Biosecurity New Zealand

Tiakitanga Pūtaiao Aotearoa

Report on the 2023 New Zealand Colony Loss Survey

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by P. Stahlmann-Brown, Manaaki Whenua – Landcare Research; T. Robertson

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Reviewed by:	Approved for release by:
Pam Booth Associate Economist Manaaki Whenua – Landcare Research	Suzie Greenhalgh Portfolio Leader – Society, Culture & Policy Manaaki Whenua – Landcare Research

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Executive Summary

The 2023 NZ Colony Loss Survey builds on eight previous NZ Colony Loss Surveys (2015–2022), providing an opportunity to monitor over-winter losses at both the national and regional level over time. Questions pertaining to autumn losses were also included for the first time, to reflect concerns among beekeepers that autumn losses exceeded winter losses.

The survey questionnaire included a core set of questions from a standardised survey that has been conducted in more than 40 countries. It also included questions that are specific to New Zealand, reflecting our unique apicultural context. The survey comprised three distinct parts, focusing on losses during autumn and winter 2023, the 2022/23 honey and pollination season, and beekeeper demographics. Additional questions pertaining to wellbeing were also included. The survey was administered online.

Invitations to participate in the survey were sent to all New Zealand beekeepers who had registered valid email addresses with the American Foulbrood (AFB) Pest Management Agency. Participation was encouraged by industry groups, presentations of the results at Apiculture New Zealand conferences and beekeeping clubs, articles in newspapers, the *New Zealand BeeKeeper*, and *The Apiarist's Advocate*. In addition, all beekeepers with more than 500 registered colonies received personal phone calls to encourage completion, targeting beekeepers who had not completed the survey at the time of the call.

In total, 3,457 beekeepers completed the 2023 NZ Colony Loss Survey, indicating a response rate of 42.6% of all registered beekeepers with living colonies at the start of winter with valid email addresses in the AFB Pest Management Agency database. Among the beekeepers who completed the survey were 19 of the 25 largest operators, indicating a response rate of 76% among this group. These beekeepers reported on 208,444 colonies, or 35.0% of all registered colonies in New Zealand. These response rates continue to be world leading in colony loss surveys.

The overall winter loss rate (i.e. total winter losses reported by survey respondents divided by the total number of colonies that entered winter) is estimated to be 12.65%, with a 95% confidence interval of 12.14–13.18%. This loss rate implies that New Zealand lost approximately 75,269 colonies over winter 2023. The 2023 winter loss rate is statistically lower than loss rates recorded over winter 2021 and winter 2022, but is higher than loss rates recorded over winter 2015, 2016, 2017, 2018, 2019, and 2020. Notably, these winter losses followed autumn losses of 16.76% (95% confidence interval of 16.11–17.44%).

As in previous years, overall loss rates during winter 2023 exhibit extensive regional variation, with estimates ranging from 9.10% for the middle South Island to 19.06% in the upper South Island. Loss rates during autumn 2023 varied from 10.87% in the upper South Island to 26.28% in the upper North Island.

Average loss rates over winter were significantly higher for non-commercial beekeepers. Nonetheless, as in previous years, the survey results indicate a wide variation in individual loss rates for both commercial and non-commercial beekeepers.

We estimate that 5.6% of all healthy, living colonies entering autumn 2023 were lost to varroa, and a further 6.4% were lost to varroa over winter 2023, similar to winter 2022.

We further estimate that 2.8% of all healthy colonies entering winter were lost to queen problems, 1.1% to suspected starvation, and 0.4% to wasps. Some 0.5% of colonies were lost to natural disasters, accidents, theft or vandalism.

Varroa monitoring enables beekeepers to optimise the timing of varroa treatment, which greatly increases a colony's chances of survival. While most beekeepers undertook formal monitoring for varroa, approximately one-quarter of hobbyists and approximately 18% of commercial beekeepers undertook no varroa monitoring. Regardless of monitoring, most beekeepers treated varroa in spring and/or autumn using a combination of flumethrin (marketed in New Zealand as Bayvarol®), amitraz (marketed as Apivar® and Apitraz®), and/or oxalic acid. Some beekeepers also treated during summer and/or winter. The vast majority of beekeepers considered their varroa treatment to be effective and point to the timing of treatment and reinvasion as reasons for varroa losses.

Based on demographic data from the survey, the 'typical' New Zealand beekeeper is a male in his late 50s with 5 years of beekeeping experience and three colonies. Using two different measures of wellbeing, hobbyists report wellbeing that is similar to or slightly above national averages. Commercial owner-operators report wellbeing well below national averages on both measures.

Additional results are available on the Manaaki Whenua – Landcare Research website:
https://www.landcareresearch.co.nz/bee-health

1 Introduction

Domesticated honey bees (*Apis mellifera*) provide honey as well as essential pollination services in crop production, yet managed honey bees are under persistent threat from pests and diseases. These threats have compelled many countries to undertake periodic surveys of honey bee colony losses, especially losses occurring over winter.

For example, winter colony losses in excess of 35% in 2005 and 2006 prompted surveys of winter colony losses in the USA (Lee et al. 2015; Seitz et al. 2022), which are annual and ongoing. Similar surveys have been undertaken in Canada (Currie et al. 2010) and across Europe (e.g. van der Zee et al. 2013, 2014, 2015; Brodschneider et al. 2016; Meixner & Le Conte 2016). Indeed, by 2008 COLOSS (Prevention of honey bee COlony LOSSes) had developed a standardised survey format to harmonise data collection on colony losses (van der Zee et al. 2014) that is regularly undertaken in more than 40 countries (Gray et al. 2023).

New Zealand did not systematically record annual wintering losses until 2015, when MPI commissioned Manaaki Whenua – Landcare Research to conduct the first NZ Colony Loss Survey. The 2015 questionnaire was based on the international COLOSS survey, but was subsequently adapted to reflect the New Zealand apiculture context. Indeed, several features distinguish the New Zealand apiculture industry from beekeeping elsewhere.

- New Zealand spans 12 degrees of latitude and has a temperate climate. The country has a diversity of native and exotic flora that provide abundant pollen and nectar resources, allowing honey bee colonies to flourish at comparatively high stocking rates (Ausseil et al. 2018). Of particular note, native trees in the Myrtaceae family (e.g. *Leptospermum scoparium* [mānuka], *Kunzea ericoides* [kānuka], *Metrosideros excelsa* [pōhutukawa], and *Metrosideros robusta* [rātā]) provide substantial seasonal nectar yields and monofloral honey crops.
- Mānuka honey continues to command significant price premiums relative to other honeys (van Eaton 2014; MPI 2018; Stahlmann-Brown et al. 2022a). These price premiums contributed significantly to market entry and an exponential increase in colony numbers from 2006, but falling prices and cost pressures in recent years have led to a significant reduction in the number of colonies. Nevertheless, New Zealand remains in the uncommon situation whereby most commercial beekeepers' livelihoods depend on honey production rather than providing pollination services. New Zealand exported 9,880 tonnes of honey worth $389 million in 2023, down from $481 million in 2021 (MPI 2023).
- Beekeeping in New Zealand is large scale. Approximately 543 beekeepers (6.7%) have more than 150 registered colonies. In contrast, less than 0.1% of beekeepers in Germany had more than 150 colonies and just 50 out of 37,888 beekeepers in the UK had more than 150 colonies in 2017 (European Parliamentary Research Service 2017). Across the European Union, approximately 2% of beekeepers had more than 300 colonies in 2013 (Chauzat et al. 2013) compared to 4.5% of New Zealand beekeepers in 2023.
- While the median beekeeper has three colonies, the industry is dominated by relatively few operators: as of June 2023, 4% of beekeepers operated more than 80% of production colonies. In comparison, 20% of beekeepers operated 80% of Canadian colonies (Canadian Honey Council 2023).
- New Zealand is geographically isolated and its strict biosecurity laws do not allow for the importation of live bees or the import of bee products, as importation may expose the national hive stock to biosecurity risks such as European foulbrood (*Melissococcus plutonius*), small hive beetle (*Aethina tumida*), *Tropilaelaps* mites (*Tropilaelaps clareae* and *T. mercedesae*), tracheal mite (*Acarapis woodi*), and Israeli acute paralysis virus (Hall et al. 2021)
- American foulbrood is one of only two animal diseases to have its own pest management agency (the AFB Pest Management Agency), the other being bovine tuberculosis. New Zealand beekeepers are legally obliged to register their apiaries in HiveHub[1] and to destroy colonies that are found to have AFB.
- *Varroa destructor* is a comparatively late arrival in New Zealand, having been discovered in the North Island in 2000 and in the South Island in 2006 (Zhang 2000; Goodwin & Taylor 2007), which has given New Zealand the advantage of being able to learn from overseas experience.

[1] HiveHub is the national apiary registry held by the AFB Pest Management Agency. See https://afb.org.nz/hivehub/.

Using methods detailed below, the NZ Colony Loss Survey has been used to estimate over-winter loss rates between 2015 and 2022, as follows:

- 2015: 8.37% with a 95% confidence interval of [7.66%, 9.15%] (Brown & Newstrom-Lloyd 2016)
- 2016: 9.57% [9.10%, 10.05%] (Brown & Newstrom-Lloyd 2017)
- 2017: 9.70% [9.37%, 10.05%] (Brown & Robertson 2018)
- 2018: 10.21% [9.85%, 10.58%] (Brown & Robertson 2019)
- 2019: 10.46% [10.10%, 10.82%] (Stahlmann-Brown et al. 2020)
- 2020: 11.30% [10.95%, 11.77%] (Stahlmann-Brown et al. 2021)
- 2021: 13.59% [13.21%, 13.99%] (Stahlmann-Brown & Robertson 2022)
- 2022: 13.46% [13.03%, 13.90%] (Stahlmann-Brown & Robertson 2023).

Colony losses result in substantial economic distress. For example, over-winter losses were valued at €32 million in Austria, €21 million[2] in Czechia, and €3 million in Macedonia for 2016/17 (Popovska Stojanov et al. 2021). In New Zealand, losses over winter 2021 were valued at more than $24 million for the subset of beekeepers who operate commercially (Stahlmann-Brown et al. 2022a).

2 Methods

2.1 Survey design

The 2023 NZ Colony Loss Survey was administered to beekeepers online. Electronic survey enumeration affords several advantages. In particular, it reduces respondent burden via branching and ensuring the relevance of each question to each respondent. For example, only those beekeepers who lost production colonies over winter were asked to provide details of the nature of those losses. In addition, electronic enumeration eliminates data-entry error, increasing the accuracy of results for analysis.

The 2015 survey questionnaire (Brown 2015; Brown & Newstrom-Lloyd 2016) was based on an annual survey of beekeepers developed by the international COLOSS honey bee research association. Survey topics included the number and nature of over-winter colony losses, queen health and performance, indicators of pests and diseases such as varroa and nosema, treatment of varroa, supplemental feeding, and colony management. Because the challenges facing New Zealand beekeepers differ from those facing beekeepers in the northern hemisphere, the 2015 NZ Colony Loss Survey added questions on competition for apiary sites and on losses from AFB, theft and vandalism, natural disasters, and wasps. It also adapted the question on nectar flow to reflect New Zealand's floral resources.

The 2016 NZ Colony Loss Survey was a refinement of the 2015 survey. While retaining the core international COLOSS questions to facilitate international comparisons, it incorporated feedback from scientists, beekeepers, and industry representatives to increase the relevance and accuracy of the information collected, including better accounting of the acquisition and disposal of colonies to improve accounting of winter losses, and replacing the Apiary Registry Location with well-understood geographical regions. In addition, new questions on emerging challenges to apiaries were added to quantify the threats posed by Argentine ants and giant willow aphid. Questions on methods for monitoring varroa were included, as were several new methods for treating varroa. The 2016 questionnaire also included new questions on beekeepers' estimates of the primary reasons that apiary sites had been lost or compromised, and revised questions on the nectar flow of selected native monoflorals.

The 2017 questionnaire was very similar to the 2016 one to facilitate trend analysis, but it did include two important refinements. First, the international COLOSS surveys include a catch-all category of losses that generally require verification. This 'colony death' category explicitly includes suspected toxic exposure and suspected starvation, and implicitly includes both varroa and related complications, and nosema and other diseases (Steinhauer et al. 2018). In both 2015 and 2016, New Zealand beekeepers attributed many losses to 'colony death' and later remarked that they found the category to be poorly defined. Hence, beginning in 2017 we asked about specific causes of losses associated with colony death (e.g. starvation and exposure to toxins) without first asking beekeepers to identify colony death as the cause. Second, we added other important explanations for colony loss,

[2] At the time of writing, €1 = $1.70.

including suspected varroa and related complications, suspected nosema and other diseases, and robbing by other bees.

The 2018 questionnaire included additional questions on the nature of queen problems, which were the leading cause of winter colony losses reported in 2017. Specifically, the survey asked whether queens disappeared, were drone layers, or had poor brood pattern and/or poor hive build up. In addition, the questionnaire was refined to collect more detailed information about winter apiaries and where losses occurred. The 2018 survey was also transitioned to a new survey platform that supports matrix-style questions, thereby making completion of the survey faster and easier.

In 2019 new questions focused on the source of new queens, and honey that was not sellable due to tutin, a toxic compound that may be present if bees collect honeydew secreted by passion vine hoppers feeding on the sap of the native tutu plant (*Coriara* genus). The survey was also optimised for phones and tablets because approximately half of all respondents complete the survey on a mobile device.

In 2020 the questionnaire was updated to simplify the recording of winter losses. Rather than asking about all forms of losses in a single page, the questionnaire categorised losses into high-level categories, specifically: unresolvable queen problems, natural disasters and accidents, theft or vandalism, and colonies that were dead upon inspection (due to AFB, varroa, wasps, disease, robbing, starvation, etc.). Beekeepers who indicated they had colonies that were dead upon inspection were then asked to specify the nature of those deaths. This reframing of the questionnaire aligns more closely with the standard COLOSS questionnaire while resolving the problems of interpreting ‘colony death’ noted in 2017. The 2020 questionnaire was also updated to capture detailed information on the location of seasonal activities, dependence on beekeeping for livelihoods, and perceptions of the operating environment, including the economics of beekeeping, environmental factors, biosecurity, and beekeeper lifestyle.

The 2021 questionnaire focused on varroa and its management. New questions were added to record perceptions of why colonies were lost to varroa, mite loads, timing of varroa treatment, dosage of any treatments used, and the duration of treatment. In addition, respondents were asked to reflect on the extent to which they considered these treatments to be successful. These questions added a significant response burden, so to accommodate the increased demands on respondents, selected questions from previous years (e.g. requeening strategies) were removed from the 2021 questionnaire.

The 2022 questionnaire retained key refinements pertaining to varroa from the 2021 survey, including the timing and type of varroa treatment and perceptions of why colonies were lost to varroa. It also included questions related to the timing of key management activities (e.g. splitting, uniting, providing pollination services, and taking honey off) and questions on each beekeeper’s risk preferences and optimism about the future of beekeeping in New Zealand. Finally, survey answer sets were streamlined to address beekeepers’ concerns about the complexity of the survey.

The 2023 questionnaire maintained its emphasis on varroa monitoring and management, but included two additional topics: autumn losses and beekeeper wellbeing. Autumn losses were included on an experimental basis because some colony loss surveys (e.g. the Bee Informed Partnerships US survey) cover losses year-round, and because at the June 2023 Apiculture New Zealand conference several large commercial beekeepers reported heavy autumn losses. Beekeeper wellbeing was included as a topic for the first time after several years of low honey prices, significant levels of exit from the industry, and a season marked by extreme weather.

2.2 Categories of colony loss used in the 2023 survey

Colony losses were attributed to queen problems (including drone-laying queens or no queen), natural disasters or accidents, theft or vandalism, AFB, wasps, robbing by other bees, Argentine ants, suspected starvation, suspected toxic exposure, suspected varroa and related issues, and suspected nosema and other diseases. Losses due to varroa mites, insecticides or plant toxins, and other pathogens and pests, may be difficult to diagnose, hence the caveat ‘suspected’. As noted above, several of these categorisations were added to the 2017 questionnaire at the suggestion of beekeepers. We acknowledge that in many cases it may be difficult to definitively determine the underlying causes of colony loss outside of a laboratory and that some colonies may be lost to multiple causes; nevertheless, we report beekeepers’ own understanding of what caused their colony losses.

2.3 Sampling strategy

Our sampling strategy aimed for inclusiveness while targeting New Zealand's largest beekeeping operations. To achieve this, we followed a two-pronged approach to recruiting respondents, first implemented in 2016.

Under the Biosecurity Act 1993, all New Zealand beekeepers are legally obliged to register colony numbers and apiaries with the AFB Management Agency and to complete an Annual Disease Return by 1 June. More than 95% of registered New Zealand beekeepers provided email addresses in HiveHub. In turn, the AFB Management Agency provided these email addresses to Manaaki Whenua – Landcare Research to conduct the 2023 NZ Colony Loss Survey.

Manaaki Whenua – Landcare Research sent personalised email invitations to participate in the survey to 8,099 registered New Zealand beekeepers who had reported having at least one living colony at the start of winter in HiveHub. In total, 110 emails bounced, probably due to invalid email addresses and/or overly aggressive spam filters. Non-respondents received up to four email reminders between 15 September 2023 and 1 November 2023.

Participation was encouraged by industry groups, presentations of the results at Apiculture New Zealand conferences, articles in newspapers, the *New Zealand BeeKeeper*, and *The Apiarist's Advocate*, and by the opportunity to win supermarket vouchers. In addition, all beekeepers with more than 500 registered colonies received personal phone calls to encourage completion; phone calls began in mid-October, targeting beekeepers who had not completed the survey at the time of the call.

In total, 3,457 beekeepers completed the 2023 NZ Colony Loss Survey, a response rate of 42.6% of all registered beekeepers with valid email addresses. Among the beekeepers who completed the survey were 19 of the 25 largest operators, indicating a response rate of 78% among this group. These response rates are significantly higher than those obtained for any European country (Gray et al. 2023).

Beekeepers reported on 208,044 colonies in the 2023 NZ Colony Loss Survey, some 35.0% of all colonies registered in HiveHub managed by beekeepers with valid email addresses. In comparison, the share of colonies included in US calculations is approximately 9.9% (Bee Informed Partnership 2021). Table 1 describes the sample for each year the NZ Colony Loss Survey has been conducted.

Table 1: NZ Colony Loss Survey sample, 2015–2023.

Year	No. of respondents	% of all registered beekeepers*	No. of colonies reported, start of winter	% of all registered colonies*
2023	3,457	42.6%	208,044	35.0%
2022	3,573	40.6%	352,419	49.1%
2021	4,355	49.1%	381,148	47.2%
2020	2,863	32.0%	304,143	34.7%
2019	3,456	36.7%	297,377	36.2%
2018	3,655	42.3%	365,986	41.6%
2017	2,066	30.9%	242,926	30.1%
2016	2,179	37.9%	275,356	40.3%
2015	366	6.7%	225,660	39.6%

* Registered colonies with valid email addresses

Table 2 describes the 2023 sample by operation size and by the region in which colonies were overwintered. Given the small number of beekeepers with more than 3,000 colonies, locations are not provided for the largest operators.

Table 2: Number of beekeepers responding to the 2023 NZ Colony Loss Survey, by region and operation size.

Region	1–10 colonies	11–50 colonies	51–250 colonies	251–500 colonies	501–3,000 colonies	3,001+ colonies
Upper North Island	683	39	19	5	16	24 (all regions)
Middle North Island	496	45	24	14	26	
Lower North Island	560	44	21	5	13	
Upper South Island	175	18	7	3	9	
Middle South Island	436	23	11	6	10	
Lower South Island	354	23	9	2	7	
Total	**2,683**	**189**	**84**	**35**	**70**	**24**

Notes: To preserve anonymity, beekeepers with 3,001+ colonies are not reported by region. Also, some beekeepers winter colonies in multiple regions. The total shown in the last row therefore reflects the total number of beekeepers in each size class and is not a column total. Beekeepers who operate in the Chatham Islands are not included in this table.

2.4 Estimating colony losses and confidence intervals

Van der Zee et al. (2013) note two ways to calculate loss rates. The ‘overall loss rate’ is calculated as the total number of winter losses by survey respondents divided by the total number of colonies that were alive at the beginning of winter. The ‘average loss rate’ is the average of the individual loss rates (i.e. the average of each respondent’s total winter losses divided by the number of living colonies at the beginning of winter). Although the loss rates experienced by beekeepers with different-sized operations are not equally variable, the latter approach weights losses equally. In addition, the average loss rate is strongly influenced by operation size. For these reasons, van der Zee et al. (2013) advocate reporting overall loss rates rather than average loss rates. This approach has been adopted by COLOSS for reporting wintering losses in Europe (Brodschneider et al. 2016, 2018) and by the Bee Informed Partnership for reporting wintering losses in the US (Lee et al. 2015; Seitz et al. 2022). We also adopt this approach.

Confidence intervals (interpreted as the true value falling within this range 95% of the time a new sample of beekeepers is drawn from the population) are generally calculated using a binomial distribution, which in this case implies that the likelihood of survival for any given colony is independent of that for any other colony and that the probability of survival is the same for all colonies (van der Zee et al. 2013).

However, the performance of one colony in an apiary often depends on the performance of other colonies in the same apiary (McCullagh & Nelder 1989). Location-specific impacts, such as disease and disaster, can have similar impacts. Such clustering of losses often leads to under- or over-dispersion in the data (McCullagh & Nelder 1989), which can affect standard errors and confidence intervals (Brodschneider et al. 2016). Thus, beginning in 2018, standard errors reported in the NZ Colony Loss Survey were calculated using a quasi-binomial distribution and a logit-link function, which derives a confidence interval for the overall loss rate based on the standard error of the estimated intercept in a model with only an intercept (McCullagh & Nelder 1989; vanEngelsdorp et al. 2012; van der Zee et al. 2013). This approach is consistent with that undertaken in Europe (Brodschneider et al. 2016, 2018) and the US (Lee et al. 2015; Seitz et al. 2022).

3 Survey questionnaire

The main questions from the standard international COLOSS survey were included to enable international comparison. Additional questions were added to reflect both the New Zealand context and feedback on the previous NZ Colony Loss Surveys provided by scientists, beekeepers, and other end users. The survey was available online between 1 September and 15 November 2023.

The 2023 NZ Colony Loss Survey comprised three distinct parts. The main part recorded the number of living colonies at the beginning of autumn and winter, the number of living colonies that survived, and the attributions of any losses. The next part focused on the 2022/23 season, particularly with regard to varroa monitoring and management. The third part emphasised beekeeper demographics (e.g. gender and years of beekeeping experience). The special topic of wellbeing was also included in the 2023 survey. Apart from obtaining consent and recording colony numbers at the beginning of autumn, winter, and spring (which are required for survey branching), all questions were optional.

The entire text of the survey questionnaire is included as an appendix at the end of this report.

4 Highlighted results

Results are presented as bar charts, pie charts, histograms, and tables. Histograms are especially useful for highlighting the range of reported values, but we also include averages to facilitate making comparisons across groups.

Most information is collected and reported at an aggregated level: upper North Island, middle North Island, lower North Island, upper South Island, middle South Island, and lower South Island. Most information is also reported by the total number of colonies comprising each beekeeping operation at the beginning of winter. Operation size is categorised into six size classes: 1–10 colonies, 11–50 colonies, 51–250 colonies, 251–500 colonies, 501–3,000 colonies, and operators with more than 3,000 colonies. Beekeepers whose colony numbers changed during the 2022/23 season are classified according to the number of colonies held at the beginning of winter.[3] Because most figures report beekeeper averages, figures reported by region restrict the sample to beekeepers with more than 250 colonies, unless noted.[4] Figures reported by operation size include all respondents.

4.1 National-level estimates of colony losses during autumn and winter 2023

We report overall loss rates and standard errors based on quasi-binomial distributions with a logit-link function in order to maintain consistency and facilitate international comparisons. (Refer to the Methods section for detail.)

The overall loss rate during autumn 2023 was 16.76%, with a 95% confidence interval of [16.11%, 17.44%].

The overall loss rate during winter 2023 was 12.65%, with a 95% confidence interval of [12.14%, 13.18%].

Autumn losses were recorded for the first time in 2023. Table 3 reports the overall loss rates and 95% confidence intervals for winter from 2015 to 2023. To compare overall loss rates between years, we paired the loss data for every two consecutive years and ran a quasi-binomial model on each data set. A dummy variable was included to distinguish between years, with the statistical significance of the coefficient indicating a statistical difference between overall loss rates (at the 0.05 level).[5] The overall loss rate for winter 2023 is statistically lower than the overall loss rate for winter 2021 and 2022, but it is nevertheless higher than for winter 2015, 2016, 2017, 2018, 2019, and 2020.

[3] For example, if a beekeeper with 600 colonies in January sold 300 colonies in May, that operation would be classified as having 251–500 colonies for all reporting.

[4] Beekeepers who have more than 250 colonies were included in such reporting even if those colonies were distributed across multiple regions.

[5] We apply the same threshold for statistical significance throughout the report. Thus, whenever we refer to results being statistically significant, we mean that they are significant at the 0.05 level or higher.

Table 3: Overall winter loss rates, 2015–2023.

Winter	Overall loss rate	95% confidence interval
2023	12.65%	[12.14%, 13.18%]
2022	13.46%	[13.03%, 13.90%]
2021	13.59%	[13.21%, 13.99%]
2020	11.30%	[10.95%, 11.66%]
2019	10.40%	[10.05%, 10.77%]
2018	10.20%	[9.85%, 10.57%]
2017	9.70%	[9.37%, 10.05%]
2016	9.53%	[9.07%, 10.02%]
2015	8.37%	[7.66%, 9.15%]

Note: Standard errors are scaled using square root of Pearson X2-based dispersion. Bracketed values indicate 95% confidence intervals.

Overall loss rates over winter 2023 were also calculated by region. Loss rates over winter 2023 vary by region, as shown in Figure 1.

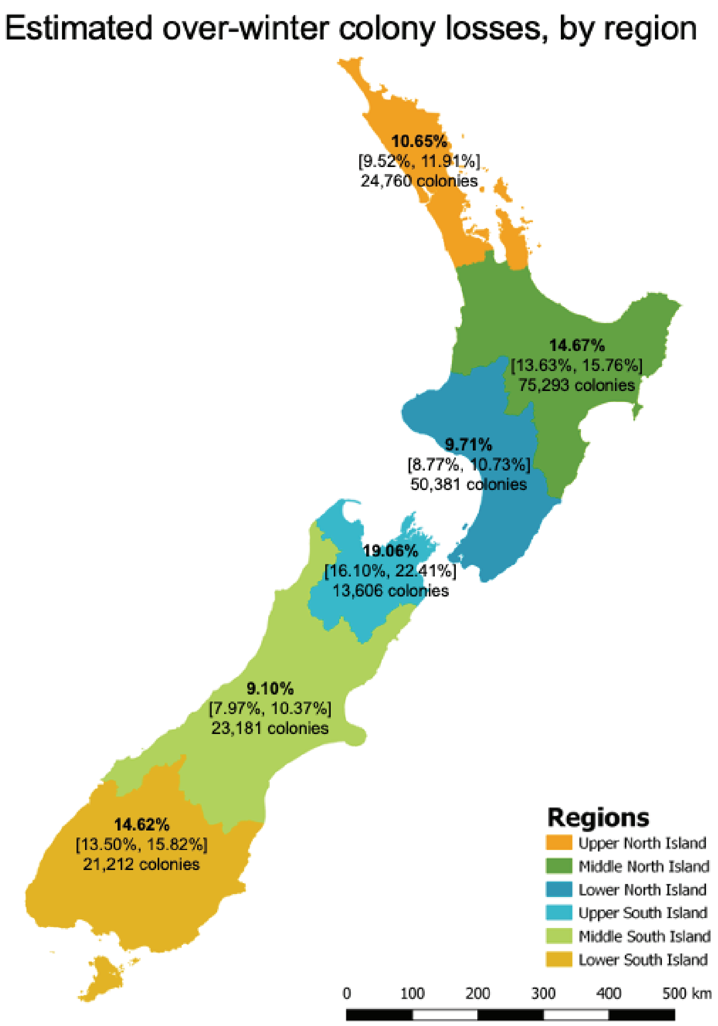

Figure 1: Estimated total over-winter colony losses among respondents in all operation size classes, by region; 95% confidence intervals and number of colonies reporting are shown below estimated total colony losses.

