APPLICATION FORM

Release

To obtain approval to release new organisms

(Through importing for release or releasing from containment)

Send to Environmental Protection Authority preferably by email (neworganisms@epa.govt.nz) or alternatively by post (Private Bag 63002, Wellington 6140)
Payment must accompany final application; see our fees and charges schedule for details.

Application Number

APP203875

Date

11/09/2020

Completing this application form

1. This form has been approved under section 34 of the Hazardous Substances and New Organisms (HSNO) Act 1996. It covers the release without controls of any new organism (including genetically modified organisms (GMOs)) that is to be imported for release or released from containment. It also covers the release with or without controls of low risk new organisms (qualifying organisms) in human and veterinary medicines. If you wish to make an application for another type of approval or for another use (such as an emergency, special emergency, conditional release or containment), a different form will have to be used. All forms are available on our website.
2. It is recommended that you contact an Advisor at the Environmental Protection Authority (EPA) as early in the application process as possible. An Advisor can assist you with any questions you have during the preparation of your application including providing advice on any consultation requirements.
3. Unless otherwise indicated, all sections of this form must be completed for the application to be formally received and assessed. If a section is not relevant to your application, please provide a comprehensive explanation why this does not apply. If you choose not to provide the specific information, you will need to apply for a waiver under section 59(3)(a)(ii) of the HSNO Act. This can be done by completing the section on the last page of this form.
4. Any extra material that does not fit in the application form must be clearly labelled, cross-referenced, and included with the application form when it is submitted.
5. Please add extra rows/tables where needed.
6. You must sign the final form (the EPA will accept electronically signed forms) and pay the application fee (including GST) unless you are already an approved EPA customer. To be recognised by the EPA as an "approved customer", you must have submitted more than one application per month over the preceding six months, and have no history of delay in making payments, at the time of presenting an application.
7. Information about application fees is available on the EPA website.
8. All application communications from the EPA will be provided electronically, unless you specifically request otherwise.

Commercially sensitive information

9. Commercially sensitive information must be included in an appendix to this form and be identified as confidential. If you consider any information to be commercially sensitive, please show this in the relevant section of this form and cross reference to where that information is located in the confidential appendix.
10. Any information you supply to the EPA prior to formal lodgement of your application will not be publicly released. Following formal lodgement of your application any information in the body of this application form and any non-confidential appendices will become publicly available.

11. Once you have formally lodged your application with the EPA, any information you have supplied to the EPA about your application is subject to the Official Information Act 1982 (OIA). If a request is made for the release of information that you consider to be confidential, your view will be considered in a manner consistent with the OIA and with section 57 of the HSNO Act. You may be required to provide further justification for your claim of confidentiality.

Definitions

Containment	Restricting an organism or substance to a secure location or facility to prevent escape. In respect to genetically modified organisms, this includes field testing and large scale fermentation
Controls	Any obligation or restrictions imposed on any new organism, or any person in relation to any new organism, by the HSNO Act or any other Act or any regulations, rules, codes, or other documents made in accordance with the provisions of the HSNO Act or any other Act for the purposes of controlling the adverse effects of that organism on people or the environment
Genetically Modified Organism (GMO)	Any organism in which any of the genes or other genetic material: • Have been modified by *in vitro* techniques, or • Are inherited or otherwise derived, through any number of replications, from any genes or other genetic material which has been modified by *in vitro* techniques
Medicine	As defined in section 3 of the Medicines Act 1981 http://www.legislation.govt.nz/act/public/1981/0118/latest/DLM53790.html?src=qs
New Organism	A new organism is an organism that is any of the following: • An organism belonging to a species that was not present in New Zealand immediately before 29 July 1998; • An organism belonging to a species, subspecies, infrasubspecies, variety, strain, or cultivar prescribed as a risk species, where that organism was not present in New Zealand at the time of promulgation of the relevant regulation; • An organism for which a containment approval has been given under the HSNO Act; • An organism for which a conditional release approval has been given under the HSNO Act; • A qualifying organism approved for release with controls under the HSNO Act; • A genetically modified organism; • An organism belonging to a species, subspecies, infrasubspecies, variety, strain, or cultivar that has been eradicated from New Zealand; • An organism present in New Zealand before 29 July 1998 in contravention of the Animals Act 1967 or the Plants Act 1970. This does not apply to the organism known as rabbit haemorrhagic disease virus, or rabbit calicivirus A new organism does not cease to be a new organism because: • It is subject to a conditional release approval; or • It is a qualifying organism approved for release with controls; or

	• It is an incidentally imported new organism
Qualifying Organism	As defined in sections 2 and 38I of the HSNO Act
Release	To allow the organism to move within New Zealand free of any restrictions other than those imposed in accordance with the Biosecurity Act 1993 or the Conservation Act 1987
Unwanted Organism	As defined in section 2 of the Biosecurity Act 1993 http://www.legislation.govt.nz/act/public/1993/0095/latest/DLM314623.html?src=qs
Veterinary Medicine	As defined in section 2(1) of the Agricultural Compounds and Veterinary Medicines Act 1997 http://www.legislation.govt.nz/act/public/1997/0087/latest/DLM414577.html?search=ts_act%40bill%40regulation%40deemedreg_Agricultural+Compounds+and+Veterinary+Medicines+Act+_resel_25_a&p=1

1. Applicant details

1.1. Applicant

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1.2. New Zealand agent or consultant (if applicable)

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2. Information about the application

2.1. Brief application description

Approximately 30 words about what you are applying to do

This is an application to introduce two parasitoids, *Volucella inanis* and *Metoecus paradoxus*, as biological control agents for the invasive German and common wasps, *Vespula germanica* and *V. vulgaris*.

2.2. Summary of application

Provide a plain English, non-technical description of what you are applying to do and why you want to do it

This is an application by the Tasman District Council, on behalf of the Vespula Biocontrol Action Group, to introduce two biological control agents for the invasive German and common wasps (hereafter referred to as *Vespula* spp. wasps, or by their species names). *Vespula* spp. wasps are significant pests of urban, rural, and natural ecosystems, and they are widely distributed throughout New Zealand, including Stewart Island. A lack of natural enemies, mild winters in comparison to their native range, and abundant food resources enable these social wasps to attain extremely high population densities in New Zealand, and the highest densities of *Vespula* spp. wasps in the world. In beech forests in the north of the South Island, densities can reach 33 wasp nests per hectare (average 12), equating to approximately 10,000 worker wasps per hectare (Thomas et al. 1990).

New Zealand's flora and fauna have evolved in the absence of social wasps. Since *V. germanica* first established in the 1940s, a wide range of New Zealand's native invertebrates, such as flies, caterpillars of moths and butterflies, wētā and spiders have been heavily preyed upon by social wasps to fulfil their protein requirements. Native insectivorous insects, birds and lizards have had to compete with these efficient generalist foragers for food. In the endemic honeydew beech forests, invasive wasps outcompete native animals for the critical sugar resource. The high densities of wasps not only negatively affect New Zealand's natural habitats, but also pose a danger to people working or enjoying recreation in these areas.

New Zealand does not have any native social wasps, so there are no native natural enemies that can play an effective role in the suppression of wasp populations.

A parasitoid wasp, *Sphecophaga vesparum vesparum* Curtis (Hymenoptera: Ichneumonidae) was released as a classical biocontrol agent against the *Vespula* spp.

wasps in 1985 (Donovan & Read 1987). It has only established at two sites, Pelorus Bridge (Marlborough) and Ashley Forest (Canterbury foothills), with little impact on the wasp problem at these sites. Despite limited success with this agent, biological control is still regarded as a potentially vital element for *Vespula* spp. wasp management because it is the only control tool that is self-perpetuating and can act over large and inaccessible areas.

The Vespula Biocontrol Action Group, a community-led group comprising 14 stakeholders, was formed in 2014 to support research and development into the biological control of invasive wasps in New Zealand. Manaaki Whenua – Landcare Research (MWLR) have conducted the research and background studies described in this application and have prepared the application and managed the application process.

The two candidates proposed for release to target *Vespula* spp. wasps in New Zealand were identified in *Vespula* spp. wasp nests in the United Kingdom (UK) in 2016 while new genetic material of *S. v. vesparum* was being collected. The wasp-nest beetle, *M. paradoxus*, was listed as a potential candidate agent in the 1980s when social wasps were first targeted for biocontrol (Donovan 1989), but the hoverfly was prioritised more recently.

Brown et al. (2019) have summarised the risks, costs and benefits of the proposal to release two biocontrol agents. The anticipated positive effects of biological control of *Vespula* spp. wasps include:

- long-term mitigation of damage to New Zealand's ecosystems,
- reduced invasion potential of *Vespula* spp. wasps in infested and uninfested areas,
- reduced control costs to managers of reserved land and to the general public,
- reduced negative impacts of *Vespula* spp. wasps on human health and wellbeing.

Significant adverse environmental or economic effects from the introduction of the biocontrol agents would occur if:

- the biocontrol agents attacked honeybees and/or bumblebees and/or native bees
- the biocontrol agents significantly altered food web interactions and competed with native pollinators
- successful control significantly affected vendor businesses and contractors due to reduced demand for chemical control of *Vespula* spp. wasps.

The application evaluates the potential risks of introduction of the biocontrol agents, but none of the effects are considered to be significant (section 5). Introduced natural enemies of *Vespula* spp. wasps must be safe to release if this management approach is to be environmentally acceptable. Literature reviews, records from the native range and host range tests provide evidence that *V. inanis* and *M. paradoxus* are only able to attack and parasitise social *Vespula* wasps and will therefore be host-specific in New Zealand. The highly specialised ecology and life history of both candidate agents preclude honeybees, bumblebees and ants present in New Zealand from serving as hosts. No solitary bees or other invertebrates are at risk. Any potential adverse food web interactions are considered to be minor and of limited ecological consequence, especially in comparison to the ecological impacts of *Vespula* spp. wasps.

The potential social and economic benefits to be gained from the introduction of the biocontrol agents outweigh any potential adverse economic impacts. No adverse social impacts could be identified (section 5).

2.3. Background and aims of application

This section is intended to put the new organism(s) in perspective of the wider activitie(s) that they will be used in. You may use more technical language but all technical words must be included in a glossary.

2.3.1 Purpose

The purpose of this application is to establish biological control for the invasive German and common wasps, *Vespula germanica* and *V. vulgaris.* The two agents selected to control these invasive wasps are a parasitic hoverfly, *Volucella inanis*, and the wasp-nest beetle, *Metoecus paradoxus*.

Approval is sought to release these new organisms from containment, for release in New Zealand. If successful, biocontrol using the hoverfly and the wasp-nest beetle would affect a high proportion of *Vespula* spp. wasp nests throughout the country and:

- reduce population densities of the invasive *Vespula* spp. wasps in the worst-affected areas
- reduce predation of native insects by *Vespula* spp. wasps
- reduce predation of pollinators by *Vespula* spp. wasps
- reduce the risk of human injuries and even fatalities caused by *Vespula* spp. wasp stings
- alleviate economic impacts through (i) a reduction in negative impacts on the beekeeping industry, (ii) a reduction in management and control costs, and (iii) a reduction in ACC claims due to wasp stings
- reduce resource competition between *Vespula* spp. wasps and native birds (for honeydew and invertebrate prey)
- partially restore normal ecosystem functioning and food webs in invaded natural habitats.

2.3.2 Biology and distribution of vespid wasps

The German wasp, *Vespula germanica*, is native to Europe and North Africa and was first confirmed as established in New Zealand at Te Rapa, Hamilton, in 1945 (Thomas 1960). Recent phylogenetic research indicates there have been at least two incursions of this species to New Zealand, with the largest population originating from the UK and a very small population originating from central Europe (Brenton-Rule et al*.* 2018). Besides New Zealand, the invasive range of *V*. *germanica* now includes Argentina, Australia, Ascension Island, Canary Islands, Chile, Iceland, Madeira, North America, and South Africa (Lester & Beggs 2019; Beggs et al. 2011).

The common wasp, *V. vulgaris*, is native to Europe and parts of Asia (e.g. Pakistan and northern China). Queens of this species were first collected in Wellington in 1978 and nests were later found there in 1982 (Donovan 1984). A phylogenetic analysis indicated at least six incursions of the common wasp to New Zealand, originating from locations in the UK, Ireland, and Western Europe (Lester et al. 2014). The invasive range of *V*. *vulgaris* now includes Argentina, Australia, Chile, Iceland, and St. Helena island (Lester & Beggs 2019; Beggs et al. 2011).

Vespula germanica and *V. vulgaris* are social wasps that can form very large colonies of several thousand individuals. Colonies of *Vespula* spp. have a caste system, with queens, workers and males. The reproductive castes (queens and males) are produced by the colonies in the autumn. The queens leave the nest to mate and locate a suitable place to overwinter until spring. In spring, a new colony is started by a queen, which builds the nucleus of the nest, lays eggs, and provisions the larvae with food until the first cohort of workers emerge. From there the queen is solely involved in the production of workers until autumn, when she will shift to producing the next generation of queens and males.

