasing complexity. First they considered and ranked seven pest control options for rats; second, they considered and ranked nine pest control options for wasps. Results are presented in Table 4. Third, participants were given a Q Method sorting task, in which they arranged 25 statements in relation to *wasp biocontrols* (participants understood *wasp biocontrols* to refer to the range of biotechnologies under consideration, not just biocontrols) onto a grid to represent their level of agreement or disagreement with each statement. After each exercise, participants explained their ranking and Q-Sorts to the others in the group. Prompts and interview questions were interspersed throughout.

The interview and four focus groups were audio-recorded and transcribed. Transcriptions were read and coded only after the students' final grades had been entered. Transcripts were compared closely with the ranking and Q-Sort exercises to give meaning and context. Quotes that illuminate findings from the Q Method analysis were selected and extracted. The small sample size of students from a single university means that this study is limited in terms of the broader application of its findings. Nonetheless, it is sufficient to illustrate the application of a new method, highlight key issues in relation to biotechnology and pests, and contribute to the conversation on gaining a social licence from an informed public.

Q method instrument design and analysis

Q Method is not hypothesis-driven, but a systematic way to measure and compare subjectivities or points of view (Brown 1993). It is a useful technique when viewpoints are wide ranging. Q Method explores the range of views on a subject, and how these relate to each other.

We curated and crafted 25 different statements to try and represent the range of concerns relevant to biotechnology, to pest control, and to Māori concepts such as kaitiakitanga (environmental stewardship). Statements are reproduced in Tables 2 and 3. Areas of importance were identified through studying literature on perceptions of biotechnology, positions expressed in biodiversity and biosecurity conferences and fora, and from work that the students themselves had previously submitted. The resulting 25 statements are this study's concourse of viewpoints.

We then offered participants a 25-statement sorting grid ranging from -4 at the left-hand side (strongly disagree) to + 4 at the right-hand side (strongly agree). One cell was available for the most extreme ends. Five cells were available for neutral or 0 in the middle. Grids were printed on A2 sized cardboard and statements printed on paper squares. Participants were given about 10 minutes to place each statement where they felt it belonged on the grid. They then took photos of their rankings and Q-Sorts with digital devices provided.

Q Method's use of a grid extends participants' ranking options. Factor analysis of these grids reveals how a participant feels about different aspects of an issue, both in reference to a negative or positive whole number, that expresses their level of disagreement or agreement with a statement and in relation to other statements in the grid. Furthermore, a statistical comparison of participants' Q-Sorts reveals similarity and distinctiveness between individuals. Q Method analysis can then identify groupings of quantitatively significant

Table 2. Statements upon which factors (participant groupings) showed consensus, according to PQ Method analysis.

		Z-scores		
Consensus statements	ID	Factor 1	Factor 2	Factor 3
I trust the government to only implement *wasp biocontrols* if demonstrated to be safe	5	−1.06	−1.23	−1.62
Wasp biocontrols would enhance the Maori economy (eg beekeeping)	6	0.61	−0.06	0.58
Wasp biocontrols would enhance the NZ economy (eg tourism)	7	−0.11	−0.14	0.58
We've learnt enough from GMO's to proceed with *wasp biocontrols*	9	−1.39	−1.21	−0.75
Wasp biocontrols would enhance Maori kaitiakitanga	10	0.52	0.12	1.12
NZ's *wasp biocontrol* research should be used outside of NZ	12	−0.02	−0.66	−0.40
Wasp biocontrols should only be used if demonstrated to be safe	14	0.87	1.21	1.75
Tangata whenua/Maori opinions count in the decision whether to use *wasp biocontrols*	16	1.17	1.43	1.22
Matauranga Maori has an important role to play in *wasp biocontrols*	22	1.21	1.78	1.25
The government should invest more funding into *wasp biocontrols*	23	0.29	0.95	0.35

Notes: The ID column is the number of the statement. *Z*-scores give an indication of the degree to which participants agreed (+ve) or disagreed (−ve) with the given statements.

Table 3. Three Factors (participant groupings) emerged from Q Method analysis.