Overall loss rates by region for autumn 2023 are reported in Table 4.

Table 4: Overall autumn loss rates, by region.

Region	Autumn	Overall loss rate	95% confidence interval	Reported colonies
Upper North Island	2023	26.28%	[24.02%, 28.66%]	31,629
Middle North Island	2023	17.88%	[16.55%, 19.29%]	96,156
Lower North Island	2023	11.24%	[10.25%, 12.32%]	59,863
Upper South Island	2023	10.87%	[9.40%, 12.54%]	15,099
Middle South Island	2023	21.65%	[19.98%, 23.41%]	28,328
Lower South Island	2023	11.50%	[10.70%, 12.35%]	23,995

Note: Standard errors are scaled using square root of Pearson X2-based dispersion. Bracketed values indicate 95% confidence intervals.

Overall loss rates by region for winter from 2016 to 2023 are reported in Table 5.[6,7] Regional variations in loss rates exhibit greater variation in 2023 than in 2022.

Table 5: Overall winter loss rates, by year and region.

Region	Winter	Overall loss rate	95% confidence interval	Reported colonies
Upper North Island	2023	10.65%	[9.52%, 11.91%]	24,760
	2022	15.49%	[14.45%, 16.59%]	43,799
	2021	13.08%	[12.26%, 13.95%]	59,127
	2020	11.07%	[10.32%, 11.86%]	47,092
	2019	10.67%	[9.85%, 11.56%]	49.593
	2018	12.82%	[12.00%, 13.68%]	61,401
	2017	9.71%	[9.05%, 10.41%]	54,297
	2016	8.06%	[7.20%, 9.03%]	45,434
Middle North Island	2023	14.67%	[13.63%, 15.76%]	75,293
	2022	12.51%	[11.54%, 13.54%]	125,100
	2021	18.70%	[17.78%, 19.66%]	131,442
	2020	13.94%	[13.20%, 14.71%]	96,695
	2019	11.99%	[11.32%, 12.70%]	97,447
	2018	9.92%	[9.17%, 10.72%]	110,561
	2017	10.37%	[9.70%, 11.07%]	83,922
	2016	10.65%	[9.77%, 11.59%]	96,451
Lower North Island	2023	9.71%	[8.77%, 10.73%]	50,381
	2022	13.98%	[13.08%, 14.93%]	93,070
	2021	8.71%	[8.11%, 9.35%]	95,051
	2020	9.34%	[8.80%, 9.90%]	95,964
	2019	7.99%	[7.43%, 8.59%]	58,509

6 Regions were defined slightly differently in our 2015 reporting so are not available for comparison; see section 2.1.

7 As noted above, the numbers provided in the table include any colonies that were either acquired or sold/given away over winter and remove any colonies for which loss information was not provided. As such, they differ slightly from the number of colonies presented in Figure 1, which reflects colonies at the beginning of winter.

Region	Winter	Overall loss rate	95% confidence interval	Reported colonies
	2018	8.06%	[7.45%, 8.71%]	84,239
	2017	9.11%	[8.30%, 9.98%]	50,584
	2016	11.63%	[10.28%, 13.14%]	63,221
Upper South Island	2023	19.06%	[16.10%, 22.41%]	13,606
	2022	14.48%	[13.05%, 16.04%]	20,258
	2021	14.02%	[12.76%, 15.39%]	21,962
	2020	12.79%	[11.19%, 14.57%]	17,430
	2019	8.01%	[6.93%, 9.23%]	29,982
	2018	9.99%	[9.06%, 11.02%]	39,782
	2017	5.27%	[4.49%, 6.17%]	12,741
	2016	5.49%	[4.56%, 6.61%]	15,382
Middle South Island	2023	9.10%	[7.97%, 10.37%]	23,181
	2022	11.46%	[10.67%, 12.31%]	45,265
	2021	9.99%	[9.25%, 10.78%]	47,266
	2020	7.84%	[6.94%, 8.86%]	31,614
	2019	10.64%	[9.40%, 12.02%]	31,573
	2018	11.36%	[10.41%, 12.39%]	43,526
	2017	11.28%	[10.20%, 12.45%]	18,636
	2016	7.67%	[6.81%, 8.63%]	30,805
Lower South Island	2023	14.62%	[13.50%, 15.82%]	21,212
	2022	15.49%	[14.37%, 16.68%]	24,889
	2021	13.02%	[12.00%, 14.11%]	26,220
	2020	12.93%	[11.63%, 14.35%]	17,005
	2019	11.87%	[10.82%, 13.00%]	26,411
	2018	10.58%	[9.14%, 12.22%]	26,390
	2017	9.79%	[8.80%, 10.87%]	18,083
	2016	7.35%	[6.50%, 8.31%]	24,882

Note: Standard errors are scaled using square root of Pearson X2-based dispersion. Bracketed values indicate 95% confidence intervals.

- The overall loss rate in winter 2023 in the upper North Island fell from 15.5% in 2022 to 10.7% in 2023, the lowest rate since 2019.
- In the middle North Island, the overall winter 2023 loss rate was 14.7%, the second highest loss rate on record for the region.
- In the lower North Island, the overall loss rate for winter 2023 reverted to its long-run average of 9.7% after spiking in 2022.
- The overall loss rate for winter 2023 in the upper South Island was 19.1%, the highest regional loss rate recorded for any region since reporting began in 2016.
- In the middle South Island, the overall loss rate for winter 2023 fell to 9.1%.
- In the lower South Island, overall loss rates stayed above 14% for the second year.

The share of overall losses attributed to specific causes of colony loss in autumn and winter are reported in Figure 2 and Figure 3, respectively. During autumn 2023, most losses were attributed to suspected varroa and its complications (35.8%), queen problems (31.4%), and natural disasters and accidents (15.4%). Over winter 2023, varroa was identified as the cause of over half (50.8%) of all losses. Queen problems was the second most commonly attributed cause of loss at 22.2%, similar to 2022. Suspected starvation was the attributed cause of 8.9% of losses compared to 6.4% for 2022. Wasps were less prominent in 2023, accounting for 3.4% of attributions versus 6.8% in 2022 and 12.0% in 2021. Natural disasters (e.g. flooding) and accidents (e.g. livestock overturning hives) accounted for 3.6% of overwinter loss attributions in 2023.

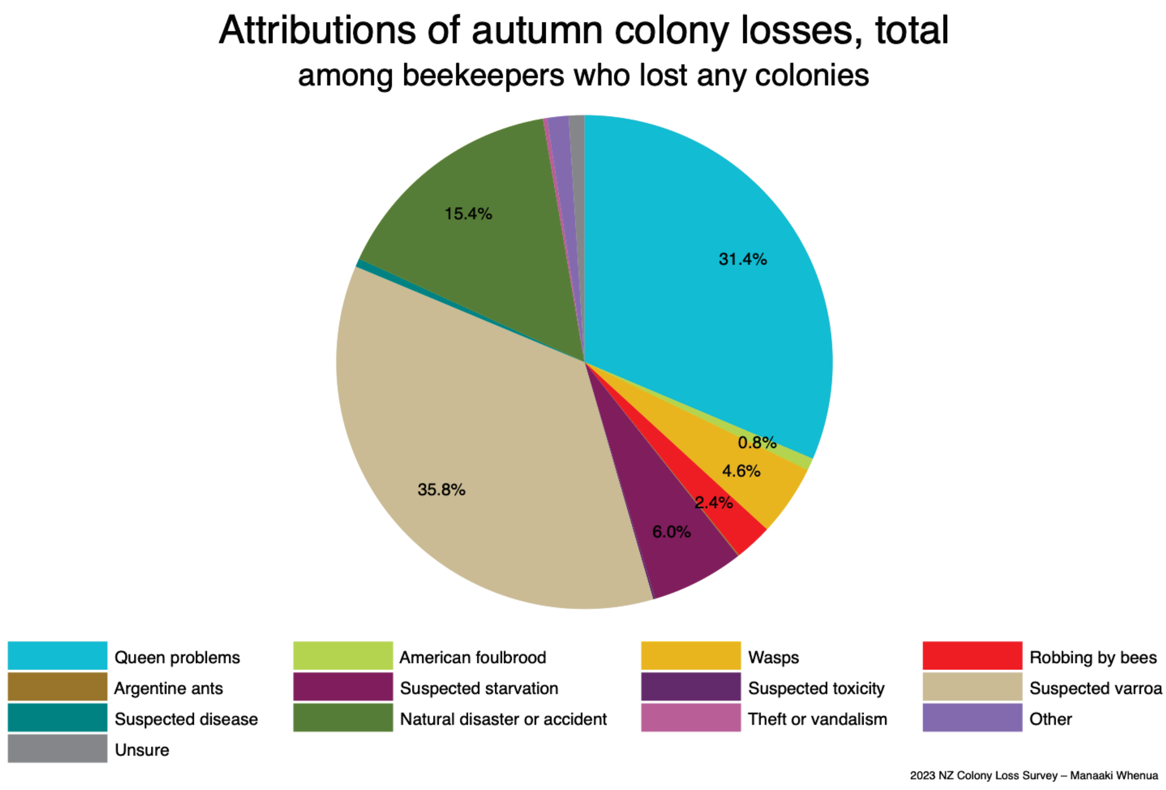

Figure 2: Share of total colony losses during autumn 2023 attributed to various causes among beekeepers who lost any colonies.

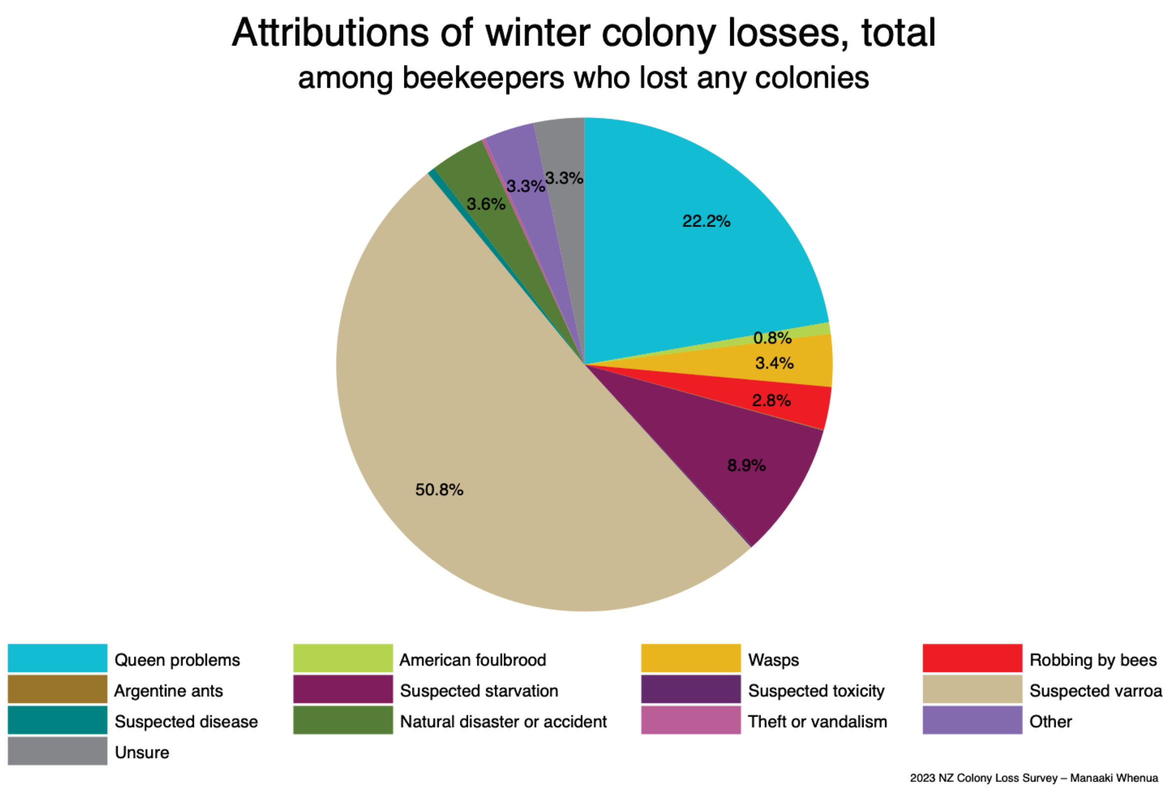

Figure 3: Share of total colony losses over winter 2023 attributed to various causes among beekeepers who lost any colonies.

4.2 Respondents by region and operation size

In line with previous years and with colony registration on HiveHub, more beekeepers reported keeping their winter apiaries in the upper North Island than in any other region (Figure 4). The middle South Island has the highest number of respondents in the South Island.

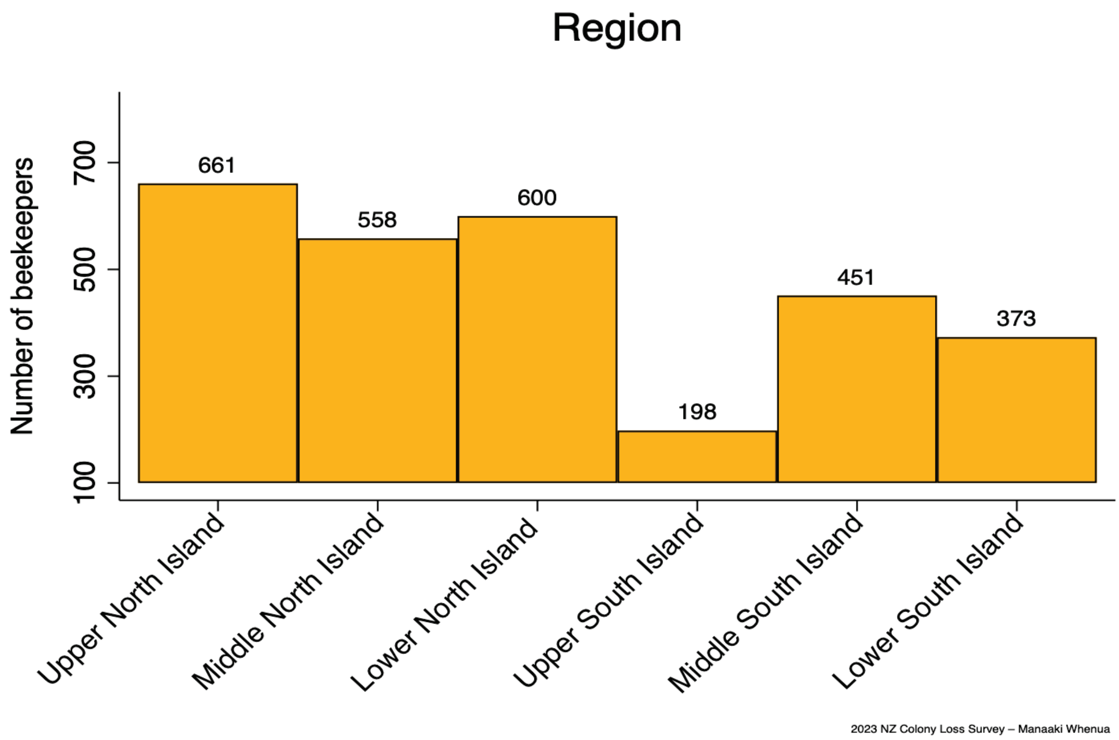

Figure 4: Number of respondents who operate in each region (regardless of operation size).

Figure 5 shows the operation size reported by each respondent at the beginning of winter. Operations with:

- 1–10 colonies comprised 87.3% of the sample
- 11–50 colonies comprised 5.9% of the sample
- 51–250 colonies comprised 2.8% of the sample
- 251–500 colonies comprised 1.2% of the sample
- 501–3,000 colonies comprised 2.2% of the sample
- more than 3,000 colonies comprised 0.6% of the sample.

Compared with HiveHub registrations, our sample is over-represented by beekeepers with 1–10 colonies and under-represented by beekeepers with 11–500 colonies.

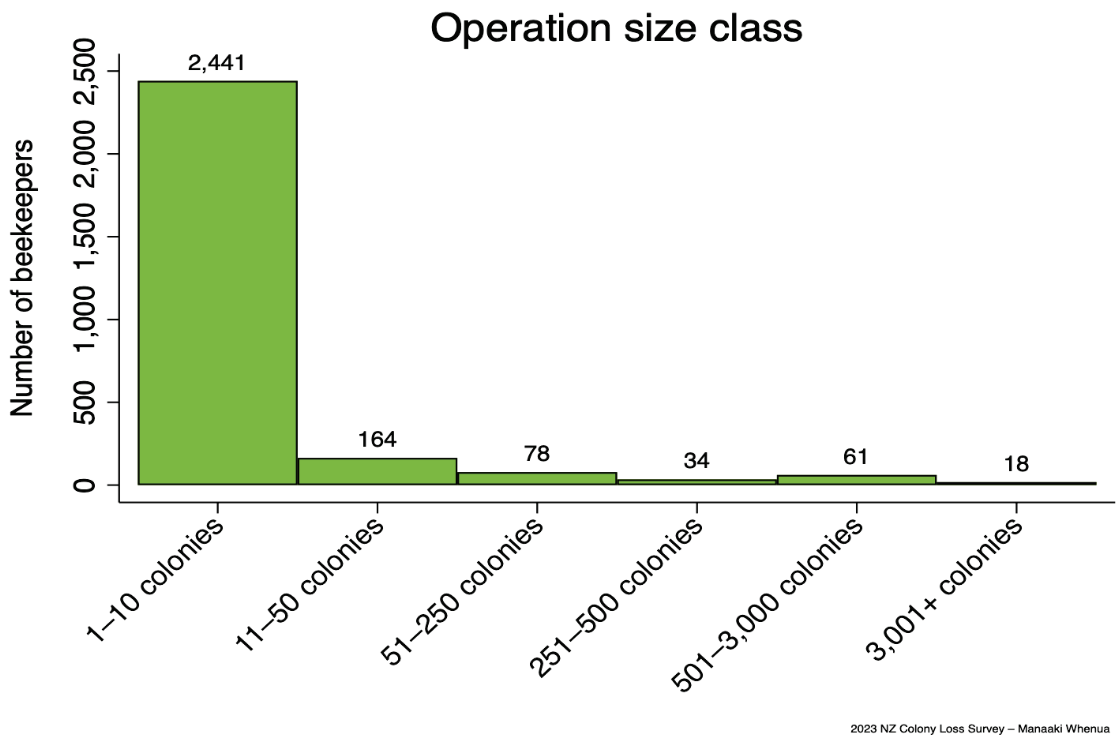

Figure 5: Operation size.

4.3 Average loss rates during autumn 2023 and winter 2023

For the remainder of this report, unless otherwise stated, numbers reported in figures are interpreted as averages within groups. For example, whereas Figure 3 shows overall loss rates for winter 2023 (combining all colonies reported), Figure 7Figure 7 reports the average loss rates for beekeepers within each region. To clarify with an example, consider a region that consists of two beekeepers, one with 500 colonies and one with 5,000 colonies. Assume that the smaller beekeeper lost 8% of their colonies and the larger beekeeper lost 12% of their colonies. The overall loss rate for the region would be 11.6%, but the average loss rate would be 10.0%.

While overall loss rates are useful for estimating total losses, average loss rates enable individual beekeepers to better understand the relative performance of their own operations. However, as noted above, loss rates experienced by beekeepers with different-sized operations are not equally variable, and average loss rates are strongly influenced by operation size. Loss rates are also strongly influenced by region; for example, wasps are problematic in certain parts of New Zealand and largely absent elsewhere, and disease may break out in one region but not another. For these reasons, it makes little sense to compare averages for a large commercial operator in the one region with those of a small, non-commercial beekeeper elsewhere. Hence, the following results are presented by region (restricting the sample to beekeepers with more than 250 colonies, unless otherwise stated) and by operation size (without regard to apiary location). These and all subsequent questions were optional, and many beekeepers chose not to provide these details; hence the number of respondents (*n*) is shown in each figure.

Among beekeepers with more than 250 colonies, the average reported colony loss during autumn 2023 was 16.8% (Figure 6). The highest losses during autumn 2023 occurred in the middle North Island and middle South Island, where beekeepers lost 19.3–19.4% of their colonies, on average. Average loss rates in the upper South Island were 8.5%. Six beekeepers with more than 250 colonies reported losing at least half of their colonies during autumn 2023, and 12 beekeepers with more than 250 colonies reported having no losses during autumn 2023.

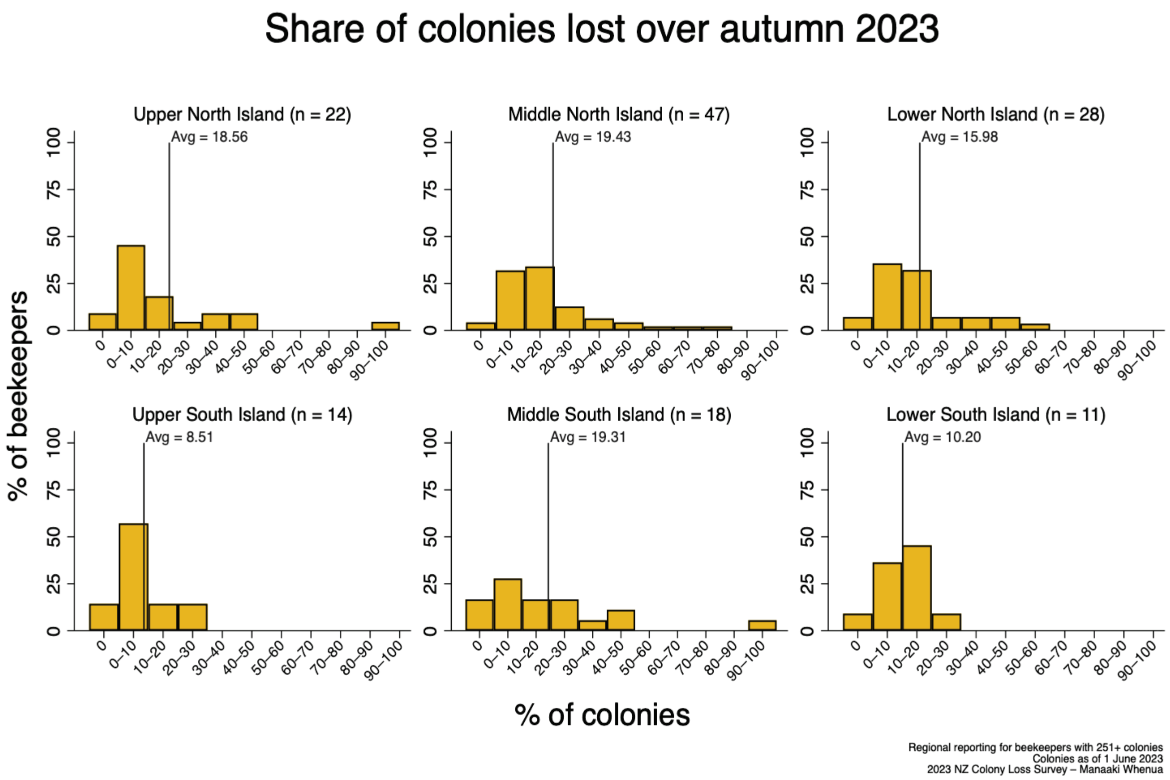

Figure 6: Autumn 2023 colony losses as a share of total autumn colonies among beekeepers with more than 250 colonies, by region.

The average reported colony loss over winter 2023 was 14.9% (Figure 7), compared with 14.2% in 2022, 15.7% in 2021, and 11.2% in 2020. The average shares of colonies lost among beekeepers with more than 250 colonies in the North Island and South Island were 14.9% and 14.8%, respectively, compared to 15.1% and 12.2% for 2022, and 17.7% and 11.2% for 2021. The highest average losses occurred in the upper South Island, at 20.1%. Six beekeepers with more than 250 colonies reported losing at least half of their colonies over winter 2023. Nine beekeepers with more than 250 colonies reported having no losses over winter 2023.

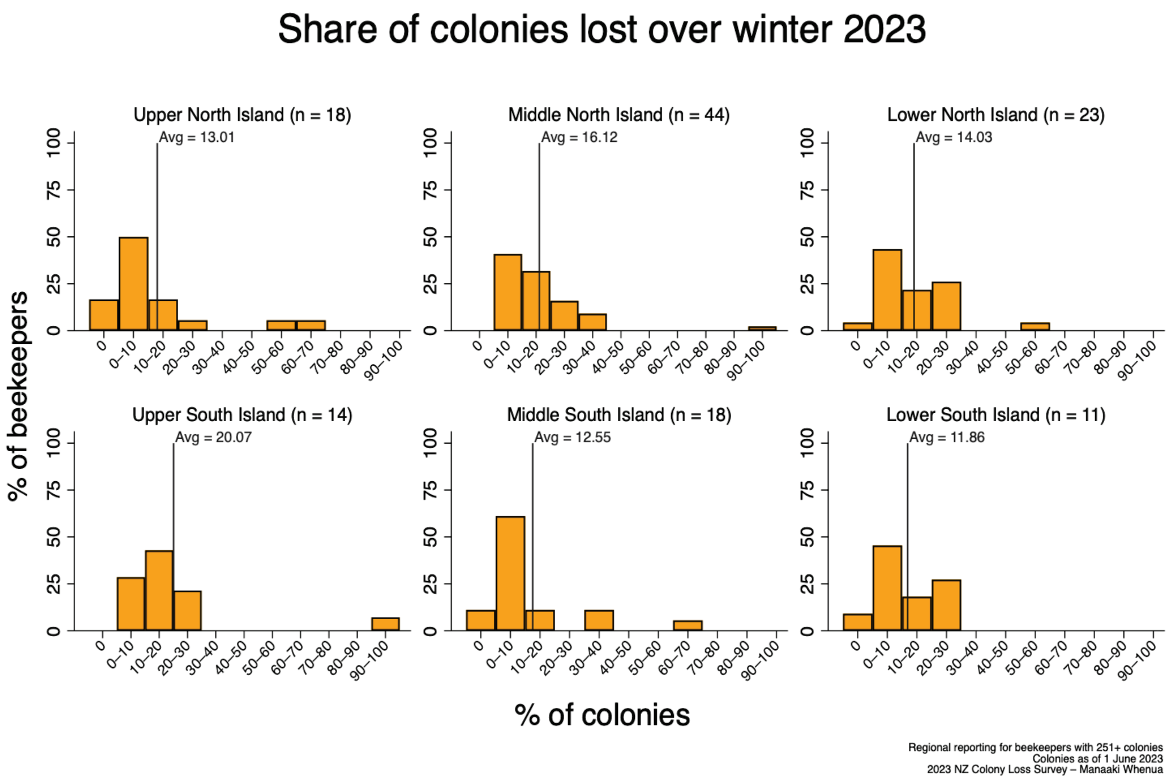

Figure 7: Winter 2023 colony losses as a share of total winter colonies among beekeepers with more than 250 colonies, by region.

Figure 8 shows the distribution of colony losses by operation size, including those with fewer than 251 colonies. Operations with 1–10 colonies lost the highest share of colonies during autumn, on average, at 25.4%, although the distribution was bimodal and over half of operations with 1–10 colonies reported having no autumn losses. Operations with 11–50 colonies lost 22.3% of their colonies during autumn, on average, with approximately 25% reporting no losses. Operations with 51–250 colonies lost 20.1%, on average, while operations with 251–500 colonies lost 18.9%, on average. Operations with 501–3,000 colonies had average autumn losses of 15.6%, and those with over 3,000 colonies lost 17.6%, on average.

