Utilisation of the Sugarbag Bee, *Tetragonula carbonaria*, for Education in Environmental Awareness

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Disclaimer

All procedures for data collection and analysis in this report have been properly addressed to ensure quality assurance/service improvement (e.g. to help inform Ku-ring-gai Council in future decisions about the program).

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Executive Summary

Most people living in the Sydney region are not familiar with native bees. Many people, when they think of bees, picture of the European honey bee. However, Australia is home to 1,600 species of native bees of which 14 species are stingless. Australian species of stingless bees belong to two genera: *Tetragonula* and *Austroplebeia*. Ku-ring-gai Council developed a program known as the Native Beehive Program which places hives of *Tetragonula carbonaria* (a native stingless bee that occurs naturally in Sydney) on residential properties in the Ku-ring-gai local government area.

In 2012, a survey was undertaken to test whether placements of beehives changed people's opinions and/or preceptions of the environment as well as determine what were the consequences from owning a *T. carbonaria* hive. At the time of the survey, 250 hives had been placed on residential properties in the council area and so a response from up to 185 people indicates the immense interest in this program. Using the Ku-ring-gai council survey, we predict that *T. carbonaria* will educate people in enironmental awareness, engaging people to have a better appreciation for the environment as participants' have responsibility to look after colony mortality and knowledge from the program of their importance to our native ecosystems.

The survey involved 18 multiple choice questions and one extended response question related to participants' experience in the Native Beehive Program. Additionally, a voluntary focus group of four participants was used to elucidate more personal experiences.

The survey revealed that after the instalment of *T. carbonaria* beehives, people expressed a deeper appreciation of insects in their garden including all native bees, honey bees, beetles, wasps, cockroaches and mosquitoes. The survey found that 41.67% of participants observed their beehive 'once or twice a day', followed by 27.77% observing a 'couple of times per week'. Another positive trend highlighted by the survey is that the majority of respondents (99.5%) believe that owning a beehive was enjoyable and most respondents (98.9%) believe that the bees are important for the ecosystem.

Utilisation of *T. carbonaria* have proved to be ideal facilitators for education in environmental awareness by changing people's opinions in three important areas:

1. More than 50% of survey participants reduced or stopped using insecticides
2. Up to 71% of survey participants became much more aware of other native bees
3. Roughly 30% of survey participants connected extreme weather events that could adversely affect their hive with climate change

Some limitations of the survey were that questions in relation to 'before' instalment of beehives and 'after', were answered subsequently during the program therefore affecting the reliability of the data. Overall, survey results show unintended consequences of the Native Beehive Program include increased planting of native flora species in gardens, reduction in the use of insecticides, understanding the importance of pollintar species, as well as provide a greater awareness of the effects of climate change on insects due to the sentivity of *T. carbonaria* to extreme temperatures.

Based on the overwhelming positive results revealed by the survey, it is recommended that Ku-ring-gai Council expand the program and that other Councils adopt this program.

1. Introduction

Australian species of stingless bees belong to two genera: *Tetragonula* and *Austroplebeia* (Michener 1990). The Tetragonula genus contains six species: *T. carbonaria, T. clypearis*, *T. davenporti*, *T. hockingsi*, *T. mellipes* and *T. sapiens* (Dollin *et al*. 1997). The sugarbag bee (*T. carbonaria*) is a native stingless bee (Hymenoptera: Apidae) endemic to Australia. *Tetragonula carbonaria* is a tiny black-coloured bee exhibiting a maximum length of 4mm (Heard & Dollin 2000), considerably smaller than the common European honey bee (*Apis mellifera*). They nest in hollow trees and logs in pantropical and temperate eucalyptus forests. Their range extends from southern Queensland as far south as Sydney (Amano *et al.* 2000). *Tetragonula carbonaria* are known to pollinate orchids (such as *Dendrobium lichenastrum*; Van der Cingel 2001) and cycads (such as *Cycas media*; Ornduff 1991). *Tetragonula carbonaria* produce consumable honey and honeycombs in their hives (Michener 2000) which are sold commercially in healthcare food stores. Stingless bee honey were used by indigenous Australians for many centuries and play a vital part in their culture (Halcroft *et al.* 2013).

Interest in stingless beekeeping has increased in recent years and conservation groups have been established, especially in south eastern Australia (Halcroft *et al.* 2013). Many conservation groups have successfully removed and relocated hives under threat from tree clearing for urbanised development (Halcroft *et al.* 2013). Other key threats to stingless bees include insecticide use and the misidentification for bees as flies. Artificial beehives developed by Heard (1988) and others, as well as educational publications by the Australian Native Bee Research Centre, have helped to facilitate conservation efforts to protect our native bees (Halcroft *et al.* 2013).

Tetragonula carbonaria are the only native social bee found as far south as Sydney (Amano, Nemoto, & Heard 2000). Recently Ku-ring-gai Council in collaboration with Wild Things NSW has developed husbandry techniques similar to Heard (1988) in attempt to educate the general public. This is known as the Native Beehive Program or the *T. carbonaria* project. The program is part of the Wild Things initiative, which aims to connect and familiarise residents of the Ku-ring-gai area with the Australian native bee. Ku-ring-gai Council has placed over 450 wooden box artificial hives, known as OATH (Original Australian Trigona Hive) throughout the council region to voluntary residential homes free of cost. Placements of beehives are strictly for educational purposes, although the program is currently experimenting with honey production. Hence, residents have the privilege to hold the hive in their gardens thereby receiving a variety of mutual benefits from an individual level (educational and emotional benefit), to the broader ecosystem level (fostering the preservation of native bees and enhancing the local ecosystem).

Not only can *T. carbonaria* be an avodcator for environmental awareness, but it can also raise awareness of the effects of extreme temperatures affecting their hives, hence climate change. *Tetragonula carbonaria* has an optimum temperature range of 18–38°C (Heard & Hendrikzn 1993). Temperatures outside their natural range can have dramatic consequences on the native bees survival. Insulation in beehives can help allievate temperature extremes. When temperatures exceed 44°C, simple precautions such as placing a wet towl over the wooden hive, relocation to a cooler area, or using foam insulation is very successful in preventing over-heating. Therefore we can predict that owning a beehive may create awareness of climate change with varying extremes in temperature.

Here we report and discuss the findings from an online survey conducted by Ku-ring-gai Council in 2012 on the change in opinions of participants in the Native Beehive Program. It was hoped that residents housing artifical beehives might reduce any intended use of insecticides, educate visitors by placing beehives in a public space, and provide a greater awareness of climate change. At the time of the survey, 250 hives had been placed on residential properties in the council area and so a response from up to 185 people indicates the immense interest in this program. Using the Ku-ring-gai council survey, we predict that *T. carbonaria* will educate people in enironmental awareness engaging people to have a better appreciation for the environment as participants' have a responsibility to look after colony mortality and knowledge from program highlighting their importance to our native ecosystems.

2. Methodology

Evaluation of *T. carbonaria* as a facilitator for environmental awareness comprised of an online survey and a focus group. The online survey was designed and produced through 'Survey Monkey' (www.surveymonkey.com) which allowed most participants to answer questions from their homes.

The survey sampled current participants of the Native Beehive Program, hence the questions were directed to their personal experience of keeping *T. carbonaria*. The survey was comprised of 18 multiple choice questions and one open ended question requiring a written response. Fourteen out of the 18 questions allowed room for extended responses, enabling participants to elucidate their opinions and experiences. The survey aimed to investigate changes in the participant's attitudes towards the native bees, as well as other important garden insects such as ants, mosquitoes and cockroaches that are essential for nutrient cycling and pollination. For example (see Appendix 1) participants were asked, 'Before your hive how did you feel about these insects? (Likert scale: 0 = not bothered by them, 4 = significantly bothered by them)'. This was compared with participant's perspectives after owning a beehive to measure any shifts of attitudes towards the importance of insects and their role in the environment.

Furthermore the survey aims were designed to understand the benefits and the experiences that those participating in the project were undergoing from owning a beehive. For example (see Appendix 1) questions such as, 'Do you enjoy having your bee hive?' and 'Has your attitude towards your garden changed in any way?' These sorts of questions will help access the successfulness of the program.

We will not focus on all the survey questions, but those that reveal a change in the perceptions of participants in the Native Beehive Program. By this we can identify any potential unintended consequences of owning an artificial beehive.

A focus group was conducted by a Macquarie University student and program organiser. It consisted of a conversation between four participants in order to obtain a better understanding of their experience in the Native Beehive Program. Topics such as introduction to beehive housekeeping, potential interactions with bees, and education to the public were discussed. The focus group conversation allowed more detailed responses than were permitted by the survey. Overall, we can interpret and gain a better understanding from participants' experiences coupled with survey responses, than from the survey alone.

3. Results

3.1 Native Beehive Program

3.1.1 Applicants Reponses to Multiple Choice Questions

Participants responded to the question, 'Before receiving your beehive how did you feel about the following insects: native Australian bees, honey bees, ants, flies, beetles, wasps, cockroaches, mosquitoes, and ticks?' Participants were then asked the question, 'Since receiving your beehive how do you feel about these insects now?' Figures 1 to 9 demonstrate the participant's tolerance to each taxon. Participants could answer on a Likert spectrum from 0 = 'Not bothered by them' to 4 = 'Significantly bothered by them'. Answers 1 to 4 represent some sort of worried concern to each taxon.

Before the installment of beehives, 95.05% of participants (n = 182) stated that they were not bothered by native bees, hence not worried by their presence in the garden. After installation of beehives, peoples' tolerance for native bees increased by 3.29% (see Figure 1). In comparison, before the installment of beehives, 84.15% of participants (n = 183) were not bothered by honey bees. After installation of beehives, peoples' tolerance for honey bees increased by 0.21% (see Figure 2). Before the installment of beehives, 59.02% of participants (n = 183) were not bothered by ants. After installation of beehives, peoples' tolerance for ants increased by 4.12% (see Figure 3). Overall most people were fairly bothered by flies. However, before the installment of beehives, 25.14% of participants (n = 183) were not bothered by flies. After installation of beehives, peoples' tolerance for flies increased by 0.42% (see Figure 4). Before the installment of beehives, 74.73% of participants (n = 182) were not bothered by beetles. After installation of beehives, peoples' tolerance for beetles increased by 0.13% (see Figure 5). Before the installment of beehives, 25.14% of participants (n = 183) were not bothered by wasps. After installation of beehives, peoples' tolerance for wasps increased by 2.08% (see Figure 6). Overall the majority of people were significantly bothered by cockroaches. Although, before the installment of beehives, 15.38% of participants (n = 182) were not bothered by cockroaches. After installation of beehives, peoples' tolerance for cockroaches increased by 4.73% (see Figure 7). Generally the bulk amount of people were significantly bothered by mosquitoes. Nevertheless, before the installment of beehives, 9.44% of participants (n = 180) were not bothered by mosquitoes. After installation of beehives, peoples' tolerance for mosquitoes increased by 0.50% (see Figure 8). In conjunction, people were significantly bothered by ticks before and after the Native Beehive Program. Before the installment of beehives, only 9.34% of participants (n = 182) were not bothered by ticks. After the installation of beehives, people's tolerance for ticks decreased by 0.40% (see Figure 9). This will be further deliberated in the discussion.