The colony grows from a single queen wasp to several thousand workers in a few months. The workers are responsible for collecting food, water and nesting material, caring for the brood, and nest defence. Both species typically nest in holes in the ground, but nests are also found in rotten logs or stumps, in forest litter and in trees. In urban areas they nest in hollow walls, attics, or aerial locations, for example under eaves or hanging from rafters. *Vespula germanica* nests are grey and are constructed with fibres from structurally sound wood, whereas nests of *V. vulgaris* are brown in colour, made from the pulp of rotting wood. *Vespula germanica* has the capacity to maintain large overwintering nests, whereas the common wasp colonies die in winter.

2.3.3 Impact of vespid wasps

2.3.3.1 Environmental impacts: predation

Vespula vulgaris and *V. germanica* are generalist predators that prey on a wide variety of arthropods, including honeybees, butterflies, flies and spiders. They have been shown to have behavioural plasticity and cognitive flexibility, and this ability to learn and adapt to new food resources quickly may be one reason why these species are such successful invaders (D'Adamo & Lozada 2008; Lozada & D'Adamo 2009; El-Sayed et al. 2018). According to Toft and Rees (1998) and Beggs and Rees (1999), predation rates on some native invertebrates by *Vespula* spp. wasps is so high that they are at risk of extinction. For example, depending on the densities, *Vespula* spp. wasps remove 1.4–8.1 kg of insect prey, per hectare, per season in beech forests (Harris 1991).

2.3.3.2 Environmental impacts: competition for honeydew

In natural environments, *Vespula* spp. wasps have detrimental effects on ecosystem functioning, food webs and the behaviour of native birds. Beech forests are the largest remaining indigenous forest type in New Zealand and are home to many of New Zealand's vulnerable and threatened native flora and fauna. The beech scale insect is vital to the food supply of a range of native insect and bird species through the production of honeydew. Honeydew has a high sugar content and is an important energy source for native birds, including tūī, bellbirds, kākā and silvereyes, as well as reptiles and insects. Further, the reduction of honeydew falling to the forest floor alters the soil composition of beech forests, potentially affecting soil fertility, nutrient cycling and decomposition. The knock-on effects could negatively impact soil microbiota, fungi, soil-dwelling insects, the growth of trees, and fundamental processes like photosynthesis, which are all essential to the survival of these unique forests (Beggs 2001; Wardle et al. 2010).

Wasps remove around 99% of the honeydew from beech forests over the 4 months of the year when their populations are growing (Moller et al. 1991). The removal of honeydew by wasps reduces the carrying capacity of beech forests for native fauna. High wasp activity levels and the removal of honeydew are also known to negatively affect the behaviour of native birds. For example, tūī spend more than 80% of their time foraging for honeydew, but when levels drop below a threshold, they reduce their feeding on honeydew or even leave beech forests. Bellbirds remain in the forest when honeydew levels are low, but they reduce their feeding and time spent on social interactions, grooming and singing. According to Elliot et al. (2010), several common and widespread native birds have had significant population declines in the last 30 years, attributed mostly to wasps but also to other invasive species.

2.3.3.3. Economic impacts

Vespula spp. wasps have major economic impacts, most notably through being the second worst pest of the beekeeping industry in New Zealand behind the varroa mite. The common and German wasps rob beehives of honey and kill honeybees, negatively affecting production, and beekeepers are forced to implement costly control measures. Recent colony loss surveys have shown wasps to be the third- and fourth-highest-ranked cause of colony loss, equating to between 9.6 and 12.1% of managed honeybee hive losses in New Zealand annually (https://www.mpi.govt.nz/protection-and-response/readiness/bee-biosecurity/bee-colony-loss-survey/). Both the German and the common wasps are very destructive invasive pests that cost the New Zealand economy up to $130 million annually in damages and management (MacIntyre & Hellstrom 2015).

2.3.3.4 **Human health impacts**

Vespula spp. wasps are intensely disliked by the New Zealand public, having been voted one of the top three most disliked wildlife (Fraser 2001). They disrupt the enjoyment of the outdoors and recreational activities and are a serious public health risk. German and common wasps are highly aggressive and respond with attack to the chemicals released by one wasp sting. The risk of people suffering multiple stings is therefore very high. This increases the risk of a severe allergic reaction known as anaphylactic shock, which can be fatal if not treated promptly. Between 2014 and 2019 ACC Analytics and Reporting recorded an average of 1,055 new claims per year due to wasp stings (ACC Analytics & Reporting 2019). Wasp stings can be fatal: Allergy NZ estimates that two to three people die each year due to insect stings, some of which are from *Vespula* spp. wasps.

2.3.4 Potential for safe biological control

Applied biological control (biocontrol) through the introduction of exotic natural enemies originally had the sole aim of protecting valuable plants such as crops and commercial forests from attack by pest arthropods and invasive exotic weeds damaging pastures. The use of applied biocontrol for the protection of native species or ecosystems has only been practised since the late 1970s. Before that, little attention was paid to non-target and ecosystem impacts, and consequently there was little focus on the host specificity of the natural enemies, which resulted in some non-target attack.

Since significant negative environmental impacts are no longer tolerable, a narrow host range of biocontrol agents for pest arthropods (and weeds) has become a requisite for biocontrol programmes, both in New Zealand and worldwide. Host range and potential risks are typically assessed by literature review of the phylogeny and ecology of the candidate agents, their affinities with native insects, the affinities of the target pest with native insects, and host range testing. When these factors are thoroughly evaluated prior to the introduction of biocontrol agents, the associated risks are significantly reduced.

2.3.4.1 Why biological control?

The science of biocontrol aims to restore a natural balance between a widespread target pest and its environment by reducing the potential for the target pest to increase. Biocontrol of *Vespula* spp. wasps in New Zealand aims to establish a complex of natural enemies that prey on or parasitise wasp larvae. If successful, biocontrol will be considered a cost-effective, long-term and sustainable approach to manage wasps, since, once established, the introduced natural enemies will colonise *Vespula* spp. nests wherever they occur, including inaccessible areas where conventional methods of control are not an option.

Current control methods for social wasps include the use of insecticides in a bait formulation (Vespex ®) or direct application of insecticides into wasp nests. Although the use of Vespex® and other insecticides has provided a reasonably effective method for managing *Vespula* spp. wasps in New Zealand, the current methods are impractical in forests and farmland because the nests are too numerous, or infested areas are inaccessible. Further, the application of insecticides and poison baits is expensive, labour-intensive, and is only effective late in the season when foraging workers are collecting bait (Rose et al. 2010) due to the high protein requirements of larvae that develop into new queens. Successful biocontrol will reduce (but not eliminate) the demand for chemical control of *Vespula* spp. wasps, which will reduce the risks associated with the use of poisons and insecticides in the New Zealand environment.

Despite the active control measures used over the past several decades, *Vespula* spp. wasps continue to attain high population densities in certain habitats, and continue to have negative environmental, social and economic impacts. The need for landscape-scale control has been recognised by the inclusion of wasp control as one of the projects of the New Zealand's Biological Heritage National Science Challenge (https://bioheritage.nz/research/wasp/). Improved control methods that can be used in an integrated manner are needed to provide effective, long-term, sustainable control of these serious pests in New Zealand. Biocontrol is self-perpetuating over landscape-scale areas, cost-effective once established, and the best approach for wasp management in certain areas. We consider that successful biocontrol of *Vespula* spp. wasps will

(i) reduce the social and economic impacts associated with these wasps;

(ii) partially restore normal ecosystem functioning of natural habitats (e.g. beech forests); and

(iii) help protect New Zealand's iconic native species.

A parasitoid wasp, *Sphecophaga vesparum vesparum* Curtis (Hymenoptera: Ichneumonidae), was released as a classical biocontrol agent against the *Vespula* spp. wasps in 1985 (Donovan & Read 1987). Initially it appeared that *S. v. vesparum* could survive in New Zealand and was self-propagating (Donovan et al*.* 1989). However, a number of studies have since examined the spread, population dynamics and impacts of *S. v. vesparum* (Moller et al*.* 1991; Beggs et al*.* 1996; Barlow et al*.* 1998; Beggs & Harris 2000; Beggs et al*.* 2002, 2008), and have found that it is only established at two sites, Pelorus Bridge (Marlborough) and Ashley Forest (Canterbury foothills), with little impact on the wasp problem at these sites. Despite limited success with this agent (thought to be due to low genetic diversity in the first adults released), biocontrol is still regarded as a potentially important element for *Vespula* spp. wasp management because it is the only control tool that is self-perpetuating and can act over large and inaccessible areas.

Several studies in South Island beech forests concluded that heavy, season-long reduction in the density of foraging wasps would be required to restore invertebrate elements of that ecosystem (Beggs & Rees 1999), if this was possible at all (Toft & Rees 1998). Models prepared by Barlow et al. (2002) suggested that the strongest determinant of variability in the density of autumn nests is the variability in queen mortality during winter and spring, or possibly mortality of early spring nests, usually by usurpation by queens. Barlow et al. (1996) earlier suggested that a future biocontrol agent with the greatest chance of significantly suppressing wasp densities was one that attacked early spring nests, after density-dependent queen competition and nest usurpation had taken place. In both models it was acknowledged that the role of survival of spring nests in wasp dynamics is uncertain, but that this is a key target for future biocontrol.

Therefore, despite the high estimates suggested by some models (e.g. Toft & Rees 1998), the applicants state that biocontrol has the potential to provide significant benefits to New Zealand's environment, economy and society because:

- attack occurs after potential nest usurpations by competing queen wasps in early spring (post-density dependence) (Barlow et al. 1996)
- biology and seasonality suggest that attack on early nests could suppress population growth of *Vespula* spp. wasps (Barlow et al. 1996)
- the previous models were based on mid- to late-season nests in honeydew beech forests and may not be universally applicable across all wasp-infested habitats in New Zealand.

There may be greater benefits in suppressing a lower proportion of the wasp population than the models have predicted. As with all biocontrol projects, it is unclear whether *Volucella inanis* and/or *Metoecus paradoxus* are capable of destroying early nests. The fecundity of both species is very high. The searching behaviour of *V. inanis* adults is single-minded (B. Brown, personal observation). *Metoecus paradoxus* overwinters as an egg, and the spring-time larval emergence is perfectly timed with initial nest building by queens, when brood numbers are very low. In their native northern hemisphere range, *M. paradoxus* has been found in nests as early as July (mid-summer), which is usually the earliest that worker traffic is active enough for people to detect wild nests.

Much of what we know about the population dynamics of *V. vulgaris* and *V. germanica* comes from studies in honeydew-fueled beech forests. Whether the same assumptions hold elsewhere is unclear, but there may be gains to be made from biocontrol in other ecosystems, and certainly in urban and rural environments (see section 5).

The candidate biocontrol agents, *V. inanis* and *M. paradoxus*, have not been used for biocontrol of *Vespula* spp. wasps anywhere else in the world so there is no documented proof of their efficacy. However, high parasitism rates of *Vespula* spp. wasp nests (Brown, pers. obs; Table 2, section 3.1.6; Carl & Wagner 1982) by both candidate agents in their native range, combined with relatively low densities of *Vespula* spp. wasps and wasp nests in their native range (0.1 to 1.7 nests per hectare in Wisely, UK; Archer 2001) compared to their invasive range (12 nests per hectare average in honeydew beech forests; Barlow et al. 2002), suggest that specialist natural enemies play a role in regulating *Vespula* spp.

populations in their native range. We predict the introduction of these two agents, often found together in *Vespula vulgaris* nests in the native range (Table 2), should have an additive, if not a synergistic, impact on population control of wasps in New Zealand.

Biological control of *Vespula* spp. wasps in New Zealand would be considered successful if their populations were reduced to levels where their negative social, economic and environmental impacts are mitigated, becoming minor to insignificant. If the candidate biocontrol agents become established in New Zealand through successfully attacking their hosts *V. vulgaris* and *V. germanica*, we can expect minor to moderate benefits to the New Zealand environment, economy and society (section 5). The greatest social and economic benefits are likely to be realised in primary industry areas, such as forestry and agriculture, where *Vespula* spp. wasps are a health hazard to workers, and foraging wasps kill or highjack important pollinators such as honeybees. The greatest environmental benefits are likely to be realised in natural and urban habitats, where *Vespula* spp. wasps do not reach exceedingly high population densities (as they do in beech forests, for example). These expected impacts will be realised either through a reduction in the numbers of foraging wasps in these environments, or through reducing the period that certain forestry areas neighbouring native bush are closed due to dangerous levels of wasp activity (A. Karalus, pers. comm.).

If the candidate biocontrol agents do not establish in New Zealand, any potential risks (as outlined in section 5) are inconsequential.

Although we consider biocontrol to be the best tool for affecting a high proportion of *Vespula* spp. wasp nests, and for reducing wasp densities at a landscape scale, Beggs (2001) has suggested that a range of control tools will be necessary to achieve an adequate reduction in wasp abundance. We consider biocontrol to be one of a few critical management tools (some of which are still in the process of being developed, such as mating disruption with the use of synthetic pheromones) that will be used in an integrated manner to achieve the highest possible levels of suppression of *Vespula* spp. wasp populations in New Zealand.