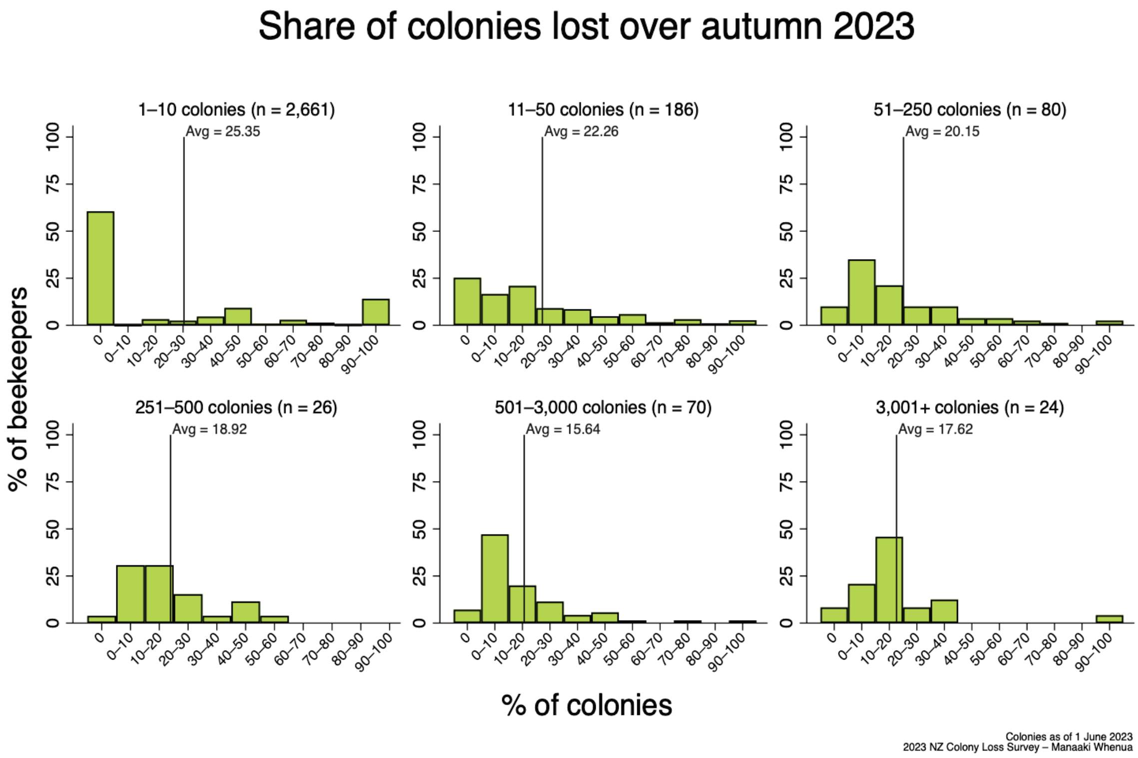

Figure 8: Autumn 2023 colony losses as a share of total autumn colonies, by operation size.

Figure 9 analogously shows the distribution of colony losses by operation size over winter 2023. Despite roughly 60% of operations with 1–10 colonies reporting no losses, these beekeepers lost the highest share of colonies over winter 2023, on average, at 26.3% (cf. 32.7% in 2022 and 29.3% in 2021). Operations with 11–50 colonies lost 21.0% (cf. 28.1% in 2022 and 26.9% in 2021) of their colonies over winter, on average. Operations with:

- 51–250 colonies lost 19.3% (21.4%; 23.8%), on average
- 251–500 colonies lost 22.2% (17.3%; 19.5%), on average
- 501–3,000 colonies lost 12.4% (13.9%; 15.4%), on average
- over 3,000 colonies lost 9.8% (11.7%; 10.5%), on average.

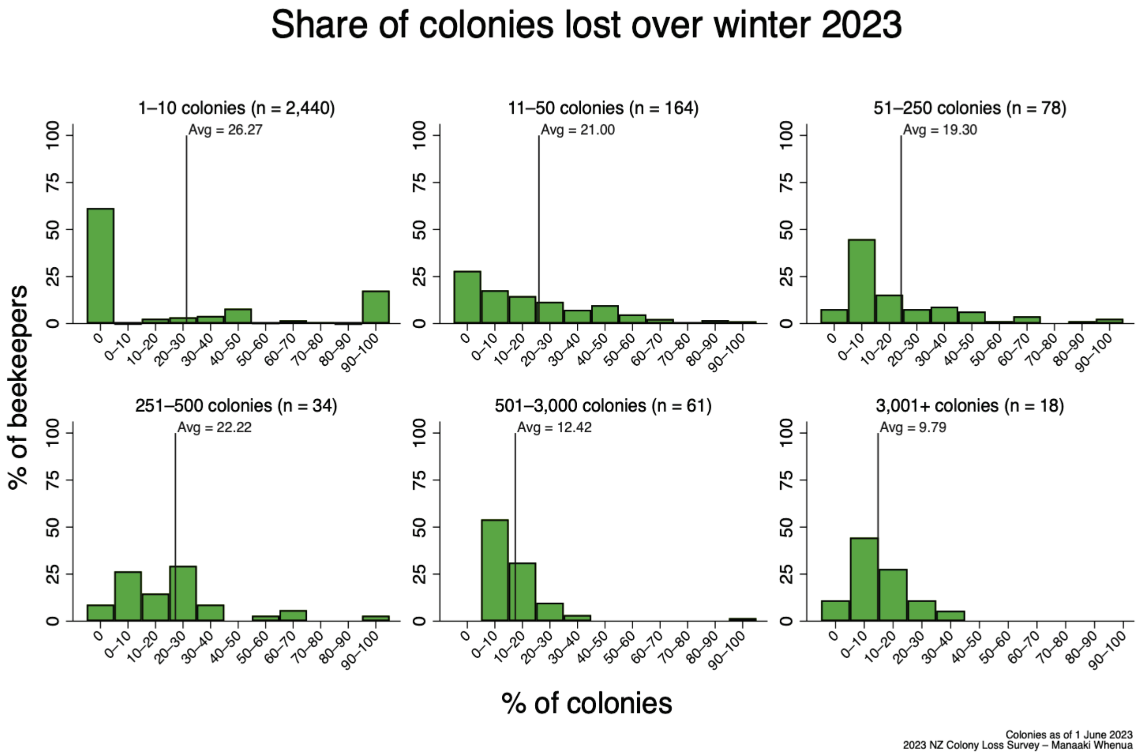

Figure 9: Winter 2023 colony losses as a share of total winter colonies, by operation size.

4.4 Colony losses by category of loss

Figure 10 and Figure 11 report the regional distribution of the reported cause of losses during autumn and winter 2023, respectively, *among beekeepers with more than 250 colonies who experienced any losses*. For example, 60.5% of autumn losses and 58.4% of winter losses were attributed to suspected varroa and related complications in the lower South Island among beekeepers with more than 250 colonies.

Suspected varroa and related complication was most commonly identified as the cause of losses during autumn 2023 everywhere except the upper North Island, where queen problems were the commonly identified cause of loss (queen problems were the second most commonly identified cause of losses in all other regions). Natural disasters such as Cyclone Gabrielle were also a common cause of losses during autumn 2023 across the North Island.

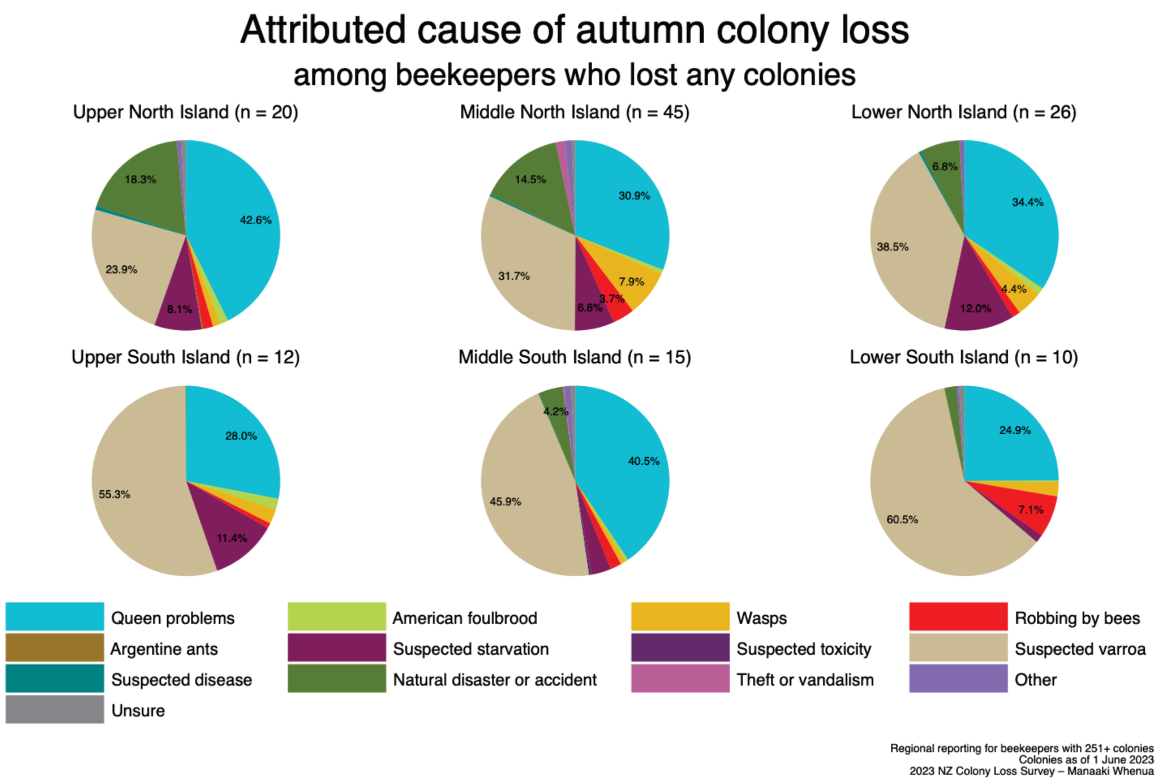

Figure 10: Share of colony losses attributed to various causes during autumn 2023 among beekeepers with more than 250 colonies who lost any colonies, by region.

The average share of winter losses attributed to suspected varroa and related complications among beekeepers with more than 250 colonies ranged from 36.1% in the middle North Island to 58.4% in the lower South Island. Among beekeepers with more than 250 colonies, the average share of losses attributed to queen problems was also high over winter 2023, ranging from 20.4% in the upper South Island to 42.1% in the upper North Island. Wasps appear to have caused fewer losses over winter 2023 than in recent winters, particularly in the middle North Island. Attributions of losses to suspected starvation ranged from less than 3.0% of losses in the middle South Island to 25.1% in the upper South Island. Natural disasters and accidents over winter 2023 were most prevalent in the upper South Island (8.9%%).

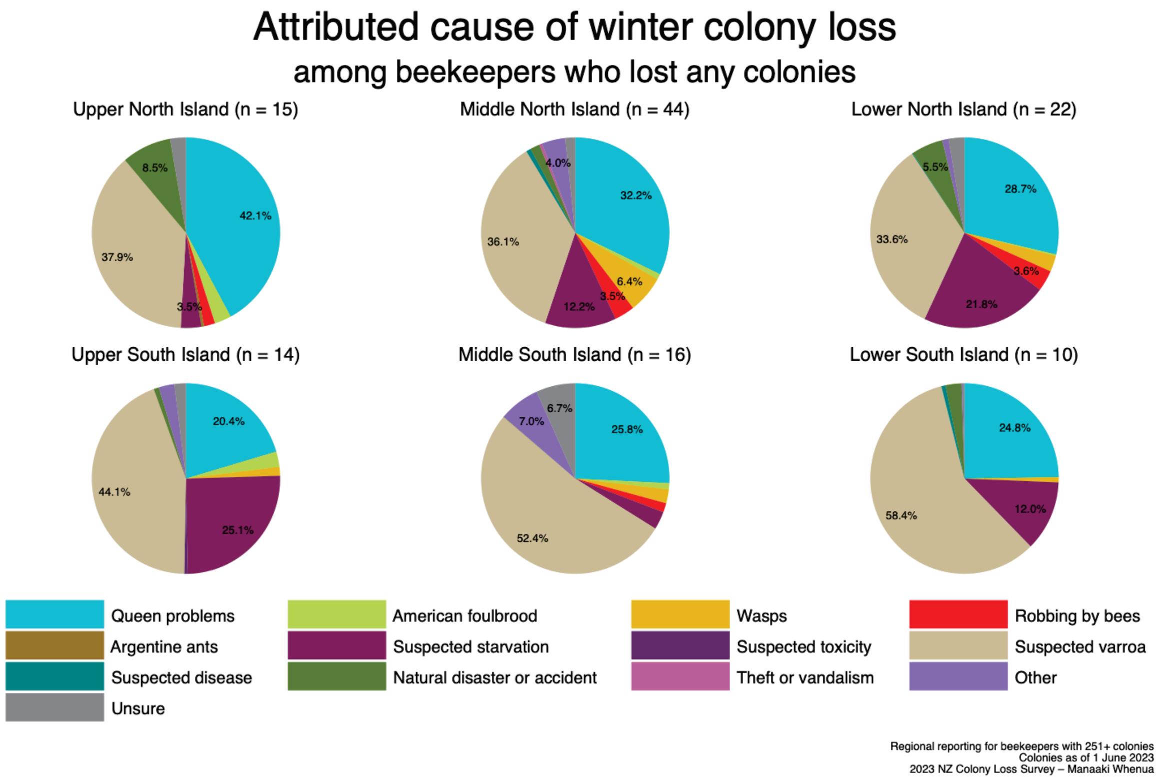

Figure 11: Share of colony losses attributed to various causes over winter 2023 among beekeepers with more than 250 colonies who lost any colonies, by region.

Beekeepers across all size classes reported that suspected varroa and related complications and queen problems accounted for more losses during autumn 2023 than any other causes (Figure 12). For example, among beekeepers with 11–50 colonies, 27.4% of autumn losses were attributed to suspected varroa and related complications, on average, as were 36.4% to queen problems. Natural disasters and accidents were prominent problems across all size classes. Wasps were more problematic for smaller operators than larger operators during autumn 2023, while suspected starvation significantly affected beekeepers in all size classes apart from those with 251–500 colonies.

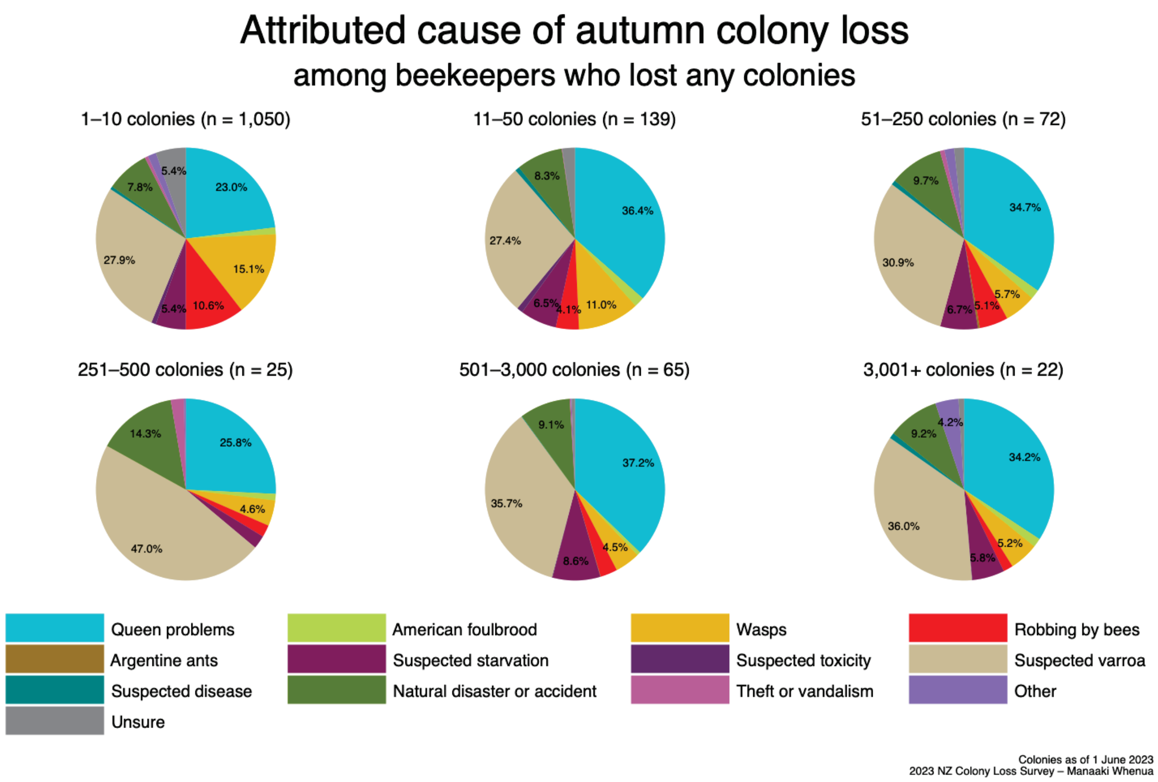

Figure 12: Share of colony losses attributed to various causes over autumn 2023 among beekeepers who lost any colonies, by operation size.

Similar patterns are evident for attributions of loss causes over winter 2023: suspected varroa and related complications was identified as the source of 26.7% of over-winter losses among beekeepers with 1–10 colonies on the low end and 46.9% of over-winter losses among beekeepers with 251–500 colonies on the high end (Figure 13). Suspected starvation was also identified as an underlying cause of over-winter losses across operation sizes, with between 9.5% (3,000+ colonies) and 13.4% (501–3,000 colonies) of losses attributed to this category.

Both wasps and robbing were also identified as underlying causes of colony loss over winter 2023. Colonies weakened by varroa are more susceptible to wasp attack and robbing by other bees (Goodwin et al. 2006), so losses attributed to wasps and robbing may reflect varroa infestation.

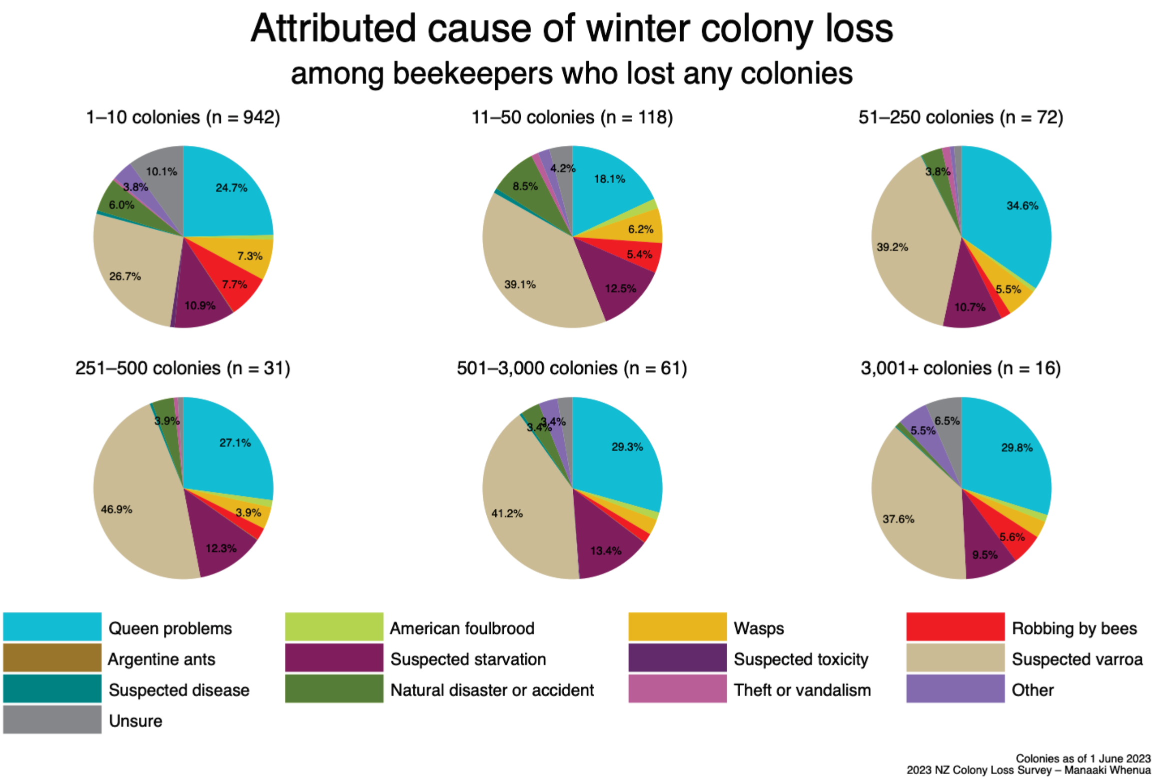

Figure 13: Share of colony losses attributed to various causes over winter 2023 among beekeepers who lost any colonies, by operation size.

Table 6 presents the estimated share of all living colonies at the beginning of autumn lost to the attributions discussed above among all beekeepers, by region. Table 7 does the same for over-winter losses for colonies that survived autumn to enter winter. Table 8 describes the share of all living colonies lost during autumn 2023 by operation size. Table 9 presents similar data for winter 2023.

Table 6: Estimated share of all colonies lost to various causes during autumn 2023, by region.

	National	Upper North Island	Middle North Island	Lower North Island	Upper South Island	Middle South Island	Lower South Island
Queen problems	4.87% [4.41%, 5.38%]	2.75% [2.45%, 3.08%]	3.13% [2.77%, 3.54%]	1.62% [1.10%, 2.39%]	7.35% [6.04%, 8.92%]	2.37% [2.05%, 2.73%]	15.88% [13.75%, 18.27%]
AFB	0.12% [0.10%, 0.16%]	0.17% [0.11%, 0.26%]	0.10% [0.06%, 0.18%]	0.07% [0.01%, 0.47%]	0.11% [0.09%, 0.13%]	0.05% [0.04%, 0.06%]	0.14% [0.06%, 0.30%]
Wasps	0.72% [0.61%, 0.85%]	1.02% [0.81%, 1.28%]	0.68% [0.44%, 1.05%]	0.19% [0.05%, 0.81%]	0.30% [0.15%, 0.61%]	0.62% [0.36%, 1.05%]	0.60% [0.36%, 1.00%]
Robbing	0.38% [0.31%, 0.47%]	0.48% [0.32%, 0.72%]	0.29% [0.17%, 0.49%]	0.22% [0.07%, 0.66%]	0.41% [0.26%, 0.66%]	0.18% [0.08%, 0.38%]	0.45% [0.27%, 0.76%]
Argentine ants	0.01% [0.01%, 0.02%]	0.00% [0.00%, 0.09%]	0% [-, -]	0% [-, -]	0% [-, -]	0% [-, -]	0.08% [0.05%, 0.12%]
Suspected starvation	0.94% [0.84%, 1.05%]	1.34% [1.10%, 1.63%]	0.72% [0.53%, 0.99%]	0.20% [0.09%, 0.42%]	0.64% [0.44%, 0.92%]	0.27% [0.20%, 0.37%]	1.23% [0.98%, 1.54%]
Suspected toxicity	0.02% [0.01%, 0.07%]	0.01% [0.00%, 43.25%]	0.00% [0.00%, 0.16%]	0.01% [0.00%, 48.21%]	0.07% [0.04%, 0.12%]	0.01% [0.00%, 36.31%]	0.08% [0.02%, 0.33%]
Suspected varroa	5.56% [5.27%, 5.85%]	5.05% [4.47%, 5.70%]	4.99% [4.31%, 5.77%]	6.82% [5.73%, 8.10%]	9.17% [8.39%, 10.01%]	7.13% [6.59%, 7.72%]	3.14% [2.61%, 3.78%]
Suspected disease	0.08% [0.07%, 0.11%]	0.09% [0.06%, 0.15%]	0.10% [0.05%, 0.19%]	0% [-, -]	0.02% [0.01%, 0.03%]	0.00% [0.00%, 0.25%]	0.19% [0.14%, 0.25%]
Natural disaster/ accidents	2.40% [2.15%, 2.67%]	5.07% [4.21%, 6.09%]	0.52% [0.31%, 0.86%]	0.16% [0.03%, 0.76%]	0.15% [0.06%, 0.38%]	0.14% [0.05%, 0.37%]	2.62% [2.18%, 3.15%]
Theft/ vandalism	0.04% [0.02%, 0.07%]	0.08% [0.04%, 0.16%]	0.00% [0.00%, 48.09%]	0.02% [0.00%, 74.09%]	0.05% [0.01%, 0.17%]	0.03% [0.00%, 0.24%]	0.02% [0.01%, 0.05%]

Note: Standard errors are scaled using square root of Pearson X2-based dispersion. Bracketed values indicate 95% confidence intervals. Confidence intervals are unreliable for loss categories selected by very few beekeepers. Calculations included all beekeepers, not just those with more than 250 colonies.

Table 7: Estimated share of all colonies lost to various causes over winter 2023, by region.

	National	Upper North Island	Middle North Island	Lower North Island	Upper South Island	Middle South Island	Lower South Island
Queen problems	2.81% [2.63%, 3.01%]	3.58% [3.15%, 4.06%]	3.37% [2.98%, 3.81%]	2.57% [2.22%, 2.99%]	3.07% [2.43%, 3.87%]	1.66% [1.32%, 2.08%]	1.62% [1.18%, 2.21%]
AFB	0.10% [0.07%, 0.13%]	0.06% [0.02%, 0.15%]	0.14% [0.08%, 0.25%]	0.06% [0.02%, 0.14%]	0.14% [0.04%, 0.49%]	0.12% [0.08%, 0.18%]	0.01% [0.01%, 0.01%]
Wasps	0.44% [0.35%, 0.54%]	0.35% [0.16%, 0.76%]	0.57% [0.41%, 0.80%]	0.44% [0.26%, 0.76%]	0.23% [0.09%, 0.59%]	0.21% [0.08%, 0.57%]	0.43% [0.21%, 0.87%]
Robbing	0.36% [0.29%, 0.44%]	0.51% [0.33%, 0.79%]	0.54% [0.39%, 0.73%]	0.30% [0.19%, 0.48%]	0.06% [0.00%, 3.18%]	0.18% [0.07%, 0.49%]	0.04% [0.00%, 0.62%]
Argentine ants	0.01% [0.01%, 0.04%]	0.04% [0.03%, 0.06%]	0% [-, -]	0.00% [0.00%, 92.94%]	0% [-, -]	0% [-, -]	0% [-, -]
Suspected starvation	1.12% [1.02%, 1.23%]	0.47% [0.25%, 0.88%]	1.36% [1.18%, 1.56%]	1.29% [1.04%, 1.60%]	1.98% [1.48%, 2.64%]	0.45% [0.27%, 0.74%]	0.82% [0.59%, 1.12%]
Suspected toxicity	0.01% [0.00%, 0.07%]	0.00% [0.00%, 3.95%]	0% [-, -]	0.00% [0.00%, 8.71%]	0.16% [0.05%, 0.51%]	0.02% [0.00%, 3.93%]	0.01% [0.00%, 44.56%]
Suspected varroa	6.43% [6.03%, 6.86%]	3.98% [3.21%, 4.92%]	6.99% [6.18%, 7.90%]	3.83% [3.32%, 4.41%]	11.94% [9.09%, 15.54%]	5.39% [4.47%, 6.49%]	11.10% [10.18%, 12.10%]
Suspected disease	0.07% [0.05%, 0.09%]	0.01% [0.00%, 27.68%]	0.10% [0.07%, 0.14%]	0.04% [0.02%, 0.08%]	0.01% [0.00%, 87.51%]	0.01% [0.00%, 22.20%]	0.16% [0.09%, 0.30%]
Natural disaster/ accidents	0.45% [0.33%, 0.61%]	0.69% [0.45%, 1.07%]	0.53% [0.31%, 0.90%]	0.57% [0.28%, 1.16%]	0.27% [0.14%, 0.52%]	0.10% [0.01%, 1.04%]	0.11% [0.02%, 0.65%]
Theft/ vandalism	0.03% [0.01%, 0.08%]	0.14% [0.04%, 0.47%]	0.03% [0.01%, 0.08%]	0.01% [0.00%, 1.30%]	0% [-, -]	0.00% [0.00%, 0.09%]	0% [-, -]

Note: Standard errors are scaled using square root of Pearson X2-based dispersion. Bracketed values indicate 95% confidence intervals. Confidence intervals are unreliable for loss categories selected by very few beekeepers. Calculations included all beekeepers, not just those with more than 250 colonies.

Table 8: Estimated share of all colonies lost to specific causes during autumn 2023, by operation size.