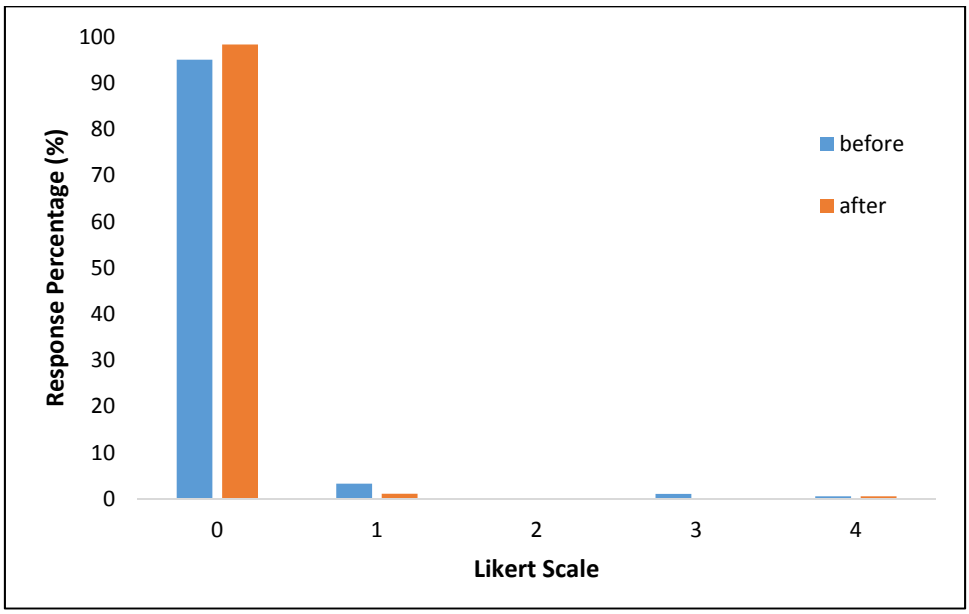

Figure. 1 Participant's responses of tolerance towards native Australian bees before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 182; after n = 181) could either reply 0 = not bothered by them; 1 = a bit bothered by them, 2 = somewhat more bothered by them, 3 = very bothered by them, or 4 = significantly bothered by them. By Jones, 2015.

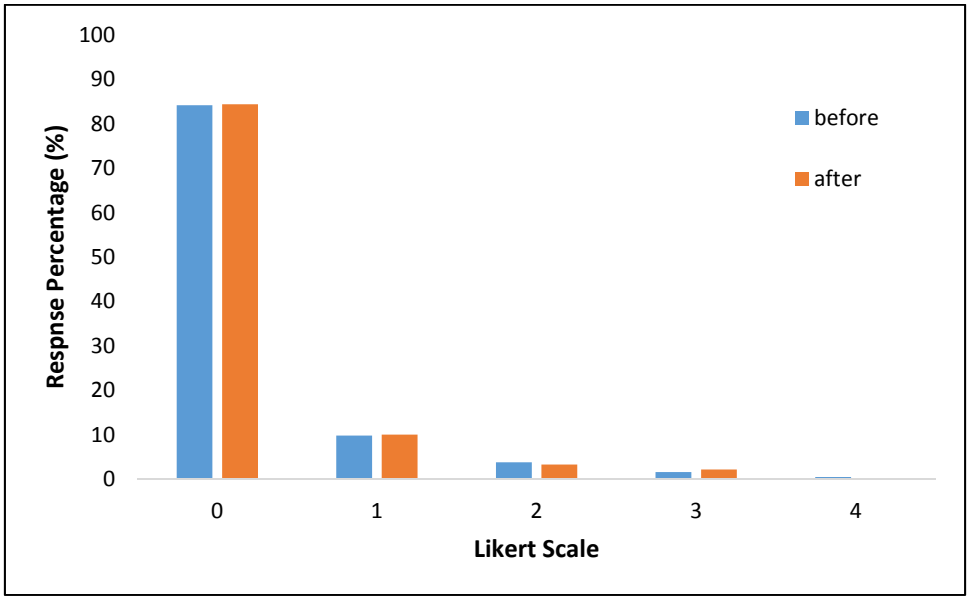

Figure. 2 Participant's responses of tolerance towards honey bees before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 183; after n = 179) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

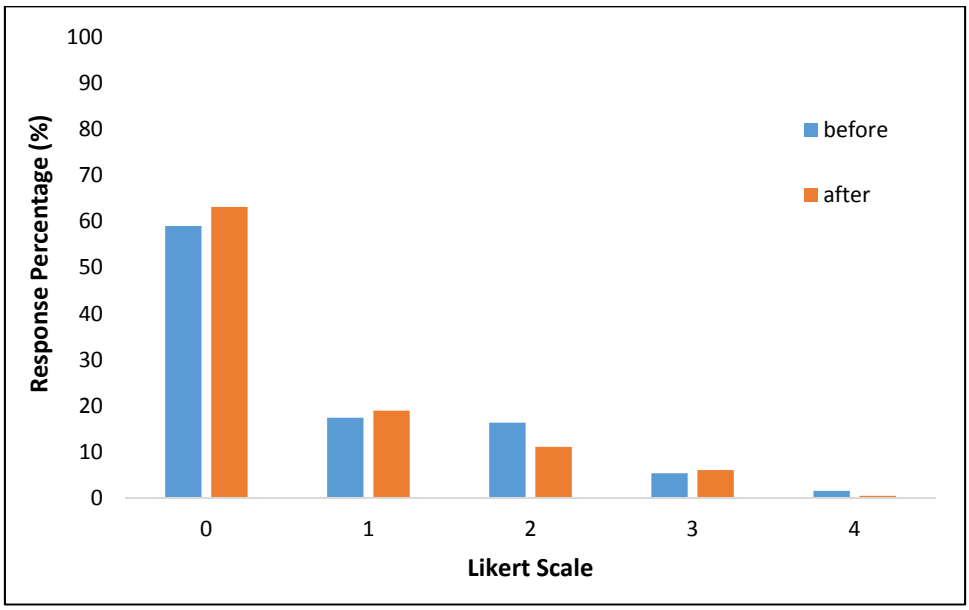

Figure. 3 Participant's responses of tolerance towards ants before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 183; after n = 179) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

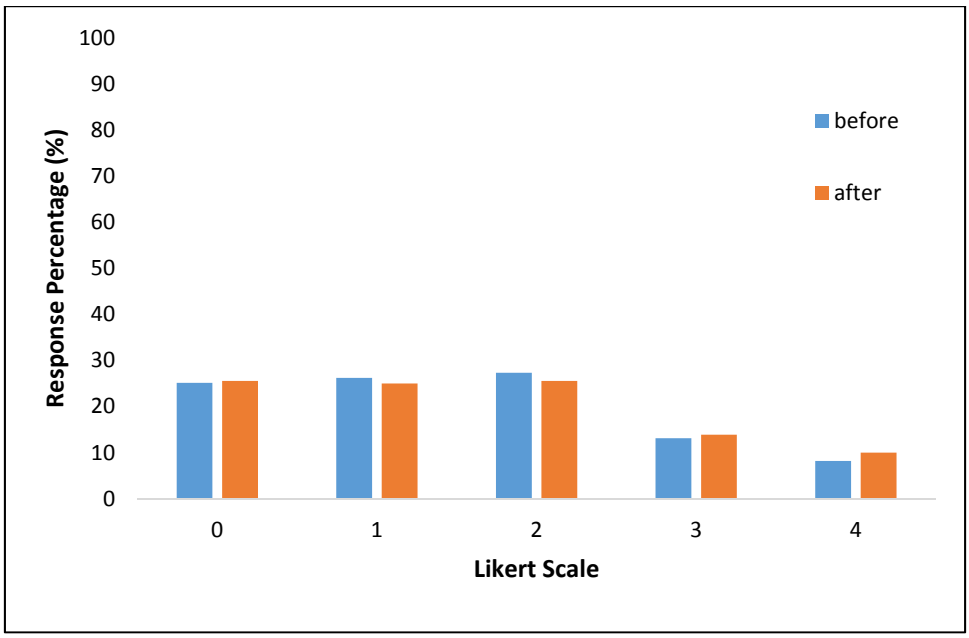

Figure. 4 Participant's responses of tolerance towards flies before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 183; after n = 180) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

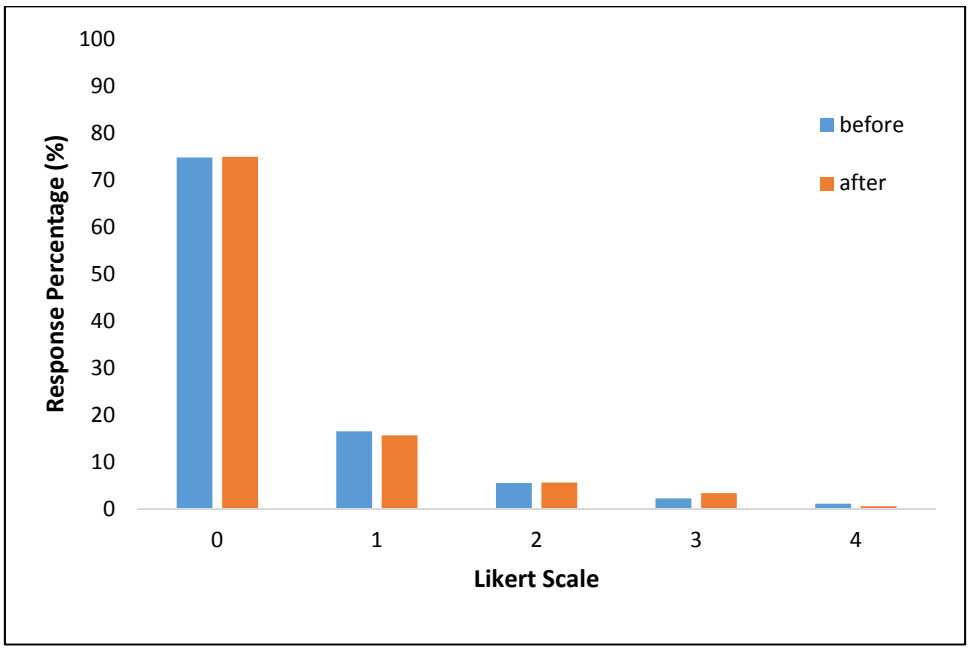

Figure. 5 Participant's responses of tolerance towards beetles before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 182; after n = 179) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