2.3.4.2 Taxonomy of *Vespula* spp. wasps

German wasp and common wasp

Order	Hymenoptera
Family	Vespidae
Sub-family	Vespinae
Genus	*Vespula*
Species	*germanica* (Fabricius, 1793) and *vulgaris* (Linnaeus, 1758)

There are no native wasps in the family Vespidae in New Zealand. However, there are six species that have been accidentally introduced. Five are social wasps: three *Polistes* and two *Vespula* species. *Polistes*, or paper wasps, are known to be a nuisance in New Zealand, particularly in the North Island and the top of the South Island. These social wasps live in small colonies that are usually exposed, such as under the eaves of a house or in a bush. The three invasive paper wasps are *Polistes chinensis antennalis*, *P. dominula*, and *P. humilis.* The sixth Vespid species is the solitary *Ancistrocerus gazella*, accidentally introduced in the early 1990s, which provisions its young almost exclusively with Lepidoptera larvae. Solitary wasps do not live in a colony like social wasps do, although they may nest near other solitary wasps. However, there is no ongoing care of the larvae after the initial provisioning. Other solitary wasps, such as the ichneumon wasps, are usually parasitoids of insects, but some also use spiders as hosts.

3. Information about the new organism(s)

3.1. Name of organism

Identify the organism as fully as possible

Non-GMOs - Provide a taxonomic description of the new organism(s).

GMOs – Provide a taxonomic description of the host organism(s) and describe the genetic modification.

Both -

- Describe the biology and main features of the organism including if it has inseparable organisms.
- Describe if the organism has affinities (e.g. close taxonomic relationships) with other organisms in New Zealand.
- Could the organism form an undesirable self-sustaining population? If not, why not?
- How easily could the new organism be recovered or eradicated if it established an undesirable self-sustaining population?

3.1.1 Taxonomy and source of agents

Control agent 1

Order	Diptera
Family	Syrphidae
Subfamily	Eristalinae
Genus	*Volucella*
Species	*inanis* (Linnaeus, 1758)

Figure 1. Female *Volucella inanis* feeding on nectar.

Control agent 2

Order	Coleoptera
Family	Ripiphoridae
Subfamily	Ripiphorinae
Genus	*Metoecus*
Species	*paradoxus (Linnaeus*, 1761)

Figure 2. A male *Metoecus paradoxus*.

3.1.2 Biology and ecology of *Volucella inanis*

Hoverflies, or Syrphidae, are a very diverse group of insects. They are usually valued for their roles as pollinators as adults and often for the role the many species with predatory larvae play in controlling populations of aphids, caterpillars, leaf beetles and other garden pests. One subfamily of syrphids, Eristalinae, usually have another important role as detritivores, breaking down dead vegetation and compost. *Volucella* is one of two genera in the Eristalinae that have developed predatory larvae.

There are 42 known species of *Volucella* in the world (Choi et al. 2006). Most are associated with social Hymenoptera (Ôhara 1985a, 1985b; Okuno 1970) and fall into four groups based on where the larvae feed and develop:

- not associated with nests; feed at sap runs on oak trees
- saprophages in bumblebee nests – larvae feed on debris and dead larvae
- saprophages with facultative predation – larvae feed largely on detritus and dead larvae at the bottom of *Vespula* and *Ve*spa spp. nests, but will consume living wasp larvae if the brood is unprotected (guard wasps attack larvae of these species discovered in comb)
- obligate parasitoids – larvae can only feed on living *Vespula* and *Vespa* larvae in intact comb (guard wasps appear to be unaware of larvae of this specialist in comb); *V. inanis* is the only known member of the genus with this life history, although *V. nitobei* also has flattened larvae suited to inhabiting cells with wasp larvae and may also be an obligate parasitoid).

While there was initially some uncertainty about its biology and life history, *Volucella inanis* has long been known to specialise as an obligate parasitoid in nests of *Vespula vulgaris*, *Vespula germanica* and *Vespa crabro* (Lundbeck 1916; Spradbery 1973; Rupp 1989; Schmid-Hempel 1998; Rotheray & Gilbert 2011; Ball & Morris 2000).

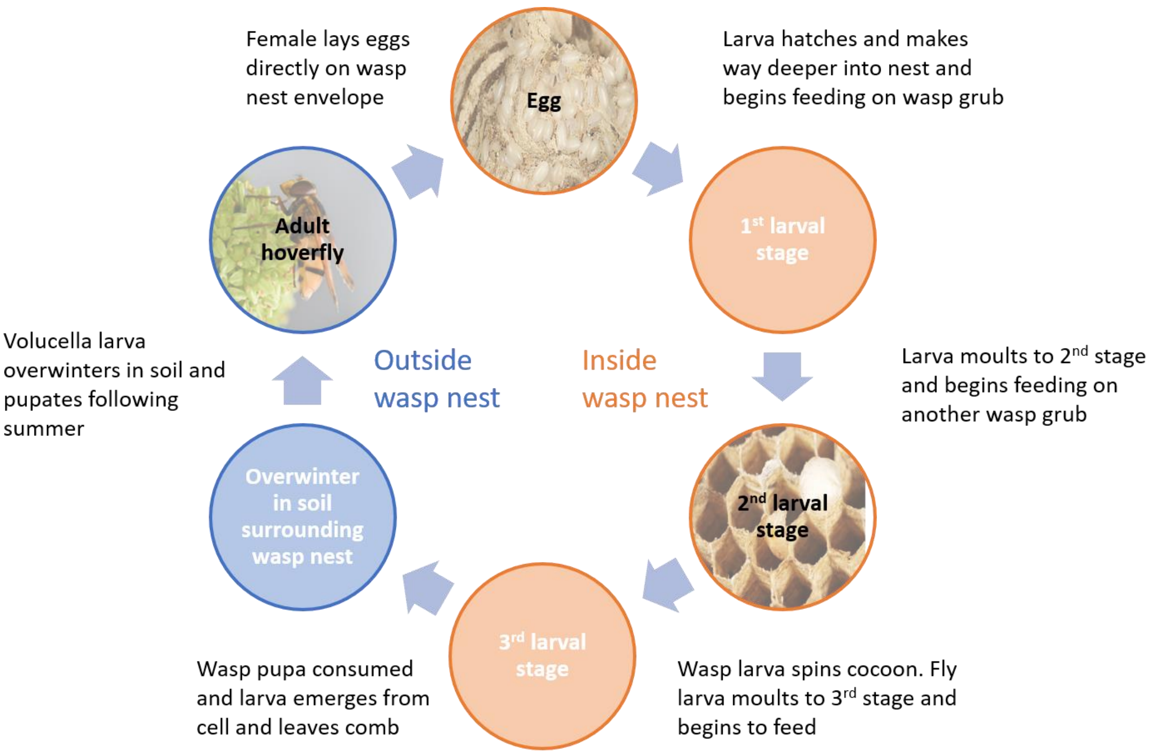
Volucella inanis has exceptionally precise host utilisation adaptations, even within the genus *Volucella*. Females appear to have as yet unknown chemical or physical adaptations that allow them to enter very close to wild wasp nests without being detected (B. Brown, personal observations). Rupp (1989) observed guard wasps attacking approaching female flies during trials in flight cages, but this was an artificial environment, which may have affected their normal behaviours.

Upon entering the wasp nest entrance hole a female lays eggs on the outside surface of the involucrum of the wasp nest (the paper layer surrounding and insulating the comb containing the brood), usually near the entrance hole. Female *Volucella* have been shown to use wasp traffic to find nests in which to oviposit (Rupp 1989). However, if a nest is vigorous, with many worker wasps coming and going, the female may oviposit near the nest entrance hole instead of risking detection by guard wasps (Rupp 1989).

Figure 3. A second instar *Volucella inanis* larva (centre) searching for an appropriate wasp grub host.

Gravid females (15–16 mm) have been reported to carry as many as 660 eggs, with an average of around 300 (Rupp 1989). It is not known how many *V. inanis* eggs are laid in small vs. large *Vespula* spp. nests, but high numbers of *V. inanis* (over 100 larvae) have been observed in wasp nests in the native range (Brown, pers. obs., https://www.youtube.com/watch?v=8ZxOTHj6iQ8).

There are three larval stages with the first two stages feeding as ectoparasites and the third stage as a predator. Since the third stage always kills its host, *V. inanis* is considered a parasitoid. Larvae have a flattened profile, which allows them to navigate the comb and invade cells occupied by wasp larvae (Figure 3). The larvae appear to be chemically adapted to avoid detection by the worker wasps within the nest as the workers are often observed to walk over them without taking any notice (Brown, pers. obs., https://www.youtube.com/watch?v=CgkfTRIoX78). The newly emerged first instar larva crawls into the wasp nest and onto the comb, where it locates an appropriate-sized host. Here, the *V. inanis* larva will enter the cell of a late larval instar (fourth or fifth) wasp larva and manoeuvre itself between the wall of the cell and wasp larva, working its way towards the posterior of the wasp. The *V. inanis* larva then pierces the integument and feeds on the haemolymph of the wasp larva.



Adapted from Rupp 1989

Figure 4. Life cycle of *Volucella inanis*.

After around 6 days the fly larva emerges from the cell as a second instar (Figure 3) and will look for a new wasp larva to feed on. The larger second instar fly larva will find a fifth instar wasp larva that is close to pupation. The fly larva will again squeeze into the cell and wait for the wasp larva to spin its pupal cap, sealing the cell. Once fully enclosed with the pre-pupating wasp larva, the fly larva moults into its final third larval instar and devours the entire wasp larva/prepupa. Each *V. inanis* larva will feed on at least two wasp larvae/prepupae. After 3 days the third instar emerges from the capped cell and leaves the wasp comb to seek a place to pupate. The overwintering larvae are often found in the soil surrounding the wasp nest in late autumn, which is probably why many previous researchers thought that they were saprophages like other species of *Volucella*. The fly overwinters as a larva, pupates in early summer and emerges as an adult (Figures 4 & 1) after 3 weeks. The males emerge first, followed by the females. Adults may live for many weeks.

3.1.3 Biology and ecology of *Metoecus paradoxus*

The family Ripiphoridae is cosmopolitan and has over 400 species in 38 genera (Lawrence et al. 2010). Unusual among beetles, all studied members of this family are parasitoids. Hosts include other beetles and cockroaches, but many are parasitoids of Hymenoptera such as bees and wasps.

Table 1. Subfamily associations in the family Ripiphoridae

Subfamily	**Genus**	**Host family: subfamily**	**Reference**
Hemirhipidiinae	*Nephrites*	Cerambycidae	Lawrence et al. 2010
Pelecotominae	*Allocinops*	Cerambycidae	Lawrence et al. 2010
	Clinops	Cerambycidae	Lawrence et al. 2010
	Rhipistena	Cerambycidae	Lawrence et al. 2010
	Pelecotoma	Ptinidae: Ptilininae	Lawrence et al. 2010
Ptilophorinae	*Evaniocera*	Unknown	Heitmans et al 1994
Ripidiinae	*Rhipidius*	Ectobiidae: Blattellinae	Heitmans et al 1994
		Ectobiidae: Ectobiinae	Heitmans et al 1994
Ripiphorinae	*Macrosiagon*	Apidae: Apinae	Falin 2004
		Crabronidae: Trypoxylonini	Batelka 2013
		Halictidae	Falin 2004
		Pompilidae: Auplopodini	Batelka 2013
		Scoliidae	Lawrence et al. 2010
		Sphecidae: Sceliphronini	Batelka 2013
		Tiphiidae:Tiphiini	Batelka 2013
		Vespidae: Eumeninae	Batelka & Hoehn 2007

Metoecus	Vespidae: Vespinae	Hattori & Yamane 1975; Carl & Wagner 1982; Nakane & Yamane 1990; Švácha 1994; Heitmans & Peeters 1996; Lawrence et al. 2010
Ripiphorus	Apidae	Lawrence et al. 2010
	Halictidae	Wcislo et al. 1994

The species that are parasitoids of bees lay eggs in places bees frequent, such as vegetation (the undersides of leaves) and flowers (flower buds) to enhance the opportunity for the triungulin larvae (see below) to encounter hosts (Lawrence et al. 2010). The species that parasitise the wood-boring beetles, such as *Pelecotoma* spp. (Table 1), lay their eggs into the xylem near the galleries of the host beetle larvae (Švácha 1994; Lawrence et al. 2010).

Metoecus is the only genus in the Ripiphoridae that attacks truly social Hymenoptera, and the hosts of all species of the genus belong to the Vespinae, a subfamily of the vespid wasps (Table 1).

M. paradoxus females deposit eggs in batches of 10–50 in crevices in decaying wood in late autumn (Carl & Wagner 1982). Although decaying wood is an actively sought-after resource, first by nest-building queens and then workers as the colony develops (predominantly *V. vulgaris*), it is a spatially rare resource, sparsely scattered through environments compared to other microhabitats. The fully developed embryo persists in the egg until spring. The first-stage larva hatches as a triungulin, a specialised larval form of parasitoid insects suited for hitchhiking on the body of their host. These triungulin larvae are equipped with one pair each of posterior suckers and cerci on their last abdominal segment, on which they assume an upright position with the legs free for grabbing, while waiting to attach themselves to passing wasps. Wasps foraging for wood pulp inadvertently provide these larvae with a ride back to their nests. While little is known how the *M. paradoxus* triungulin larvae locate or identify their host species, another beetle with triungulin larvae (Meloidae: *Meloe franciscanus*) uses chemical mimicry to attracts its host (Saul-Gershenz and Millar 2006). Since *M. paradoxus* triungulin larvae can survive for a long period without food, they most likely respond to chemical cues from foraging wasps, rather than releasing chemical signals to attract their hosts. We were unable to find any reports in the literature of *M. paradoxus* attaching to and hitchhiking on invertebrate species that are not host species.