	1–10 colonies	11–50 colonies	51–250 colonies	251–500 colonies	501–3,000 colonies	+3,001 colonies
Queen problems	5.11% [4.53%, 5.75%]	4.49% [3.20%, 6.28%]	4.81% [3.09%, 7.41%]	4.28% [2.91%, 6.27%]	3.65% [1.90%, 6.90%]	5.95% [1.40%, 21.94%]
AFB	0.20% [0.12%, 0.35%]	0.32% [0.15%, 0.68%]	0.18% [0.08%, 0.40%]	0.10% [0.02%, 0.46%]	0.03% [0.01%, 0.08%]	0.18% [0.08%, 0.40%]
Wasps	3.13% [2.67%, 3.65%]	1.05% [0.65%, 1.69%]	1.08% [0.61%, 1.92%]	1.32% [0.53%, 3.23%]	0.68% [0.37%, 1.27%]	0.35% [0.17%, 0.71%]
Robbing	1.68% [1.38%, 2.06%]	0.44% [0.19%, 1.03%]	0.74% [0.39%, 1.41%]	0.46% [0.14%, 1.47%]	0.23% [0.15%, 0.36%]	0.31% [0.10%, 1.01%]
Argentine ants	0% [-, -]	0.10% [0.03%, 0.34%]	0.09% [0.02%, 0.41%]	0.09% [0.02%, 0.39%]	0% [-, -]	0% [-, -]
Suspected starvation	1.02% [0.81%, 1.28%]	1.12% [0.69%, 1.81%]	0.61% [0.34%, 1.09%]	1.50% [0.68%, 3.27%]	1.15% [0.50%, 2.61%]	0.63% [0.28%, 1.39%]
Suspected toxicity	0.12% [0.06%, 0.24%]	0.07% [0.01%, 0.47%]	0% [-, -]	0.12% [0.02%, 0.64%]	0% [-, -]	0.01% [0.00%, 0.07%]
Suspected varroa	5.58% [5.04%, 6.18%]	5.27% [3.89%, 7.11%]	6.59% [4.51%, 9.55%]	13.18% [9.01%, 18.88%]	5.18% [3.87%, 6.90%]	4.74% [2.38%, 9.23%]
Suspected disease	0.11% [0.05%, 0.25%]	0.34% [0.17%, 0.69%]	0.02% [0.00%, 0.23%]	0.03% [0.01%, 0.13%]	0.12% [0.04%, 0.35%]	0.06% [0.01%, 0.28%]
Natural disaster/ accidents	1.30% [1.03%, 1.65%]	4.56% [2.79%, 7.38%]	4.82% [2.52%, 9.03%]	5.44% [2.57%, 11.15%]	3.00% [1.45%, 6.11%]	1.11% [0.51%, 2.40%]
Theft/ vandalism	0.07% [0.03%, 0.14%]	0.02% [0.00%, 0.18%]	0.34% [0.11%, 1.01%]	0.12% [0.03%, 0.51%]	0% [-, -]	0% [-, -]

Note: Standard errors are scaled using square root of Pearson X2-based dispersion. Bracketed values indicate 95% confidence intervals. Confidence intervals are unreliable for loss categories selected by very few beekeepers.

Table 9: Estimated share of all colonies lost to specific causes over winter 2023, by operation size.

	1–10 colonies	11–50 colonies	51–250 colonies	251–500 colonies	501–3,000 colonies	+3,001 colonies
Queen problems	5.56% [4.92%, 6.27%]	3.33% [2.26%, 4.88%]	3.76% [2.33%, 6.03%]	3.39% [1.85%, 6.12%]	2.96% [2.11%, 4.15%]	2.34% [1.32%, 4.14%]
AFB	0.27% [0.15%, 0.48%]	0.25% [0.12%, 0.53%]	0.18% [0.03%, 1.10%]	0.06% [0.01%, 0.39%]	0.08% [0.04%, 0.15%]	0.09% [0.03%, 0.28%]
Wasps	2.11% [1.70%, 2.61%]	1.71% [0.90%, 3.20%]	1.04% [0.40%, 2.69%]	0.93% [0.35%, 2.49%]	0.28% [0.11%, 0.69%]	0.29% [0.14%, 0.60%]
Robbing	1.92% [1.56%, 2.35%]	1.05% [0.55%, 1.96%]	0.37% [0.12%, 1.12%]	0.50% [0.19%, 1.34%]	0.12% [0.05%, 0.28%]	0.39% [0.18%, 0.87%]
Argentine ants	0.03% [0.00%, 0.29%]	0% [-, -]	0% [-, -]	0.06% [0.01%, 0.31%]	0.01% [0.00%, 0.02%]	0% [-, -]
Suspected starvation	2.39% [1.98%, 2.89%]	1.60% [1.03%, 2.45%]	1.05% [0.69%, 1.60%]	2.00% [0.98%, 4.01%]	1.35% [0.92%, 1.97%]	0.74% [0.29%, 1.88%]
Suspected toxicity	0.18% [0.08%, 0.37%]	0% [-, -]	0% [-, -]	0% [-, -]	0.03% [0.00%, 0.28%]	0% [-, -]
Suspected varroa	7.06% [6.31%, 7.88%]	8.39% [6.41%, 10.91%]	7.52% [4.96%, 11.25%]	14.21% [8.42%, 22.98%]	7.34% [4.85%, 10.97%]	4.54% [2.33%, 8.66%]
Suspected disease	0.16% [0.07%, 0.34%]	0.03% [0.00%, 0.30%]	0.03% [0.00%, 0.64%]	0.12% [0.02%, 0.84%]	0.11% [0.05%, 0.26%]	0.02% [0.01%, 0.10%]
Natural disaster/ accidents	1.39% [1.05%, 1.84%]	3.22% [1.64%, 6.21%]	1.90% [0.56%, 6.28%]	1.10% [0.29%, 4.12%]	0.36% [0.16%, 0.84%]	0.14% [0.05%, 0.39%]
Theft/ vandalism	0.11% [0.03%, 0.37%]	0.22% [0.03%, 1.91%]	0.38% [0.12%, 1.15%]	0.08% [0.01%, 0.71%]	0% [-, -]	0% [-, -]

Note: Standard errors are scaled using square root of Pearson X2-based dispersion. Bracketed values indicate 95% confidence intervals. Confidence intervals are unreliable for loss categories selected by very few beekeepers.

4.4.1 Suspected varroa and related complications

The varroa mite is an ectoparasite that feeds off the fat body tissue of honey bees[8] and is regarded as the biggest threat to beekeeping worldwide (Rosenkrantz et al. 2010; Ramsey et al. 2019). The varroa mite transmits and activates several single-stranded RNA viruses, including acute bee paralysis virus, black queen cell virus, Israeli acute paralysis virus (which has not been found in New Zealand), Kashmir bee virus, sacbrood virus, and deformed wing virus (Chen & Siede 2007; Runckel et al. 2011; Grozinger & Flenniken 2019). The varroa mite arrived in the North Island in 2000 and spread to the South Island in 2006, resulting in higher colony losses and increased labour and control costs.

An estimated 5.6% of all living colonies were lost to suspected varroa and related complications during autumn 2023. Varroa was most problematic in the middle South Island, where 9.1% of all living colonies entering winter were estimated to have been lost to suspected varroa and related complications (Table 6).

If colonies with high mite loadings were lost during autumn instead of winter, winter losses may be constrained. Nevertheless, an estimated 6.4% of all colonies were lost to suspected varroa and related complications over winter 2023, compared with 6.4% over winter 2022, 5.5% over winter 2021, 3.5% over winter 2020, 3.0% over winter 2019, 2.3% over winter 2018, and 1.6% over winter 2017. Nearly 12% of all healthy colonies entering winter in the upper South Island were lost to suspected varroa and related complications, as were 11.1% in the lower South Island (Table 7).

We estimate that suspected varroa and related complications resulted in the loss of (Table 8 and Table 9):

- 5.6% of all healthy colonies during autumn 2023 and 7.1% of all healthy colonies over winter 2023 among beekeepers with 1–10 colonies
- 5.3% of all healthy colonies during autumn 2023 and 8.4% of all healthy colonies over winter 2023 among beekeepers with 11–50 colonies
- 6.6% of all healthy colonies during autumn 2023 and 7.5% of all healthy colonies over winter 2023 among beekeepers with 51–250 colonies
- 13.2% of all healthy colonies during autumn 2023 and 14.2% of all healthy colonies over winter 2023 among beekeepers with 251–500 colonies
- 5.2% of all healthy colonies during autumn 2023 and 7.3% of all healthy colonies over winter 2023 among beekeepers with 501–3,000 colonies
- 4.7% of all healthy colonies during autumn 2023 and 4.5% of all healthy colonies over winter 2023 among beekeepers with more than 3,000 colonies.

In 2023, respondents who attributed colony losses over winter 2023 to suspected varroa and related complications were asked to identify the single largest factor underlying those losses. Seven out of 10 respondents specified that ineffective varroa management led to their losses, which can be broken down to:

- 2.2% attributed their losses due to varroa to the fact that they simply did not treat for varroa (cf. 2.1% in 2022 and 2.4% in 2021)
- 16.3% attributed their losses to varroa to winter weather conditions (cf. 12.9% in 2022 and 11.3% in 2021)
- 31.0% stated that they treated for varroa at the wrong time (cf. 13.5% in 2022 and 32.1% in 2021)
- 6.1% reported using an ineffective dosage (cf. 3.1% in 2022 and 8.1% in 2021)
- 17.8% reported that the treatment was ineffective (cf. 18.9% in 2022 and 18.7% in 2021)
- 26.7% reported reinvasion after treatment (cf. 52.7% in 2022 and 27.4% in 2021).

Figure 14 and Figure 15 present results across regions and operation sizes, respectively.

[8] Ramsey et al. (2019) conclude that 'Varroa are exploiting the fat body as their primary source of sustenance: a tissue integral to proper immune function, pesticide detoxification, overwinter survival, and several other essential processes in healthy bees'.

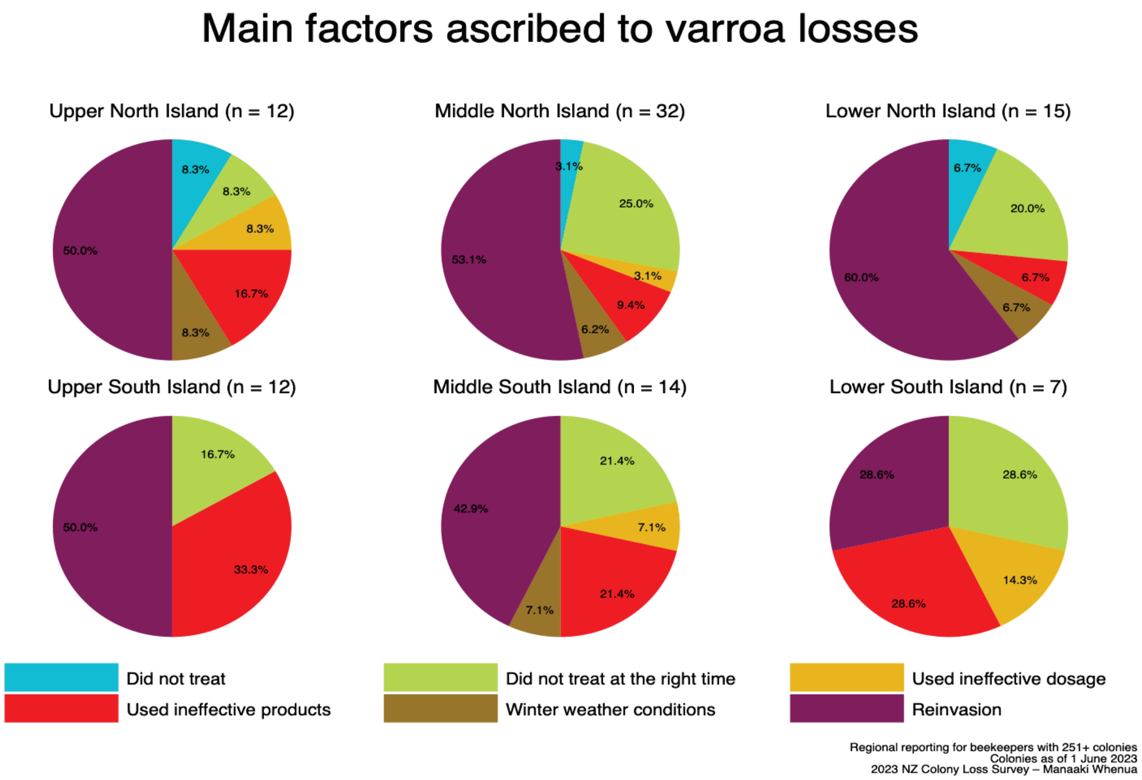

Figure 14: Factors explaining varroa loss over winter 2023 among beekeepers with more than 250 colonies, by region.

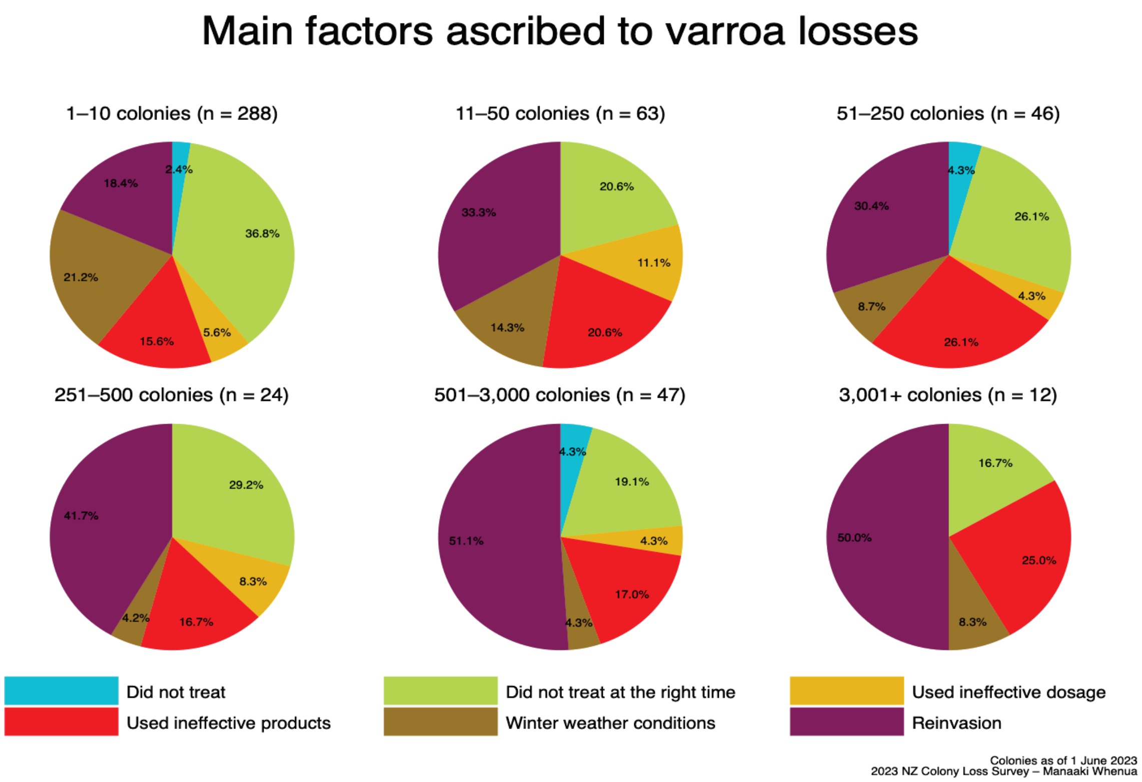

Figure 15: Factors explaining varroa loss over winter 2023, by operation size.

4.4.2 Queen problems

Queen problems are difficult to diagnose because other health problems may present as queen problems (Lee et al. 2019). Nevertheless, many beekeepers attribute losses to queen problems, and we record those attributions here.

Because colonies function as 'superorganisms', any disruption in the replenishment of each cohort can cause a colony to fail (Pettis et al. 2016). A well-mated, healthy queen is integral to driving the reproduction and growth of the colony, but she needs nurse bees to feed her, which in turn need foragers to bring pollen and nectar to make royal jelly. The queen also needs healthy drones for mating to produce worker bees. Queens may fail for several reasons, including poor mating and pathogen infection (Pettis et al. 2016). In addition, temperatures during queen shipment affect sperm viability and thus the quality of mated queens (Pettis et al. 2016).

Consistent with international studies (Brodschneider et al. 2016; Pettis et al. 2016; Gray et al. 2019; Lee et al. 2019), perceived queen problems were a major contributor to colony losses across all regions and all operation sizes. Indeed, we estimate that 4.9% of all colonies were lost to what beekeepers described as queen problems during autumn 2023 (Table 6), as were 2.8% of all colonies over winter 2023 (Table 7). That said, the share of all colonies lost to queen problems has been relatively stable since 2017, when the current suite of loss categories was first implemented in our survey. Between 2017 and 2022 the share of all living colonies lost over winter that were attributed to queen problems fluctuated between 3.1% and 3.9%.

Among beekeepers with more than 250 colonies, queen problems accounted for an estimated 4.9% of losses over autumn 2023. Queen problems were especially acute in the lower South Island (Table 6), where it is estimated that 15.9% of colonies were lost over autumn 2023 due to challenges with queens. Queen problems were the second-highest cause of losses in all other regions after varroa. Queen problems were also identified as the second-highest cause of losses over winter 2023 (after varroa) in all six regions (Table 7).

Queen problems were also the second-largest contributor (after varroa) to estimated losses during autumn 2023 for operations with 1–3,000 colonies and the largest contributor for operations with 3,000+ colonies (Table 8). Queen problems were the second-largest contributor (after varroa) to losses over winter 2023 for all size classes (Table 9).

It is generally accepted that younger queens outperform older queens (Rangel et al. 2013), and re-queening is a common strategy for reducing potential queen problems, especially among commercial beekeepers. Indeed, among beekeepers with more than 250 colonies, 53.2% of colonies were re-queened during the 2022/23 season (compared with 50.5% of colonies during the 2021/22 season, 54.7% of colonies during the 2020/21 season, and 46.6% of colonies during the 2019/20 season). Re-queening was most common in the lower North Island, as shown in Figure 16. Operators with more than 3,000 colonies re-queened nearly two-thirds of colonies, whereas operators with 1–10 colonies re-queened fewer than one-third of colonies (Figure 17).

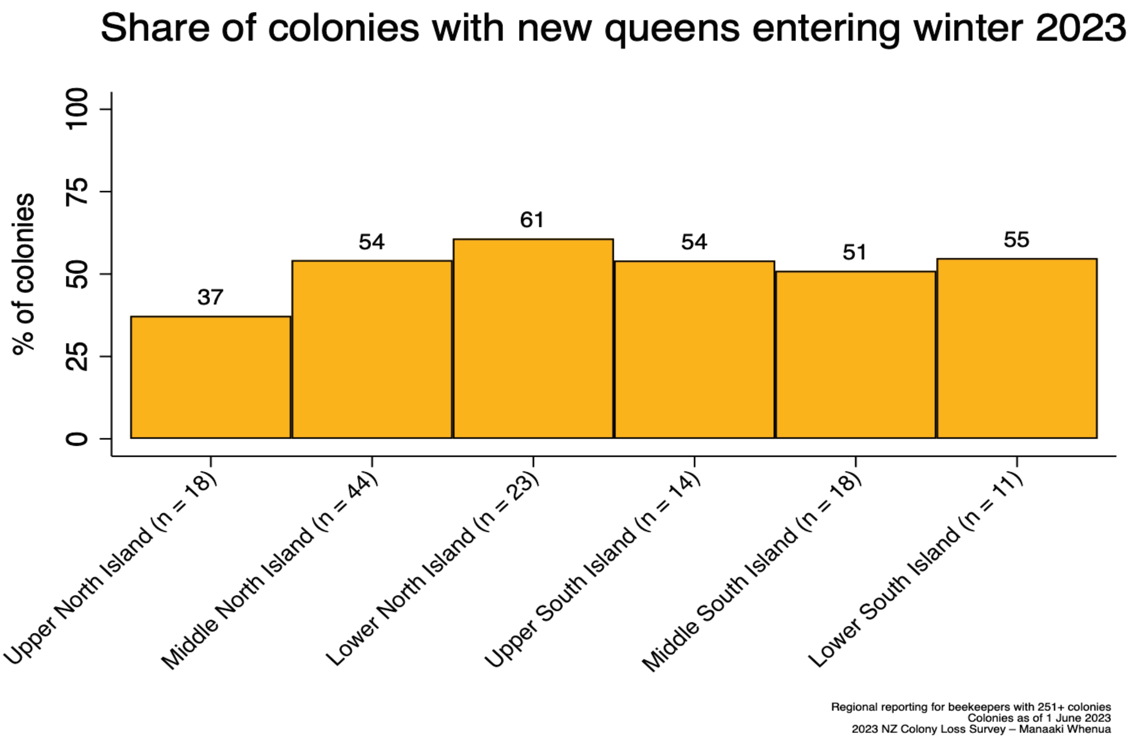

Figure 16. Share of colonies that were re-queened during the 2022/23 season among beekeepers with more than 250 colonies, by region.

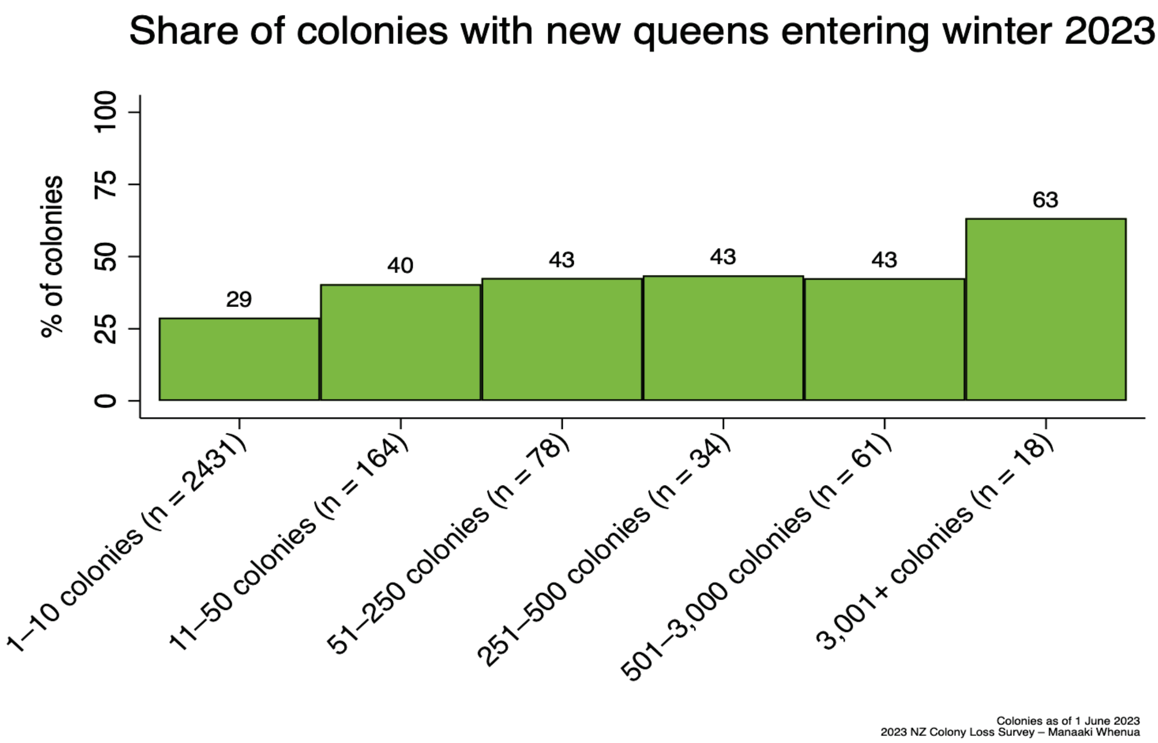

Figure 17: Share of colonies that were re-queened during the 2022/23 season, by operation size.

4.4.3 Wasps

Wasps debilitate honey bee colonies in winter by robbing their honey stores and seeking protein (including both adult bees and brood) to feed their own young, which can lead to starvation and a reduced workforce of foragers.

Beekeepers lost an estimated 0.7% of living colonies to wasps during autumn 2023. They lost 0.4% of all living colonies over winter 2023 to wasps as compared to 0.9% of colonies over winter 2022, 1.7% of colonies over winter 2021, 0.8% of colonies over winter 2020, and 1.0% of colonies over winter 2019. Wasps were most prevalent in the middle North Island, although wasp problems were relatively mild even there.

Protection against wasps can be achieved by maintaining strong colonies and reducing hive entrances in autumn to facilitate more effective defence by the bees. Pesticides such as Vespex® have also been shown to be effective for wasp control but safe for use near honey bee colonies (Edwards et al. 2017).

Small operators were most affected by wasps: beekeepers with 1–10 colonies lost an estimated 3.1% of colonies to wasps during autumn 2023 and 2.1% of colonies to wasps over winter 2023. In contrast, beekeepers with more than 500 colonies lost an estimated 0.4–0.7% of colonies to wasps in autumn and 0.3% of colonies to wasps in winter.

In 2023, commercial beekeepers with more than 250 colonies were asked to describe winter wasp activity in their region (Figure 18). One-quarter of respondents with colonies wintering in the upper North Island described wasp activity as being 'extreme' or 'a lot'. Some 54.5% of respondents across the North Island described wasp activity as 'extreme', 'a lot', or 'some' (compared to approximately 67% in 2022). The lowest prevalence of wasps was in the lower South Island, although 35.8% of beekeepers there nevertheless reported at least 'some' wasp activity (compared to 34.3% in 2022).

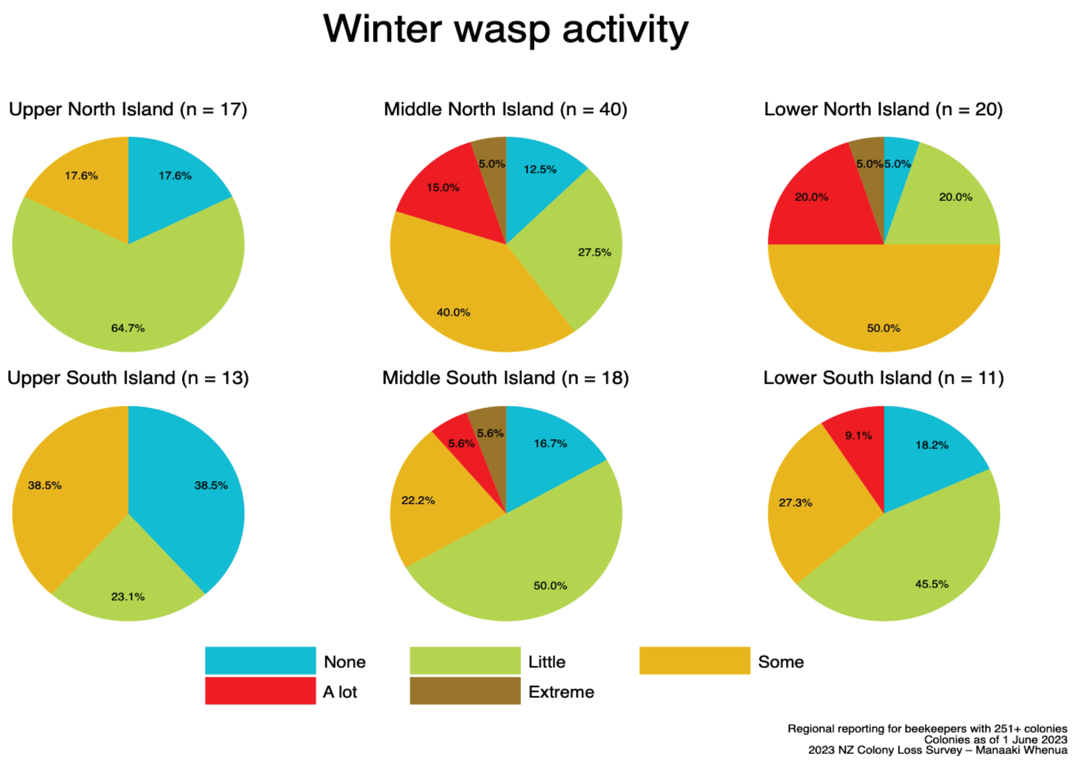

Figure 18: Wasp activity over winter 2023 as described by beekeepers with more than 250 colonies, by region.