Factor/ cluster	Sorts/ participants	Distinguishing statements	ID	Z-score	F1	F2	F3
1	2A, 3S, 4C, 4J*, 4S	Wasp *biocontrols* will be a crucial step toward a Predator-Free 2050	19	1.59		−0.16	0.11
		I am comfortable with research being done on wasp *biocontrols*	20	1.37		−1.03	−0.13
		Wasp *biocontrols* are more humane than traditional wasp controls	24	0.81		−0.40	0.03
		I know enough about wasp *biocontrols* to make an informed decision	17	0.31		−0.57	−1.49
		My opinion counts in the decision whether to use wasp *biocontrols*	15	−0.01		0.77	−0.77
2	PA, 1A*, 1T	My opinion counts in the decision whether to use wasp *biocontrols*	15	0.77	−0.01		−0.77
		Wasps can be eradicated from Aotearoa without *biocontrols*	1	0.71	−1.26		−1.14
		Wasp *biocontrols* should never be used outside the laboratory	21	0.40	−0.79		−0.72
		Aotearoa's environment would be degraded if we used wasp *biocontrols*	2	0.31	−1.15		−1.09
		I know enough about wasp *biocontrols* to make an informed decision	17	−0.57	0.31		−1.49
		Wasp *biocontrol* research would be positive for me and my whānau	11	−1.01	0.39		0.53
		I am comfortable with research being done on wasp *biocontrols*	20	−1.03	1.37		−0.13
3	2K, 3M*, 3N	Scientists communicate effectively about wasp *biocontrol* research	4	1.48	−1.57	−1.09	
		I trust scientists to develop ethical wasp *biocontrols*	3	1.19	−0.88	−1.05	
		Wasp *biocontrols* should only be used in NZ with a social licence	13	0.37	1.25	1.92	
		I am comfortable with research being done on wasp *biocontrols*	20	−0.13	1.37	−1.03	
		My consent to pest wasp *biocontrols* is consent for *biocontrols* generally	8	−0.54	−1.62	−1.66	
		My opinion counts in the decision whether to use wasp *biocontrols*	15	−0.77	−0.01	0.77	
		I know where to go to find information about wasp *biocontrols*	18	−1.46	0.04	0.54	
		I know enough about wasp *biocontrols* to make an informed decision	17	−1.49	0.31	−0.57	

Notes: Column 3 shows the statements unique to each factor. Column 2 shows the participants whose sorts are consistent with each factor. Participant codes with asterisks denotes a defining sort, i.e. the participant who most strongly represents the factor. The *Z*-Scores column indicates the degree to which each factor agreed (+ve) or disagreed (−ve) with the given statements. The final three columns present *Z*-Scores for the other factors: F1 is factor 1, F2 factor 2 and F3 factor 3.

similarity. It is then for the researcher to understand the underlying connections that make each grouping unique.

These features make Q Method an excellent tool for more deeply understanding perceptions of pest control, on which the range of views is so extensive and polarising as to potentially paralyse the discourse and debate (van Eeten 2001). Ranking exercises gauge participants' levels of comfort with different forms of control but do not address the reasons for participants' rankings. Responding to statements which have been curated from general views on the topic relieves some of the intellectual burden on participants to consider and articulate any of the many political, cultural, ethical, economic and spiritual implications of a charged topic such as this. The variety of Q Method

Table 4. Mean/average, median and standard deviation of likert scale rankings of preferred pest control methods for rats and wasps.

Control options	Rats			Wasps		
	Mean	Median	Std Dev	Mean	Median	Std Dev
Do nothing	−1.92	−2	1.08	−3.0	−3	0.95
Manual extraction	0.58	0.5	1.68	−0.58	−1	1.83
Non-species-specific poison	−2.42	−3	0.79	−3.58	−4	0.51
Species-specific poison eg vespex	1.33	1.5	1.67	0.33	0	2.23
Trojan-mite	0.58	1	1.73	0.83	1	2.12
RNAi	0.83	1	1.64	1.08	1	2.27
Gene drive	1.00	1	1.60	2.17	2.5	1.64
Trojan female	–	–	–	1.17	2	2.17
Pheromone lure	–	–	–	1.50	1.5	1.88

Note: Participants were given all five biotechnological control methods only for the wasps scenario.

statements can also trigger expanded reflection beyond what participants brought to the session.

Furthermore, this technique removes some of the emotional burden on participants to consider, raise, and articulate any objections they have, particularly in a focus group where they would normally be expected to defend a viewpoint. The appearance of te ao Māori perspectives in the statements validates them, freeing participants to speak more productively and deeply about that viewpoint. From a kaupapa Māori perspective, all 25 statements are equally as valid and have equal 'place' in the conversation, whether the participant agrees with them or not. Through this exercise participants read, consider, decide upon and act (through ranking) on 25 position statements. But rather than answering 25 questions on different topics their placement of the statements together on a grid retains a link between them.