Once in the nest the triungulin larva leaves the worker and finds a cell containing an appropriate wasp grub and penetrates its integument. The beetle larva begins its next phase of development as an internal parasite feeding on the haemolymph of late-stage *Vespula* larvae. Once the parasitised wasp larva begins to spin its cocoon, the beetle larva emerges from the host as a second instar, leaving the cast skin as a plug to seal the hole in the host where they have emerged. This second-stage beetle larva mounts the wasp pupa, forming a kind of collar, and begins feeding as an external parasitoid. Feeding continues during the third and fourth larval stages (Figure 5), consuming almost the entire wasp pupa, before pupating in its host cell. The adult beetle (Figure 2) emerges approximately 2 days after unparasitised wasps in surrounding cells have emerged.

The development from first-stage larva to adult beetle takes approximately 3.5 weeks. For each adult beetle produced, one wasp pupa is consumed. The reproductive capacity of *M. paradoxus* is high, with females producing up to 700 eggs each (Carl & Wagner 1982). Although beetle numbers in *Vespula* spp. nests have been reported to be fairly low (1–25 individuals per nest) (Heitmans & Peeters 1996), this is not unexpected since nests are not the habitat niche of adult beetles, which are likely to exit nests soon after eclosion to avoid detection by guard wasps, and to seek mates and oviposition sites. Further, since the triungulin larvae can survive for up to 2 months without food (Heitmans & Peeters 1996) while waiting to attach to a foraging wasp, there are likely to be different cohorts of adults beetles from the same egg batch, which may complete their development up to 2 months apart. Adult beetles can be found emerging from wasp nests from July through to October (Heitmans & Peeters 1996).

Metoecus paradoxus has only ever been recorded as a parasitoid of Vespinae and possesses highly unusual biology and specific behavioural traits described here facilitate and reinforce this host association. This beetle is most commonly found in the nests of *Vespula vulgaris* species, but it has also been found in *V. germanica*, *Dolichovespula saxonica* (Carl & Wagner 1982) and *V. flaviceps* (syn. *lewisi*) (Hattori & Yamane 1975).

The placement of eggs on rotting wood not only maximises the likelihood of transfer of triungulin larvae to a *Vespula* adult but also ensures that larvae will only be transmitted to brood found in nests made of paper. *Polistes* species in the UK have paper nests but *M. paradoxus* has never been found associated with these species. This implies that either triungulin larvae are selective in terms of which vespid adults they transfer to, or that larvae cannot survive in nests other than Vespula nests.

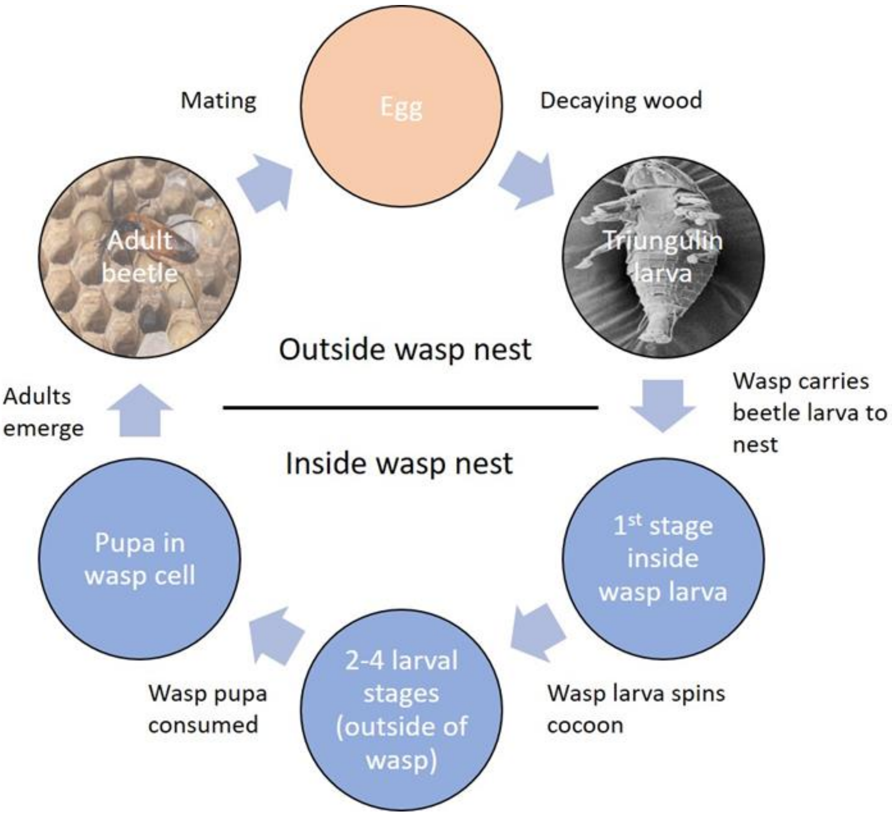


Figure 5. Life cycle of *Metoecus paradoxus*.

3.1.4 Affinities with the New Zealand fauna

It is currently thought that there are 91 species of Syrphidae flies in New Zealand (Thompson 2008). Of these species, 37 are endemic, one is native to Oceania, and five are introduced. The other 48 species have yet to be named. There are no native species in the subfamily Volucellinae. The larvae of many native species are predatory, usually associated with aphid, mealybug or scale colonies on plants. Adult flies feed on pollen. None of the syrphids present in New Zealand have been associated with social wasp nests, and they lack the behavioural adaptations needed to successfully invade a nest. It is highly improbable that any hoverfly species currently present in New Zealand adversely affects the wasp population. Because of the specialised behaviour of *V. inanis* (section 3.1.2), it is improbable that it could share egg, larval or pupal parasitoids with native syrphids.

There are five known native species of ripiphorids in New Zealand: *Allocinops brookesi* (Broun, 1921), *Rhipistena cryptarthra* (Broun, 1904), *Rhipistena lugubris* (Sharp, 1878), *Rhipistena sulciceps* (Broun, 1904), and *Sharpides hirtella* (Broun, 1880). The native species are in the subfamily Pelecotominae, while *M. paradoxus* is in the Rhipiphorinae. The definitive host species of the native ripiphorids are unknown, though they are likely to be wood-boring cerambycid beetles (Table 1). None of the native ripiphorids have ever been found in wasp nests (Brown, pers. observation; Donovan, pers. comm.) and therefore will not provide any measure of control.

Because of the specialised behaviour of *M. paradoxus* (section 3.1.3), it is unlikely that it could share larval or pupal parasitoids with native ripiphorid species or any other syrphid. The overwintering eggs of *M*. *paradoxus* would be available to generalist parasitoids and predators of beetle eggs, but only those foraging on rotten wood where these eggs are laid. Nothing is known of these potential relationships, but there can only be an interaction where *M. paradoxus* eggs and larvae occur in the environment, which is only on rotten wood.

3.1.5 Predicting the host range of *Volucella inanis* in New Zealand

In Europe *Volucella inanis* is an obligate parasitoid that attacks social wasps belonging to the genus *Vespula*. The evidence for this comes from:

- knowledge of specialist behaviours necessary for successful parasitism
- literature records in Europe
- surveys of fauna inhabiting the nests of social Hymenoptera in Europe.

V. inanis exhibits behaviour that ensures it can colonise host nests and complete development there. All social Hymenoptera use specialist guard workers to protect the hive or nest from intruders. However, *V. inanis* females are able to enter the nests or approach very near to the nest entrance to lay eggs. Newly emerged larvae are able to make their way to the wasp brood comb. As *V. inanis* larvae develop and move from cell to cell they appear invisible to workers maintaining the health and security of the nest. The behavioural or pheromonal mechanisms that allow the parasitoid to exploit nests in this way are not yet known, but must be specific to the host, and it is highly unlikely that such a suite of adaptations would enable colonisation of nests of more distantly related Hymenoptera with different methods for nest protection.

All *Volucella* species are associated with nests of social Hymenoptera, but only *V. inanis* is an obligate parasitoid. The species that could potentially be at risk from *V. inanis* in New Zealand include honeybees, bumblebees, ants, and other vespids.

3.1.5.1 Honeybees

The National Bee Unit (NBU) in the UK[1] has surveyed an average of over 30,000 honeybee hives per year since 2010[2]. Although the national database is not publicly available, the NBU Contingency Planning & Science Officer has confirmed that *V. inanis* has not been found in beehive material, despite having reference specimens of *V. inanis* (N. Semmence, pers. comm., Appendix 3).

3.1.5.2 Bumblebees

There have been numerous studies of bumblebee nests in Europe that have recorded natural enemies among brood. *Volucella bombylans* is the only *Volucella* species in Europe that is recorded in bumblebee nests (Rupp 1989). If European bumblebees are not hosts of *V. inanis* in their home range, the same species will not be hosts in New Zealand.

To confirm this, a laboratory trial tested if *V. inanis* larvae (n = 6) would attack the bumblebee *Bombus terrestris,* and confirmed that the *V. inanis* larvae would not attack the bumblebee larvae after 1 hour, but after moving the *V. inanis* larvae near wasp comb they quickly found and attacked *V. vulgaris* larvae. The duration of the test was restricted because initial testing showed *V. inanis* larvae without access to wasp brood begin dying shortly after an hour (Brown, 2019).

3.1.5.3 Ants

Several syrphid genera that live within the native range of *Volucella inanis* are strongly associated with ant colonies. *Chrysotoxum* spp., *Xanthogramma* spp., *Pipizella* spp., and possibly *Doros* spp. are found in various species of ant colonies and are thought to feed on root aphids inside ant nests (Rotheray & Gilbert 2011). The New Zealand syrphid species *Platycheirus milleri* is also thought to feed this way (Rotheray et al. 1996). The most widespread genus associated with ants is that of the ant predators, *Microdon*. *Microdon* have a very specialised larval form to survive and feed on the eggs and brood of ants (Rotheray & Gilbert 2011). In a review of natural enemies of the *Myrmica* genus of ants, *Microdon* spp were the only hoverflies listed (Witek et al 2014). In a review of nest associates of red wood ants (*Formica rufa* group) *Microdon spp.* were also the only syrphids identified as natural enemies (Parmentier et al 2014). In the course of these studies in Europe no *Volucella* sp. larvae have ever been observed in ant nests.

Female *V. inanis* orient to and lay eggs on paper within vespid wasp nests. They are large insects, and the entrance holes of ant nests are too small to allow access by *V. inanis* adults, which are approximately 12–14 mm in length. Also, there is no paper associated with the entrance of ant nests. It is highly unlikely that larvae hatching from any eggs laid outside the nest could survive the protective behaviour of worker ants on entry, find the

[1] http://www.nationalbeeunit.com/ index.cfm?sectionid=43
[2] http://www.nationalbeeunit.com/public/BeeDiseases/ trendDiseaseChart.cfm

ant brood chamber and survive there. Ant larvae are small and do not develop within a cell structure. The conditions within an ant nest are therefore not adequate for effective parasitism to take place. As in Europe, ants will not be hosts for *V. inanis* in New Zealand.

3.1.5.4 Solitary bees

As with ants, the entrances to the nest holes of solitary bees and wasps are too small to allow ingress of *V. inanis* females to lay eggs. Female *V. inanis* normally select oviposition sites within nests, and it seems improbable that eggs would be laid outside the nest hole of a solitary bee or wasp instead. Entrances to the nests, or the cells within the nests, of many solitary bees are blocked with vegetation, cellophane-like material or sand (Donovan 2007). *V. inanis* larvae, which are adapted to move freely within the voids of wasp nests, lack robust mandibles for digging through the protective barriers used by solitary bees. The parasitoids of solitary bees and wasps have been the subject of a number of studies in Europe, and there have been no records of *Volucella* species in such nests.

In summary, larvae of *V*. *inanis* are obligate ectoparasitoids of *Vespula* spp. wasp larvae. The evidence for this conclusion comes from literature sources, behavioural studies, and surveys in Europe (Lundbeck 1916; Gilbert & Jervis 1998), PhD research (Rupp 1989). Other social Hymenoptera in Europe available as potential hosts to *V*. *inanis* include paper wasps, honeybees, bumblebees and ants. However, *V*. *inanis* has never been found to be associated with any other social Hymenoptera than the subfamily Vespinae.

3.1.6 Predicting the host range of *Metoecus paradoxus* in New Zealand

The genus *Metoecus* belongs to the sub-family Ripiphorinae. While species in other subfamilies parasitise beetles and cockroaches, all species in this sub-family are parasitoids of Hymenoptera (Table 1). No ripiphorine beetles have ever been found in ant nests in Europe. *Metoecus* spp. are restricted to social wasps belonging to the family Vespidae (section 3.1.3).