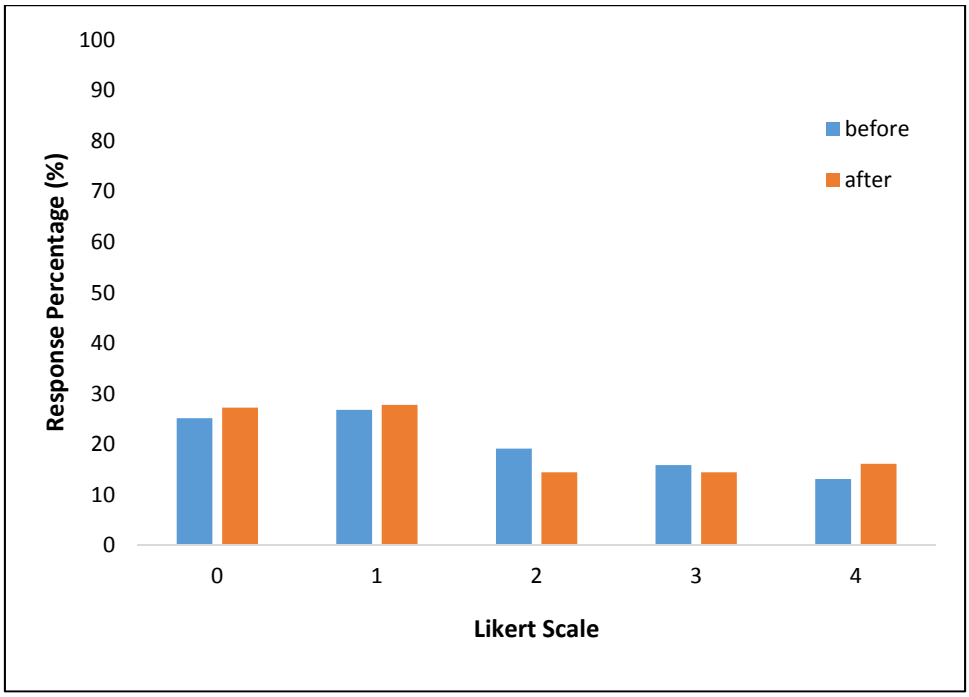

Figure. 6 Participant's responses of tolerance towards wasps before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 183; after n = 180) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

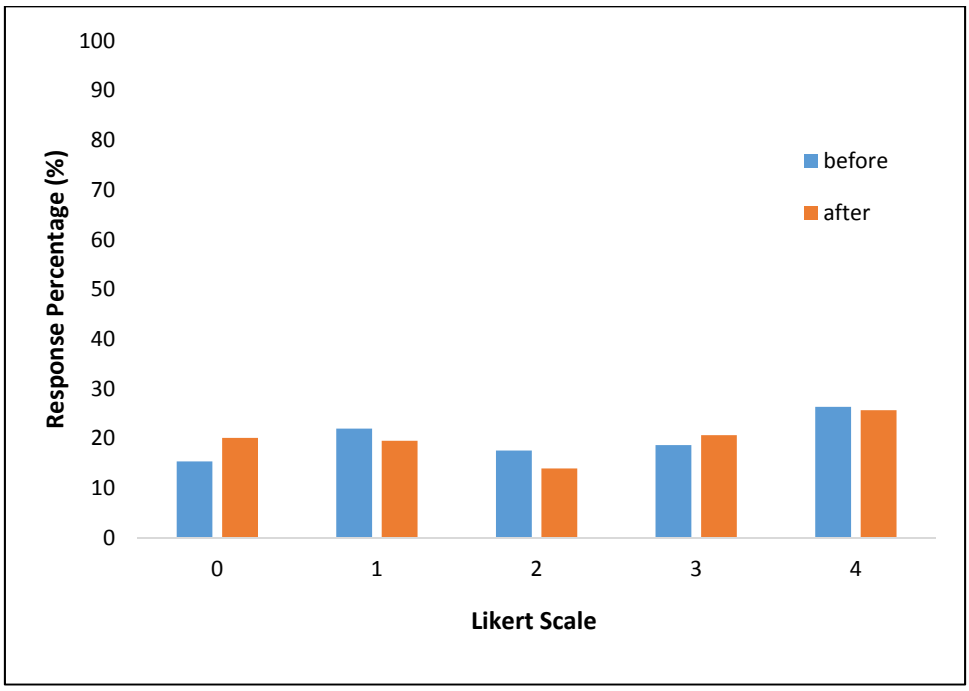

Figure. 7 Participant's responses of tolerance towards cockroaches before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 182; after n = 179) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

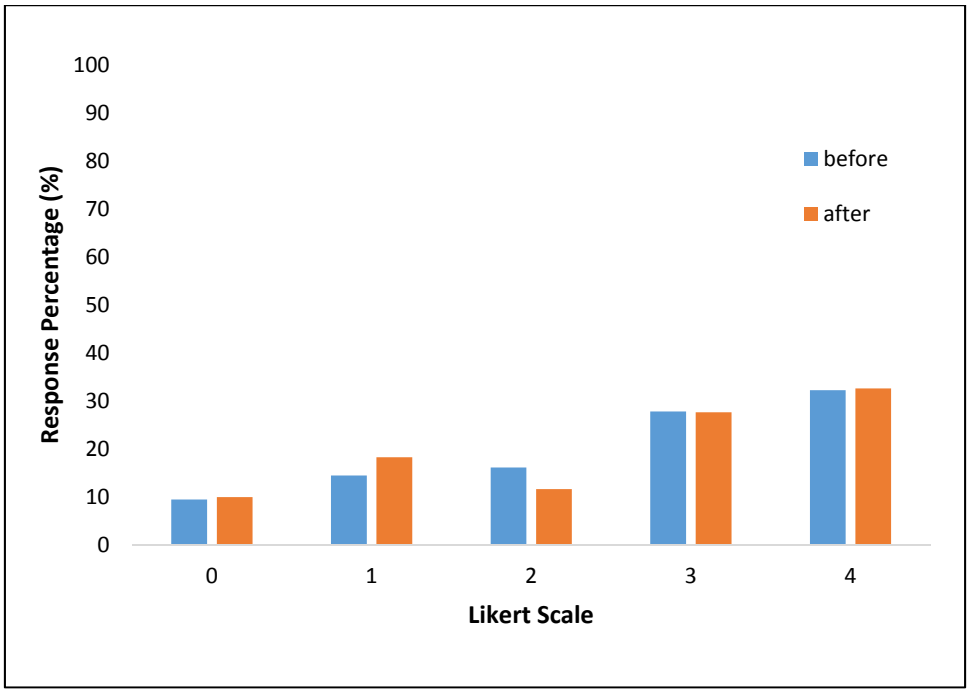

Figure. 8 Participant's responses of tolerance towards mosquitoes before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 180; after n = 181) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

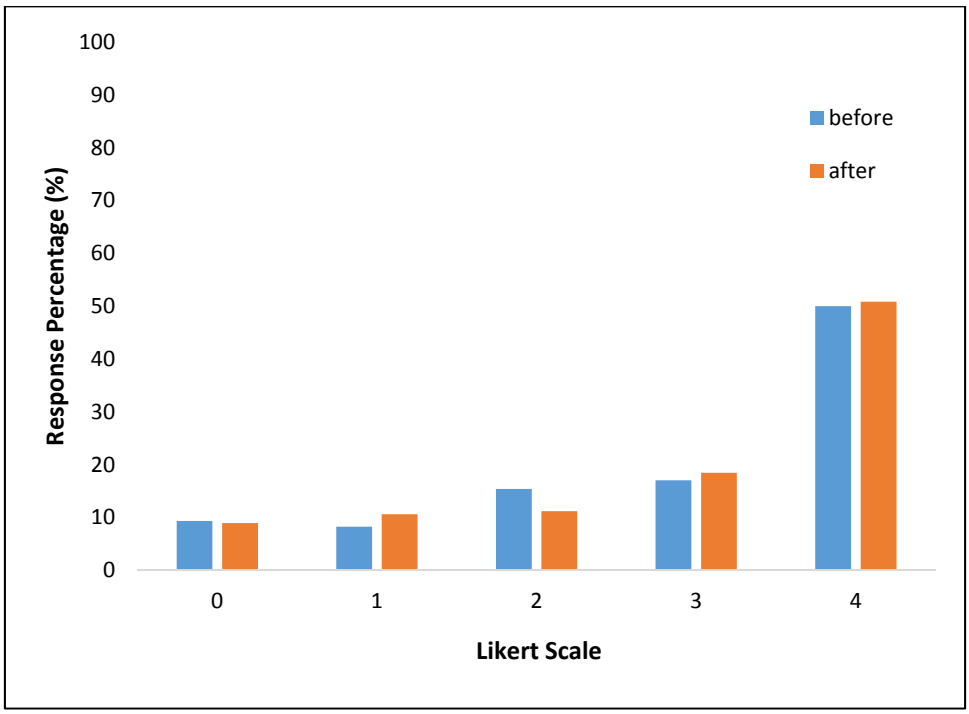

Figure. 9 Participant's responses of tolerance towards ticks before and after receiving their beehives from Kur-ring-gai Council. Participants (before n = 182; after n = 179) answered on a Likert scale: 0 = not bothered by them to 4 = significantly bothered by them. By Jones, 2015.

Participants were asked, 'How often do you observe the native bees since receiving your beehive?' Remarkably, 65.56% of the total number of respondents (n = 180) stated that they were observing their beehives every day. This was followed by 27.77% of participants observing their beehives a couple of times per week. The remaining 3.88% of people stated 'once or twice a month' and 2.77% specified 'rarely' often (see Table. 1).

Table. 1 Survey data showing the number of participant's responses when asked how often they observe their beehive. Participants (n = 180) could answer from five options. By Jones, 2015.

Answer Options	Response Percentage (%)
Many times a day	23.89
Once or twice a day	41.67
A couple of times a week	27.77
Once or twice a month	3.88
Rarely	2.77

Participants (n = 184) were asked, 'Since receiving your beehive have you found the native bees to be enjoyable?' The majority of respondents (99.5%) said yes. Some people

said in their discussion that they enjoyed the fragrance of their hives, enjoyed watching them being active outside their hives and pollinating flowers, enjoyed knowing by having the beehive they were helping promote conservation of this species and that it provided an educational tool for their children, friends and family. Other responses stated that the bees provided a form of connectivity with nature.

Participants (n = 184) were then asked if native bees, such as the *T. carbonaria*, are important to the ecosystem. The majority of respondents (98.9%) said yes. Most people said in their discussion that bees are important because they assist in pollination. Other responses included the promotion of biodiversity and that they are essential to our well-being.

Following this question, participants (n = 181) were asked, 'Since receiving your beehive has it changed your perception and/or attitude towards the environment?' The majority of respondents (59.1%) said no. Some people stated in their discussion that they had the same attitude towards the environment, but a new appreciation for native bees since installment of their beehive. Most respondents claimed that they appreciate the environment due to their own experiences such as growing up in a time before plastics and insecticides (except DDT), others were undergoing environmental studies at a tertiary level, or the fact that they were living within an environmental friendly area (such as Lane Cove National Park).