Finally, Q Method suits small sample sizes – usually between 20 and 40 – as it surfaces the range of viewpoints rather than how those views are represented in a population (Brown 1980). However, sample sizes as low as 12 also produce useful results (Barry and Proops 1999; Webler et al. 2009), as it is more important that there is diversity within a sample than its numerical size. While this small and confined cohort may be seen as a limitation, broader public perceptions are addressed by other research (McDonald 2017).

We used Peter Schmolck's PQ Method software for quantitative analysis of Q-Sorts. A Principal Components Analysis coupled with a Varimax rotation was used on the 13 Q-Sorts. This combination is recommended for users new to Q Method but is also seen as a more objective way to extract data (Watts and Stenner 2012), as it requires minimal human interference. We tried a Centroid analysis and hand rotation and subsequently decided that the factors/groupings produced from the automated process made the most sense qualitatively. We inspected and accepted PQ Method's suggestions for which Q-Sorts 'loaded' (most greatly associated with) onto which factors. Two of the Q-Sorts were 'confounded' that is, loaded on to two or more factors. All other Q-Sorts loaded according to two conditions: at least 0.5 and greater than 0.14 difference from the nearest factor loading. Our sample revealed three clear and justifiable factors.

Results

Human–wasp relations – narrative positioning

For course assessment, students wrote personal narratives about encounters with wasps and pinned these descriptions to geographical locations in Google Earth. Encounter stories spatially extended all over Aotearoa NZ.

Narratives generally focused on the sting of the wasp and its actual or perceived threat. Some revealed they'd never been stung by wasps, but nonetheless acted with caution and fear around them. Wasp aversion and control methods included stories of avoiding wasps and nest sites (once located), running away, 'shooing', thumping individual wasps with rolled up newspaper, throwing rocks and poking sticks at nests, dowsing with petrol and other poisons, using a home-made flamethrower and bringing in exterminators. Some stings arose due to accidental contact, some from wasps effecting perceived deliberate attacks. Wasp sting relief techniques included cold water, vinegar, lavender oil, epi pens, visiting the doctor and in some cases, visits to the hospital. Positive memories associated with tales of childhood wars with wasp nests highlighted human bravado and triumph in spite of wasp stings. These overall negative feelings were reinforced when students heard that beech forest in the Nelson Lakes area was infested with exotic wasps, and students treated the information as Lester presented it: a serious problem for humans, native insects and birds. That this cohort identified a wasp's positive value in terms of human behaviour it induces – such as courage – confirms exotic wasps as an expedient choice of test species. In this context, students were more willing to discuss new ways to control pests, in spite of their reservations about biotechnology. 'Even though we don't like pests. [laughter] We don't like biotechnology even more, or genetic modification even more' 4C.

Focus groups – identifying participant clusters from Q-sorts

This section is organised into subsections by different aspects of the method. The Q factor analysis is presented first, in order to illustrate the significant consensus and distinctiveness amongst participants. The overall aim of this section is to present the various perspectives on the biotechnologies – in specific and general terms.

Q-sort consensus statements

PQ Method identified 10 statements that all participants showed consensus upon, as seen in Table 2. Participants strongly agreed (*Z*-Scores > +1) with three of the statements: that mātauranga Māori has an important role to play in *wasp biocontrols*, that tangata whenua opinions count in the decision whether to use *wasp biocontrols* and that *wasp biocontrols* should only be used if demonstrated to be safe. Participants interpreted 'safety' in various ways: safety for other species and the environment, indicated by the term 'collateral damage' 1T; risk of 'unforeseen circumstances' 2T; and in a general risk management sense 'pest control has got so out of control' 4S.

> Safety is everything. If it wasn't safe there could be massive dire consequences. So when you're talking about *biocontrols* and that kind of thing, ko te ture matua, you know, that's

> the number one rule. So for me that was by far and away more important than anything else. 2K

With appropriate checks, participants were open to trialing the emerging biotechnologies on wasps: 'we should never rule anything out once we've assessed the risks and determined what they might be. I think there's no issue with wasp *biocontrols*' 1P. The students agreed that mātauranga and tangata whenua opinions need to be genuinely engaged and accounted for 'Mātauranga Māori is important for anything that you do in Aotearoa, because Aotearoa is pretty much Te Ao Māori.' 2A. Specific contributions of mātauranga to *wasp biocontrols* included tikanga.

> So those mechanisms themselves are very tapu. So engaging in that there'd have to be tikanga around it. For someone who is specifically Māori or whatever there are different ideas about tikanga Māori, kaitiakitanga, tapu versus noa. But if someone is under that sort of whakaaro and if they were to engage in the modification of the species, the genetic make-up, then they themselves would be under tapu. 4J

This student in a sense equates tapu with safety, caution and heightened awareness. These and thus tapu are all key risk aversion strategies. Whether spoken in terms of risk, safety or tapu, this was a key consideration for the whole cohort.