Like all other known species of *Metoecus*, *M. paradoxus* are exclusively found in colonies of eusocial vespid wasps (Hattori & Yamane 1975; Carl & Wagner 1982; Nakane & Yamane 1990; Švácha 1994; Heitmans & Peeters 1996). Across its native range from NW to NE Palearctic (UK to Japan), it has been reported from the nests of *Vespula vulgaris*, *V*. *germanica*, *V*. *flaviceps* and *Dolichovespula saxonica* (Hattori & Yamane 1975; Carl & Wagner 1982; Nakane & Yamane 1990).

In Europe, *M*. *paradoxus* is an obligate parasitoid that attacks social wasps belonging to the genera *Vespula* and *Dolichovespula* (rarely). The evidence for this comes from literature records in Europe, surveys of fauna inhabiting the nests of social Hymenoptera in Europe (Carl & Wagner 1982; Schmid-Hempel 1998; Mumford et al 2008; Parmentier et al 2014; Witek et al. 2014; van Ostaeyen et al. 2015; Davies 2019), and knowledge of specialist behaviours necessary for successful parasitism as described in the sections below:

- oviposition behaviour
- mode of access to the nest
- chemical mimicry mechanisms

Together these preclude expansion of the host range of this species beyond social wasps.

Metoecus paradoxus lays eggs only on rotten wood, and hatching larvae wait for workers foraging for raw material to build a paper nest. Social wasps that do not form paper nests will not transfer larvae to the nest. In New Zealand only *Vespula* and *Polistes* species produce paper nests. *Metoecus* spp. are only known to parasitise wasps in the Vespinae subfamily. *M. paradoxus* has never been found to attack *Polistes* spp. in Europe as they belong to the subfamily Polistinae and not Vespinae. This indicates either that triungulin larvae select which vespid wasps they attach to, or that nests other than *Vespula* nests are not suitable for other reasons.

The nests of all social Hymenoptera are tended by guards that remove threats such as predators, parasitoids and even nest mates that are unhealthy. *Metoecus paradoxus* larvae are ignored in nests, indicating specialist behavioural or pheromonal attributes that confuse the normal protection mechanisms within the nest. Newly emerged adults have been demonstrated to mimic the cuticular hydrocarbon profile of *V. vulgaris* that helps them to avoid attack as they exit the nest (van Ostaeyen et al. 2015). Further demonstrating specialised adaptation to living as a parasitoid in *V. vulgaris* nests, the adult beetles also produce the *V. vulgaris* queen pheromone, which may serve to calm workers that may otherwise attack the adult beetles (van Oystaeyen et al. 2015).

The social Hymenoptera that are potentially susceptible to *M. paradoxus* in New Zealand are honeybees, bumblebees, other (exotic) vespid wasps and ants. Of these, only ant species are native.

3.1.6.1 Honeybees and bumblebees

Honeybees and bumblebees make hives from wax rather than paper and do not forage on rotting wood. Routine surveys of the health of honeybee hives within the native range of *M. paradoxus* in the UK have never recorded *M. paradoxus* in hives (N. Semmence, pers. comm., Appendix 3). Similarly, there have been numerous studies of bumblebee nests in the UK that have recorded natural enemies amongst brood, but *M. paradoxus* has never been recorded in bumblebee hives. Honeybees and bumblebees will not be hosts of *M. paradoxus* in New Zealand.

3.1.6.2 Ants

Foraging ants could potentially pick up triungulin larvae and return them to nests. To complete development, an *M. paradoxus* larva requires access to a single large larva within a cell (section 3.1.3). Ant larvae are minute by comparison with a wasp larva and are not contained within a hive structure. *M. paradoxus* larvae are not adapted to feed on successive small larvae. In Witek et al's (2014) review of natural enemies of the *Myrmica* genus of ants, the only beetle listed as a natural enemy was the staphylinid beetle, *Lomechusa pubicollis*. A review of the nest associates of the red wood ants (*Formica rufa* group) states that there are 52 species of Coleoptera known to be associated with nests (Parmentier 2014). None of the beetles listed in the supplemental tables are from the Ripiphoridae family (Parmentier 2014). Ripiphorid species in Europe are known to be parasitic on beetles, cockroaches, bees and wasps, but none have been associated with ant nests (Table 1). It is improbable that ant nests in New Zealand could be colonised by *M. paradoxus.*

3.1.6.3 Solitary bees and wasps.

Many studies have been conducted in the native range of *M. paradoxus* examining the species associated with nests of solitary bees and wasps. These found several species of ripiphorine parasitic beetles, notably *Microsiagon* and *Ripiphorus* species, attacking larvae in the nest holes of a range of species (Table 1). Significantly, *M. paradoxus* was never encountered in these studies. If solitary species are not hosts in Europe, then it is improbable that they would be hosts in New Zealand.

Solitary bees and wasps in New Zealand dig a blind nest hole, usually in the ground but sometimes in wood and cavities, and provision this with food on which a larva develops. Native bees are not generally known to harvest rotting wood to furnish nests (Donovan 2007). There is no reason why adult solitary species would routinely visit rotting wood, so there would be little opportunity for triungulin larvae to be picked up and transferred to nest holes. It is also improbable that larvae could adapt search profiles and seek nearby nest holes in wood rather than await a ride to a wasp nest. The larvae of native bees that nest in wood holes are much smaller than those of vespid wasps and could not support the development of an *M. paradoxus* larva.

3.1.6.4 Other vespid species

Although *Polistes* spp. create paper nests and could potentially carry triungulin larvae to the nest, species of this genus are not recorded hosts in Europe and will not be hosts of *M. paradoxus* in New Zealand. Surveys conducted in the native range suggest a high degree of host preference, even within the vespid wasps (Carl & Wagner 1982).

Vespula vulgaris and *V. germanica* in southern England were surveyed for potential biological control agents in 2018 and 2019. A total of 32 nests were dug up and examined (Table 2). Nearly all nests were found to be parasitised by at least one species. The most common species found was *Volucella inanis*, in over 83% of nests. *Metoecus paradoxus* was the second most common in *V. vulgaris* nests at 50% frequency. No *Metoecus paradoxus* were found in the surveyed *V. germanica* nests.

Table 2. Summary of Vespula wasp nest survey done in 2018/19 in the UK showing prevalence of the two putative biological control agents (Brown unpublished).

Wasp species	No. of nests surveyed (total)	No. parasitised	% parasitised	No. with *V. inanis*	% with *V. inanis*	No. with *M. paradoxus*	% with *M. paradoxus*
V. vulgaris	26	24	92.3	23	88.5	13	50
V. germanica	6	6	100	5	83.3	0	0

In 1980 and 1981 Carl and Wagner (1982) surveyed 220 nests of *V. vulgaris*, 54 of *V. germanica*, five of *V. rufa*, 54 of *Dolichovespula saxonica* and four of *D. media* in Switzerland, Germany, and Austria, for natural enemies. *M. paradoxus* was found in 106 (48%) nests of *V. vulgaris*, seven (13%) of *V. germanica* and one (c. 2%) of *D. saxonica*. None were found in nests of *V. rufa* or *D. media*. In 2011, 83 *V. vulgaris* and 26 *V. germanica* nests were collected near Leuven, Belgium. *M. paradoxus* was found in 55 (66.3%) of the *V. vulgaris* nests. No *M. paradoxus* were found in *V. germanica* nests.

When combined, these surveys demonstrate a bias for *M. paradoxus* to attack *V. vulgaris* colonies over *V. germanica* in the native range. This apparent host preference may be caused by the beetles' preference to oviposit on the type of decomposing wood that *V. vulgaris* uses to construct nests, instead of the more robust wood that *V. germanica* prefers to use for nesting material.

These nests were surveyed in mid- to late season in the native range, so we cannot be sure of the parasitoid incidence in early season nests. Because early season nests are difficult to locate due to their small size and low worker traffic, any effect that natural enemies have during the early colony stages can currently only be speculated on. We think it is likely that at least a portion of early season wasp colonies fail in the native range due to parasitism by one or more species of parasitoid.

Since the host preference for this genus is so narrow it is unlikely there would be a host shift to solitary wasps once *M. paradoxus* is released in New Zealand. However, there is a chance that any newly introduced social *Vespula*, *Vespa*, or *Dolichovespula* species could be targeted by these beetles.

In summary, *M. paradoxus* is an obligate parasitoid that is specific to wasps in the subfamily Vespinae. It is improbable that *M. paradoxus* could attack any species other than *V. germanica* and *V. vulgaris* in New Zealand. The intricate life history and biological characteristics preclude other hosts. This conclusion is supported by numerous surveys conducted in Europe (see table 1).

3.1.7 Establishment and eradication of unwanted populations

The purpose of this application is to establish self-sustaining populations of *V. inanis* and *M. paradoxus* wherever *Vespula* spp. wasps occur in the South Island. It is likely that these control agents will also colonise wasp nests in the North Island. The information provided in section 5 is sufficient to conclude that the risks of introduction of these species are negligible and the benefits of successful control considerable. The introduction of the hoverfly and the wasp-nest beetle is not expected to have any significant adverse ecological, economic, cultural or social effects. It is highly unlikely that any populations of these species will be unwanted.

Both agents have mobile adults. Once each agent has completed one generation in the field and new adults have dispersed, there will be no feasible technique to determine its distribution effectively or to undertake eradication. Release of these agents should be considered irreversible.

3.2. Regulatory status of the organism

Is the organism that is the subject of this application also the subject of:

An innovative medicine application as defined in section 23A of the Medicines Act 1981?

☐ Yes ☒ No

An innovative agricultural compound application as defined in Part 6 of the Agricultural Compounds and Veterinary Medicines Act 1997?

☐ Yes ☒ No

4. Māori engagement

Discuss any engagement or consultation with Māori undertaken and summarise the outcomes.
Please refer to the EPA policy 'Engaging with Māori for applications to the EPA' on our website (www.epa.govt.nz) or contact the EPA for advice.

The potential beneficial and adverse effects of this proposal on the environment and economics of Aotearoa New Zealand, and on the health and well-being of all New Zealanders, are discussed in depth in section 5. Section 4 addresses those effects that are specific to Māori, particularly the potential for any cultural risk associated with the effects discussed in section 5. Māori were consulted before the application was written to establish what areas of potential cultural risk should be addressed.

Māori views on this proposal have been sought by four routes:

- consultation with members of Te Herenga
- consideration of issues raised in previous similar applications
- consideration by a recent reference group

- ongoing consultation in the applicant's region (Tasman), where first releases would be made.

4.1. Consultation with Te Herenga

The EPA's national network, Te Herenga, comprises approximately 80 environmental managers and practitioners with expertise in environmental matters from iwi, hapū or Māori organisations, with national geographical coverage. Information about proposed biological control of *Vespula* spp. wasps was distributed to members of Te Herenga by EPA Kaupapa Kura Taiao staff in November 2019. The announcement directed readers to the Manaaki Whenua – Landcare Research website for further detail and invited dialogue and feedback (Brown, 2019). It also described how the applicant intended to assess the risks, costs and benefits associated with the proposed introductions, and invited members to identify any issues they would like to have addressed in the applications.

No feedback has yet been received via this pathway. Any issues brought to the attention of the applicant before formal consideration of this application will be made available to the EPA. Members of Te Herenga will also be specifically informed by the EPA when each application is open for public submission and will be able to comment on how the applicant has addressed issues raised during consultation.

4.2. Issues raised in previous consultations

Vespula spp. wasps were the target of a previous biological control project when the parasitoid *Sphecophaga vesparum vesparum* was approved for release in the 1980s. The parasitoid has established in at least two sites in New Zealand, but for reasons summarised by Ward (2014) this insect has not contributed significantly to reducing the wasp problem nationally. There are no records of any consultation with Māori undertaken before that approval was obtained. However, biological control projects share characteristics, and some of the issues raised by Māori over other biocontrol proposals, even weed control projects, are relevant to the biological control programme against wasps.

The key areas identified in previous consultations are:

- possible direct effects on native species (see section 5.1.2)
- possible indirect effects on native flora and fauna, and on other valued species (see sections 5.1.2, 5.3.2)
- the need to monitor future effects (see section 7)
- predictability of effects (see section 5.1.2)
- specific benefits to Māori
- compromising of cultural and spiritual values
- integration of control methods, and indigenous solutions

- pesticides and biological control (see section 5.1.1)
- aversion to the introduction of new organisms
- lack of capacity within iwi to respond to biosecurity issues precludes comment.

4.3. Māori Reference Group

In 2014 the EPA convened a Māori Reference Group (MRG) to consider general issues surrounding applications to introduce new organisms for the biological control of weeds that would be of particular significance to Māori. The MRG was made up of four members with expertise and/or experience relevant to biocontrol proposals. After undertaking a review of the information available on the proposals, the MRG identified initial draft principles or themes that apply to biological control proposals generally[3] .