Furthermore, participants (n = 185) were asked if their attitude towards their garden changed in any way, and if so how. Respondents closely tied in state of opinions, having 54.1% say no and 45.9% say yes. Most people said that they have always been very conscientious about their gardens before installation of beehives. Other concerns where that some people stated that they have no time and unfortunately no money to look after their gardens. However, some people have been encouraged to plant native flora species in their gardens, especially those with prominent flowers.

Change in attitudes towards their garden and how they see *T. carbonaria* as an important pollinator raised questions about the use of insecticides. Participants (n = 185) were asked, 'Before receiving your beehive did you use insecticides in your garden?' This was juxtaposed with the question, 'Do you still use insecticides in your garden after installment of OATH beehive?' Before installation of beehives, most of the respondents (67.6%) said no. Since participants (n = 181) have received their beehive, the majority of respondents (86.2%) said no to the use of insecticides on their gardens. After the installment of beehives, roughly 34 people from originally 60 people who use insecticides on their gardens now either reduce or refuse to use insecticides. Some people said that they used to spray plants when they were being attacked by herbivory. Now people are using alternative methods to strengthen their plants immunity, such as fertilisers and compost to promote resistance to disease and herbivory from insects. Other alternative methods are the use of natural and/or homemade products such as garlic and chili sprays to eradicate or forestall an infestation.

Since the placements of beehives, participants (n = 185) were asked, 'Since receiving your beehive have any of your friends, family or neighbours been inspired to get a beehive?' The bulk amount of respondents (53.5%) said yes. Others (35.7%) were not sure. Some people declared that their friends and family were fascinated and showed an interest but failed to act upon it. Other responses were that close relatives and friends didn't live within Ku-ring-gai Council area, which they would if there was an initiative similar found in other councils. The majority of people who said 'yes' stated in their discussion that they are easy

to look after and have low maintenance costs. Others liked the fact that they are stingless which has a lot of appeal especially to those who risk anaphylactic shock from a honey bee sting. Some people have been successful to inspire others to install a beehive; in fact, the council now has a long waiting list for more local residents who can have a beehive of their own. One participant stated that if they had the right resources and equipment such as a wooden box and polystyrene box, they would split their hive and share it with others. However this is not recommended by the council.

Participants (n = 175) were asked if they take care of their hive in any way. The majority of respondents (75.4%) said yes. Some people stated in their discussion on hot days they would either place the beehive into a cooler location preferably in the shade or they would alleviate the heat by placing damp towels on the hive, provide shade with a tarp cover, or spray cool water onto the hive. If the beehive were cold, people specified they would provide extra insulation by putting an extra layer of polystyrene sheets or blankets on top or in the beehive. Other regular maintenance care people did was removal of spiders and their webs, check for ants and cockroaches, clean out any dead bees and litter from the entrance of the hive. One particular applicant stated that they placed photos to the exterior of the hive to warn off birds from pecking the polystyrene. Another useful technique to warn off intruders such as Brush Turkeys and Cockatoos was the application of chicken wire around the hive. For those who do not do regular maintenance said that they do not need to take care for their hive because it is either in a favourable position on their property or that the native bees are capable of maintaining themselves. A few applicants adopted the motto, ‘leave it to the bees’ or ‘let nature take its course’.

Participants (n = 184) were asked if they are more aware of solitary native bees since joining the Native Beehive Program. The majority of respondents (71.2%) said yes. One participant actively observes many species of solitary bees in their garden such as the Blue-Banded bee, Leaf-Cutter bee, Teady-Bear bee, Metallic Carpenter bee and Neon Cuckoo bee.

Since receiving a beehive, participants (n = 183) were asked if they were more aware of extreme temperatures. The majority of respondents (75.4%) said yes. Participants (n = 149) were then asked if they connect their awareness of extreme temperatures affecting their beehives with climate change. Just over a third of the amount of respondent’s (38.26%) said yes, followed by those who said (36.24%) no, and lastly (25.50%) not sure. Some people claimed that they are noticing more extremes in temperatures and by having the responsibility to look after their beehives; this has brought people to become more aware of these changes. Few people believe that we should not confuse natural variability through weather events with climate change. Participants have noticed peak activity movements with their bees happening around 18°C. At temperatures below 18°C, bees become less active and prefer to stay inside their hive. One participant observed their bees making another hole which they did not use for an entrance. This behavior caused the owner to wonder whether the bees had made a ventilation hole.

3.1.2 Focus Group Meeting

A focus group was conducted by project organisers along with four willing participants to grasp a better understanding of their experience in the project. Topics such as introduction to beehive housekeeping, potential interactions with bees, and education to the public were discussed.

Introduction to beehive housekeeping

Participants learnt through both their own experiences as well as information provided by the council how to do general beehive housekeeping. For example participants were advised if they should relocate their beehives whether due to temperature preference or moving homes, they should seal up the entrance to the beehive at night and allow the bees to get used to the new location during the day.

Interactions with neighbours and bees

Discussions brought up in the focus group meeting were if the presence of the native bees bothered surrounding neighbours. One individual lived at a village complex where each property lies within close proximity of each other. Once neighbours were told that they are native bees, noiseless and are stingless, people quickly accepted their presence. Another participant failed to tell their neighbours but said that they have not even noticed them. The participant was confident if their neighbours knew they were native bees, and they saw them swarming they wouldn't be troubled.

Loss of a colony

One participant lost a colony of *T. carbonaria* to an unknown cause. Project organiser suggested extreme temperatures outside the native bees temperature range could be a plausible explanation. Another explanation could be invasion of small hive beetles (*Aethina tumida*). One candidate confessed that they lost around ten percent of their bee colony in 2013 due to small hive beetles.

Bees as an educational tool

Some private and public schools in the council region had expressed their interests to own a beehive each for educative purposes. One candidate claimed that they didn't know there was a difference between native bees and exotic bees until being a part of the Native Beehive Program. The native bees' characteristics such as size and colour go against a lot of ideas about what a bee is to the general public. Native bees are closely related to the same superfamily (*Apoidea*) as wasps. Hence the Native Beehive Program would be a useful tool to communicate to all ages of people the importance of native bees, such as *T. carbonaria*, as an educator in environmental awareness and conservation.

4. Discussion

Our findings suggest that *T. carbonaria* have proved to educate participants' in the Native Beehive Program in environmental awareness. Some of the benefits and unintended consequences of owning a beehive include a better appreciation of insects and their role in the environment, more time spent outside especially in the garden, reduction in the use of insecticides and having more awareness of extreme temperatures.

Ku-ring-gai Council survey established after installation of beehives, peoples' tolerance for

native bees, honey bees, ants, flies, beetles, wasps, cockroaches, and mosquitoes increased from their original perception before owning a beehive. However ticks decreased in amount of tolerance. This could be due to the current controversy of Lime disease in Australia sparked by tick bites. Nevertheless, the Native Beehive Program has had a positive influence on the local residents within Ku-ring-gai Council in relation to the significance of the role of insects in relation to pollination and nutrient cycling.

The survey found that the majority of participants were observing their beehive from a couple of times a week to a few times a day. Most respondents wrote in their discussions that a plausible reason of why they were observing their beehives very often could have been due to the beehive's position on their property. Beehives near people's porches, decks and balcony scored 52% from participant's as a favourable location to place their beehives. Other locations included their front or back garden, and back patios under pergolas. The survey also found that 99.5% of people enjoyed having the bees and 98.9% of people understand their importance to the ecosystem. Some people stated that they enjoyed their fragrance, enjoyed watching them being active outside their hives, watching them pollinate flowers, enjoyed knowing by having the beehive they were helping promote conservation of the species and that it provided an educational tool for their children, friends and family. A study by Halcroft *et al*. (2013) found that the majority of beekeepers (surveyed in 1998-9 and 2010) in the Australian stingless bee industry kept stingless bees for enjoyment. This was followed by conservation, pollination of bushlands, pollination of crops, honey production, hive sales, education and research (Halcroft *et al*. 2013). Halcroft *et al*. (2013) stated that *T. carbonaria* honey holds an unusual fermented aroma which many people believe it to be appealing.

Since owning a beehive, 59.1% of participants believed that their perception and/or attitude towards the environment didn't change. Some people stated that this experience allowed a new appreciation for native bees. Most respondents claimed that they already had a great appreciation towards the environment due to their own experiences. This was similar to the participant's perception towards their gardens after installment of beehives. Roughly 54.1% of respondents said no and 45.9% said yes to change in attitudes towards their garden. Most people said that they have always been very conscientious about their gardens before placement of beehives. Other concerns where that some people stated that they have no time and nor money to look after their gardens. However, some people stated that they were encouraged to plant native flora species in their gardens, especially those with prominent flowers. Nevertheless, owning beehives proved that participants continued with mutual attitudes towards the environment and their gardens, but did in some cases promote people to become active in care of their gardens.

Although the majority of people didn't change in the way they perceive their garden, the survey did find a significant change in the use of insecticides before and after installment of beehives. After placements of beehives, 18.6% of people who once used insecticides on their gardens now either reduce or refuse to use it. Some people stated in their discussion, that they use alternative methods to strengthen their plants immunity, such as fertilisers and compost. Other alternative methods include both natural and/or homemade products such as garlic and chili sprays to eradicate or forestall an infestation. A report by Valdovinos-Núñez *et al.* (2009) found that pesticides cause detrimental effects to the populations of stingless bees in Mexico. In general, stingless bees colony reproduction rate is very low, thus population mortality from the use of pesticides will have a big impact beehive colony (Slaa *et al.* 2006). Valdovinos-Núñez *et al.* (2009) recommend if any agrochemicals must be used, to avoid direct application on the hive and spray in hours of least bee activity.

Since the placements of beehives, friends, family and neighbours have showed an interest to owning a beehive but many have failed to act upon it. Some of the peoples' close relatives and friends do not live within Ku-ring-gai Council area. To date, there are no other councils within the Sydney region operating a similar program. For participant's that were successful in inspiring others to install a beehive, the council now has a long waiting list to make more beehives. On top of this, some private and public schools in the council region have expressed their interests to own a beehive for educative purposes. Maginnity (2013) article, *Using stingless bees as an educational tool in Australian schools*, identifies the importance of stingless bees' in the role of pollination and maintaining genetic diversity of floral species for education of biology and agricultural. Other useful knowledge that students could learn from owning stingless bee hives includes honey production, colony propagation and multiplication, and learning the importance of cerumen (a mixture of stingless bee wax and collected plant resins) as a valuable food source in Australian indigenous culture (Maginnity 2013).