4.4.4 Suspected starvation

Dead worker bees in cells with no food present in the colony is indicative of starvation. An estimated 1.0% of all colonies were lost to suspected starvation during autumn 2023 (Table 6). A further 1.1% of all colonies were lost to suspected starvation during winter 2023 (Table 7), compared with 0.9% over winter 2022, 1.0% over winter 2021, 0.9% over winter 2020, and 1.0% over winter 2019. Suspected starvation during autumn 2023 was most pronounced in the middle North Island; over winter 2023, starvation was most acute in the upper South Island, where 2.0% of all colonies were estimated to have died due to suspected starvation. Loss rates due to starvation were quite low among beekeepers with more than 3,000 colonies (Table 8 and Table 9), similar to the previous four winters.

Supplemental feeding has been associated with reduced varroa infestations (Giacobino et al. 2014), and has obvious benefits when colonies are facing starvation (Ahmad et al. 2021). However, the effects of supplementation are complex, and the wider effects on colony health remain unclear (Steinhauer et al. 2021; Mortensen et al. 2019).

4.4.5 Robbing by other bees

Weak hives are susceptible to robbing from strong hives, particularly when there is a dearth of nectar sources. An estimated 0.4% of all colonies were lost due to robbing by other bees during autumn 2023 (Table 6), with a further 0.4% lost due to robbing over winter 2023 (Table 7). The latter figure compares with 0.4% over winter 2022, 0.6% over winter 2021, 0.5% over winter 2020, and 0.5% over winter 2019. As in previous years, robbing was more common in the North Island. Robbing was more frequently observed among small operators: beekeepers with 1–10 colonies had estimated loss rates due to robbing of 1.7%–1.9% compared to less than 0.4% for beekeepers with more than 500 colonies (Table 8 and Table 9).

4.4.6 Natural disasters and accidents

Estimates of losses due to natural disasters and accidents during autumn 2023 ranged from 0.15% across the South Island to 2.6% in the upper North Island and 5.1% in the middle North Island (Table 6). Losses to natural disasters and accidents were highest among beekeepers with 11–500 colonies, many of which are one- or two-person operations.

Unprecedented losses to natural disaster in autumn were driven by Cyclone Gabrielle, a severe tropical cyclone that wreaked havoc on parts of the North Island in February 2023. Cyclone Gabrielle was the worst tropical cyclone ever recorded in the Southern Hemisphere in terms of financial impacts, which were estimated in excess of $13 billion (Sowden 2023). Damages were severe in parts of Hawke's Bay, Gisborne, Bay of Plenty, the Coromandel peninsula, Auckland, and Northland.

In March 2023, Apiculture New Zealand estimated that 5,000–6,000 colonies were lost or damaged, figures that were widely cited in the national (e.g. RNZ 2023) and international media (e.g. Graham-McLay 2023). These numbers were expected to increase as damaged roads and washed-out bridges made accessing many hives impossible.

The 2023 survey asked beekeepers whether they lost any colonies to Cyclone Gabrielle, and if so, how many they lost. Given that the survey was administered a full seven months after Cyclone Gabrielle, we believe that survey data may provide a fuller picture of losses than the early estimates provided by Apiculture New Zealand.

144 respondents in the upper North Island, middle North Island, and lower North Island reported that they lost colonies as a result of Cyclone Gabrielle. Five beekeepers reported that they lost at least 500 colonies, two of whom reported that their losses exceeded 1,000 colonies. Together, these 144 respondents reported losing 7,659 colonies as a result of the cyclone.

While our sample covered 35% of honeybee colonies under management nationally as of the beginning of winter, we do not know exactly what share of colonies were represented in specific affected regions or what share were represented as of February 2023. As such, it is difficult to extrapolate an accurate figure for the total number of colonies lost to Cyclone Gabrielle based on our sample. However, under the very strong assumption that our sample covers 35% of all colonies in each region in February, then we estimate that more than 21,000 colonies were lost as a result of Cyclone Gabrielle.

Losses attributed to natural disasters and accidents were appreciably lower over winter 2023, both by geography (Table 7) and operation size (Table 9).

4.4.7 Suspected nosema and other diseases

Nosema apis and *Nosema ceranae* are microsporidian parasites that invade the intestinal tracts of honey bees, causing nosemosis. *Nosema apis* had been in New Zealand historically, whereas *Nosema ceranae* was only identified internationally in 2006 (Higes et al. 2006) as a pathogen in *Apis mellifera* and was first identified in New Zealand in 2010 (MAF 2011). Nosemosis is exacerbated when bees cannot leave their colonies to eliminate waste (e.g. during cold and wet winters).

Symptoms of nosemosis may include dysentery. Colonies suffering from nosema tend to dwindle rapidly, with no dead bees present in or outside the hive. However, these symptoms are not syndromic, meaning they may be confused with other honey bee diseases (including parasitic mite syndrome) or with poor queen quality (Borowik 2019).

An estimated 0.1% of colonies were lost due to causes attributed to suspected diseases during both autumn 2023 (Table 6) and winter 2023 (Table 7). By comparison, 0.2–0.3% of all colonies were lost to suspected disease over winter 2020, 2021, and 2022. Suspected disease was highest in the upper North Island during autumn 2023 and in the lower South Island over winter 2023. Losses to suspected disease were low across all size classes (Table 8 and Table 9).

4.4.8 American foulbrood disease (AFB)

New Zealand has a Pest Management Plan (PMP) under the Biosecurity Act 1993 that aims to eliminate AFB nationwide. Measures to control AFB under the PMP include colony registration, beekeeper training, annual inspections, and a requirement to burn colonies and associated equipment with any symptoms of AFB infection.

Among the 208,044 wintering colonies reported on by beekeepers in the 2023 NZ Colony Loss Survey, there were 317 cases of AFB (cf. 501 cases out of 352,419 colonies for winter 2022, 518 cases out of 381,148 colonies for winter 2021, 216 cases out of 304,143 colonies for winter 2020, and 331 cases out of 297,345 colonies for winter 2019). These losses represent 0.10% of all colonies entering winter (Table 7). An estimated 0.6% of colonies were lost to AFB over winter 2015, 0.21% over winter 2016, 0.27% over winter 2017, 0.12% over winter 2018, 0.11% over winter 2019, 0.07% over winter 2020, 0.14% over winter 2021, and 0.14% over winter 2022.

AFB losses over winter 2023 were highest in the middle North Island and upper South Island, each of which lost an estimated 0.14% of living colonies to AFB over winter (Table 7). Winter 2023 losses to AFB were highest among beekeepers with 1–50 colonies (Table 9).

Autumn 2023 losses to AFB follow similar patterns, with the highest losses recorded in the middle North Island (Table 6) and among beekeepers with 1–50 colonies (Table 8).

Just 0.32% of all colonies were estimated to have been lost to AFB. Estimated losses were highest among beekeepers with 11–50 colonies, who are estimated to have lost 0.8% of all colonies to AFB over winter 2023. In contrast, beekeepers with more than 500 colonies are estimated to have lost less than 0.1% of colonies to AFB.

4.4.9 Suspected toxic exposure

Having a large number of dead bees in or in front of the colony may indicate exposure to chemicals such as insecticides, fungicides, and surfactants, or naturally occurring toxins such as karaka (Palmer-Jones & Line 1962).

During autumn 2023, 0.02% of colonies were lost to suspected toxic exposure (Table 6). Over winter 2023, this figure was 0.01% (Table 7), compared to 0.06% over winter 2022, 0.08% over winter 2021, 0.15% over winter 2020, and 0.11% over winter 2019. All regions had low loss rates from suspected toxicity during both autumn and winter. Exposure to toxicity was highest among beekeepers with 1–10 colonies, who lost 0.19% of all colonies to suspected toxicity during autumn 2023 (Table 8) and 0.18% of all colonies to suspected toxicity over winter 2023 (Table 9).

4.4.10 Theft or vandalism

Theft and vandalism were rare overall, affecting just 0.04% of all colonies during autumn 2023 (Table 6) and 0.03% of all colonies during winter 2023 (Table 7). The incidence of theft and vandalism was lower than in 2019, 2020, 2021, and 2022, with a model over-winter loss rate of 0.10%). Theft and vandalism were most common among beekeepers with 51–250 colonies and rare for operators with more than 250 colonies.

4.5 State of surviving colonies

Production colonies may survive winter but enter spring in a weakened state. In spring 2023, beekeepers with more than 250 colonies reported that 24.1% of their colonies were weak but queenright, on average (cf. 20.9% in spring 2022, 22.0% in spring 2021, 24.4% in spring 2020, and 19.8% in spring 2019) (Figure 19). Similar to spring 2022, smaller operators reported lower shares of weak colonies in spring 2023, on average (Figure 20).

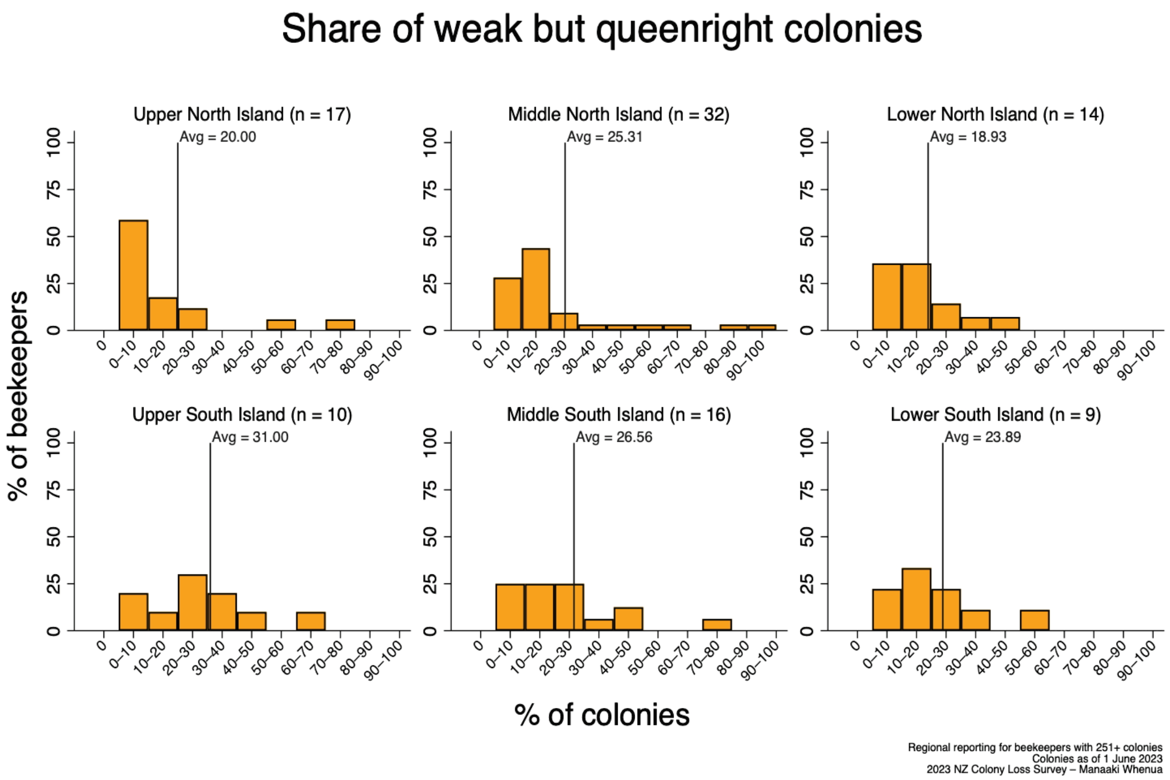

Figure 19: Share of colonies that were weak but queenright at the beginning of spring 2023 among beekeepers with more than 250 colonies, by region.

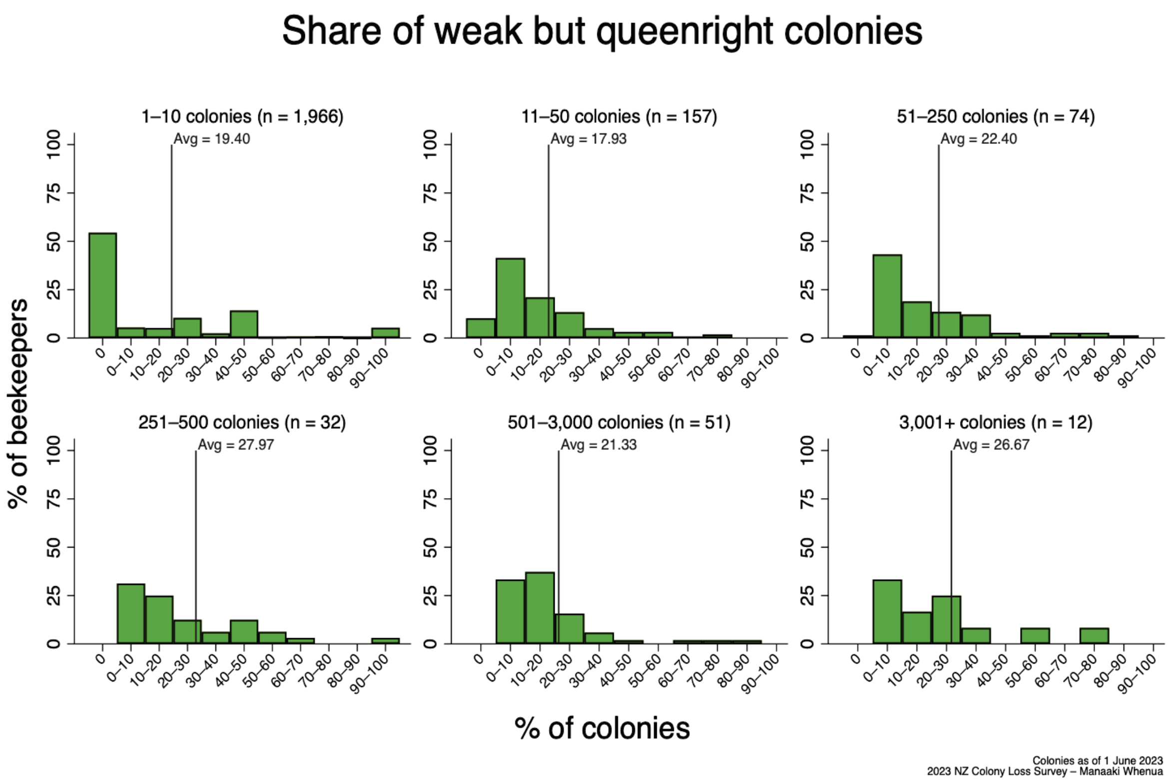

Figure 20: Share of colonies that were weak but queenright at the beginning of spring 2023, by operation size.

4.6 2022/23 season

The third part of the 2023 NZ Colony Loss Survey asked respondents to reflect on the previous season. The 2021 survey focused on varroa and its management, and many of these questions (e.g. regarding the type and timing of treatment) were retained for 2022 and 2023. Specifically, the questionnaire covered varroa monitoring (including viruses associated with varroa, monitoring methods, and mite loadings), and varroa management (including the type and timing of treatments and the perceived successfulness of those treatments). This section also asked beekeepers to report on the main use of their colonies over the 2022/23 season.

4.6.1 Varroa monitoring

Deformed wing virus (DWV) is the most prominent virus related to varroa (van der Steen & Vejsnæs 2021). The virus causes deformities in adult honey bees, including stubby wings, malformed abdomens, discolouration, and paralysis; infected bees showing symptoms are often unable to forage (Kielmanowicz et al. 2015). Indeed, detection of just 11 malformed bees in a 15,000-bee colony in autumn has been associated with a low probability of winter survival in Europe (Dainat & Neumann 2013).

Prior to 2022, beekeepers were asked if they had *noticed* DWV in their hives at any time during the season. The proportion of beekeepers who reported DWV hovered between 75% and 80% each year between 2016 (when the question was first included) and 2021 (Stahlmann-Brown & Robertson 2022). Beginning in 2022, beekeepers were instead asked about the *prevalence* of DWV in their hives.

The vast majority of beekeepers with more than 250 colonies described the prevalence of DWV as 'limited' (Figure 21), although roughly one-third of beekeepers in the upper North Island, upper South Island, and middle South Island described the prevalence of deformed wings as 'extensive'. Nearly half of beekeepers with 1–10 colonies reported that they saw no deformed wings, a much higher rate than in other operation sizes (Figure 22).

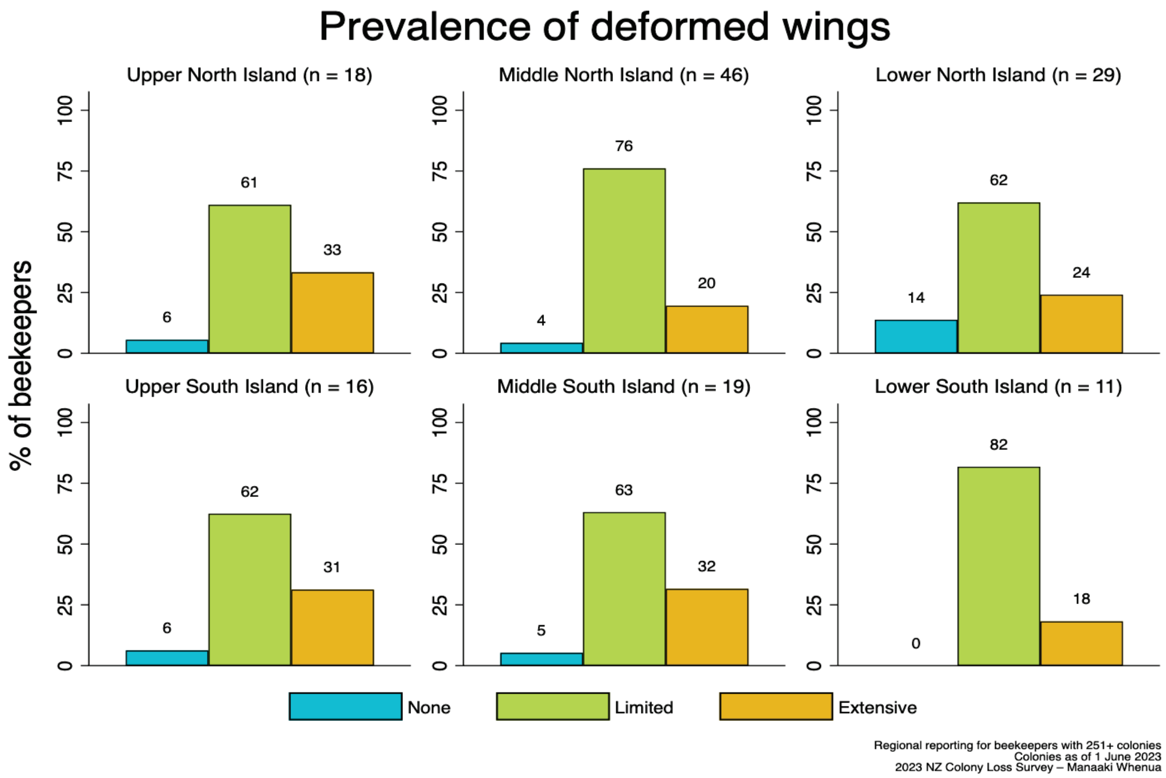

Figure 21: Prevalence of deformed wings reported by beekeepers with more than 250 colonies, by region.

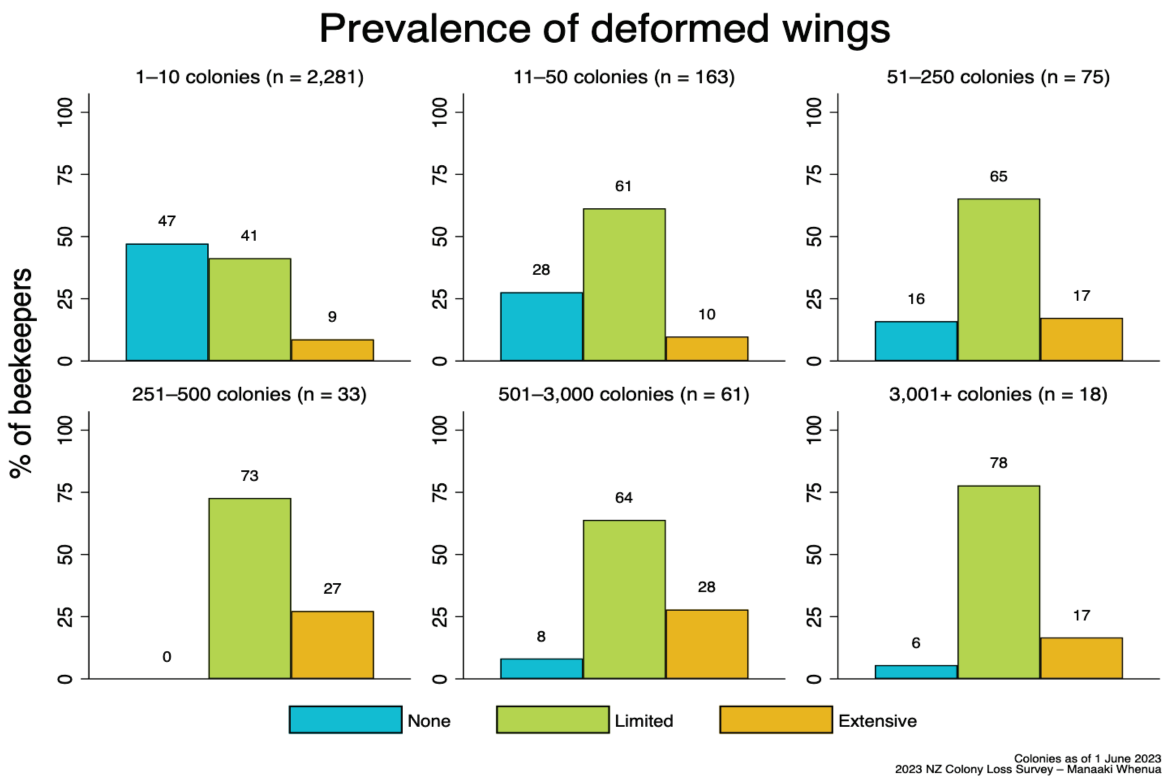

Figure 22: Prevalence of deformed wings, by operation size.

Parasitic mite syndrome (PMS) presents with spotty brood patterns and sunken, dark, or perforated cell cappings, although only larvae and prepupae are affected. PMS only occurs with infestations of varroa mites. Prior to 2022, beekeepers were asked if they had *noticed* PMS in their hives at any time during the season. The proportion of beekeepers who reported PMS was approximately 62% in 2017 and 2018, increasing to approximately 75% in 2019, 2020, and 2021 (Stahlmann-Brown & Robertson 2022). Beginning in 2022 beekeepers were instead asked about the *prevalence* of PMS in their hives.

Among beekeepers with more than 250 colonies, the prevalence of PMS (Figure 23) was similar to that of deformed wings (Figure 21), with the highest incidence of PMS reported in the middle South Island and upper South Island.

The share of beekeepers who describe PMS as ‘extensive’ varies from 8% for beekeepers with 1–10 colonies to 31% for beekeepers with 251-500 colonies (Figure 24). Analogously, the share of beekeepers who did not observe PMS in their colonies ranged from 6% for beekeepers with 251–500 colonies to 55% for beekeepers with 1–10 colonies.

Coupled with previous findings that more experienced beekeepers were more likely to have reported symptoms of DWV and PMS in their hives (Stahlmann-Brown & Robertson 2023), these results suggest an opportunity for raising awareness in clubs catering to hobbyist beekeepers.

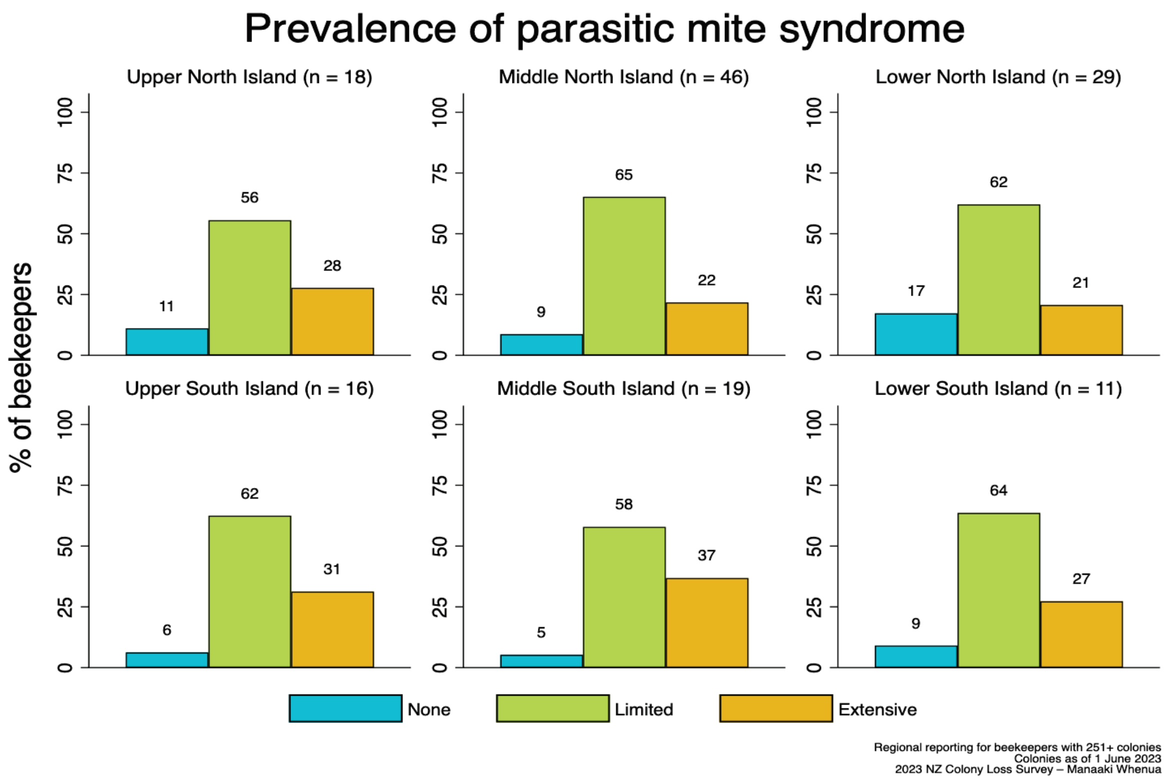

Figure 23: Prevalence of parasitic mite syndrome reported by beekeepers with more than 250 colonies, by region.

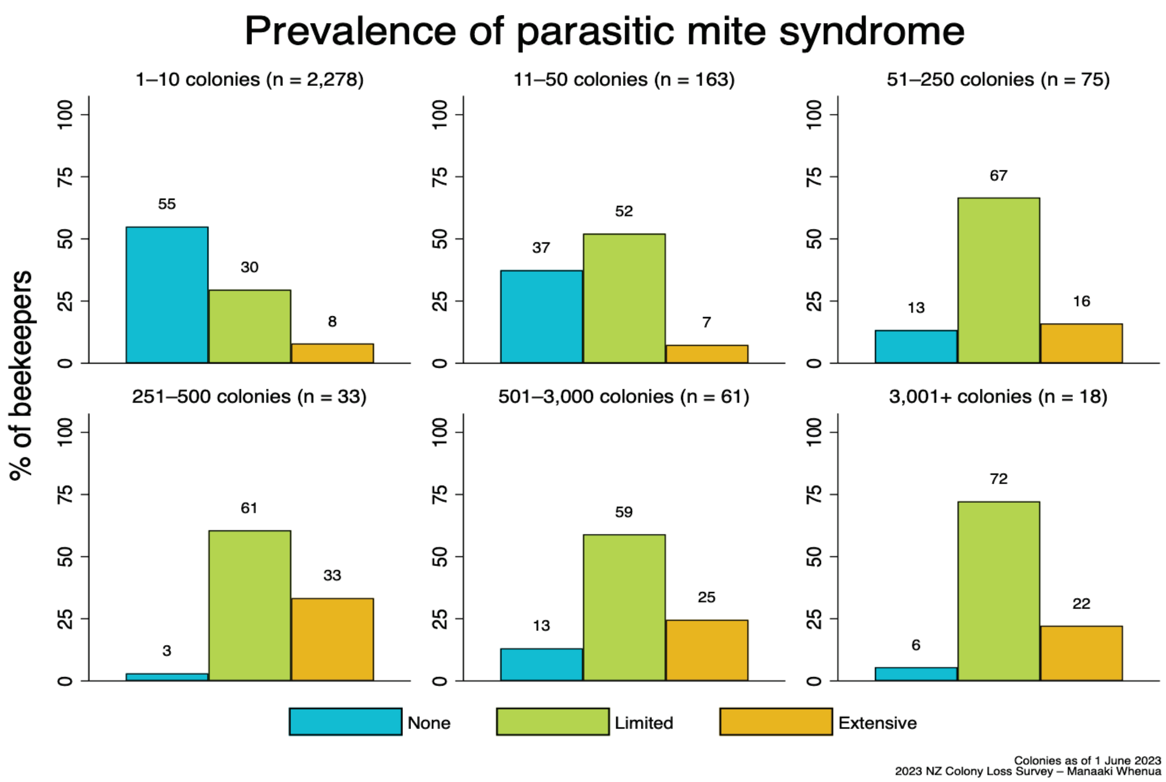

Figure 24: Prevalence of parasitic mite syndrome, by operation size.