So although the MRG was convened to discuss weed biocontrol proposals, most findings are equally relevant to the proposed biological control programme for wasps. The following key principles were identified:

- impact on kaitiakitanga – the responsibility of Māori to manage natural resources within and beyond hapū and iwi boundaries
- impact on manaakitanga – the ability of Māori to protect cultural rights and ownership within hapū and iwi boundaries
- whakapapa as the foundation for kaitiakitanga, and the need to consider the potential impacts of biocontrol agents across the breadth of trophic and ecosystem levels (see section 5.1.2)
- the requirement for applicants to provide comment and/or data to evaluate potential impacts
- the need to define the regional scope of effects, and effectively consider effects on iwi and hapū at a local level
- the need to specifically address benefits to Māori.

With reference to the initial draft principles, the MRG noted that the proposed introduction of these biocontrol agents might have significant direct beneficial effects on culturally valued species and indirect benefits for the wider native ecosystem. The MRG specifically commented that the presence of weeds of significant stature within the margins of te ngahere adversely affects our appreciation of the forest environment. This is even truer for wasps.

Communities, along with local and national governments, currently invest heavily in pesticide baiting and direct insecticide application to nests that limit *Vespula* spp. wasp numbers to protect biodiversity and human health. These efforts are labour- and cost-

[3] https://www.landcareresearch.co.nz/__data/assets/pdf_file/0003/88338/Maori_Reference_Group_Report.pdf

intensive and are therefore limited to areas of high wasp impact. Biological control offers the prospect of enhancing control in those areas, as well as reducing wasp impacts in parts of the environment that cannot currently be reached (see section 5.1.1). Biological control will therefore enhance the ability of Māori to fulfil their role as kaitiaki.

Apart from their biodiversity impacts, wasps pose significant nuisance and health risks to iwi nationwide (see sections 2 and 5). This risk is proportional to the number of foraging wasps present. Currently this can only be managed effectively by using pesticide baits. Reductions in wasp numbers through biocontrol would reduce interactions between wasps and tāngata whenua and reduce the incidence of stings and adverse reactions. If sufficiently successful, biocontrol would reduce or eliminate the use of pesticides and their distribution in the environment (see section 5). Biological control would therefore assist Māori in the exercise of manaakitanga.

The addition of these two biocontrol agents would change the fauna within hapū and iwi boundaries. However, both are functionally host specific, with a low ecological footprint (see section 5.1.2). Neither is expected to have an adverse impact on the functioning of ecosystems, or on the exercise by Māori of kaitiakitanga or manaakitanga.

No potential benefits or costs have been identified that are exclusive to Māori. Benefits and costs associated with the introduction of the biological control agents (BCAs) or the control of wasps would accrue generally to the market economy and to the environment throughout Aoteoroa New Zealand (see sections 5.1, 5.3). However, biocontrol is the only intervention that can deliver control at a landscape level, and without it *Vespula* spp. wasps will continue to have significant effects on how Māori exercise their cultural and spiritual values.

The previously introduced *S. v. vesparum* has not significantly reduced the adverse impacts of wasps on the environment, on the economy or on human health (see section 2). There appear to be no indigenous natural enemies attacking *Vespula* spp. wasps that could be exploited for its management.

4.4. Regional consultation

This application is in the name of Tasman District Council, on behalf of the Vespula Biocontrol Action Group. This group comprises interest groups (including the Department of Conservation) and is supported by the Sustainable Farming Fund (administered by the Ministry for Primary Industries). The focus of the group is the effective management of *Vespula* spp. wasps in the north of the South Island. If the introduction of the biocontrol agents is approved, then this group will release them in the South Island. If the agents establish, it is likely that natural spread will see the insects progressively colonise both the North and South Islands. Regional and local consultation was therefore concentrated in the South Island, where eight iwi are tāngata whenua:

- Ngāti Tama ki Te Tau Ihu
- Te Ātiawa o Te Waka-a-Māui
- Ngāti Rārua
- Ngāti Kōata
- Ngāti Toa Rangatira
- Ngāti Kuia
- Ngāti Apa ki te Rā Tō
- Rangitāne o Wairau.

Optimum pathways for consultation were discussed with the Kaihautū, Tasman District Council, who provided appropriate contacts. The eight iwi were contacted in November 2019 and invited to provide information, or to start dialogue, on any issues the proposed biological control posed locally. Ngāi Tahu has manawhenua in adjoining areas. The Principal Manager, Policy, at Te Rūnanga o Ngāi Tahu, was also contacted to facilitate input, and attempts were made to contact the Ngāi Tahu HSNO komiti for comment. Consultation with Ngāi Tahu HSNO komiti is continuing.

This consultation pathway yielded one response, from Te Ātiawa Manawhenua ki te Tau Ihu Trust. The questions raised were in relation to:

- the nature of control, and the prospects and consequences of eradication
- the extent of competition with resident pollinators
- risk to native bees
- previous biological control attempts and follow-up monitoring.

Successful biological control would drive populations of *Vespula* spp. wasps down, possibly to low levels, but could never eradicate the pest. These two agents are completely dependent on *Vespula* spp. wasps to survive, and so would also become less common as wasp numbers decline. The parasitoids would coexist at a new low equilibrium with their hosts, and populations would respond if there was a resurgence in wasp numbers (see section 5). Biological control is still regarded as a vital element for *Vespula* spp. wasp management because it is the only control tool that is self-perpetuating and can act over very large and inaccessible areas.

The larvae of the hoverfly *Volucella inanis* feed exclusively on social wasp larvae, but adult flies that emerge from the wasp nest feed on pollen. There are two aspects to this. The establishment of *V. inanis* would introduce a new pollinator that could potentially enhance pollination of desirable native and economic plants. On the other hand, if the amount of pollen present for harvest were limited, then the introduction of *V. inanis* could reduce the reproductive success of resident pollen-feeding species. This would include native bees and hoverflies, but also flower-living beetles and other species. However, we anticipate that any added competition by *V. inanis* would be negated by their successful control of wasps and therefore provide an overall benefit to native pollinators and honeybees.

The most abundant resident species feeding on pollen are introduced bumblebees and honeybees, which are managed to maximise flower visits and honey yields (including mānuka honey). These are the strongest competitors for pollen. It is highly unlikely that the biomass of *V. inanis* will ever challenge that of honeybees and bumblebees, and so the increase in competition with native species resulting from the establishment of *V. inanis* is likely to be marginal and insignificant (see section 5). There are hundreds of native species of flies, beetles and Hymenoptera that already compete for pollen resources. Adding another species (*V. inanis*) is unlikely to change the existing patterns of pollen use in New Zealand.

Species of the genus *Metoecus* have only ever been recorded from the nests of social wasps (section 3). Honeybees and bumblebees make their hive structures out of wax and cannot be hosts of *M. paradoxus*. Ants do not harvest rotting wood to create nests and so cannot be hosts either. No other social Hymenoptera are present in New Zealand. Adult *M. paradoxus* beetles are short lived and do not feed at all as adults (B. Brown, unpublished data), and will not compete for food with native insects.

Native insects are integral to the mauri of terrestrial ecosystems and are taonga. The introduction of *M. paradoxus* and *V. inanis* to Aotearoa New Zealand is highly unlikely to have any detrimental impact on the viability of any native species, and hence would have negligible effect on how Māori exercise their cultural and spiritual values. The highly specific biology of both biocontrol agents severely limits the influence either species can have on terrestrial ecosystems (see section 3). Both rely on social insects to complete their life cycle, and there is no evidence that either can use hosts other than *Vespula* spp. wasps.

The only native social Hymenoptera in this country are the ants. The ecology of many ant species has been exhaustively studied in Europe for over 100 years. No *Volucella* species has ever been reported from an ant nest there (see section 3.1), and there is no reason to believe that ants could be a host in New Zealand. All other native Hymenoptera are ground nesting, solitary bees that do not form hives. There are 250 such bee species resident in the UK, and these are not hosts of the biocontrol agents (see section 5.1.1.).

A previous biocontrol programme in the 1980s introduced the parasitoid wasp *Sphecophaga vesparum vesparum. S. v. vesparum* did not establish well but can still be found in two of the original release areas. The parasitoid has been studied extensively since its release (see section 2), which has shown that *S. v. vesparum* has not reduced wasp numbers in Aotearoa New Zealand, and thus has not had the desired effect on wasp populations.

Any further information received before the consideration of this application will be passed to the EPA. This dialogue is expected to continue through the development of the agent and initial releases.

5. Risks, costs and benefits

Provide information of the risks, costs and benefits of the new organism(s).

These are the positive and adverse effects referred to in the HSNO Act. It is easier to regard risks and costs as being adverse (or negative) and benefits as being positive. In considering risks, cost and benefits, it is important to look at both the likelihood of occurrence (probability) and the potential magnitude of the consequences, and to look at distribution effects (who bears the costs, benefits and risks).

Consider the adverse or positive effects in the context of this application on the environment (e.g. could the organism cause any significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats or cause significant adverse effect to New Zealand's inherent genetic diversity, or is the organism likely to cause disease, be parasitic, or become a vector for animal or plant disease?), human health and safety, the relationship of Māori to the environment, the principles of the Treaty of Waitangi, society and the community, the market economy and New Zealand's international obligations.

You must fully complete this section referencing supporting material. You will need to provide a description of where the information in the application has been sourced from, e.g. from in-house research, independent research, technical literature, community or other consultation, and provide that information with this application.

The potential risks, costs and benefits of the proposed introduction of the hoverfly and the wasp-nest beetle to New Zealand have been identified by literature review, by review of issues raised in previous applications to ERMA/EPA to introduce biocontrol agents for invasive pest species, and by consultation with stakeholders. All effects identified during this process are listed on the Manaaki Whenua – Landcare Research website[4] and in Appendix 1. Those effects considered to be potentially significant are highlighted on that list, and only those effects are addressed in detail here (section 5).

Potential effects are associated with:

- permanent establishment in New Zealand of the hoverfly and the wasp-nest beetle
- reduction in the number of wasps as a result of parasitism
- successful biological control, whereby the biocontrol agents significantly suppress *Vespula* spp. wasp populations.

Stakeholders were consulted in 2019 during preparation of the application[4]. A selection of comments from the submissions is presented in section 5. All submissions received are presented in Appendix 2.

[4] https://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/invertebrates/invasive-invertebrates/approvals/current-applications/vespula-species

5.1. Potential effects on the environment

5.1.1 Potential beneficial effects on the environment

Successful control by the hoverfly and the wasp-nest beetle would benefit the New Zealand environment through:

- reduced predation of invertebrates by wasps, leading to greater prey resources for native birds
- improvement to, or restoration of, normal ecosystem functioning of beech forests, with more honeydew available for native species
- reduced contaminants from insecticides.

5.1.1.1 Reduced predation by Vespula wasps leading to increased invertebrate prey resources for native birds

Successful biocontrol is likely to have major benefits for New Zealand's unique biodiversity, including populations of several native bird species, through:

- an increase in native invertebrate populations currently under severe predation pressure from *Vespula* spp. wasps (see section 2.3.2)
- increased prey resources for native birds through reduced competition with *Vespula* spp. wasps (see section 2.3.2).

A study by Harris (1991) showed that *Vespula* spp. wasps harvest between 1.4 and 8.1 kg of arthropod prey (bees, butterflies, flies and spiders) per hectare, per season, in beech forests. Modelers have suggested that high levels of reduction in worker numbers will be required to achieve significant ecosystem benefits unless control measures can target early nests and attack is post-density dependence. However, we consider that any level of reduction in the number of hunting wasps will reduce pressure on populations of invertebrate prey species, which could have a positive, knock-on effect for native birds, particularly in other natural habitats where *Vespula* spp. wasp populations are not fueled by honeydew. It is uncertain whether biocontrol can achieve this, but it is possible (see sections 2.3.4.1). If biocontrol is successful, then benefits will be moderate to major (Table 3).

5.1.1.2 Improved ecosystem functioning of beech forests

Honeydew is an important resource for New Zealand's native species that have evolved in beech forests. Any reduction in numbers of foraging *Vespula* spp. wasps in honeydew beech forests will make more honeydew available to sustain higher numbers of native species that are dependent on this resource, such as kākā (see section 2.3.3.2). This will benefit individuals, but it is uncertain whether it would have highly significant benefits at a population level.

Prior to the invasion of beech forests by *Vespula* spp. wasps, honeydew produced by the endemic scale insect supported a diverse ecosystem. The unharvested honeydew dripped into the soil, which played an important role in nutrient cycling (Beggs 2001; Wardle et al. 2009) in the honeydew beech forest community (see section 2.3.3.2). *Vespula* spp. wasps forage for, and remove, up to 99% of honeydew from beech forests during spring and summer when their populations are growing, with massive impacts on ecosystem functions. A reduction in the number of foraging *Vespula* spp. wasps will partially restore normal top-down and bottom-up ecosystem processes in New Zealand's beech forests.

5.1.1.3 Reduced contamination of air, soil and water from poison baits and direct poisoning of nests

Successful control, where wasp numbers fall below damaging levels, will lead to reductions in the use of poisons for managing wasp populations (currently the only widely used method, which is only effective in specific situations, section 2.3.4.1). This will have a direct benefit to the New Zealand environment as a result of:

- reduced use of pesticides containing an ecotoxin[5]
- reduced use of a pesticide that is toxic to aquatic and terrestrial invertebrates and fish[6]– the active ingredient fipronil is a broad-spectrum insecticide
- reduced risk of poisoning of people, birds and pets (although Vespex is considered to be of very low risk to these groups).