The majority of participants agreed that they do take care of their beehive. On hot days some people would place the beehive into a cooler location, place damp towels on the hive, provide shade with a tarp cover, or spray cool water onto the hive; all in which are accepted as good methods to alleviate extreme heat by Ku-ring-gai Council. If temperatures were cold, people specified they would provide extra insulation by putting an extra layer of polystyrene sheets or blankets on top or in the beehive. The design of OATH outer foam layer alone can prevent heat from dissipating out of the hive. Other regular maintenance include the removal of spiders and their webs, removal of ants, cockroaches and other invaders, as well as removal of fallen litter their the entrance of their hive. Some people stated that they do not need to take care for their hive because it is either in a favourable position on their property or that the native bees are capable of maintaining themselves. This has proven not the case in many studies on beekeeping. For example, studies by Greco *et al.* (2010) found that colonies of *T. carbonaria* in OATH can melt when ambient temperatures reach 46°C resulting in total colony collapse. Amano, Nemoto and Heard (2000) beehives consist of an inner box hive and an outer box. The outer box is equipped with a heating system on a fixed temperature during winter months (Amano, Nemoto and Heard 2000). It is vital that participants understand their maximum temperature range and their lack for adaptability out of this range. Other threats include parasite, small hive beetles (*A. tumida*) and parasitoid euphorine braconid (*Syntretus trigonaphagus*) recently reported by Gloag, Shaw and Burwell (2009). Another factor influencing their survival pointed out by Amano, Nemoto and Heard (2000) is providing suitable homes that are within their flight range (< 1 km) to find native vegetation. Participants should be educated in standardised maintenance requirements for the best survival rates of *T. carbonaria*. This could be achieved by giving out informative pamphlets on general beekeeping with each beehive.

Since receiving a beehive, the majority of participants were more aware of extreme temperatures. However when participants were asked if they connect their awareness of extreme temperatures affecting their beehives with climate change there were split opinions. Some people claimed that they were noticing more extremes in temperatures by having the responsibility to look after their beehives. This was juxtaposed with very few people believing that we should not confuse natural variability through weather events with climate change. A study by Memmott *et al.* (2007) declared within the last century, global warming has prompted the first flowering period of plants and seasonal flight activities of some insect pollinators, on average, by 4 days per degree Celsius in temperate zones. This has resulted in 17–50% of most pollinator species experiencing a disturbance in their

general food supply (Memmott *et al.* 2007). In regards to climate change, broad plant-pollinator networks are being investigated (Tylianakis *et al.* 2008). In relation to foraging behavior of stingless bees, colony and availability of resources (both colony stores and outside floral resources), and weather variability can have huge implications to colony structure and functionality (Heard and Hendrikz 1993). Heard and Hendrikz (1993) studies in Australiua found that temperature and radiation (short-wave and visible light) were the most important variables that affected daily flight activity in *T. carbonaria*. In cooler months, the length of daily flights ranged between 3 to 9 hours, having temperature as the limiting factor during the morning and radiation in the evening (Heard and Hendrikz 1993). In warmer months, daily flight activity ranged between 10 to 14 hours, having radiation as the only limty factor (Heard and Hendrikz 1993). Temperature activity threshold peaked at 18-19°C (Heard and Hendrikz 1993). Thus climate change will inevitably have an influence on *T. carbonaria* with unpredictability of temperatures. It is therefore important to educate local residents housing *T. carbonaria* beehives to be more aware of climate change and how it can influence colony mortality.

Some of the limitations of the survey were that questions in relation to 'before' instalment of beehives and 'after', were answered subsequently during the program. Thus people would have had a change in opinions causing bias in truthful answers to responses before placement of beehives. If the council did another survey needing 'before' and 'after' answers, questions should be directed to new participants. Another limitation was the inconsistency of the amount of people answering 'before' and 'after' questions. Results could only be transcribed as a percentage rather than the total amount of people that changed in attitudes or state of opinions.

5. Conclusions

In conclusion, the Native Beehive Program demonstrates that stingless bees, such as *T. carbonaria*, are an ideal facilitaor providing environemtal awareness, as well as educating pepople of the significane of pollinator species. Utilisation of *T. carbonaria* have proven to educate people in the problems of using insecticides to colony mortality, as well as provide a greater awareness in the effects of climate change. Over the past decade, participants have been engaged in the Native Beehive Program that Ku-ring-gai Council offers and have learnt more about our native stingless bees. We hope by placing more installments of beehives into peoples properties, in public spaces, and in schools that there will be a greater awareness of Australian stingless bees and their importnace in our native environment. We hope this program is incorpuated into other council Sydney regions. More studies should assess other possible benefits of owning native stingless beehives and reduce any knowledge gaps that still exist.

6. Recommendations

Based on the overwhelming positive results revealed by the survey, it is recommended that Ku-ring-gai Council expand the program and that other Councils adopt this program. Other further suggestions include a development of Temperate Climate (TC) hive design suggested by Greco *et al*. (2010). The design of OATH is effective in tropical and subtropical areas of Australia. Placement of TC in the Ku-ring-gai region will better suit the temperature requirements of *T. carbonaria* in temperate zones.

7. Acknowledgements

We thank Ku-ring-gai Council Environment and Sustainability department, especially Peter Clarke and Liz Gibson, for their efforts in providing survey data and valuable knowledge about *T. carbonaria*. Our sincere gratitude to Alice Assmar, Elisa Fernandes and Raphael Laghi for survey construction and implementation, as well as result gathering. We also like to thank Raphael Laghi for conducting the focus group and transcribing participants' responses.

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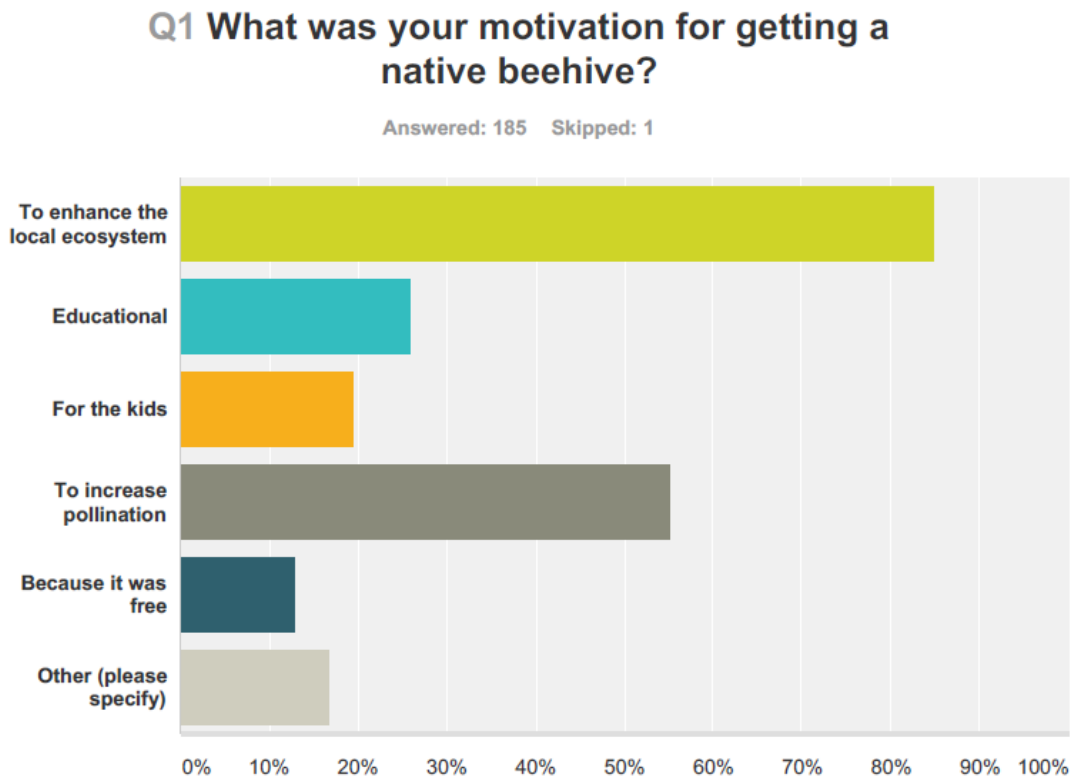
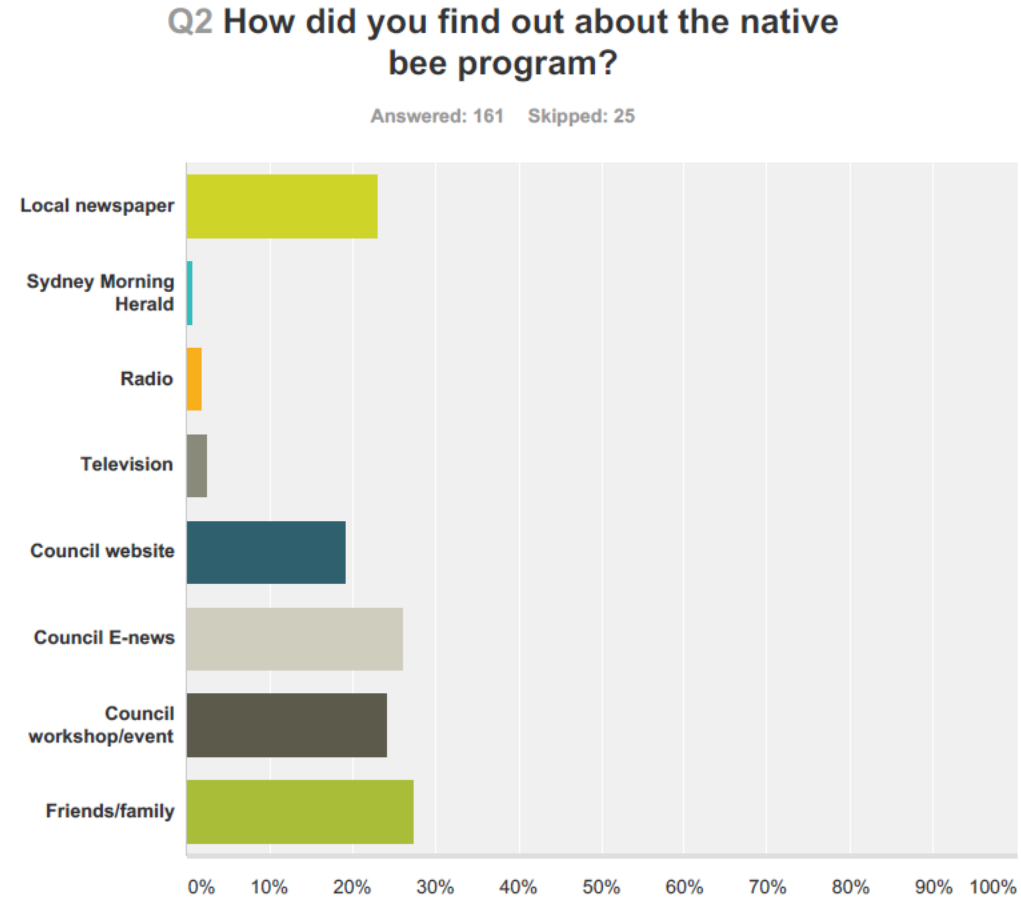
9. Appendix