Participants strongly disagreed (Z-Scores < -1) with two of the statements: that they trust the government to only implement wasp *biocontrols* if people agree and that we've learnt enough from the Royal Commission on Genetic Modification on GMO's to proceed with wasp *biocontrols*.

> I just don't trust the government. It's just from all the legal stuff I've done. 2A

> I think that's just the way politics works. Governments, politicians will only make change that will keep them in government. You know, and sometimes I think it will take something drastic before drastic [changes] happen. 3M

At the time NZ had been governed by a centre-right coalition for 9 years. Expansions on this sentiment included mentions of politicians' self-interest, and law-making for the convenience of the economy and short-term projects, rather than people and the environment. Voting, engaging in dialogue, community activism and protest were seen as important ways the public could make their opinions known to government. Participants stressed however the importance of knowing the facts.

> When I think about a protest that happened around GMO food and that a few years ago, I don't think they really knew what they were fighting against. They have this bad vision of GMO in that it's gonna get out of the farmer's paddock, and it's gonna cross over to the organic [farms]. But I don't think they have a true concept of what this stuff actually is and what these biotechnologies actually are. So they're protesting on very small information, pieces. It's good to stand up against it but we need to be more informed. 4C

A complete spectrum of accurate information is seen here as critically important to meaningful and useful contributions the debate.

Participants slightly disagreed that NZ wasp *biocontrol* research should be used outside Aotearoa NZ. But they slightly agreed that the government should spend more on wasp biocontrol research. This gestures to an understanding that wasp overpopulation is a local problem, with potential negative consequences should *biocontrol* research be used in countries where wasps are ecologically integrated. Perhaps related to this, participants were fairly neutral about the impact of wasp *biocontrols* on the NZ and Māori economies.

Q-sort distinguishing statements – I

While there was considerable agreement, Q analysis also revealed distinctiveness. 'Factors' mark out groups of participants who have similarly clustered statements and as mentioned earlier, 3 distinct factors emerged from the analysis.

Factor 1 (extracted by PQ Method) accounts for 53% of study variance and has an eigenvalue of 6.9. Five of 13 participants load onto this Factor, and these participants were found in three of the four focus groups. All three of the participants of focus group four are Factor 1 – this focus group was held directly after teaching had finished and included 2 students from MAOR202.

The group strongly agrees that wasp *biocontrols* are critical to PF2050 and are comfortable with research being done on wasp *biocontrols*. They also agree that *biocontrols* are more humane than traditional wasp controls, inferring they find them more acceptable. On the face of it, this group appears to support biotechnological controls.

While *not* distinguishing statements, an inspection in Table 3 of other statements germane to a 'biotechnology has potential' stance is illuminating. Factor 1 participants disagree that wasps can be eradicated without *biocontrol* (line ID1, column F1); they disagree that *biocontrols* should never be used outside of the laboratory (line ID21, column F1), and they disagree that the environment would be degraded by using wasp *biocontrols* (line ID2, column F1).

> If they can be demonstrated to be safe then wasp *biocontrols* should be used. I'm really comfortable with research being done on it. 4J

The above quote from the participant whose sort most defines this factor reflects the broader sentiment of this group. With the right checks and balances in place, Factor 1 see the *potential* of wasp biotechnology, and overall are positive about its possible contribution.

Factor 2 accounts for 11% of the study variance, with an eigenvalue of 1.5. Three of the participants load onto this Factor. These participants were in the interview and first focus group.

This group feel that wasps can be eradicated without resorting to *biocontrols*, and furthermore weakly agree *biocontrols* should never be used outside of the laboratory. They have a slight concern that Aotearoa's environment could be degraded by use of *biocontrols*. They disagree that research on wasp *biocontrols* would be positive for them and their whānau, and overall are quite uncomfortable with research being done on novel wasp biotechnologies.

> Although manual trapping seems to be time consuming and costly, it's still the most agreeable to me … possibly because we don't have to interfere with their own make up as much as we would with the other methods. 1A

The arising of these sentiments and the quote above from the defining sort suggests that this group see biotechnology as unnecessary interference given the technologies available. We describe participants in Factor 2 as in a position of *doubt* about *biocontrols*.

Factor 3 accounts for 9% of the study variance, with an eigenvalue of 1.2. Three of the participants are associated with this Factor. These participants were spread across two of the focus groups.