Monitoring for varroa enables timely treatment as part of an integrated pest management plan (Imdorf et al. 1996). Failing to monitor substantially increases the likelihood of colony loss (Honey Bee Health Coalition 2015).

In addition to sending samples to a lab for testing, three monitoring methods are recognised internationally as providing reliable estimates of mite populations: the sugar shake (or powdered sugar shake), alcohol wash (or soap wash), and carbon dioxide injection (Azizi et al. 2008; De Jong et al. 1982; de Feraudy et al. 2019; Fakhimzadeh 2000; Lee et al. 2010; Macedo et al. 2002). Each of these methods requires placing approximately half a cup of bees (about 300) into a jar with a perforated lid.

In the sugar shake method, beekeepers add approximately 2 tablespoons of powdered sugar to the jar and vigorously shake the jar for at least 1 minute to cover the bees and dislodge the mites. After 3–5 minutes, the jar is inverted and any mites are shaken out. An additional tablespoon of sugar is added, the jar is re-shaken, and after an additional 3–5 minutes the jar is inverted and the mites are shaken out.

In the alcohol wash method, sufficient alcohol or liquid soap is added to the jar to completely cover the bees. The jar is vigorously shaken for at least 1 minute to dislodge any mites from the bees. After shaking, the liquid is poured through a mesh screen, and the process is repeated.

In the carbon dioxide injection method, bees are rendered unconscious before being shaken to dislodge mites onto a screen. In all cases, beekeepers count the number of mites on the screen to assess infestation levels. As an alternative, bee samples can be sent to a lab.

Field trials undertaken in New Zealand by Taylor et al. (2023) indicate that the alcohol/detergent wash and sugar shake methods are equally reliable, as two sugar shakes and three alcohol/detergent washes each resulted in over 95% of mites being extracted. They note, however, that there are pros and cons for each method. For example, alcohol/detergent washes kill the bees and varroa, so the results may be more consistent across beekeepers than sugar shakes, but the washes require liquids to be managed in the apiary. Sugar shakes do not kill the bees but cannot be used to monitor varroa levels during wet weather or the honey flow. Also, the number of shakes/washes determines how effective the methods are at extracting the varroa from the bees.

Other methods for monitoring varroa include placing sticky boards beneath the hive (enabling the beekeeper to monitor debris that has fallen from the hive, including varroa mites)and assessing drone brood. These methods are considered to be less accurate than those described above. In assessing drone brood, for example, it can be difficult to interpret the results of the percentage of brood infected (Honey Bee Health Coalition 2015), and guidelines suggest that at least 100 brood cells must be uncapped to assess infestation levels (Wilkinson & Smith, 2002). With sticky boards, other insects may remove mite bodies, interfering with estimates. In addition, because mites collect on sticky boards over time and because colony sizes vary, it is difficult to interpret infestation rates or even mite loads at a specific point in time (Honey Bee Health Coalition 2015).

Visual inspection of adult bees is considered to be wholly ineffective because mites are not easily seen unless they are present on the thorax or top of the abdomen, and findings of mites on adults likely indicate that a high mite population already exists (Hall et al. 2021). For this reason, beekeepers who reported that their only form of varroa monitoring is visual inspection of adult bees are re-classified for this report as not having undertaken any monitoring at all.

While many beekeepers monitor for varroa using multiple methods, 35.3% of beekeepers monitored using at least one of the four recommended processes (alcohol wash, sugar shake, carbon dioxide injection, and sending samples to the lab) during the 2022/23 season (cf. 32.8% during the 2021/22 season and 31.5% during the 2020/21 season). Among beekeepers with more than 250 colonies, the uptake of these monitoring methods was lowest in the lower South Island (45.5%), upper North Island (55.6%), and middle North Island (58.7%), and highest in the middle South Island (81.3%). Some 17.3% of beekeepers with more than 250 colonies undertook no mite monitoring in 2022/23 (cf. 23.7% in 2021/22), including 20.0% in the lower South Island (Figure 25), a dramatic increase in monitoring relative to the 2021/22 season, when 43.8% reported undertaking no monitoring.

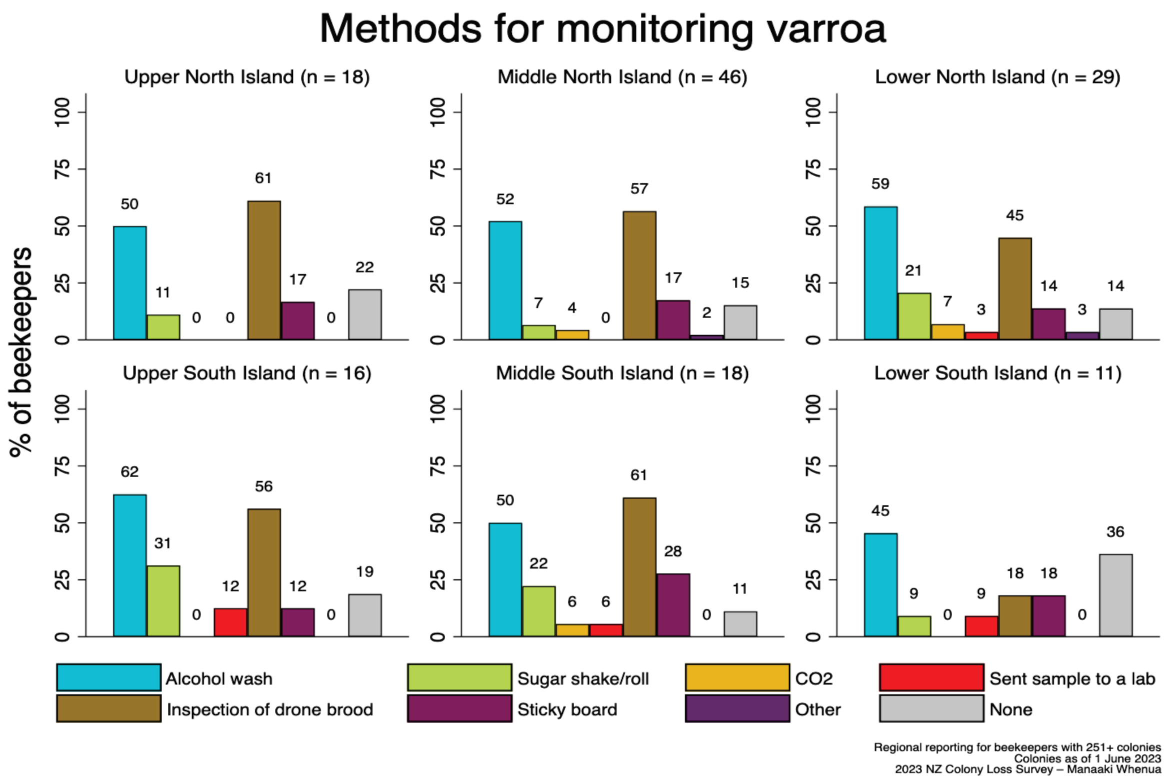

Figure 25: Methods for monitoring varroa during the 2022/23 season among beekeepers with more than 250 colonies, by region.

The use of the preferred monitoring methods varies from 34.6% among beekeepers with 1–10 colonies (cf. 30.8% in 2021/22) to 88.9% of beekeepers with more than 3,000 colonies (cf. 58.6% in 2022/23). Smaller operators who undertook monitoring were more likely to rely on visual inspection of drone brood as their main method (Figure 26). Monitoring rates across all size classes improved over 2021/22 rates.

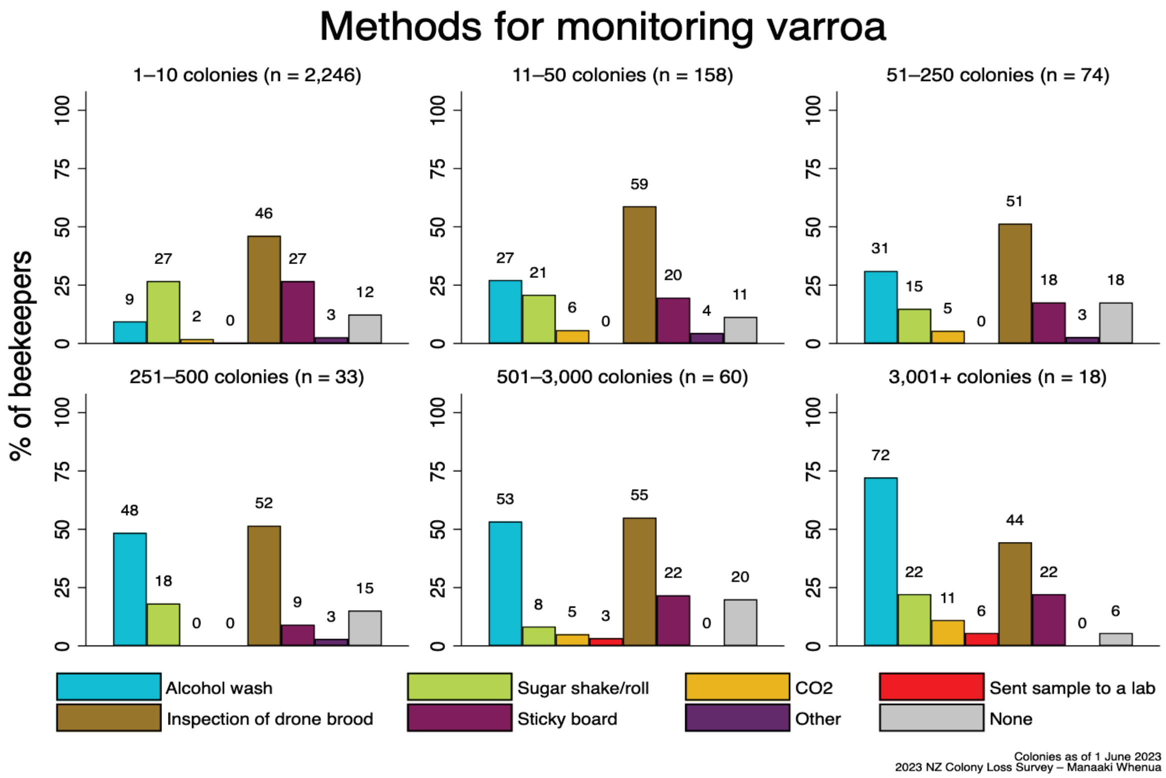

Figure 26: Methods for monitoring varroa during the 2022/23 season, by operation size.

There is no consensus on the damage threshold for varroa in the scientific literature, but a 3% infestation rate (9 mites per 300 bees) is popularly considered the level at which colony damage could occur (Hall et al. 2021). Thus, beekeepers with at least 51 colonies[9] who monitored for varroa using an alcohol wash, sugar shake, or carbon dioxide injection were subsequently asked to report the share of colonies meeting this threshold. Among beekeepers with more than 250 colonies, mite loadings were highest in the upper South Island and lower South Island (Figure 27). In the middle South Island, the distribution was bimodal, with 50% of beekeepers experiencing mite loads of 11% or higher and 34% of beekeepers experiencing mite loads of 2% or lower. Beekeepers with 251–500 colonies, who reported low levels of formal monitoring during the 2021/22 season, experienced higher mite loads than beekeepers in other size classes during the 2022/23 season (Figure 28).

[9] To shorten the questionnaire for smaller operators, this question was only asked of those with at least 51 colonies.

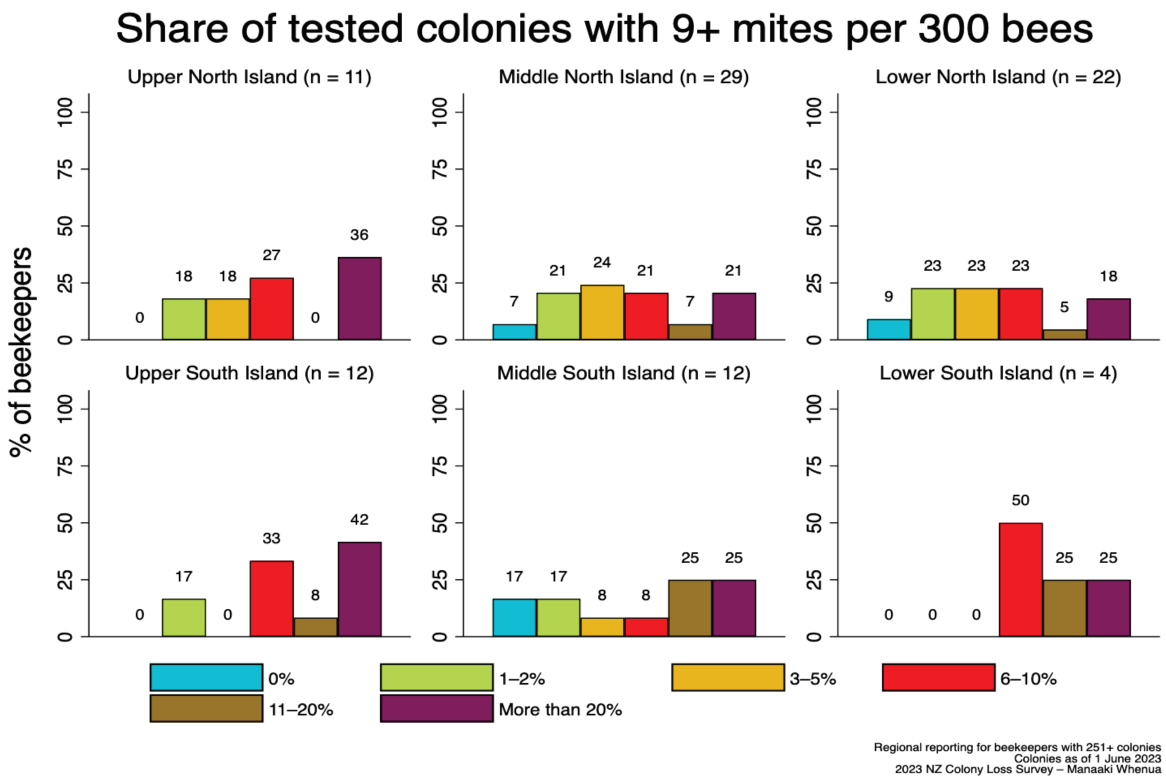

Figure 27: Share of autumn colonies tested with 9+ mites per 300 bees among beekeepers with more than 250 colonies, by region.

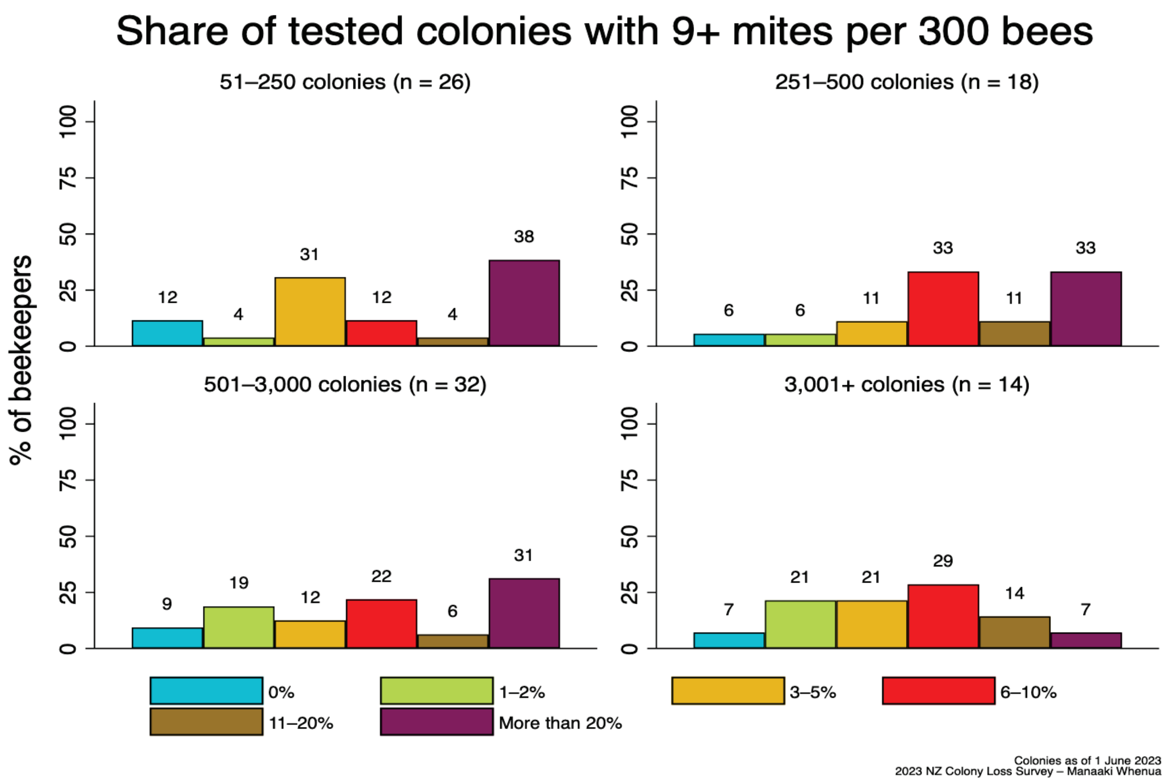

Figure 28: Share of autumn colonies tested with 9+ mites per 300 bees among beekeepers with more than 50 colonies, by operation size.

While many New Zealand beekeepers treat varroa based on evidence of its presence (a 'need-based strategy', according to van der Steen and Vejsnæs [2021]), others treat varroa regardless of the infection rate ('systematic treatment'). Hence, a lack of monitoring does not necessarily reflect a lack of treatment. Indeed, 26.0% of beekeepers who treated for varroa did not undertake any formal monitoring during the 2022/23 season (cf. 28.2% for the 2021/22 season and 22.4% for the 2020/21 season).

4.6.2 Varroa treatment

Regardless of monitoring, varroa treatment is critical for reducing winter losses (Le Conte et al. 2010; Rosenkrantz et al. 2010; Dainat et al. 2012). Fortunately, beekeepers have a variety of varroacides and other management tools for helping to control varroa, ranging from synthetic to organic miticides such as essential oils.

Different varroacides affect the mite's biological systems in different ways. For example, flumethrin (marketed in New Zealand as Bayvarol®) and tau-fluvalinate (marketed as Apistan®) cause cell dysfunction by changing the mite's sodium channels (van der Steen & Vejsnæs 2021). Amitraz (marketed as Apivar® and Apitraz®) affects neural transmission by increasing the cell's octopamine receptor (Strachecka et al. 2012). Oxalic acid binds to minerals such as calcium, iron, and sodium, inhibiting their dietary function (Aliano et al. 2006). Thymol (including Thymovar®, Apiguard®, and ApilifeVAR®) and other essential oils disrupt neural functioning (Blenau et al. 2012), while formic acid reduces the availability of oxygen to the mite's body (van der Steen & Vejsnæs 2021).

Active management can also play a role in controlling varroa. For example, because varroa mites prefer drone brood over worker brood for reproduction (Fuchs 1990), removing drone brood significantly reduces the ratio of mites to bees in the colony (Charrière et al. 2003). Similarly, removing all capped brood from the colony in mid-summer ensures that all remaining mites are phoretic (i.e. attached to adult bees); if adults are treated with other methods, then subsequent generations will grow under low varroa loads. Finally, because varroa mites die at temperatures above 41°C while brood can withstand temperatures of up to 45°C for up to 45 minutes (Komissar 1985), hyperthermia is another possibility for non-chemical treatment.

Evidence from earlier waves of the NZ Colony Loss Survey showed that New Zealand beekeepers rely on chemical controls, so the 2023 survey only asked about these treatments. Flumethrin, amitraz (whether Apivar® or Apitraz®), and oxalic acid (whether in the form of sublimation/vaporisation, dribbling/trickling, or glycerine strips/staples) applications are used far more frequently than other forms of treatment.

Figure 29 reports the share of all reporting beekeepers who treat with flumethrin, amitraz, oxalic acid, and any other treatment, alone or in combination. It further indicates that 3.0% of beekeepers did not treat for varroa at all between the first day of spring 2022 and the last day of winter 2023 (cf. 4.4% in 2020/21 and 1.5% in 2021/22).[10]

Between spring 2022 and winter 2023, 9.2% of beekeepers treated with flumethrin only (cf. 12.3% for 2021/22), 10.7% (9.7%) treated with amitraz only, 6.5% (6.3%) used oxalic treatments only, and 5.8% (5.9%) relied exclusively on other forms of treatment (Figure 29). Among beekeepers who used more than one treatment type, the most common combination was flumethrin and amitraz, with 24.8% (28.4%) of beekeepers reporting this combination. Some 7.3% (6.0%) of beekeepers reported treating with flumethrin, amitraz, and oxalic acid, and 2.1% (1.7%) reported using flumethrin, amitraz, oxalic acid, and other treatments.

[10] Beekeepers who manage colonies exclusively in Stewart Island and the Chatham Islands are excluded from these calculations because varroa is not present.

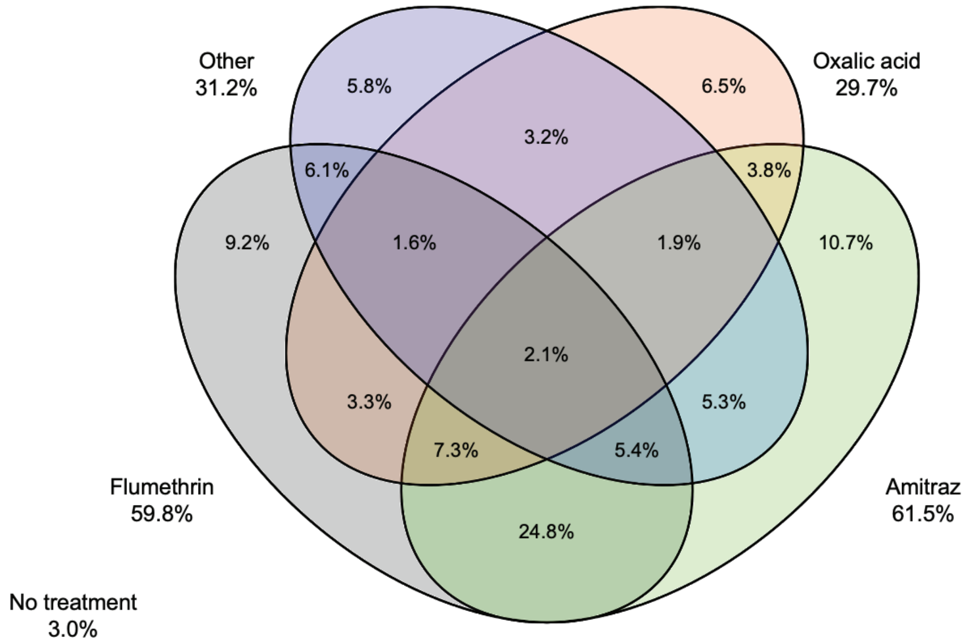

Figure 29: Varroacide treatments used between the first day of spring 2022 and the last day of winter 2023, among all beekeepers.

Among beekeepers with more than 250 colonies, 8.4% treated varroa with amitraz and 67.0% treated with flumethrin; 54.5% treated with both amitraz and flumethrin (cf. 60.1% in 2021/22); and 36.6% treated with amitraz, flumethrin, and oxalic acid (cf. 27.3% in 2021/22) (Figure 30). All beekeepers with more than 250 colonies who completed the 2023 NZ Colony Loss Survey reported that they treated for varroa during the 2022/23 season.

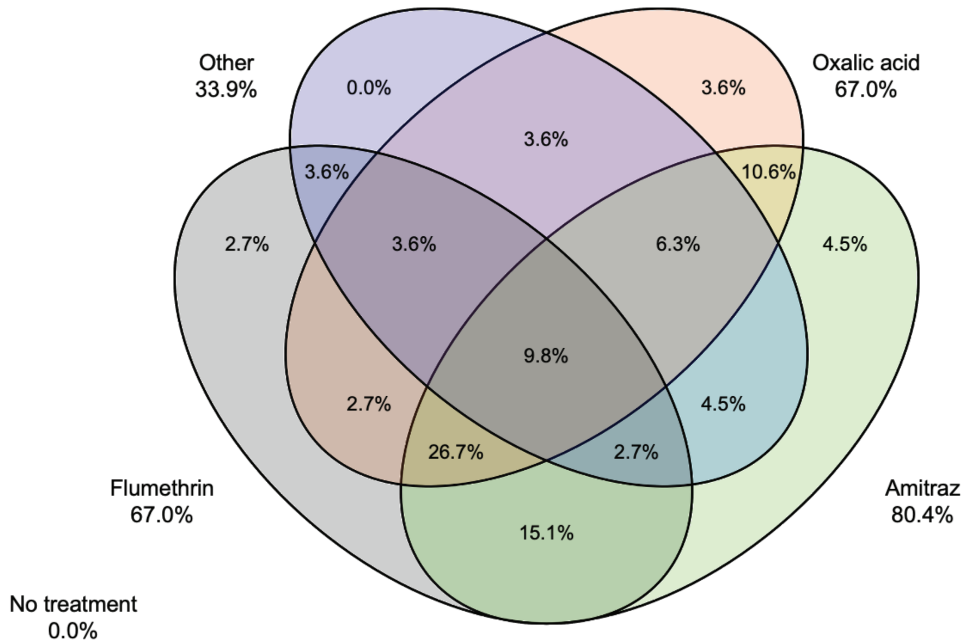

Figure 30: Varroacide treatments used between the first day of spring 2022 and the last day of winter 2023, among beekeepers with more than 250 colonies.

Beekeepers who used each treatment were asked to describe how successful the product or technique was for managing varroa, answering ‘not at all successful’, ‘partly successful’, ‘mostly successful’, or ‘completely successful’. The results are presented in Table 10: Reported effectiveness of varroa treatments, among all beekeepers.

Across treatments, approximately half of beekeepers described the efficacy as being ‘mostly successful’. Treatments are described as being ‘mostly successful’ or ‘completely successful’ by 80.1% of amitraz users,79.1% of tau-fluvalinate users, 75.8% of formic acid users, and 73.9% of flumethrin users. In addition, 66.6% of thymol users, 66.7% of glycerine strip/staples users, and 65.7% of oxalic sublimation/vaporisation users described the treatment as being ‘mostly successful’ or ‘completely successful’. The reported success rate of oxalic dribbling/trickling was considerably lower.

Table 10: Reported effectiveness of varroa treatments, among all beekeepers.

	Amitraz	Flumethrin	Formic acid	Tau-fluvalinate	Thymol	Oxalic: sublimation/ vaporisation	Oxalic: dribbling/ trickling	Oxalic: glycerine strips/ staples
Not at all successful	2.9%	5.0%	3.6%	2.3%	7.1%	3.2%	10.2%	3.4%
Partly successful	16.3%	21.1%	20.6%	18.5%	26.3%	31.1%	34.7%	29.7%
Mostly successful	52.2%	48.8%	48.4%	52.4%	47.4%	52.7%	44.9%	48.0%
Completely successful	28.6%	25.1%	27.4%	26.7%	19.2%	13.0%	10.2%	18.7%
N	1,940	1,892	281	389	369	347	49	663

4.6.3 Colony management among beekeepers with more than 250 colonies

Nearly 83% of colonies managed by beekeepers with more than 250 colonies are primarily used for honey production (Figure 31). In addition, 12.0% are primarily used for pollination, 3.3% are primarily used for the production of queens, and 1.8% are primarily used for the production of products such as bee venom, royal jelly, and propolis.