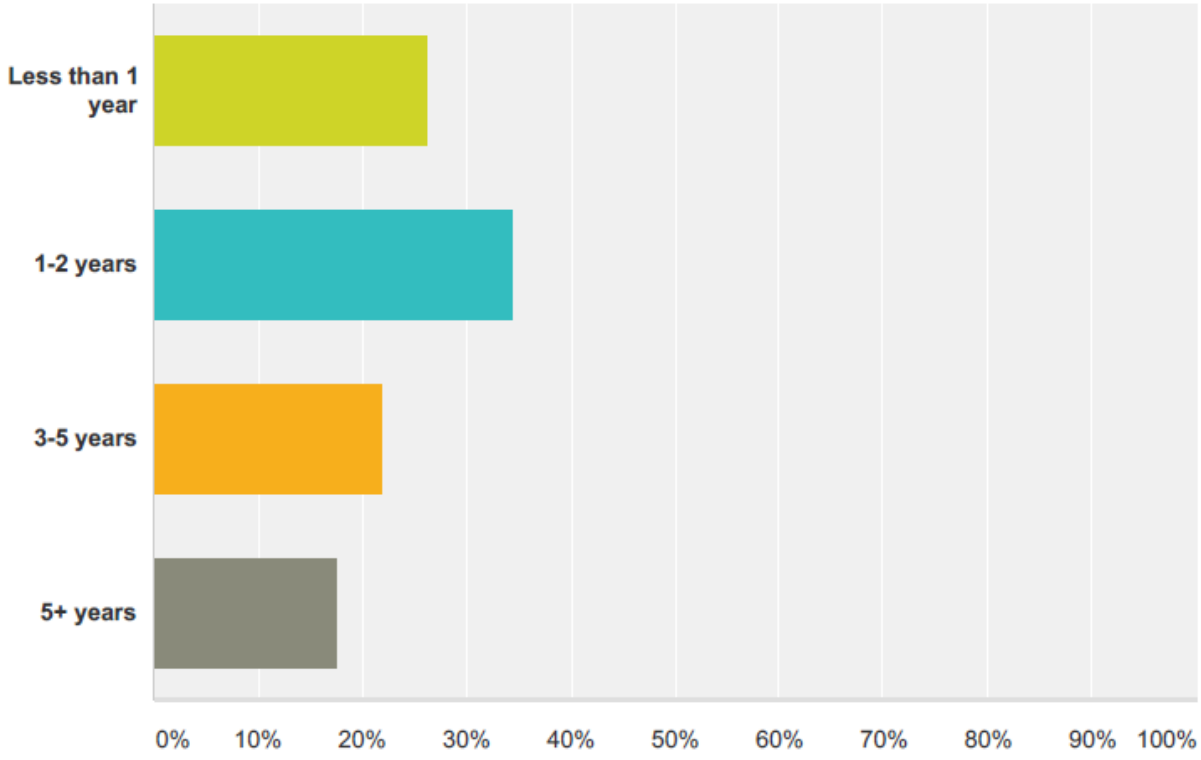
Appendix 1. Ku-ring-gai Council Native Beehive Program Survey Questions





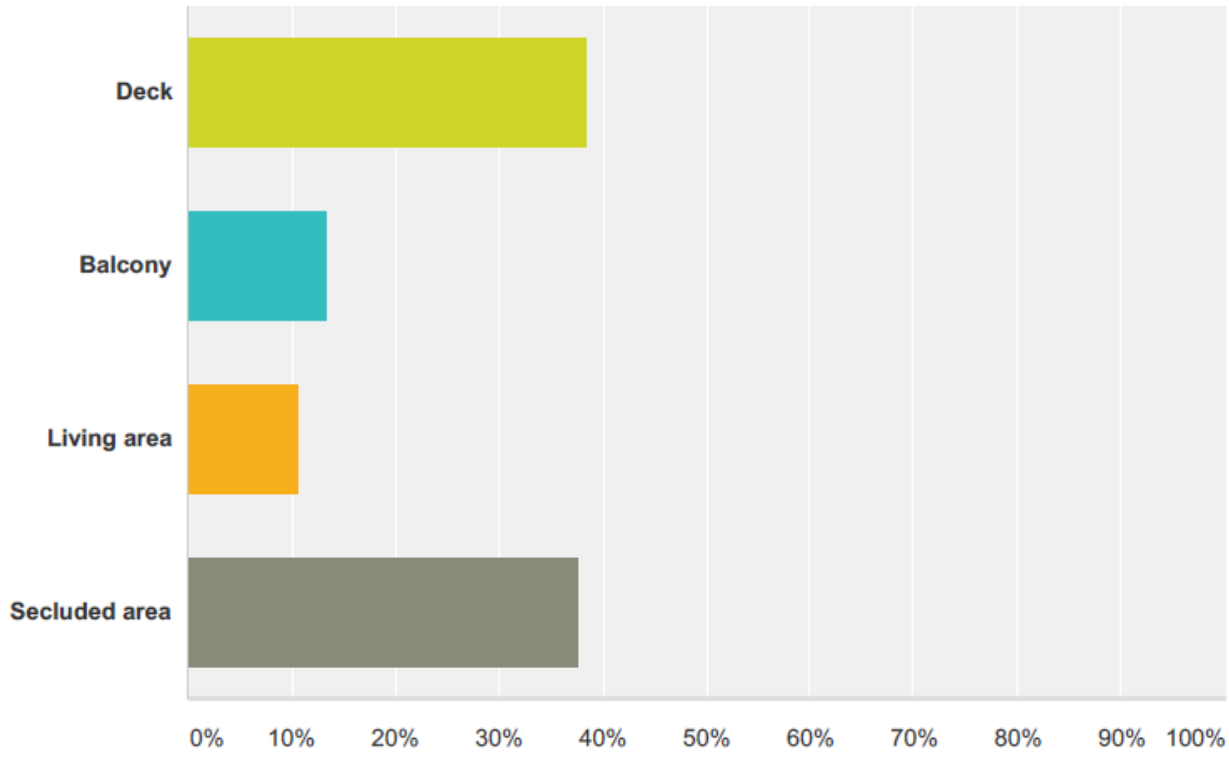
Q3 How long have you had your beehive?

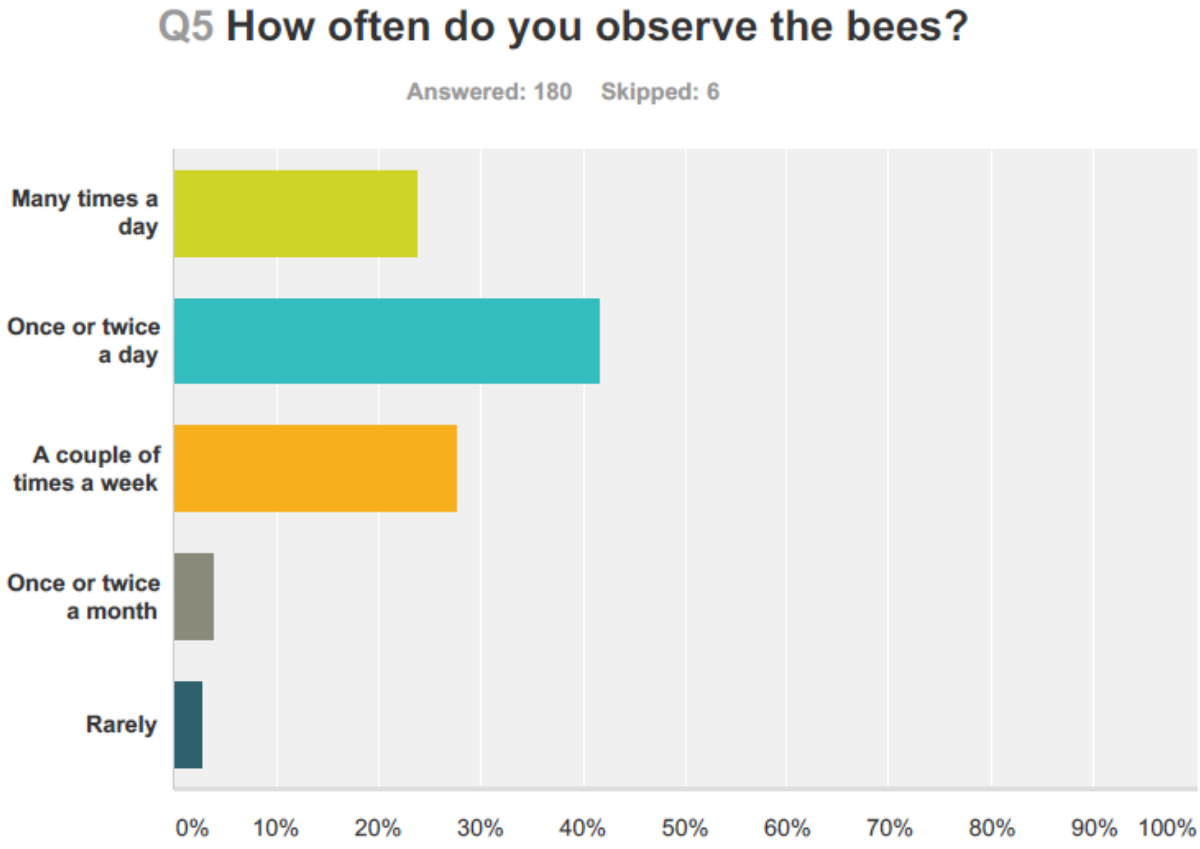
Answered: 183 Skipped: 3

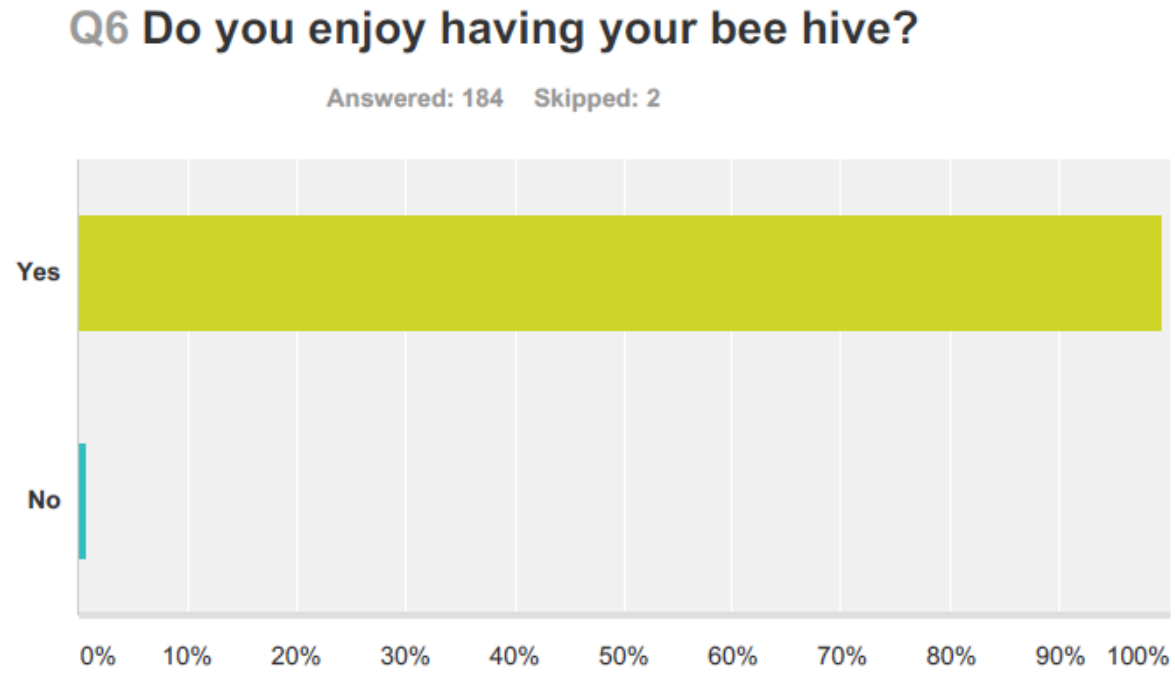


Q4 Where is your beehive located?