This group most strongly agreed that scientists communicate effectively about wasp *biocontrol* research and that scientists can be trusted to develop ethical wasp *biocontrols*. This is in contrast with Factors 1 and 2, who disagree with both of these statements. Factor 3 was neutral about NZ research being done on wasp *biocontrols*.

This factor least objected to their consent for wasp *biocontrols* being taken as consent for other biotechnology:

> I have just a little bit of blind faith that our scientists are doing the right thing … I think from the sort of scientific side … a scientist is a scientist. They … in theory they don't have a political agenda, and so what they do is just give their research and that's it. As long as they're effectively communicating then that's all good. 3M

The group was thoughtful and articulate about aspects of the biotechnology, and their distinguishing statements lead us to see them as in a position of *trust* in scientists. This stands in contrast to their level of trust in governmental authority – of the three factors the *trust* group actually had the lowest level of trust in the government (see Table 2, ID 5). One might expect a position of *trust* to have arisen from meeting and listening to Lester and being influenced by his talk on biotechnologies. However, it's hard to argue this for the three participants who loaded on to Factor 3, as none of them attended Lester's lecture.

Q-sort distinguishing statements II

An observant reader will have noted from Column 3 of Table 3 that three statements – with ID's 15, 17 and 20 – occur across all three factors. An inspection of the Z-Scores for each shows that it is the numerical difference that differentiates the statement in each grouping. The range in possible Z-Scores, from –ve (disagree) through 0 (neutral) to + ve (agree), presents 3 measurably distinct positions on each statement.

That these statements occur as distinguishing statements in all three factors first reveals them as significant, polarising statements. Each statement begins with a personal pronoun, and probes feelings on the matter: 'I am comfortable'; 'My opinion counts'; 'I know enough'. This links to studies on emotions in perception studies (Sleenhoff et al. 2015). Secondly, the three possible readings of each statements – groups agreed, were neutral or disagreed – distinguish them. Thirdly, PQ Method finding statistical significance in the relative configuration of these statements reinforces the validity of our extraction and interpretation of these three factors.

Factor 1 participants – who see the *potential* of biotechnologies – felt most comfortable about research on *biocontrols*, but were nonetheless ambivalent about whether their opinions count on the issue. However, of all the factors, they are most confident that they know enough to make an informed decision.

Factor 2 participants – in the *doubt* position – felt least comfortable about research on *biocontrols*. Although they don't feel they know enough about *biocontrols* to make an informed decision, they are the factor that most strongly agree that their opinion counts in the debate.

Factor 3 participants – in the *trust* position – felt neutral about research on *biocontrols*. They strongly disagree that they know enough about wasp *biocontrols* to make an informed decision (equally strongly disagreeing that they know where to go to find information about the technology). They also disagreed that their opinion counts in the decision-making about the technology.

Which Biotechnology? Student Assignment Choice

For their assessment students selected one of the biotechnological controls to research and write a submission on for the Royal Society: Te Apārangi, with the option to advocate for or against their chosen control method. Of 46 submissions across three courses, only one student chose a hostile stance towards a technology. Most argued (some quite strongly) that a solution was needed for pest wasps in Aotearoa, and weighed up both pros and cons for their chosen control method, displaying critical awareness of the contested climate within which these debates arise. Student choices of biotechnology were very evenly spread across the pheromone, Trojan mite and Trojan female techniques, with the RNAi technique not significantly behind. We introduced a discussion of the gene drive only in 2017.

> Pretty much all of the sciencey things, Trojan mite, RNA, gene drive, I'll probably say that they're around about even … I think that they could be quite interchangeable 3S.

By this measure of choice, there is no clear preference amongst the different techniques. This suggests that the question of 'which technology' is less important than other socio-political considerations. This evenly spread choice also supports our claim that Lester came across as impartial, making no single technology more or less appealing than any other to students.

Which biotechnology? Focus group – ranking exercise

Table 4 presents results of averaging the rankings ascribed by participants to the different control methods for rats, and for wasps. The rat ranking exercise with fewer emerging *bio-control* options was intended to ease participants into the exercise, and connect to a target species in PF2050.

Participants voiced their most united and strongest disagreement with using a 'non-species-specific poison' to control both rats and wasps. This is consistent with concerns about the harmful effect of poisons on non-target species and possibly concerns about 'inhumane' target species deaths.