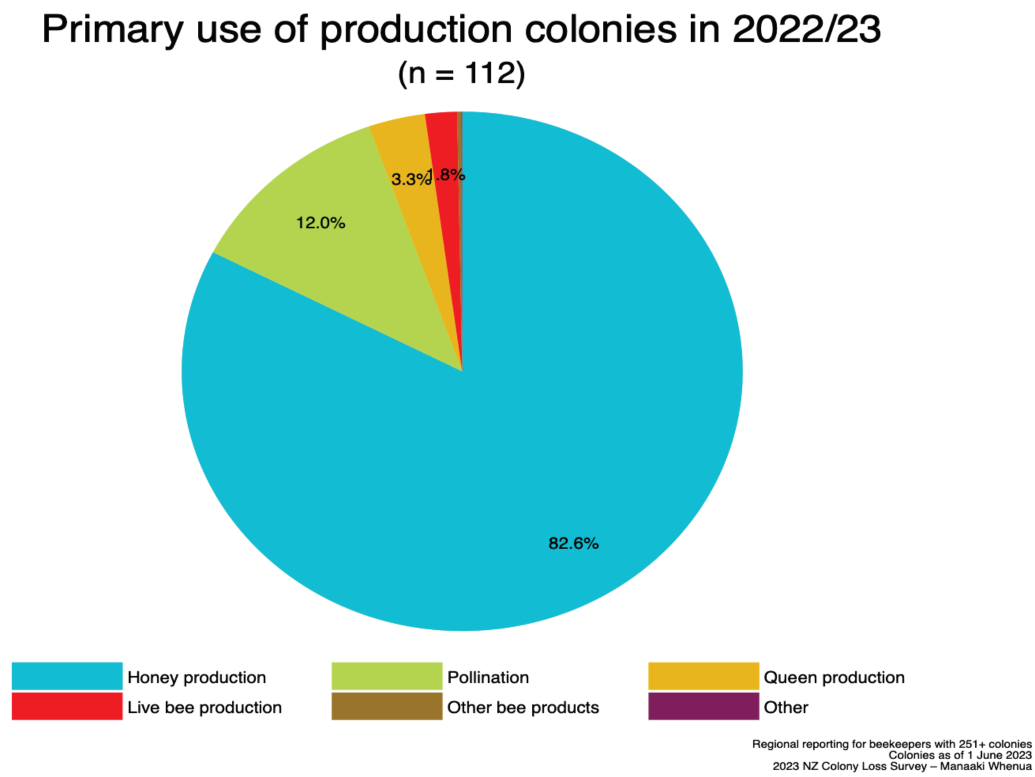

Figure 31: Primary use of production colonies among beekeepers with more than 250 colonies, nationally.

4.7 Profile of New Zealand beekeepers

The final section of the 2023 NZ Colony Loss Survey recorded beekeeper demographics, including gender, age, years of beekeeping experience, and number of generations the family has been involved in beekeeping. It also recorded loss levels that beekeepers consider to be economically sustainable. Finally, it included questions on wellbeing.

4.7.1 Demographics

While both national-scale industry groups and several large and well-known beekeeping operations are led by women, beekeeping in New Zealand is dominated by men. Indeed, two-thirds of survey respondents who provided an answer are male (Figure 32).

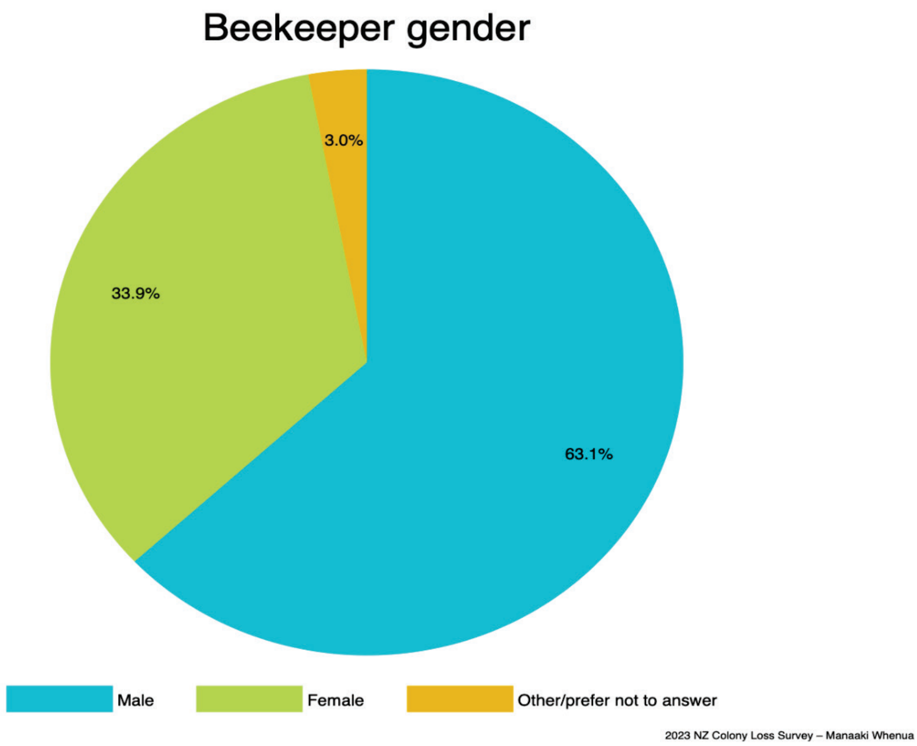

Figure 32: Gender of respondents.

Despite the significant physical demands of beekeeping (e.g. repetitive motion and heavy lifting), few young people are involved in the industry (Figure 33). Indeed, the 2023 NZ Colony Loss Survey has nearly as many respondents in their 80s and 90s (1.8%) as respondents in their late teens and twenties (2.7%). The median respondent was 57 years old.

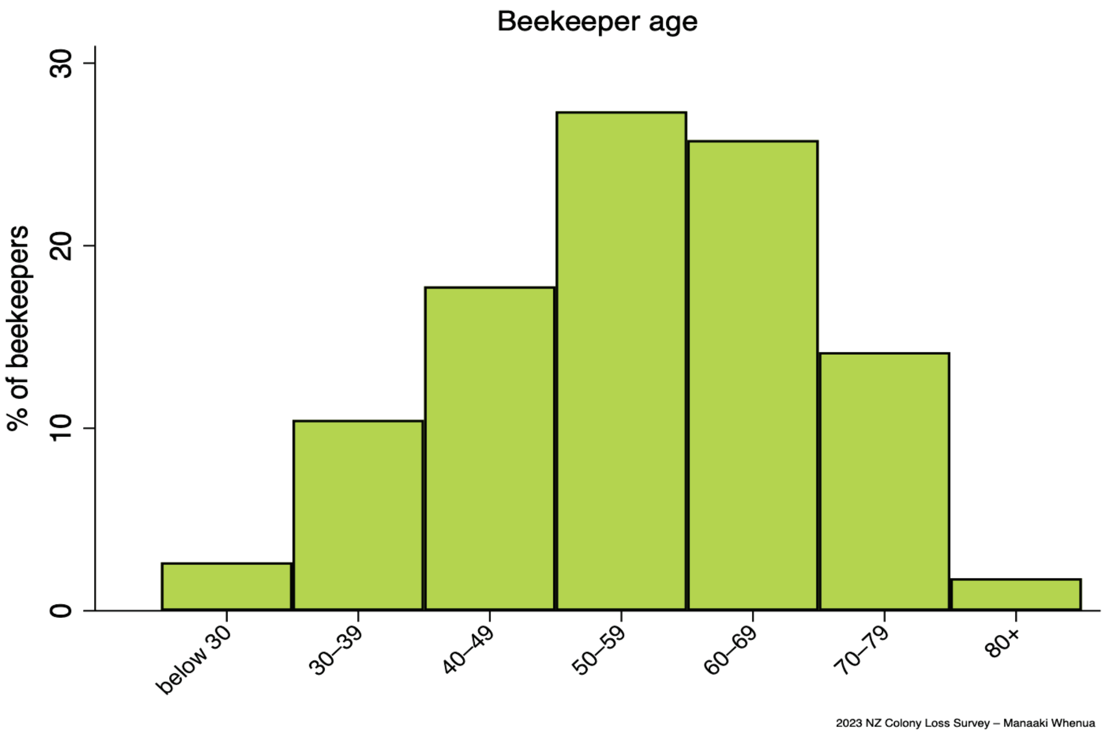

Figure 33: Age of respondents.

The median New Zealand beekeeper has 5 years of experience (Figure 34). More beekeepers have 1 year or less experience than have 21 or more years of experience.

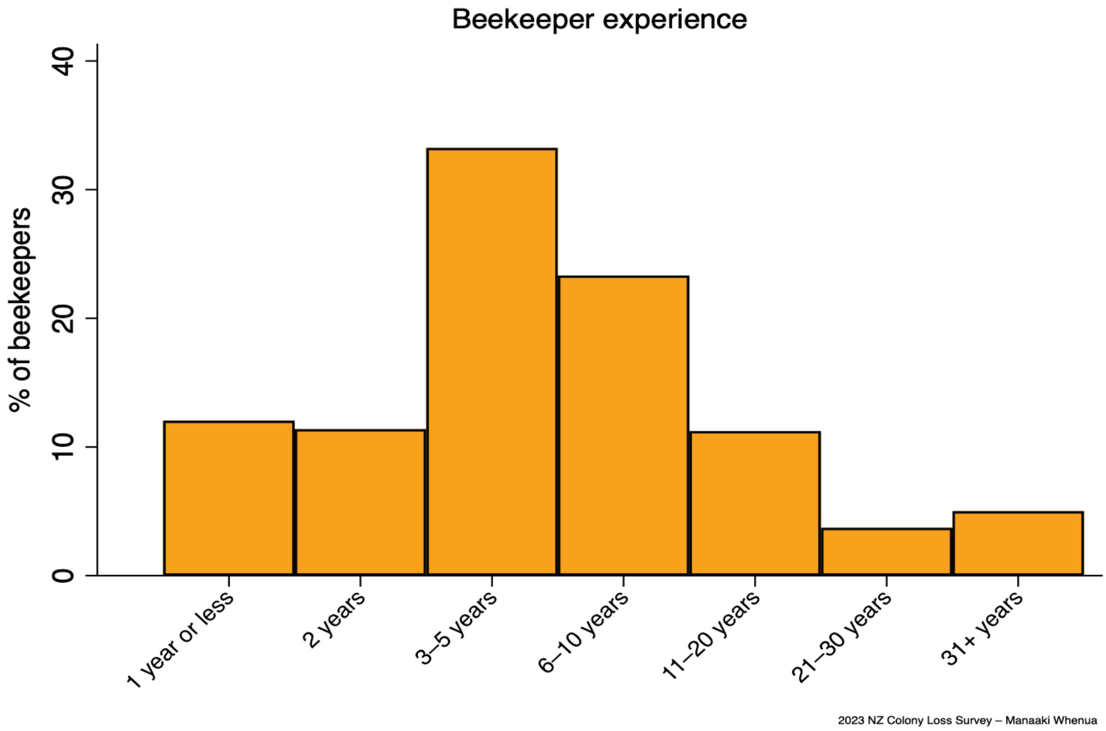

Figure 34: Years of beekeeping experience among respondents.

One percent of all beekeepers have long family histories of beekeeping of four or more generations (Figure 35): 11.8% are second-generation and 3.3% are third generation. The rest are first generation beekeepers.

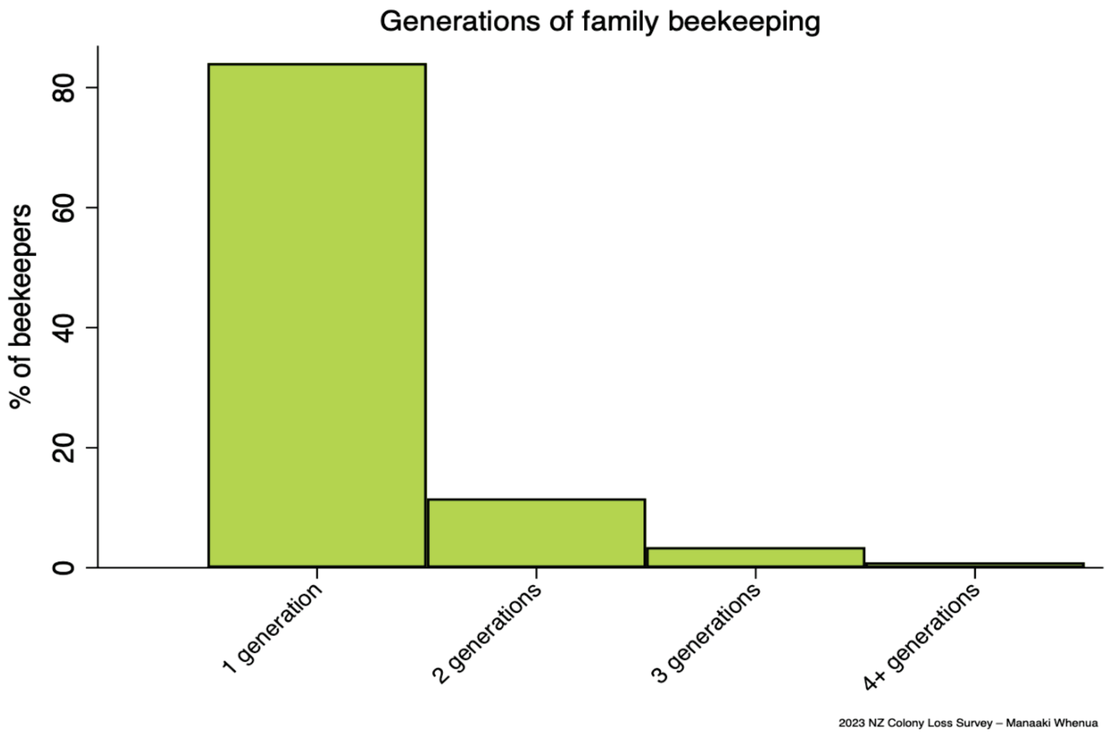

Figure 35: Number of generations that beekeepers' families have been involved in beekeeping.

4.7.2 Economically sustainable losses

Beginning in 2017, respondents were asked to specify the level of over-winter losses – commonly referred to as ‘economic injury level’ – they considered to be economically sustainable. As with past waves of the survey, responses ranged from 0 to 100%. The median acceptable loss was 10%, identical to the median acceptable loss rates in 2018, 2019, 2020, 2021, and 2022.[11]

Figure 36 shows the winter loss rates considered to be economically sustainable by beekeeping operations with 1–50 colonies, 51–250 colonies, and more than 250 colonies. Across all three groups (and for at least the third year in a row), current loss rates exceed the economically sustainable loss rate for a majority of beekeepers. It is thus unsurprising that the number beekeepers with at least 50 colonies registered in HiveHub fell 14% between winter 2022 and winter 2023.

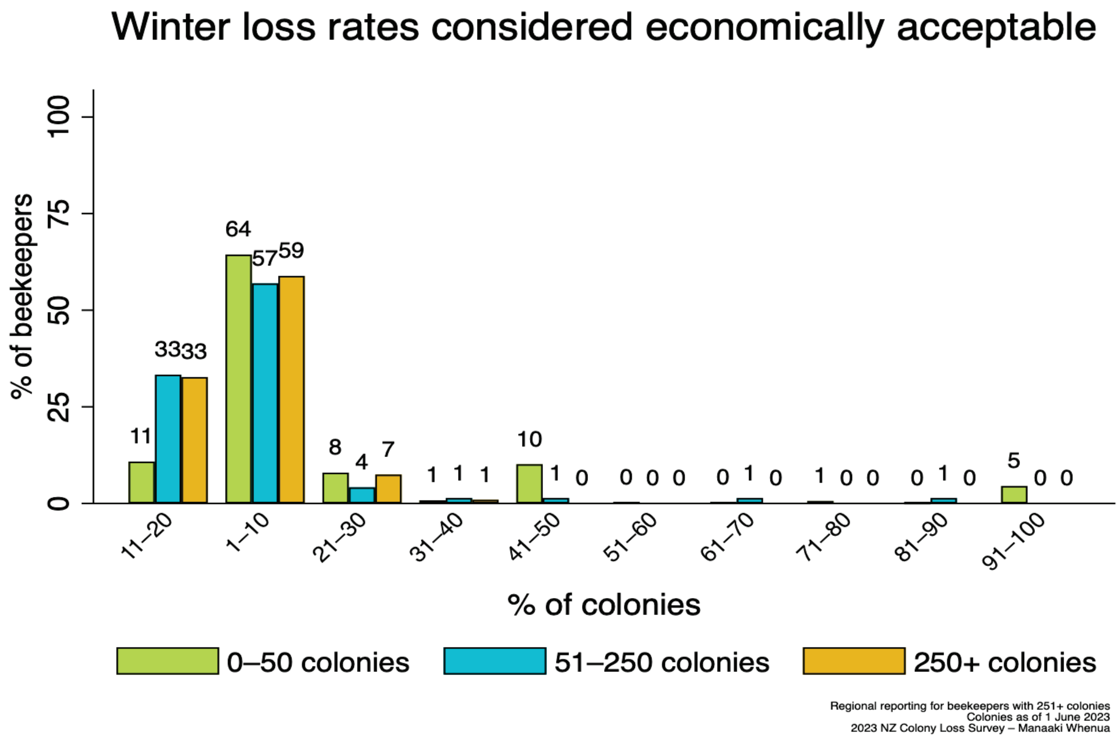

Figure 36: Winter loss rates considered economically acceptable, by operation size.

4.7.3 Wellbeing

Previous waves of the NZ Colony Loss Survey asked beekeepers to reflect on the beekeeping environment, including biosecurity, economics, environment, and lifestyle. Each of these factors potentially affects beekeeper wellbeing. The 2023 survey focused on wellbeing directly by including two common measures of subjective wellbeing: the WHO-5 wellbeing index and the Cantril Ladder measure of life satisfaction.

The WHO-5 inventory (World Health Organisation 1998) is a concise, effective inventory for assessing subjective wellbeing. It has been validated as a screening tool for mental health issues in clinical settings (Bech et al. 2003) and has been used to evaluate the efficacy of interventions to improve wellbeing over time (Topp et al. 2015). The WHO-5 inventory consists of the following five statements:

[11] Bunching at round numbers is not uncommon in survey research. See, for example, Mazza & Hartog 2011.

1. ‘I have felt cheerful and in good spirits’
2. ‘I have felt calm and relaxed’
3. ‘I have felt active and vigorous’
4. ‘I woke up feeling fresh and rested’
5. ‘My daily life has been filled with things that interest me’.

Respondents indicate the extent (measured as frequency) with which they agreed with the statements during the previous 2 weeks on a scale ranging from 0 ('at no time') to 5 ('all of the time'). Summing the values assigned to each statement yields an overall score between 0 and 25. Scores of 18 and above indicate high wellbeing and positive mental health, while scores of 13 and below suggest poor wellbeing and indicate a higher likelihood of experiencing anxiety, depression, and other mental health challenges (Topp et al. 2015).

The average WHO-5 score across all beekeepers is 15.58, which is similar to the average WHO-5 score for the general New Zealand population reported in IPSOS (2021). However, the average score among owner-operators with more than 250 colonies is 13.08. Indeed, 49.4% of these beekeepers fall within the 0–13 range.

Figure 37 describes the WHO-5 score for commercial owner-operators geographically. The average wellbeing score is lowest in the middle South Island and highest in the lower South Island.

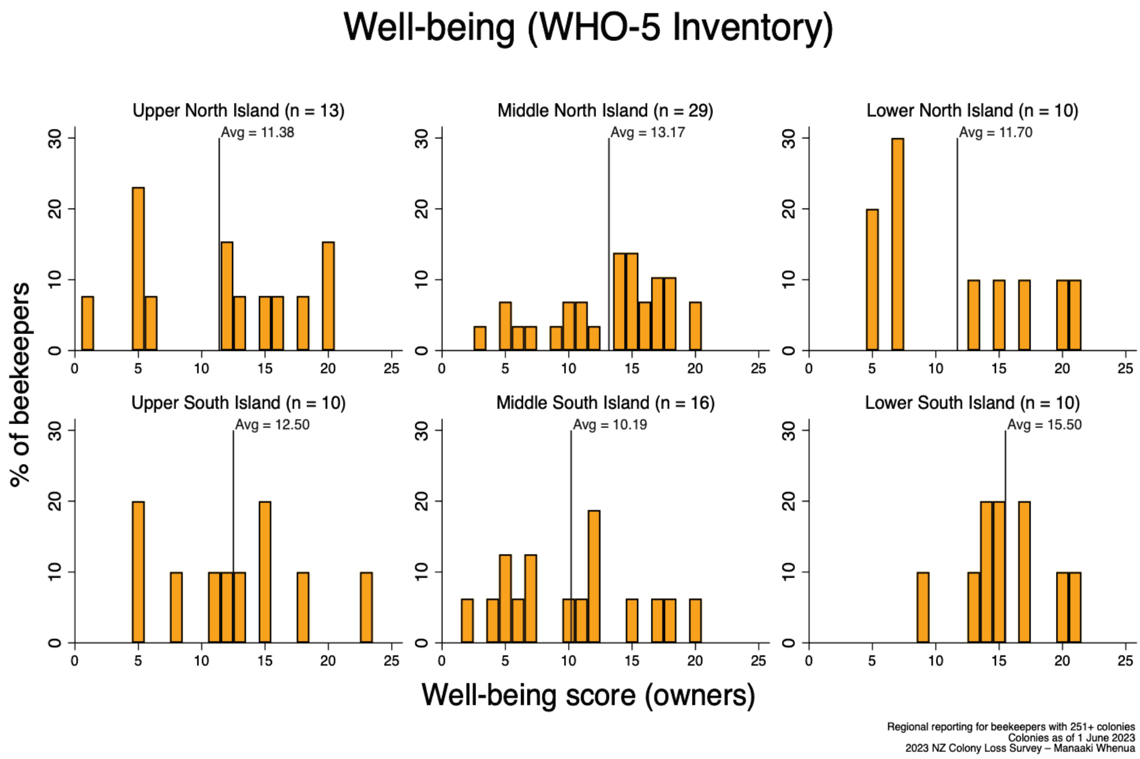

Figure 37: WHO-5 wellbeing score among commercial owner-operators, by region.

Figure 38 reports the average WHO-5 score by operation size, again restricting the analysis to owner-operators. Hobbyists report wellbeing close to the population average while commercial beekeepers report considerably lower wellbeing.

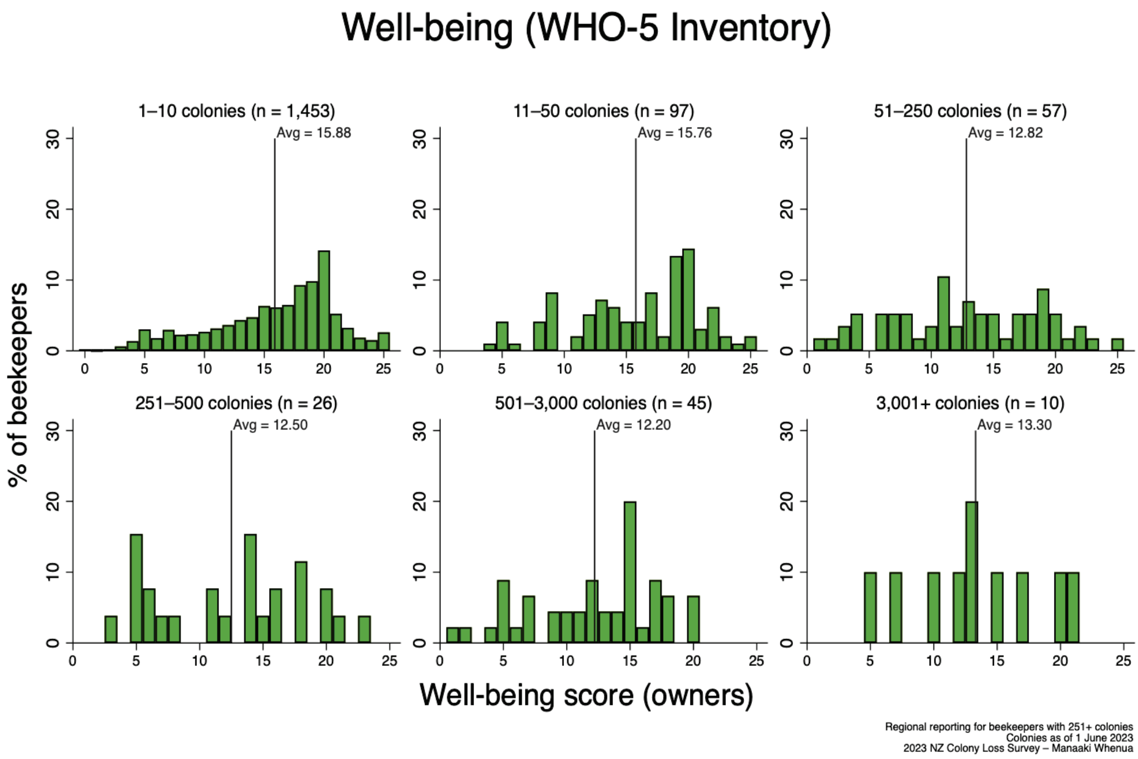

Figure 38: WHO-5 wellbeing score among owner-operators, by operation size.

The Cantril Self-Anchoring Striving Scale, or Cantril Ladder (Cantril 1965), is another measure of subjective wellbeing. The question is worded as follows: 'Please imagine a ladder with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time? On which step do you think you will stand about five years from now?'

The Cantril Ladder measure is included in nationally representative surveys in more than 160 countries (Helliwell et al. 2023) as a robust and reliable measure of life satisfaction (Diener et al. 2009). On this scale, respondents may be categorised as 'thriving' (scores of 7+), 'suffering' (scores of 0–4), or 'struggling' (all other scores) (Gallup 2016). Finland and Denmark reported the highest average scores in 2022 at 7.80 and 7.57, respectively, with New Zealand ranked tenth at 7.12; respondents in Afghanistan reported the lowest average score at 1.86.

The average Cantril Ladder score across all beekeepers is 7.08, which is similar to the average score for the general New Zealand population reported in Helliwell et al. 2023. However, the average score among owner-operators with more than 250 colonies is much lower, at 6.15, at the top end of the 'struggling' range, while 20.9% of commercial owner-operators report Cantril Ladder scores in the 'suffering' range of 0–4.

Among commercial owner-operators, the lowest average Cantril Ladder scores were reported in the upper North Island and middle South Island (Figure 39). Average scores fall within the 'struggling' range in all six regions.