Answered: 104 Skipped: 82

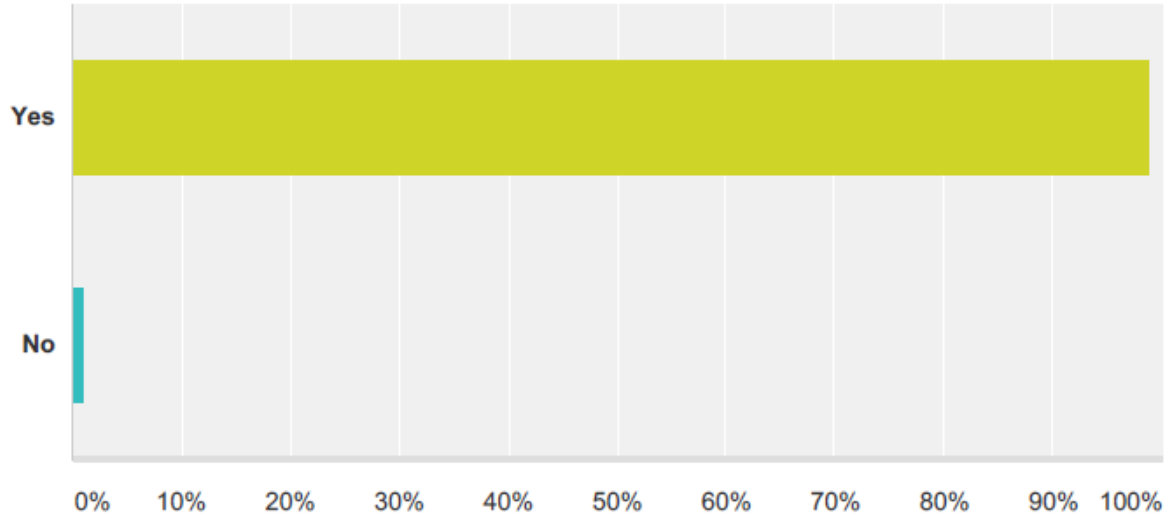



Q5 How often do you observe the bees?
Answered: 180 Skipped: 6
Many times a day
Once or twice a day
A couple of times a week
Once or twice a month
Rarely
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Q6 Do you enjoy having your bee hive?
Answered: 184 Skipped: 2
Yes
No
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

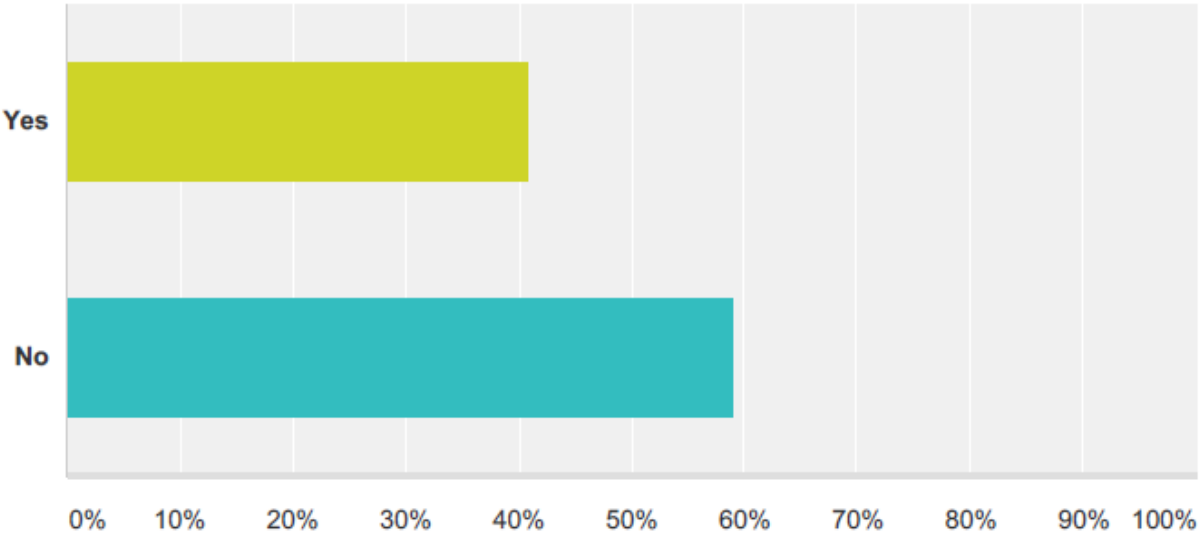
Q7 Do you think the native bees are important to the ecosystem?

Answered: 184 Skipped: 2



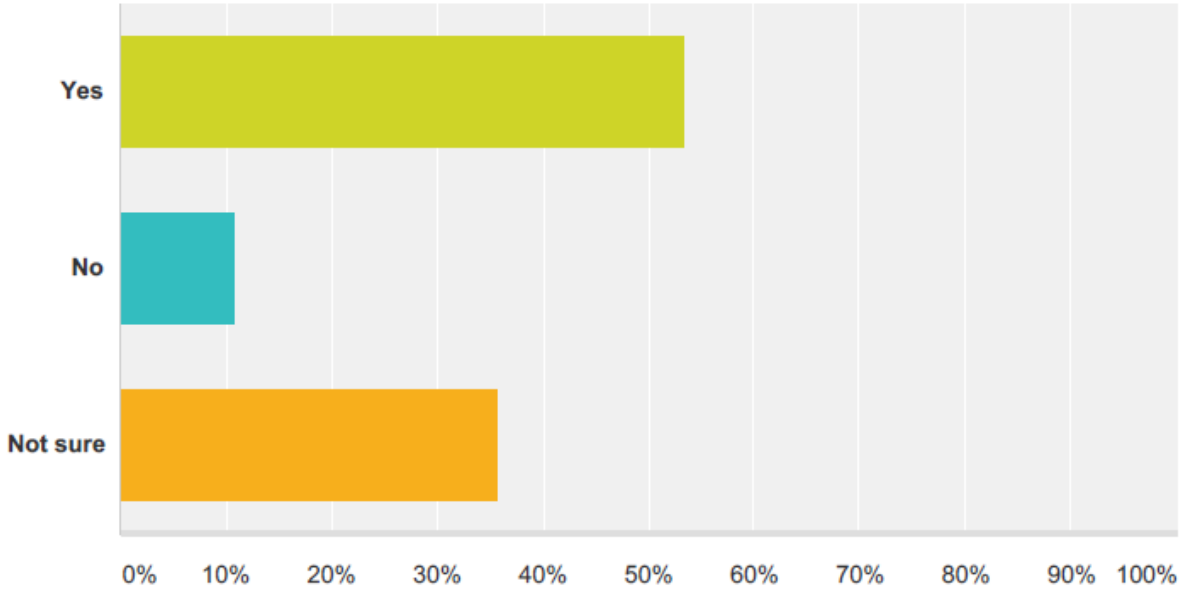
Q8 Since receiving your hive has it changed your perception and/or attitude towards the environment?

Answered: 181 Skipped: 5



Q9 Since receiving your hive have any of your friends, family, neighbours, et al., been inspired to get a hive?

Answered: 185 Skipped: 1

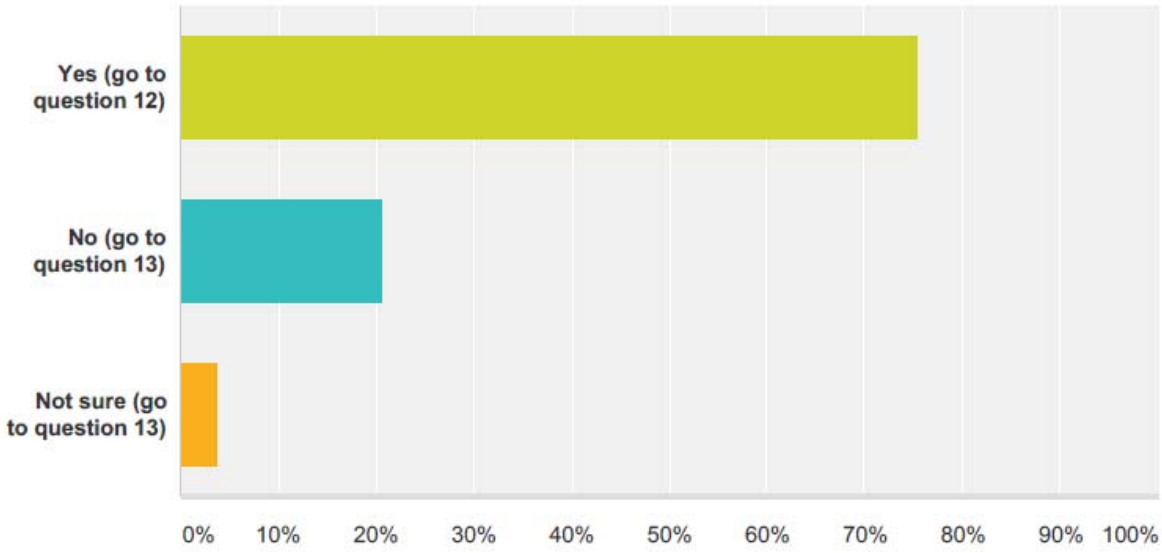


Q10 Do you take care of your hive in any way?