The next most disagreeable, and also a strong consensus, was to 'do nothing' about pests. All disagreed, in the case of wasps, and all were either neutral or disagreed in the case of rats. Again, this finding falls in line with other studies on New Zealanders' perceptions of pest control (Russell 2014): doing nothing is inconsistent with both Māori and Pākehā views. 'A form of pest control needs to be found in order to restore the mauri [life-force] in the natural environment' 4C. Restoring balance to the natural world is key to kaitiakitanga (guardianship). While manual extraction was overall seen as a better option for rats than for wasps, when forced to make a choice, participants overall felt manual control to be less favourable than biotechnology, especially for wasps.

Opinions on the different biotechnologies are more divergent, as represented by higher standard deviations in Table 4. This may reflect varying levels of familiarity with the new techniques and a feeling of interchangeability about them. They are ranked positive on average, showing overall favour compared to traditional options. This data is presented here to give context to this group of participants and is not intended to be generalisable.

Which biotechnology? Focus group – specific responses

To explore these preferences further we examine participants' responses in relation to specific *biotechnologies*. For brevity, we have synthesised and summarised these in column two of Tables 5 and 6. Example quotes from participants are presented in column three.

We did not specifically ask about each biotechnological control, nonetheless multiple positives and negatives emerged for each. Furthermore, as we've tried to represent through the diverse quotes in the table, participants in support of the biotechnologies came from all three participant factors, including those in the *doubt* position. Participant responses revealing lack of support also came from all participant factors, including those in the *potential* position. As may be expected, there were more positive than negative responses about *biocontrols* identified for participants in the *trust* position. Overall, participants were willing to identify both positives and negatives in relation to wasp

Table 5. A summary of reasons given by participants for their support of the five novel biotechnological controls, as well as indicative participant comments.

Biotechnological control	Comment themes	Example comments
Pheromone	Natural Specificity Familiarity Benign way to attract wasps to a trap Low collateral damage	*I felt I guess [you're] less likely to have collateral damage with it.* 1T *I think those are the ones I guess that are effective to at least some extent and the technologies are probably understood.* 2T *… just the word pheromones, and I was like ooh, that's interesting. And I was just sorta like … that's almost like sorta using nature* 3M *I like the pheromone idea in the sense that it's almost a natural process* 4S
Trojan mite	Natural predator Not GM	*… most acceptable, because you're not affecting anything on the genetic-cellular level* 1P *… the Trojan mite was seen as the 'natural enemy'* 1T *I kinda chose the Trojan mite 'cause as you say it replicated the natural world a little bit.* 2K
RNAi	Humane Natural process Specificity Control	*I really agree that we should do that RNA process, 'cause it seems sort of natural* 2A *I've got the RNA interference at the top which is kind of like the most kind of humane kind of interruption* 3N *These gene silencing things that I've got on my agree end of the spectrum seem to be a little bit more humane if we are going to go and, you know, kill off a bunch of wasps* 3S
Trojan Female technique	Specificity Control Represents the feminine Reminiscent of te Ao Māori Name resonates	*I agree that we should have some sort of technique like about the woman. Like where the woman gives and takes away the life. Just because in Te Ao Māori the women is the whare tangata, like she is the bringer of the life. And that's probably why I agree with the gene drive or the RNA one, 'cause it's such a Te Ao Māori perspective and understanding anyway.* 2A *I like the specificity of the Trojan female [technique] … the point is to cull out the reproduction situation* 4S
Gene drives	Permanence Specificity Control Ecologically contained	*If I'm thinking pest-free then I went to the gene drive end as the most agreeable, yeah. And the [most permanent] long term result* 4C *… gene drive doesn't introduce another life form* 4C *To me the gene drives are almost fool-proof in the sense that they're either gonna work or they're gonna fail* 4S

Table 6. A summary of reasons given by participants for their lack of support for the five novel biotechnological controls, as well as indicative participant comments.