Where wasp densities are very high (such as in beech forests), biocontrol may only partially suppress *Vespula* spp. wasp populations, and thus continued use of poison baits and insecticides in these areas where wasps are actively managed would still be required.

Comments received during the consultation:

> So while Vespex may be a relatively effective option, the issue is the public (particularly the public/landowners) using baits like jam baits, fly sprays, which also kill bees. We would also note that as with insecticide that poses a moderate health risk to humans and the environment, we would like to eventually see insecticide replaced by bio-control or other non-chemical methods. (ApiNZ submission)

> Vespula wasps are a perfect candidate for biological control. As agencies managing invasive species threats, a target is only considered for population level management if there are tools available to manage the threat and the nature of the infestation means the population can be feasibly managed as a whole. Vespula wasps fall outside these parameters. The impacts however continue to be felt widely and strongly, so should there be agents that can reduce or even suppress Vespula populations, this is whole-heartedly endorsed by Marlborough District Council. In short, a reduction in Vespula populations to even a modest amount, would relate a tremendous positive effect on our community, environment and local economy (apiculture). (Marlborough Regional Council submission)

[5] www.merchento.com/vespex.html
[6] www.merchento.com/assets/vespex_label.pdf

> DairyNZ supports in principle the use of biocontrol agents providing they meet all the requirements for host specificity etc. and are approved via the EPA process … I wish you every success with the approval process. Biocontrol agents for wasps can make a big difference for native biodiversity and ecosystem services. (Dairy NZ submission)

5.1.2 Potential adverse effects on the environment

The introduction of the two biocontrol agents would adversely affect the New Zealand environment if:

- a decline in *Vespula* spp. wasp populations makes the New Zealand environment more susceptible to invasion by worse social wasps
- insect populations are reduced through non-target attack
- the presence of the agents sufficiently alters food web interactions to cause significant displacement of native organisms through 'apparent competition'
- the biocontrol agents are ineffective, but abundant in the environment, and compete with native pollinators.

5.1.2.1 Decline of common and German wasp populations opens the New Zealand environment to invasion by worse social wasps

There is no existing evidence that *Vespula* spp. wasps are preventing the establishment of other social wasps in New Zealand. For example, the European paper wasp, *Polistes dominula,* has established in New Zealand within the past decade. This risk is considered unlikely, but must be considered uncertain. The current ecological damage caused by *Vespula* spp. wasps is unsustainable in the long term. It would not be tenable to suggest maintenance of wasp populations to exclude niche invasion by other, more aggressive social wasps. It is unlikely that any other invader in the wasp family, Vespidae, could be any more damaging than *V. germanica* and *V. vulgaris*.

5.1.2.2 The biocontrol agents attack native solitary bees, ants and wasps

Neither *V. inanis* nor *M. paradoxus* has ever been found to be associated with solitary bees, solitary wasps or ants in their native ranges in Europe, although many parasites and predators are known for these groups (see sections 3.1.5, 3.1.6). As generalist predators, *Vespula* spp. wasps present a significantly greater threat to native solitary bees, wasps and ants as well as other important pollinators. The potential impacts on apiculture are dealt with in section 5.3.2.

5.1.2.3 Food web interactions: introduction of a new prey species enhances predator/parasitoid populations, having an indirect negative effect on native prey species such as native hoverflies

Successful biocontrol is unlikely to have significant adverse environmental effects because the biocontrol agents:

- are not expected to share parasitoids with native species

- are not expected to be a significant food source for other predators.

Classical biocontrol agents can accumulate native parasitoids, and/or become prey for native generalist predators, once established in their area of introduction (Van Driesche & Hoddle 2016). The incidence is likely to be higher when there are native 'ecological analogues' of the biocontrol agents in their region of introduction (Paynter et al. 2010). New Zealand has 91 species of native hoverfly and five species of ripiphorid beetles (section 3.1.4), but none of these are associated with social wasps (or any comb-forming Hymenoptera), and thus cannot be considered ecological analogues of either biocontrol agent*.*

The candidate biocontrol agents have highly complex and specialised life histories, with their immature stages closely associated with *Vespula* spp. wasp nests. It is highly improbable that the eggs, larvae and pupae of *V. inanis* will by encountered by native and resident parasitoids that are capable of using them as hosts. It is highly improbable that the late instar larvae and pupae of *M. paradoxus* will be encountered by native and resident parasitoids that are capable of using them as hosts. The triungulin larvae of *M. paradoxus* may be encountered by generalist predators such as ants, but any effects would only be evident in the immediate vicinity of rotten wood, and would thus be habitat specific and highly incidental.

The adults of *V. inanis* and *M. paradoxus* may fall prey to generalist predators in the New Zealand environment, but they would form a small proportion of individual insects available as prey, and thus it is highly improbable that this would have a positive population-level effect on any generalist predators. If the biocontrol agents are not attacked by specialist parasitoids and/or predators in the New Zealand environment, the potential for any associated, indirect effects on native syrphids and ripiphorids is considered negligible to low.

5.1.2.4 Food web interactions: the biocontrol agents are ineffective at reducing wasp populations, but are abundant in the environment, leading to competition with native pollinators

The adults *of V. inanis* are pollen feeders, but it is improbable that these hoverflies will be significant competitors of native pollinators. The pollen requirements of *V. inanis* adults are likely to be miniscule in comparison to native and introduced bees, which rely on floral resources for raising their brood. Even if *V. inanis* adults are abundant in the environment, their populations are likely to be miniscule, both spatially and temporally, in comparison to honeybees and bumblebees, which are the strongest pollen competitors of native pollinators. The applicants consider that *Vespula* spp. wasps are a greater threat to New Zealand's native pollinators through predation than *V. inanis* could be through interspecific resource competition.

Comments received during the consultation:

> Hoverflies only consume pollen as adults so they are not going to have the same impact that bees (introduced and native) have on native habitat pollen resources. Therefore I'd suggest that honey bees and bumblebees (that can be very abundant in native ecosystems) are going to have a much greater impact on at least pollen resources than the introduction of this hover fly species. (B Howlett, Plant & Food Research)

5.2. Potential effects on human health

5.2.1 Potential beneficial effects on human health

The introduction and establishment of the candidate biocontrol agents would have a positive effect on human health through:

- reduced risk of injuries and even deaths caused by wasp stings
- reductions in stings to gardeners, forestry workers, conservation staff, volunteers, trampers, farmers, school groups and tourists caused by disturbing wasp nests.

5.2.1.1 Reduced risk of injuries and deaths caused by wasp stings

Allergy New Zealand estimates two to three people die each year due to insect stings, some of which are from *Vespula* wasp stings, which can cause a severe allergic reaction known as anaphylactic shock. Any reduction in the number of *Vespula* spp. wasps from biocontrol will reduce the abundance and distribution of wasps and wasp nests in the environment, which is likely to reduce the incidence of wasp stings. This, in turn would significantly reduce the risk of fatal wasp stings.

5.2.1.2 Reduction in stings to gardeners, forestry workers, conservation staff, *volunteers, trampers, farmers, school groups and tourists caused by disturbing wasp nests*

Vespula spp. wasps pose a serious health and safety threat to workers and to the public trying to enjoy the outdoors. Between 2014 and 2019, ACC Analytics and Reporting recorded a total of 6,330 new claims for wasp sting injuries, with a total claim value in active costs of $522,983 (ACC Analytics and Reporting 2019). Any reduction in the number of *Vespula* spp. wasps from biocontrol will significantly reduce the probability of encounters between wasps and humans, which will lead to an associated reduction in the number of wasp stings.

Comments received during the consultation:

> In terms of impacts, we receive a large amount of community feedback that Vespula wasps cause immense frustration when the public are using the likes of picnic areas, camping areas and the forested ecosystems at large in the Marlborough Sounds. This is primarily through the wasps attempting to forage food. When in large numbers, we have received feedback that the wasps can also be a considerable danger with areas becoming virtually unusable due to the risk of attack. (Marlborough Regional Council submission)

> Every year wasps are a problem in some orchards – usually at harvest (March to June), presenting a health and safety risk to harvest workers … Contractors carry 'Expra Stop

Wasps' spray and 'Permex' insect dust to apply to nests. These pesticides are only partially successful, contractors get stung once every 5 to 10 working days. Reducing wasps populations, through a successful biological control programme, will reduce risk of serious harm from common and German wasps to contractors controlling wild kiwifruit. (Kiwifruit Vine Health submission)

5.2.2 Potential adverse effects on human health

No significant adverse effects from the release and establishment of the biocontrol agents have been identified[7] (Appendix 1).

5.3. Potential effects on the market economy

5.3.1 Potential beneficial effects on the market economy

A cost analysis study by MacIntyre and Hellstrom (2015) estimated the cost of direct impacts of wasps at $75 million per year. The indirect impacts of wasps to New Zealand (tourism, recreation) was estimated to cost $2m per year (MacIntyre and Hellstrom 2015). The introduction and establishment of the candidate biocontrol agents would have a positive effect on the market economy through:

- an increase in pollination services by honeybees – kiwifruit growers contract beekeepers to provide hives for placement in orchards to assist with pollination, but *Vespula* spp. wasps are reported to attack hives and to rob bees of their harvested solutions, thus compromising their pollination services in these kiwifruit orchards (Kiwifruit Vine Health submission, see Appendix 2)
- increased profitability of the apiculture industry by reduced predation and hive robbing by wasps
- reduced control costs for occupiers, regional councils, the Department of Conservation (DOC), and others.

5.3.1.1 Increased profitability of apiculture industry by reduced predation and hive robbing by wasps

It is widely acknowledged and reported that *Vespula* spp. wasps have significant detrimental impacts on honeybees in New Zealand (see Appendix 2). In 2019 the NZ Colony Loss Survey reported the loss of 81,965 honeybee colonies. Wasps accounted for 9.6% of those losses[8] (~7869 colonies). This loss has an estimated direct cost (replacing

[7] https://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/invertebrates/invasive-invertebrates/approvals/current-applications/vespula-species
[8] https://www.mpi.govt.nz/protection-and-response/readiness/bee-biosecurity/bee-colony-loss-survey/

the colonies and lost profits) to beekeepers of $4M/year (B Foster Pers Comm, Appendix 4). Greater levels of suppression of *Vespula* spp. wasp populations are likely to have major benefits for the honeybee industry and the ecosystem services that honeybees provide through:

- a reduction in economic losses due to heavy predation of honeybee workers by wasps, which reduces hive productivity
- a reduction in losses due to the destruction of honeybee hives during hive robbing.

Comments received during the consultation:

> *Vespula* sp. wasps have significant impacts as outlined in the Colony Loss Surveys from 2015 to 2019. Wasps consistently ranked highly as a cause of colony loss: 12.1% in 2018 (ranked 3rd highest cause); 9.7% in 2017 (ranked 4th highest cause); 11.7% in 2016 (ranked 3rd highest cause). (ApiNZ submission, see Appendix 2).

This may be of particular significance to the mānuka honey industry, which, as a result of its international success, has driven growth of the total New Zealand honey industry.

5.3.1.2 Reduced control costs for occupiers, regional councils, DOC, and others

Vespex® is the most widely used poison bait for the control of *Vespula* spp. wasp populations when they are expanding, and up to 25 bait stations may be required per hectare where infestations are dense. In addition to the cost of the bait, several safety accessories are mandatory (e.g. bait stations, protective gloves, public warning signs and other precautionary products and materials) to set up and manage wasp bait stations. In 2017-2018, $80,000 was donated to Wasp-Wipeout to treat 20,000 hectares in Nelson, Tasman, Marlborough and Canterbury (https://www.doc.govt.nz/about-us/our-partners/our-supporting-partners/wasp-wipeout/). In 2018-2019 Wasp-Wipeout collected another $80,000 in donations to treat 30,000 hectares in the same regions. These costs don't include labour as the projects rely heavily on volunteers to administer and maintain the bait lines. Successful biocontrol is likely to result in moderate reductions in the use of baits and other insecticides, significantly reducing control costs currently borne by private landowners and the New Zealand government.

Comments received during the consultation:

> The cost of wasp sprays would likely be up to $300 yearly (per contractor). Contractors also have to purchase anti-histamines, also approximately $300 yearly. (Kiwifruit Vine Health submission)

5.3.2 Potential adverse effects on the market economy

The introduction and establishment of the candidate biocontrol agents would have adverse effects on the market economy through:

- agents attack honeybees or bumblebees
- reduced wasp bait (Vespex) sales significantly affecting vendor's businesses
- reduction in revenue for pest control contractors and suppliers.

5.3.2.1 The biocontrol agents attack honeybees or bumblebees

Volucella inanis and *Metoecus paradoxus* have never been found amongst material submitted by beekeepers or beehive inspectors to the UK National Bee Unit for identification (N. Semmence, pers. comm., Appendix 3.). Further, extensive historical knowledge of the ecology and life history of the biocontrol agents is available to predict that the risk of the biocontrol agents attacking honeybees or bumblebees is negligible (see section 3.1.4). *Vespula* spp. wasps present a significantly greater threat to these and other important pollinators.