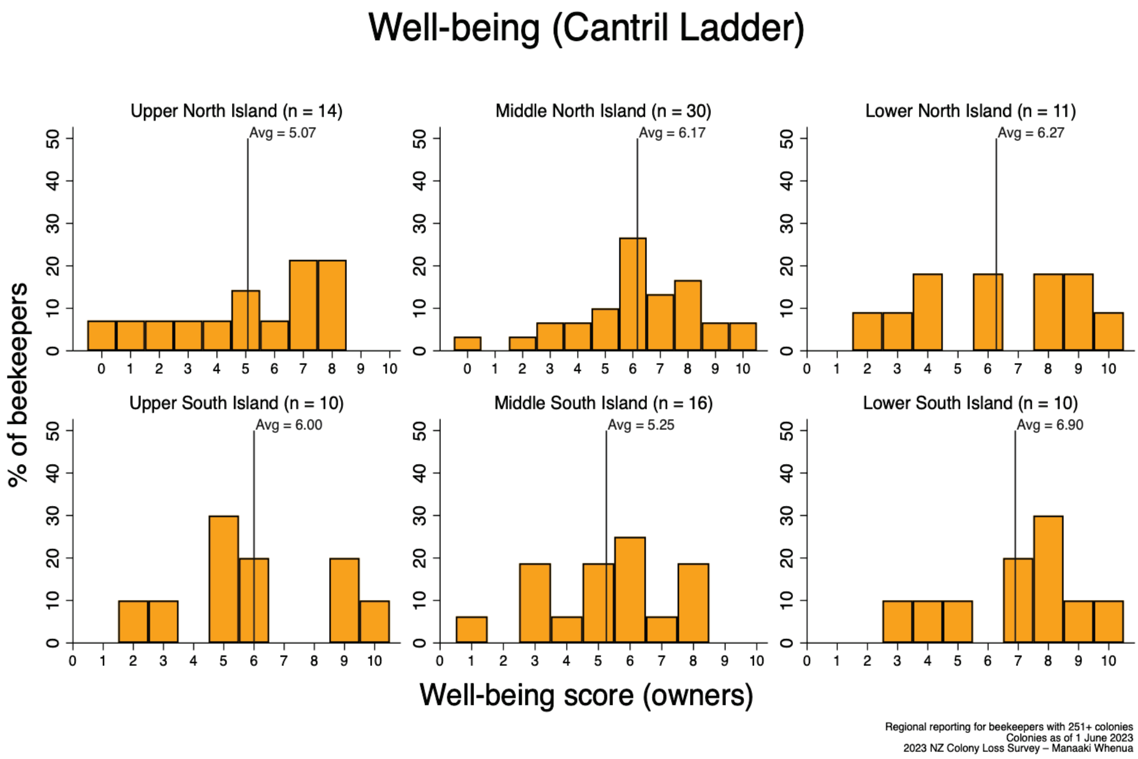

Figure 39: Cantril Ladder wellbeing score among commercial owner-operators, by region.

Figure 40 reports the average Cantril Ladder score by operation size, again restricting the analysis to owner-operators. Small-scale hobbyists report average wellbeing scores slightly above the national average (Helliwell et al. 2023), while commercial beekeepers report considerably lower wellbeing.

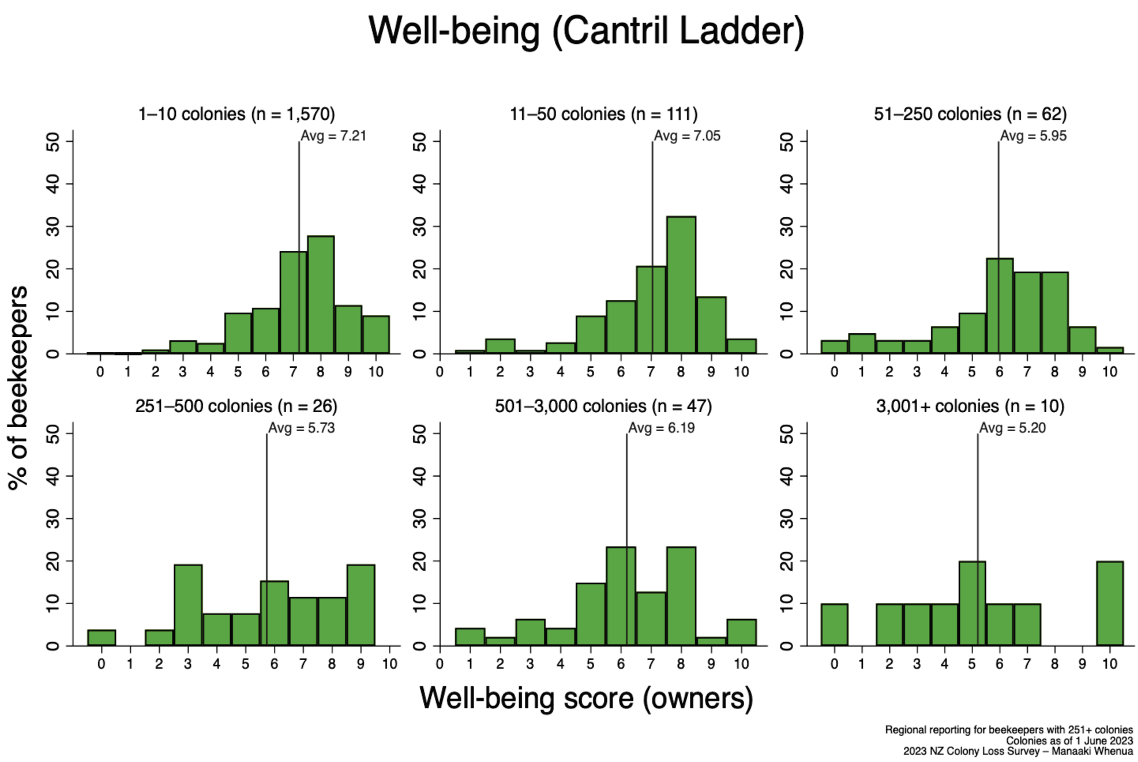

Figure 40: Cantril Ladder wellbeing score among owner-operators, by operation size.

5 Discussion

According to Annual Disease Return filings, there were 595,014 honeybee colonies in New Zealand over winter 2023. We estimate the overall winter loss rate to be 12.65%, meaning that New Zealand lost approximately 75,269 colonies over the winter of 2023. This loss rate is statistically lower than the over-winter loss rates we reported in 2021 and 2022, but higher than those of 2015, 2016, 2017, 2018, 2019, and 2020.

Losses over winter 2023 followed autumn losses of 16.76%. Since this is the first time the survey has recorded autumn losses, we cannot quantify whether losses over autumn 2023 were high relative to recent years, although that is certainly what we have heard from many beekeepers. Regardless, winter and autumn losses have a substantial impact on the profit margin of commercial beekeepers (Stahlmann-Brown et al. 2022a).

While it is relatively straightforward to quantify losses, it is more difficult to extract the underlying causes of colony losses from surveys rather than by lab testing (Stahlmann-Brown et al. 2022b). Nevertheless, between 2017 and 2023, beekeepers most frequently attributed over-winter losses to suspected varroa and related complications, queen problems, suspected starvation, and wasps. Table 11 reports the total share of over-wintering colonies attributed to these causes every year since 2017.

Table 11. Estimated share of all colonies lost to specific causes, 2017–2023.

	2023	2022	2021	2020	2019	2018	2017
Suspected varroa	6.43% [6.03%, 6.86%]	6.37% [6.09%, 6.66%]	5.31% [5.06%, 5.57%]	3.50% [3.29%, 3.73%]	2.95% [2.73%, 3.20%]	2.28% [2.10%, 2.47%]	1.64% [1.49%, 1.81%]
Queen problems	2.81% [2.63%, 3.01%]	3.09% [2.93%, 3.26%]	3.28% [3.14%, 3.44%]	3.74% [3.57%, 3.93%]	3.14% [3.01%, 3.28%]	3.88% [3.74%, 4.03%]	3.33% [3.16%, 3.50%]
Suspected starvation	1.12% [1.02%, 1.23%]	0.86% [0.78%, 0.94%]	0.98% [0.90%, 1.07%]	0.86% [0.78%, 0.94%]	1.04% [0.94%, 1.14%]	0.83% [0.74%, 0.92%]	1.35% [1.24%, 1.46%]
Wasps	0.44% [0.35%, 0.54%]	0.91% [0.79%, 1.05%]	1.66% [1.52%, 1.81%]	0.75% [0.64%, 0.87%]	0.95% [0.84%, 1.07%]	0.90% [0.79%, 1.03%]	0.94% [0.84%, 1.06%]

Suspected varroa first eclipsed queen problems as the leading attribution of colony losses over winter 2021, and the share of losses attributed to varroa has continued to increase. Indeed, while overall winter losses were statistically lower than in 2021 and 2022, losses attributed to varroa have not decreased. Losses to queen problems and wasps were below the 2017–2022 averages, while losses to suspected starvation were slightly above the 2017–2022 averages.

Many colonies were lost to what beekeepers identified as varroa despite having been treated in the autumn. Beekeepers with 1–50 colonies most commonly chalked these losses up to not treating at the right time. Beekeepers with more than 50 colonies most often identified re-invasion as the root cause of their losses to varroa. Varroa losses attributed to ineffective products were higher in 2023 than in 2022, although registered varroacides and various oxalic treatments alike are generally seen as successfully controlling mites. Monitoring for varroa has not changed markedly in recent years.

The 2023 NZ Colony Loss Survey also included questions pertaining to beekeeper demographics and beekeeper wellbeing. The typical New Zealand beekeeper is a first-generation male in his late 50's with 5 years of beekeeping experience managing three colonies. Hobbyist beekeepers reported wellbeing similar to or slightly above national averages using two different measures, while commercial beekeepers reported wellbeing well below national averages on both measures. We hypothesise that honeybee health and biosecurity, financial aspects of beekeeping, regulation and compliance, workload and time management, weather and working outdoors, other beekeepers and landowners, the physical aspects of beekeeping, and technical and financial support for beekeepers potentially affect wellbeing among commercial owner-operators, and we will explore these factors in detail in a separate analysis.

6 Acknowledgements

The 2023 report draws extensively from earlier reports, to which Linda Newstrom-Lloyd and Oksana Borowik contributed extensively.

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8 Questionnaire

Welcome to the 2023 NZ Colony Loss Survey!

This survey is for **every beekeeping operation**, large or small. Whether you lost 0% or 100% of your hives, please complete the survey soon after hives have been opened in spring.
Similar surveys are undertaken in more than 35 countries. In New Zealand, it has been **conducted annually since 2015**. The project is funded by Biosecurity New Zealand and is undertaken by Manaaki Whenua - Landcare Research, a Crown Research Institute.

Your participation makes it possible to identify trends in New Zealand beekeeping, to compare loss rates across countries, and to better understand risk factors. Click here to see a summary of last year's results.

Before you begin, a few important notes related to your privacy:

- Data are collected for **research purposes only**.
- Your participation in this survey is **voluntary**. You can stop the survey at any time. If you decide that you do not want your data to be used, email Pike at the address below before 15 November 2023 and it will be excluded.
- Individual results will remain **confidential** and all data will be stored on password-protected computers. We will not share your personal information with Biosecurity New Zealand, other beekeepers, or anyone else. Read our statement on survey privacy and ethics here.
- **Anonymized results** will be shared with beekeepers and reported in scientific papers and reports.

And a few notes about how the survey works:

- Some questions include blue text, which can be clicked to show additional information. Additional information may include definitions or an explanation of why a question is being asked. Click this text to hide the additional information.
- This year's survey takes about 10 minutes for most small operators and about 20 minutes for most commercial beekeepers.
- We recommend using a computer, but the survey also works on mobile devices (for best results, we suggest turning your phone sideways).
- By completing the survey, you will be eligible for a prize draw for one of five $100 supermarket vouchers.

Please email Pike at surveys@landcareresearch.co.nz if you run into problems.

Q3 Click **YES** to begin the survey, then **NEXT** (scroll down if needed) to continue

- ○ **YES, take me to the survey**
- ○ NO, I don't want to do the survey this year

Q4 Which of the following best describes your beekeeping operation?

- ○ Small-scale or hobby beekeeping
- ○ Commercial or semi-commercial beekeeping

Q5 Which of these best describes your role within the operation?

- ○ Owner/partner/executive
- ○ Apiary manager

Q6 Do you personally manage all apiaries?

- ○ Yes
- ○ No

Q7 Ideally, managers will complete the survey for the apiaries that they manage. Do you wish to complete the survey yourself or to ask managers to complete the survey?

If you will report on some apiaries and managers will report on others, please select 'Apiary managers will complete the survey'.

- ○ I will complete the survey myself

- Apiary managers will complete the survey
- I will complete the survey for some apiaries and apiary managers will complete the survey for other apiaries

Q8 Please enter the email address of each apiary manager in the box below. We will send a request to complete the survey directly to the apiary manager(s).
Enter each address on a new line. ______________________

Q9 Please enter the email address of each apiary manager in the box below. We will send a request to complete the survey directly to the apiary manager(s).
Enter each address on a new line. ______________________

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*The survey has three parts. This first has always covered losses over **winter**. This year, this part of the survey also covers losses during **autumn**.*

*We consider **autumn** to be the time when beekeepers are working to prepare their colonies for winter (i.e wintering down).*

*We consider **winter** to be the time when bees cluster together on the brood combs and when beekeeper management is minimised.*

Q11 Did you have **at least one colony** at the beginning of autumn 2023? At the beginning of winter 2023?

Please only consider colonies that were queenright and that would be strong enough to provide a honey harvest and/or pollination services.

- Beginning of autumn
- Beginning of winter

{For each of the above}

- Yes
- No

Q12 In which region(s) were your apiary sites located during autumn and winter 2023?

Please tick at least one location under Autumn 2023 if you had autumn colonies and at least one location under Winter 2023 if you had winter colonies.

- Autumn 2023
- Winter 2023

{For each of the above}

- Upper North Island (Northland, Auckland, Coromandel)
- Middle North Island (Waikato, Bay of Plenty, Gisborne, Hawke's Bay)
- Lower North Island (Taranaki, Manawatu-Wanganui, Wairarapa, Wellington)
- Upper South Island (Tasman, Nelson, Marlborough)
- Middle South Island (Canterbury, West Coast)
- Lower South Island (Otago, Southland)
- Chatham Islands

Q13 How many production colonies did you have at the **beginning of autumn**? How many production colonies did you acquire or sell/give away or sell as package bees?

Enter whole numbers only. If you do not have an exact figure, please estimate. Please consider autumn to be the time when beekeepers are working to prepare colonies for winter (i.e wintering down).

{For each region}
Viable production colonies at the **beginning of autumn** : ________
How many were **added to this number** during autumn? ________
How many were **sold or given away** during autumn? ________
How many colonies were **sold as package bees**? ________

Q14 At the **end of autumn**, how many were alive but had unsolvable queen problems? How many were lost due to natural disasters or accidents? To theft or vandalism? How many colonies were intentionally depopulated through management? And how many colonies died due to other reasons?

Enter whole numbers only. If you do not have an exact figure, please estimate.
Please include any colonies that were intentionally lost.
For example, if a colony was lost to starvation because it was too expensive to provide supplemental sugar, please include this loss under 'dead upon inspection'. If the beekeeper shook the bees onto the ground, please include this under 'intentionally depopulated by beekeeper management'.

{For each region}
How many of these colonies did you lose during autumn because they were **alive but had unsolvable queen problems**? ________
How many colonies did you lose during autumn because of **natural disasters or accidents**? ________
How many of these colonies did you lose during autumn as a result of **theft or vandalism**? ________
How many of these colonies were **united during the wintering down period** ? (if 5 colonies were united with 5 others, please write 10) ________
How many of these colonies were **intentionally depopulated by beekeeper management**, e.g. shaking bees onto the ground? ________
How many of these colonies **were dead upon inspection** (AFB, varroa, wasps, disease, robbing, starvation, etc) by the end of autumn? ________

Q15 How many of the **{number} colonies that were dead upon inspection in autumn** were lost to each of the following causes?

Enter whole numbers only. If you do not have an exact figure, please estimate.
Please include any colonies that were intentionally lost. For example, if a colony was lost to starvation because it was too expensive to provide supplemental sugar, please include this loss under 'suspected starvation'.

{For each region}
How many of these dead colonies were lost to **AFB**? ________
How many of these dead colonies were lost to **wasps**? ________
How many of these dead colonies were lost to **robbing by other bees**? ________
How many of these dead colonies were lost to **Argentine ants**? ________
How many of these dead colonies were lost to **suspected starvation**? : ________
How many of these dead colonies were lost to **suspected toxic exposure**? : ________
How many of these dead colonies were lost to **suspected varroa and related issues**? : ________
How many of these dead colonies were lost to **suspected nosema and other diseases**? : ________
How many of these were lost to **other causes not listed above**? : ________
How many of these dead colonies were lost to **reasons that you are unsure of**? : ________

Q16 How many production colonies did you have **going into winter 2023**? How many production colonies did you acquire or sell/give away over winter?

Enter whole numbers only. If you do not have an exact figure, please estimate. Please consider winter to be the time when bees cluster together on the brood combs and when beekeeper management is minimised.

{For each region}
Viable production colonies at the **start of winter** : ________
How many were **added to this number** during winter? ________
How many were **sold or given away** during winter? ________

Q17 When you checked colonies **during the first spring round**, how many were alive but had unsolvable queen problems? How many were lost due to natural disasters or accidents? To theft or vandalism? And how many colonies died due to other reasons?
Enter whole numbers only. If you do not have an exact figure, please estimate.
Please include any colonies that were lost for intentionally lost.
For example, if a colony was lost to starvation because it was too expensive to provide supplemental sugar, please include this loss under 'dead upon inspection'.

{For each region}
How many of these colonies did you lose during winter because they were **alive but had unsolvable queen problems**? ________
How many colonies did you lose during winter because of **natural disasters or accidents**? ________
How many of these colonies did you lose during winter as a result of **theft or vandalism**? ________
How many of these colonies were **dead upon inspection** (AFB, varroa, wasps, disease, robbing, starvation, etc) by the end of winter? ________

Q18 How many of the **{number} colonies that were dead upon inspection in early spring** were lost to each of the following causes?
Enter whole numbers only. If you do not have an exact figure, please estimate. Please include any colonies that were intentionally lost. For example, if a colony was lost to starvation because it was too expensive to provide supplemental sugar, please include this loss under 'suspected starvation'.

{For each region}

How many of these dead colonies were lost to **AFB**?	________
How many of these dead colonies were lost to **wasps**?	________
How many of these dead colonies were lost to **robbing by other bees**?	________
How many of these dead colonies were lost to **Argentine ants**?	________
How many of these dead colonies were lost to **suspected starvation**?	________
How many of these dead colonies were lost to **suspected toxic exposure**?	________
How many of these dead colonies were lost to **suspected varroa and related issues**?	________
How many of these dead colonies were lost to **suspected nosema and other diseases**?	________
How many of these colonies were lost to **other reasons not listed above**?	________
How many of these dead colonies were lost to **reasons that you are unsure of**?	________

Q31 Please describe **wasp activity** in your area during autumn and winter 2023.
{For each region for Autumn 2023 and for Winter 2023}

- None
- Little
- Some
- A lot
- Extreme
- Unsure

Q32 In your opinion, what was the single largest factor in **losses to varroa** over winter?

- Did not treat for varroa
- Did not treat for varroa at the right time
- Used ineffective dosage of varroa treatment
- Used ineffective products for treating varroa
- Winter weather conditions
- Reinvasion

Q33 Were any of your production colonies **re-queened** during the 2022-2023 season?
{For each region}

- Yes
- No

Q34 Approximately what **percentage** of the production colonies that you had in winter 2023 were re-queened during the 2022-2023 season?
{For each region}

- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

Q35 Out of all of your queenright colonies in spring 2023, approximately what percentage were **weak**?
{For each region}

- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

*This is the second of three parts of the survey. It focuses on the **2022-2023 season**, especially **varroa**.*

Q37 Did you have at least one colony during the 2022-2023 season (spring through honey flow)?

- ○ Yes
- ○ No

Q38 In which region(s) were your apiary sites located during the 2022-2023 season (spring through honey flow)?

- ▢ **Upper North Island** (Northland, Auckland, Coromandel)
- ▢ **Middle North Island** (Waikato, Bay of Plenty, Gisborne, Hawke's Bay)
- ▢ **Lower North Island** (Taranaki, Manawatu-Wanganui, Wairarapa, Wellington)
- ▢ **Upper South Island** (Tasman, Nelson, Marlborough)
- ▢ **Middle South Island** (Canterbury, West Coast)
- ▢ **Lower South Island** (Otago, Southland)
- ▢ **Chatham Islands**

Q39 During the 2022-2023 season, approximately what share of production colonies were **primarily used** for the following purposes?

Primarily honey production : ________
Primarily pollination : ________
Primarily queen breeding : ________
Primarily live bee production : ________
Primarily other bee products (wax, pollen, beebread, propolis, royal jelly, venom, etc.) : ________
Other (please explain) : ________

Q40 Are your apiary sites in the Lower South Island located on **Stewart Island only**?

- ○ Yes
- ○ No
- ○ Unsure

Q41 We are interested in reporting the impact of Cyclone Gabrielle on beekeepers. Did you lose any colonies as a result of Cyclone Gabrielle?

- ○ Yes
- ○ No
- ○ Unsure

Q42 Please indicate how many colonies you lost as a result of Cyclone Gabrielle.
Colonies lost to Cyclone Gabrielle _____________

Q43 Did you see signs of deformed wing virus or parasitic mite syndrome in your production colonies at any time between spring 2022 and winter 2023 (inclusive)?

- Signs of deformed wing virus e.g. shrunken and deformed wings or other developmental abnormalities.
- Signs of parasitic mite syndrome e.g. spotty brood patterns, increased levels of brood disease, and/or white larvae that are chewed or pecked down by workers.

{for each of the above}

- ○ None
- ○ Limited
- ○ Extensive
- ○ Unsure

Q44 The rest of this section focuses on varroa. Did you **monitor** your production colonies for varroa at any time between spring 2022 and winter 2023 (inclusive)?

- ○ Yes
- ○ No
- ○ Unsure

Q45 What **methods** did you use to monitor your production colonies for varroa between spring 2022 and winter 2023 (inclusive)?
Select all that apply.

- ▢ Alcohol / detergent wash
- ▢ Sticky board (or other collection tray below the hive)

- ▢ Sugar shake / roll
- ▢ Visual inspection of adult bees
- ▢ Visual inspection of drone brood / De-capping brood
- ▢ Sent sample to a lab
- ▢ CO2
- ▢ Other (please explain) ____

Q46 Approximately what % of your tested colonies had mite counts of at least **9 mites per 300 bees (1/2 cup)** at any time between spring 2022 and winter 2023 (inclusive)?

- ○ 0%
- ○ 1-2%
- ○ 3-5%
- ○ 6-10%
- ○ 11-20%
- ○ More than 20%
- ○ Unsure

Q47 Did you **treat** varroa between spring 2022 and winter 2023 (inclusive)?

- ▢ Yes, during **spring build-up 2021**
- ▢ Yes, during **honey flow**
- ▢ Yes, **between harvest and winter**
- ▢ Yes, during **over-wintering**
- ▢ No, did not treat

Q48 What **methods** did you use to treat varroa between spring 2022 and winter 2023 (inclusive)?
Tick all that apply.

- ApiLife VAR®
- ApiStan®
- Apitraz®
- Apivar®
- Bayvarol®
- FormicPro®
- Thymovar®
- Oxalic acid - sublimation / vaporisation
- Oxalic acid - dribbling / trickling
- Oxalic acid - glycerine strips / staples
- Other (please describe below)

{for each of the above}

- ▢ During spring build-up Yes, during **honey flow**
- ▢ During honey flow
- ▢ Between harvest and winter
- ▢ During over-wintering

Tick all that apply.

Q49 Some beekeepers have reported treating for varroa multiple times between harvest and winter. **How many times** did you treat your colonies for varroa during the time between harvest 2023 and winter 2023, on average?

- ○ 1
- ○ 2
- ○ 3+

Q50 In general, **how successful** were these products and techniques for managing varroa between spring 2022 and winter 2023 (inclusive?)
ApiLife VAR®

- ApiStan®
- Apivar®
- Apitraz®
- Bayvarol®
- FormicPro®
- Thymovar®
- Oxalic acid - sublimation / vaporisation
- Oxalic acid - dribbling / trickling
- Oxalic acid - glycerine strips / staples
- {Other Q48}

{For each of the above}

- ○ Not at all successful
- ○ Partly successful
- ○ Mostly successful
- ○ Completely successful

In this part of the survey, we're trying to better understand how various types of pressures in the sector are affecting beekeepers. These same questions were asked in two other surveys recently, one for farmers and one for urban residents. These questions were developed in consultation with our friends at FarmStrong.

Are you interested in answering 4 questions about wellbeing and potential factors related to beekeeping? Or would you rather skip this part of the survey?

- ○ Show me the questions about wellbeing
- ○ I would rather skip these questions

Q51 *In this part of the survey, we're trying to better understand how various types of pressures in the sector are affecting beekeepers. These same questions were asked in two other surveys recently, one for farmers and one for urban residents. These questions were developed in consultation with our friends at FarmStrong.*

Q52 Please indicate for each of the 5 statements which is closest to how you have been feeling over the past 2 weeks. **Over the past 2 weeks...**

- ...I have felt cheerful and in good spirits
- ...I have felt calm and relaxed
- ...I have felt active and vigorous
- ...I woke up feeling fresh and rested
- ...my daily life has been filled with things that interest me

{For each of the above}

- ○ At no time
- ○ Some of the time
- ○ Less than half the time
- ○ More than half the time
- ○ Most of the time
- ○ All of the time

Q53 *This question is called Cantril's Ladder, and it has been used to measure wellbeing of hundreds of thousands of people worldwide.*

Please **imagine a ladder** with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time? On which step were you standing about 5 years ago? On which step do you think you will stand about 5 years from now?

- Present time
- 5 years ago
- 5 years from now

{For each of the above}

- ○ 0: Worst possible life for me
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10: Best possible life for me

Q54 How do each of the following factors affect how you are feeling at the present time, if at all? Please consider both positive and negative aspects of each category, if applicable.

- Honeybee health and biosecurity
- Financial aspects of beekeeping
- Regulation and compliance
- Workload and time management
- Weather and working outdoors
- Other beekeepers and landowners
- Physical aspects of beekeeping
- Technical and financial support for beekeepers
- Other factors (please describe)

{For each of the above}

- ○ Very negative
- ○ Somewhat negative
- ○ Neither negative nor positive
- ○ Somewhat positive
- ○ Very positive

{For Q56 - Q62, only one question is displayed to the user which is chosen randomly}

Q55 You chose {answer Q54} under **honeybee health and biosecurity**. Please briefly describe the things that came to mind when you thought about honeybee health and biosecurity.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

Q56 You chose {answer Q54} under **financial aspects of beekeeping**. Please briefly describe the things that came to mind when you thought about financial aspects of beekeeping.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

Q57 You chose {answer Q54} under **regulation and compliance**. Please briefly describe the things that came to mind when you thought about regulation and compliance.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

Q58 You chose {answer Q54} under **workload and time management**. Please briefly describe the things that came to mind when you thought about workload and time management.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

Q59 You chose {answer Q54} under **weather and working outdoors**. Please briefly describe the things that came to mind when you thought about weather and working outdoors.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

Q60 You chose {answer Q54} under **other beekeepers and landowners**. Please briefly describe the things that came to mind when you thought about other beekeepers and landowners.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

Q61 You chose {answer Q54} under **physical aspects of beekeeping**. Please briefly describe the things that came to mind when you thought about physical aspects of beekeeping.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

Q62 You chose {answer Q54} under **technical and financial support for beekeepers**. Please briefly describe the things that came to mind when you thought about technical and financial support for beekeepers.
Note: The factor we ask you to comment on was chosen randomly. We'll ask other beekeepers about the other factors.

This final part of the survey focuses on who you are as a beekeeper. It covers both personal and financial aspects. If you don't want to answer any of these questions, please select 'prefer not to answer'.

Q64 What is your **gender**?
- Male
- Female
- Other gender

Q65 What is your **birth year**?
Your birth year:
- Prefer not to answer
- {selection between 1919 and 2005}

Q66 Approximately how many years of **beekeeping experience** do you have? Please round to the nearest number.
- prefer not to answer
- Less than 1 year
- {selection between 1 year and 60 years}
- more than 60 years

Q67 How many **generations** has your family been involved in beekeeping?

- 1 generation
- 2 generations
- 3 generations
- 4 generations
- 5 generations
- 6 or more generations
- unsure / prefer not to answer

Q68 Which of the following best describes your **role** in this beekeeping operation?

- Owner
- Paid employee
- Unpaid helper
- Other (please describe) ____

Q69 Approximately what share of your **household income** was derived from beekeeping in the last 12 months?
Why are we asking this question?
We'd like to better understand how much beekeepers rely on beekeeping for their livelihoods.

- 0%
- 1%-10%
- 11%-25%
- 26%-40%
- 41%-60%
- 61%-75%
- 76%-90%
- 91%-99%
- 100%
- Unsure
- Prefer not to answer

Q70 What percent of over-winter losses do you consider to be **economically sustainable**?

- 0%
- 1%
- 2%
- 3%
- 4%
- {5% to 100% in increments of 5}
- Unsure / prefer not to answer

Q71 Thank you for completing the 2023 NZ Colony Loss Survey. If you have any comments about the survey, please enter them in box below. **Press NEXT to submit your survey.**

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