Biotechnological control	Comment themes	Example comments
Pheromone	Impermanent Requires continued manual labour	*The pheromones and Trojan stuff is seasonal you know … you gotta do it all of the time* 4C *I mean that's talking about manual processes and stuff, which is the pheromone, the nest removal … it's just not going to happen. People like to commit and then not commit to those [actions]* 4S
Trojan mite	Violence Impermanent Introduced pests becoming pests	*There's some creepy mites out there that do some crazy things. It's nature, but …* PA *First Nations were given blankets for small pox, and it decimated them. That's what the Trojan mite reminded me of* 3N *We're introducing another pest, on top of another pest, on top of another pest. So we're just bringing in another introduced species, which I don't like either.* 4C *Introducing a disease carrying mite into a wasp nest … I don't know about that, like, using another species and having it's sole purpose to be to go in and kill the wasps* 4J
RNAi	Impermanent Perceived as GM Removing fertility	*I just feel like with infertility, I don't feel right with taking that from any of them.* 1T *Yeah RNA, it's too invasive in my mind, which is weird because the gene drive's definitely the most [way out] [laughter] like it's way … I dunno, to me [RNA]'s too stop-start.* 4S
Trojan Female technique	GM Ethically challenging Impermanent Removing fertility	*I just don't feel comfortable … it feels weird taking away someone's ability to reproduce. Like I don't think that should be something that we have control over.* 1A *The Trojan female always sounds really like cool to me, but also like it sounded like the most ethically challenging* 3N
Gene drives	GM A new and uncertain technological frontier Pest control demands Most controversial Could escape beyond NZ	*You kind of worry about whether or not it's going to get out of the country, cos it's native somewhere else, but the benefits outweigh all of that.* 4C *Pest control has got so out of control, beyond human ability to be able to prevent it, that we're having to actually delve into, you know, like, how we're made. But worrying that it's got to a point where we're actually having to turn to that technology to have to deal with it.* 4S

biocontrols, from either or both of the group conversation and their individual rankings and Q-Sorts.

Participants discussed how the biotechnologies could improve upon traditional wasp control techniques in various ways. They may be more humane, more specific and targeted, may be easier to manage and control, may mimic processes in nature, may be consistent with Māori values, may bring about permanent solutions, and in the case of pheromones, may be more familiar than other biotechnological controls.

Participants mentioned many things associated with their negative perceptions. Some scenarios were ethically challenging and even inhumane. For instance, some participants felt like the 'whare tangata' – the womb – was sacred and not to be tampered with, whether associated with 'tangata' – humans or not. Some biotechnologies were tainted by their relationship with GM – a still-contested technology. Some controls were impermanent, thus presented a riskier overall proposition than current options. Participants were wary of unknown consequences: the main scenarios discussed were that an introduced biocontrol attacks unintended targets and becomes the next pest, or that there would be unforeseen and unintended spinoffs from the new technology.

For this cohort, replication of nature in designing pest control methods is a strong theme. This appears to be additional to the findings of Wilkinson and Fitzgerald (2014), from whose focus groups with various communities 9 key aspects of an acceptable pest control method emerged. It also raises many questions about how the participants understand 'nature' and their part in it (Coyle and Fairweather 2005).

Which biotechnology? Focus groups – general responses

Participants also had perspectives on pests, on technological controls, on decision-making processes and social elements of the debate. Some felt that in spite of intervention pests would adapt, revealing their belief that even the most eradicative biotechnological controls are not a 'match' for nature (again, see Coyle and Fairweather 2005).

To some, all the biotechnologies looked effective in theory. Questions on which to pursue then focused on which might carry fewer environmental and ethical risks and which might give the best cost-benefit ratio.

Some stated that because technologies were still in development, we don't yet know all their limitations. They also pointed out the often large gap between our knowledge of how biotechnological controls might work in theory or in the laboratory, versus how they work in real-world application. This indicates a need for more information in order to make good decisions.

> I just think education is vital to this whole discussion on both sides. You know talking about the Māori input or what are their thoughts and feelings on this, then adding the western element. And also everyone needs to know what they're saying yes or no to, and knowing GMOs and the science and all that is a big thing to know about. 4S

Gaining scientific literacy and remaining current with technological developments is quite a demand on the public. This educated, interested and engaged cohort of students were incentivized in multiple ways to become informed. Could elements of the methodology be replicated outside of educational contexts? Gaining a social licence from the public more broadly continues to be a key challenge, as Aotearoa NZ researchers work toward a biotechnology capable of eradicating a small mammalian predator by 2025.

Discussion and conclusions

Our focus on Māori viewpoints reflects a general appetite for decisions to account for multiple worldviews and stakeholder concerns, paying particular heed to Treaty of Waitangi partner considerations. The engagement of these students in and leading up to focus groups reveals their commitment to joint decision-making on big issues. Our Māori-centred and kaupapa Māori approach with its diverse Q Method statement concourse encouraged and normalised participants' use of a Māori lens. The consensus amongst participants about the importance of tangata whenua and mātauranga to the debate signalled that participants acknowledged, affirmed and extended on Māori perspectives. Māori participants also navigate bicultural milieu, reflecting non-Māori concerns also (Munshi et al. 2016). As such, these participants reflect, challenge and add to widespread sentiments in Aotearoa and its hundreds-year-old history of protecting endemic species from harm through various pest control interventions.