Comments received during the consultation:

> We support introducing the control agents … We are not aware of any ecological effects of introducing the control agents. (ApiNZ submission)

5.3.2.2 Reduced wasp bait (Vespex) sales significantly affecting vendors' businesses (Vespex is only effective in specific situations)

Successful control of *Vespula* spp. wasps will reduce the demand for the use of poison baits and insecticides, reducing sales of these products. However, specialist products such as Vespex® are likely to be used in some instances as part of integrated control programmes aimed at achieving the greatest levels of suppression of wasp populations in all habitats and environments where they are problematic.

5.3.2.3 Reduction in revenue for pest control contractors and suppliers

Successful control of Vespula spp. wasps, resulting in a significant decline in wasp numbers, will reduce the demand for pest control activities, which would have a direct impact on the revenue of pest control contractors and suppliers. However, an integrated control programme will most likely be required to bring about the highest levels of suppression of wasp populations, so the demand for pesticide will be reduced but not eliminated.

5.4. Potential effects on society and communities

The introduction and establishment of the candidate biocontrol agents would have a positive effect on society and communities through:

- reduction in stress in conservation and forestry workers and managers.

5.4.1 Potential beneficial effects on society and communities

5.4.1.1 Reduction in stress in conservation and forestry workers and managers

The presence of high numbers of *Vespula* spp. wasps irritate and stress forestry and conservation workers as they pose a direct threat to their health and safety, due to the risk of unintentionally disturbing wasp nests while conducting their work. A reduction in wasp numbers due to biocontrol will lead to an associated reduction in the incidence of wasp to human encounters, which will have a positive impact on the mental wellbeing of workers at risk of stings.

5.4.2 Potential adverse effects on society and communities

No significant adverse effects on society and communities have been identified[9].

5.5 Summary tables of risks and benefits

Through an evaluation of the host range of the candidate agents (sections 3.1.5, 3.1.6) and an assessment of the potential risks associated with their introduction, we consider *V. inanis* and *M. paradoxus* to be sufficiently host specific for release in the New Zealand environment, **and that the potential cumulative benefits outweigh the potential cumulative risks**.

Table 3: Magnitude and likelihood of benefits to New Zealand *if* biocontrol of *Vespula* spp. wasps proves to be *successful*.

Source and description of benefit	Likelihood of benefit effect occurring	Consequence (magnitude)	Level of benefits
To the environment: Increased invertebrate prey resources for native birds	Highly likely	Moderate to major	Significant (medium to high)
Improved ecosystem functioning of beech forests	Highly likely	Major	Significant (high)
Reduced contamination of the environment from insecticides	Likely	Minimal to minor	Significant (low)
To human health: Reduced risk of injuries or deaths caused by wasp stings	Likely	Moderate	Significant (medium to high)
Reduction in stings to the public and workers	Highly likely	Moderate to major	Significant (medium to high)
To the market economy: Increased profitability of apiculture industry by	Likely	Major	Significant (high)

[9] https://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/invertebrates/invasive-invertebrates/approvals/current-applications/vespula-species

reduced predation and hive robbing			
Reduced control costs for occupiers, regional councils, DOC and others	Likely	Moderate	Significant (low to medium)
To society and communities: Reduction in stress in conservation and forestry workers	Likely	Minor to moderate	Significant (low to medium)

Table 4: Likelihood and magnitude of risks and adverse effects to New Zealand (A) *if* biocontrol of *Vespula* spp. wasps proves to be *successful*, or (B) from *establishment* of the hoverfly and wasp-nest beetle.

Source of the risk	**Likelihood of adverse effect occurring**	**Consequence (magnitude)**	**Level of risk**
To the Environment: A decline in *Vespula* spp. wasps leads to invasion by worse invasive wasps	Unlikely	Minor	Negligible to low
The biocontrol agents attack native bees, ants and wasps	Highly unlikely	Minimal	Negligible
Food web interactions: Indirect negative effect on native prey species, such as native hoverflies	Highly unlikely	Minimal to minor	Negligible to low
Food web interactions: Competition with native pollinators	Unlikely to likely	Minimal to minor	Negligible to low
To the market economy: Reduced wasp bait (Vespex) sales significantly affecting vendors' businesses	Likely	Minor to moderate	Low to medium
Attack on honeybees or bumblebees	Highly unlikely	Minimal	Negligible
Reduction in revenue for pest control contractors and suppliers	Likely	Minor to moderate	Low to medium

6. Pathway determination and rapid assessment

Under sections 38I and 35 of the HSNO Act your application may be eligible for a rapid assessment. The pathway for your application will be determined after its formal receipt, based on the data provided in this application form. If you would like your application to be considered for rapid assessment (as per the criteria below), we require you to complete one of the below sections. **Fill in the section that is relevant to your application only.**

6A. New organism that is or is contained within a veterinary or human medicine (section 38I)

6.1. Controls for organism

Describe the controls you propose to mitigate potential risks (if any). Discuss what controls may be imposed under the ACVM Act (for veterinary medicines) or the Medicines Act (for human medicines)

Not applicable

6.2. Discuss if it is highly improbable (after taking into account controls if any):

- The doses and routes of administration of the medicine would have significant adverse effects on the health of the public or any valued species; and
- The organism could form an undesirable self-sustaining population and have significant adverse effects on the health and safety of the public, any valued species, natural habitats or the environment

Do not include effects of the medicine or new organism on the person or animal being treated with the medicine

6.2.1 Risk of unwanted populations

It is highly unlikely that the agents could be successfully eradicated once established, and so release into the New Zealand environment should be considered irreversible. The object of introducing biocontrol agents for the German and common wasps is to establish desirable, self-sustaining populations wherever populations of these wasps occur in New Zealand. The biocontrol agents would only be considered undesirable if they adversely affected valued native insects or ecosystems. The proposed biocontrol agents are not expected to have severe adverse economic, social or environmental effects in New Zealand (see sections 5.1.2, 5.3.2, 5.4.2). Given the potential benefits of introducing the biocontrol agents, none of their established populations are expected to be unwanted.

6B. New organism (excluding genetically modified organisms) (section 35)

6.3. Discuss if your organism is an unwanted organism as defined in the Biosecurity Act 1993

Neither *Volucella inanis* nor *Metoecus paradoxus* is listed in the New Zealand Unwanted Organisms Register[10]. *Volucella dracaena* is classed as an unwanted organism, but the species referred to in the register is a fruit-inhabiting species now known to be *Copestylum chalybescens* (Diptera: Syrphidae)[11].

6.4. Discuss if it is highly improbable, after taking into account the proposed controls, that the organism after release:

- Could form self-sustaining populations anywhere in New Zealand (taking into account the ease of eradication)
- Could displace or reduce a valued species
- Could cause deterioration of natural habitats,
- Will be disease-causing or be a parasite, or be a vector or reservoir for human, animal, or plant disease
- Will have adverse effects on human health and safety or the environment

6.4.1 Formation of self-sustaining populations

The establishment of self-sustaining populations of these organisms is the purpose of this application. These populations will not be unwanted.

6.4.2 Risk of displacement of valued species

Significant displacement of valued species is considered improbable for the following reasons.

- The evidence presented in sections 3.1.4 and 5.1.2 indicates that native insects are not at significant risk of attack by either of the biocontrol agents.
- It is improbable that any native invertebrate species or pollinators would be significantly displaced (section 5.1.2). The wasps are a greater threat to the displacement or extinction of New Zealand's native invertebrates.
- Any change in the abundance of *Vespula* spp. wasps from biological control is likely to be gradual over years. It is highly improbable that this control agent will cause a sudden decline in *Vespula* spp. wasp populations that might lead to widespread, rapid

10 https://www1.maf.govt.nz/uor/searchframe.htm
11 https://repository.si.edu/bitstream/handle/10088/18510/ent_FCT_61.pdf

change in any native habitat. Successful biocontrol could partially restore affected areas to a pre-invasion state over time.

6.4.3 Risk of deterioration of natural habitats

Deterioration of natural habitats as a result of the introduction of the hoverfly and the wasp-nest beetle is highly improbable. We expect the introduction of the biocontrol agents to significantly improve the quality, functionality and integrity of New Zealand's natural environments and ecosystems.

6.4.4 Risk of carrying disease

Insects can transmit disease-forming organisms actively (vectored) or passively. The candidate biocontrol agents are not pathogenic organisms and are not parasitic on vertebrates and thus are incapable of actively vectoring vertebrate disease. All colonies of the candidate biocontrol agents will be checked for the presence of harmful associated organisms prior to release, as required and stipulated by MPI import health standards[12].

6.4.5 Risk of adverse effects on human health

The hoverfly and the wasp-nest beetle are highly specialised parasitoids that live in close association with *Vespula* spp. wasp nests. Neither of these insects is capable of biting or stinging, or of vectoring human diseases. A short literature search (PubMed) revealed no records of syrphids or ripiphorids implicated in adverse effects on human health. Significant adverse effects on human health are improbable (see section 5.2.2).

[12] https://www.biosecurity.govt.nz/dmsdocument/1857-non-exotic-invertebrates-from-all-countries-import-health-standard

7. Other information

Add here any further information you wish to include in this application including if there are any ethical considerations that you are aware of in relation to your application.

7.1 Post-release monitoring and measurement of impact

Measurement of how a new biocontrol agent performs in its new environment falls into five phases:

- confirmation of establishment
- checking for non-target attack at the time of release
- keeping track of growth in agent populations
- measuring effects on populations of the target once peak agent populations are well established

- assessing the role of the biocontrol agent in trophic webs.

The Vespula Biocontrol Action Group will check for establishment of the agents for at least 2 years following release. *Volucella inanis* populations can be estimated by observing adult numbers near nest entrances. *Metoecus paradoxus* adults are cryptic. It is not immediately clear how to monitor the establishment of this species without digging nests, but there is a low probability of detecting low populations of control agents by this method. If no control agents are detected, monitoring will cease.

The populations of both biocontrol agents immediately following establishment will be extremely low. It is highly unlikely that any non-target attack could be detected within the first years of establishment. Nevertheless, local beekeepers will be alerted to the releases and asked to report the presence of either species in hives during routine inspections. Bumblebees nests are particularly difficult to locate, and so monitoring of the abundance of bumblebees may be required to detect non-target impacts.

The Vespula Biocontrol Action Group and Manaaki Whenua – Landcare Research would like to measure the effect of the biocontrol agents on the density of foraging wasps. However, concrete assessment plans cannot be developed at this stage because of uncertainties over:

- when to begin assessment of relative populations
- where to assess impact
- which agent to assess.

Manaaki Whenua – Landcare Research has indicated that assessment research would be a suitable subject for a future application for SSIF funding. However, premature assessment of the agents would be inconclusive and wasteful. It is not known whether agents will establish, or how long it will take for agents to reach equilibrium populations with their host. This is likely to take at least 5–10 years, and detailed population measurements before this timeframe would be inaccurate. Similarly, impacts of the biocontrol agents are likely to vary between habitats, and it is not clear which habitats should be investigated to measure impacts. It is unlikely that the establishment success, performance and preferences of the two agents will be the same, and assessment techniques, sites and times may well vary for each. Appropriate assessment strategies will only become evident once agents are widely established. (See Fowler et al. 2012; Paynter et al. 2010).

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8. Checklist

9. This checklist is to be completed by the applicant

Application		**Comments/justifications**
All sections of the application form completed or you have requested an information waiver under section 59 of the HSNO Act	☒ Yes ☐ No (If No, please discuss with an Advisor to enable your application to be further processed)	
Confidential data as part of a separate, identified appendix	☒ Yes ☐ No	
Supplementary optional information attached:		
• Copies of additional references	[redacted] ☐ No	
• Relevant correspondence	☒ Yes ☐ No	
Administration		
Are you an approved EPA customer?	☒ Yes ☐ No If Yes are you an: Applicant: ☐ Agent: ☒	
If you are not an approved customer, payment of fee will be by: • Direct credit made to the EPA bank account (preferred method of payment) Date of direct credit: • Cheque for application fee enclosed	☒ Yes ☐ No ☐ Payment to follow ☐ Yes ☐ No ☐ Payment to follow	
Electronic, signed copy of application e-mailed to the EPA	☐ Yes	

10. Signature of applicant or person authorised to sign on behalf of applicant

☒ I am making this application, or am authorised to sign on behalf of the applicant or applicant organisation.

☒ I have completed this application to the best of my ability and, as far as I am aware, the information I have provided in this application form is correct.

11/09/2020

Signature **Date**

Robert Smith (Acting E&P Manager for Dennis Bush-King)

11. Request for information waiver under section 59 of the HSNO Act

☐ I request for the Authority to waive any legislative information requirements (i.e. concerning the information that has been supplied in my application) that my application does not meet (tick if applicable).

Please list below which section(s) of this form are relevant to the information waiver request:

12. Appendices and referenced material (if any) and glossary (if required)

Appendix 1: Risks, costs and benefits

Appendix 2: Stakeholder/iwi questions and responses not included in the application

Appendix 3: Correspondence with National Bee Unit (UK)

Appendix 4: Correspondence with Barry Foster (ApiNZ)