So these participants represented New Zealander's opinions more broadly when they ranked non-species-specific poisons as the worst control option; worse, in fact, than doing nothing. While their most favoured control option for rats would be to develop a targeted poison, for wasps they favoured all of the biotechnological control methods above the popular Vespex® (only attractive to wasps, not bees), with gene drive getting the strongest agreement and consensus of the biotechnologies. This is a controversially powerful technique, with a co-inventor of the CRISPR-Cas9 mechanism sounding cautions against it being used in uncontrollable environments (Esvelt and Gemmell 2017). By contrast, a large-scale nationwide survey (McDonald 2017) comparing gene drive and Trojan female technique, revealed a preference for the latter. That this cohort favoured 'gene drive' above other possible wasp controls should not be taken as social license, even when failsafe measures are incorporated, such as in daisy-chain gene systems (Esvelt 2016). All, including those in a *trust* position disagreed that their consent for wasp *biocontrols* implies consent for emerging biotechnologies more generally. It is thus important to press home that participants do not see their responses as generalisable to rats, possums and stoats. Nor should these concerns be generalised to other issues in relation to biotechnology.

This is an arguably very well-informed cohort. Most participants had attended a lecture and learnt about 4-5 biotechnological controls of wasps; reflected on their own positionality in relation to wasps through geo-located personal narratives; chosen, researched and written about a specific biotechnology; had read a primer on the biotechnologies; and had a chance to ask questions on and discuss these in focus groups. Yet, the cohort *at best* only weakly agreed that they know enough to make an informed decision. While a measure of humility may give context to this observation, it reveals a problem for getting public perceptions from well-informed positions, particularly as only small parts of society may be in a *trust* position. Furthermore, large parts of society will be apathetic or agnostic, and thus not intrinsically motivated to become informed in this way.

The reasons given by participants for their support or lack of support for the different biotechnologies springboarded from many of the concerns that have been raised in previous studies, indicating the continued relevance of viewpoints on genetic modification, captured in various publications. In terms of the kinds of control that participants find acceptable, all of the 9 key attributes (Wilkinson and Fitzgerald 2014) were represented: for instance that a control should be humane, targeted, not harm other animals and that rigorous testing is needed in order to reduce risk. However, another clear theme emerged, and this was a preference for a control that is perceived as natural. Human intervention is seen as less invasive if the intervention is patterned off a naturally occurring process, particularly if that process could have occurred within the natural course of things. This new attribute for an acceptable pest control method has the unique potential to be facilitated by the more sophisticated and precise understandings that modern science brings, allowing better understanding and replication of natural systems. It is confounded of course by the varying understandings of nature (Coyle and Fairweather 2005). For this cohort, a heritage connection to atua beings who represent aspects of 'nature' is perhaps a way to understand their responses – human biotechnological 'intervention' is seen as an extension of nature because humans are embedded in realms of Papatūānuku, Tāne and Tāwhirimātea. Human agency can be demonstrated through biotechnology, but must operate within the tikanga of 'nature'. When participants engaged specifically with biotechnologies and their functions, it gave them new scenarios from which to elicit tikanga-related reflections, including mana wahine (female dignity) and te whare tangata (female fertility) in relation to the Trojan female Technique, and tapu – or balancing risk and safety – in relation to intervening in biological mechanisms.

All participants agreed that wasp *biocontrols* should only be used if demonstrated to be safe, but they mistrusted the government to act according to the wishes of the people. Mistrust in government stems from various things: historic grievance linked to breaches of the Treaty of Waitangi, contemporary examples of colonisation, practices of consultation where outcomes are predetermined, continuing challenges to Māori autonomy and sovereignty, the list goes on. Furthermore, the short terms of government mean continually shifting ground in relation to nationwide decisions, contrasting with the longer term, generational planning that is usually seen in iwi, hapū and other communities. In fact, with another 12 parliamentary elections between now and 2050, Aotearoa NZ could see as many as a dozen changes in leadership and as many renegotiations in new relationships.

Finally, what room is there for social, cultural and spiritual issues to operate within the 'problem-research-solution-apply' narrative that dominates scientific enquiry, and arguably, the premise of this research? The cohort empathised with many issues related to the broader social ecosystem, including a consensus that they mistrust government, and varying levels of trust in scientists' ethicality and ability to communicate. This is a real dilemma given that the engine powering science in Aotearoa is largely government-led, and that a business-corporate funded science is likely to be even more distrusted. While these participants might see the potential of biotechnologies, giving a degree of social licence to continue investigating new technologies for biodiversity conservation, that is tempered by the machinations of a socio-political engine that remains largely out of their control.

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