Answered: 175 Skipped: 11

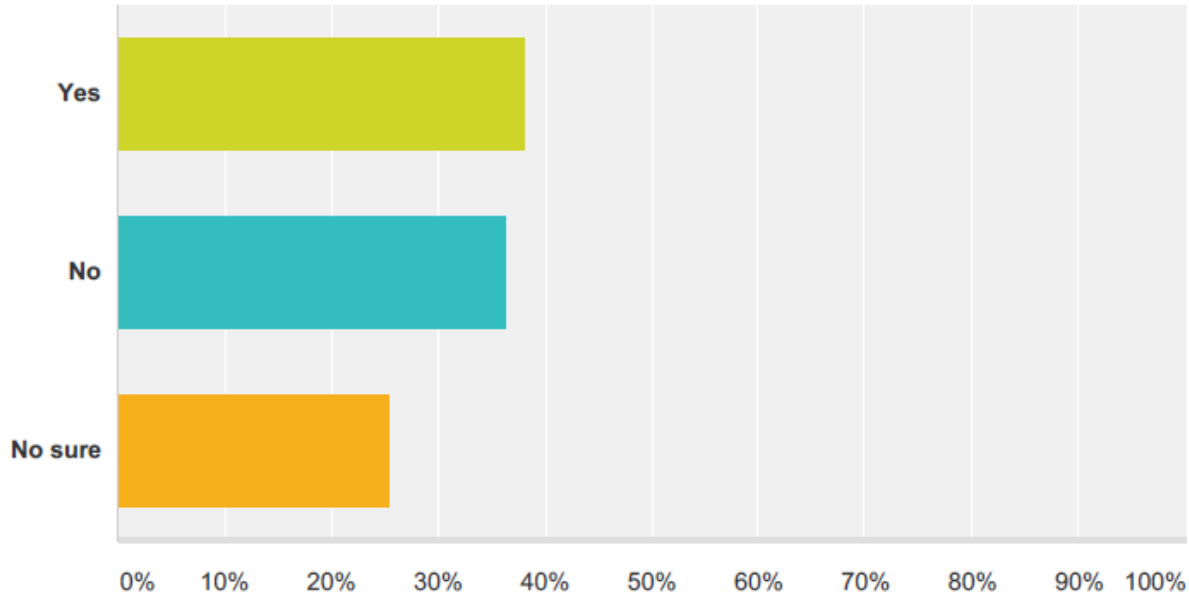
Q11 Are you more aware of extreme temperatures since you got the hive?

Answered: 183 Skipped: 3



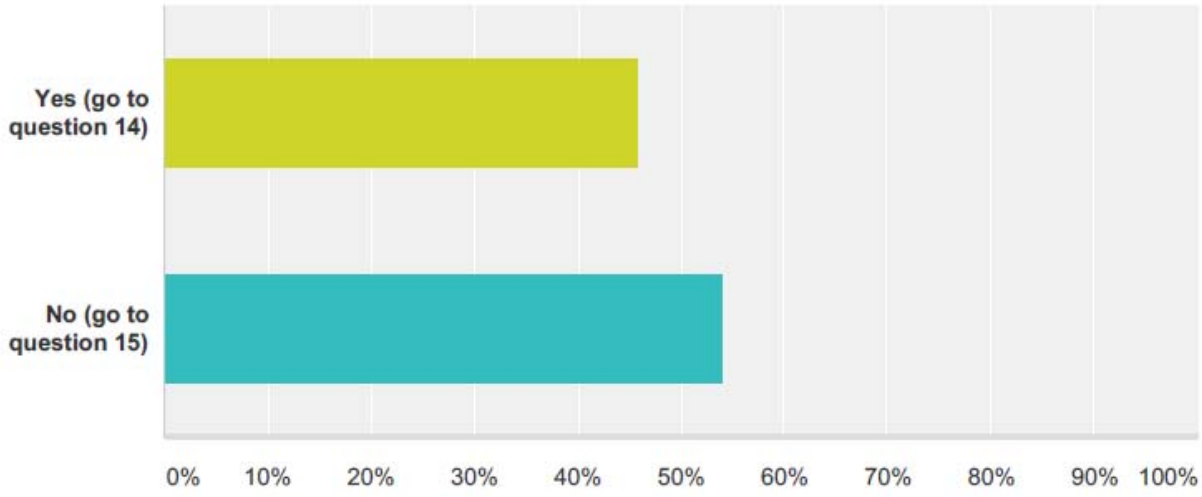
Q12 Do you connect your awareness of extreme temperatures affecting the hive with climate change?

Answered: 149 Skipped: 37



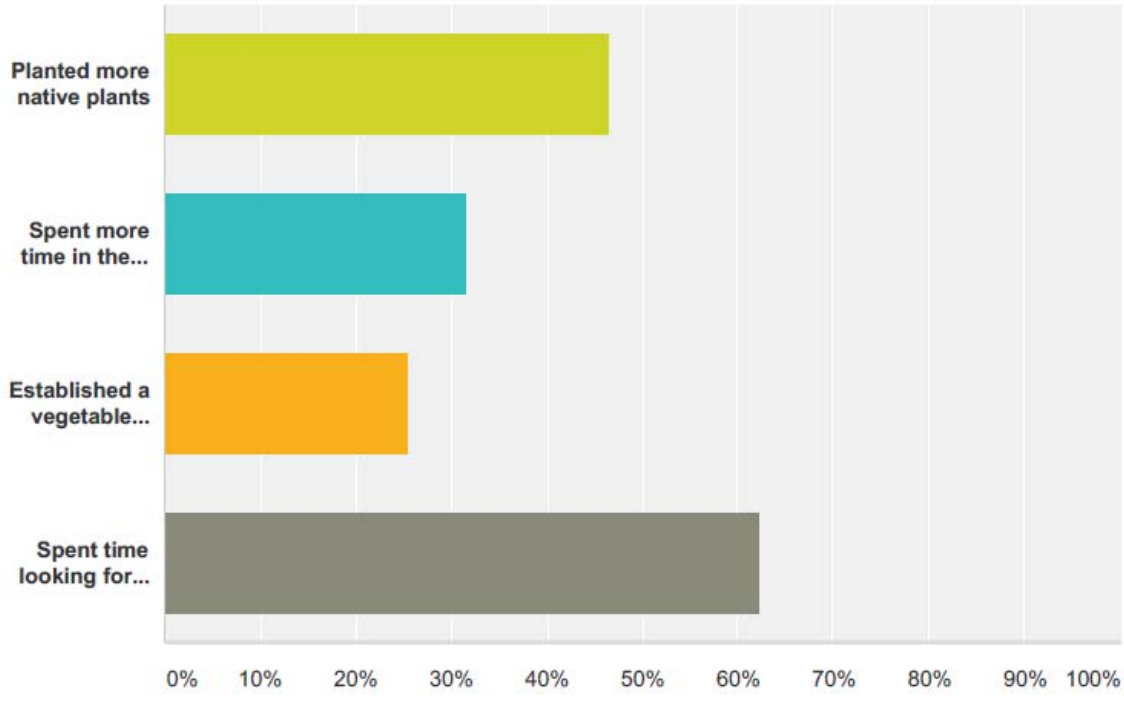
Q13 Has your attitude towards your garden changed in any way?

Answered: 185 Skipped: 1



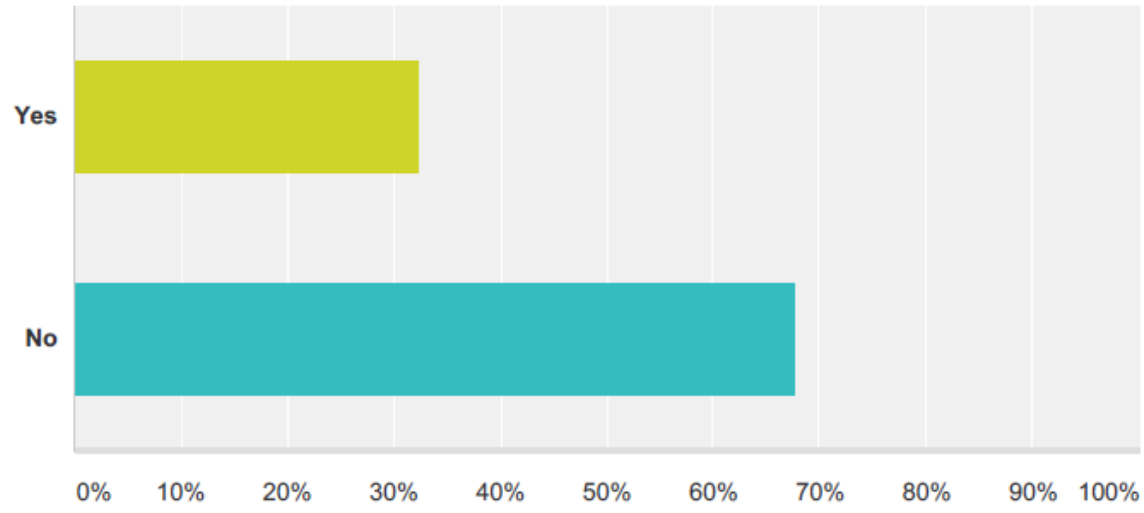
Q14 How did your attitude change?

Answered: 114 Skipped: 72



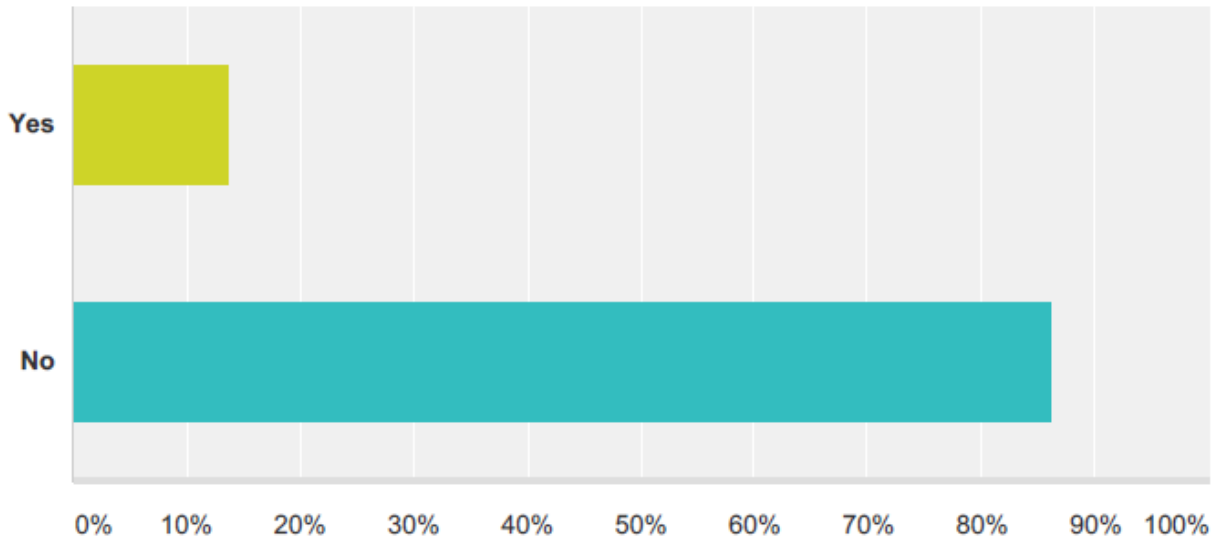
Q15 Before getting the hive did you use insecticides in your garden?

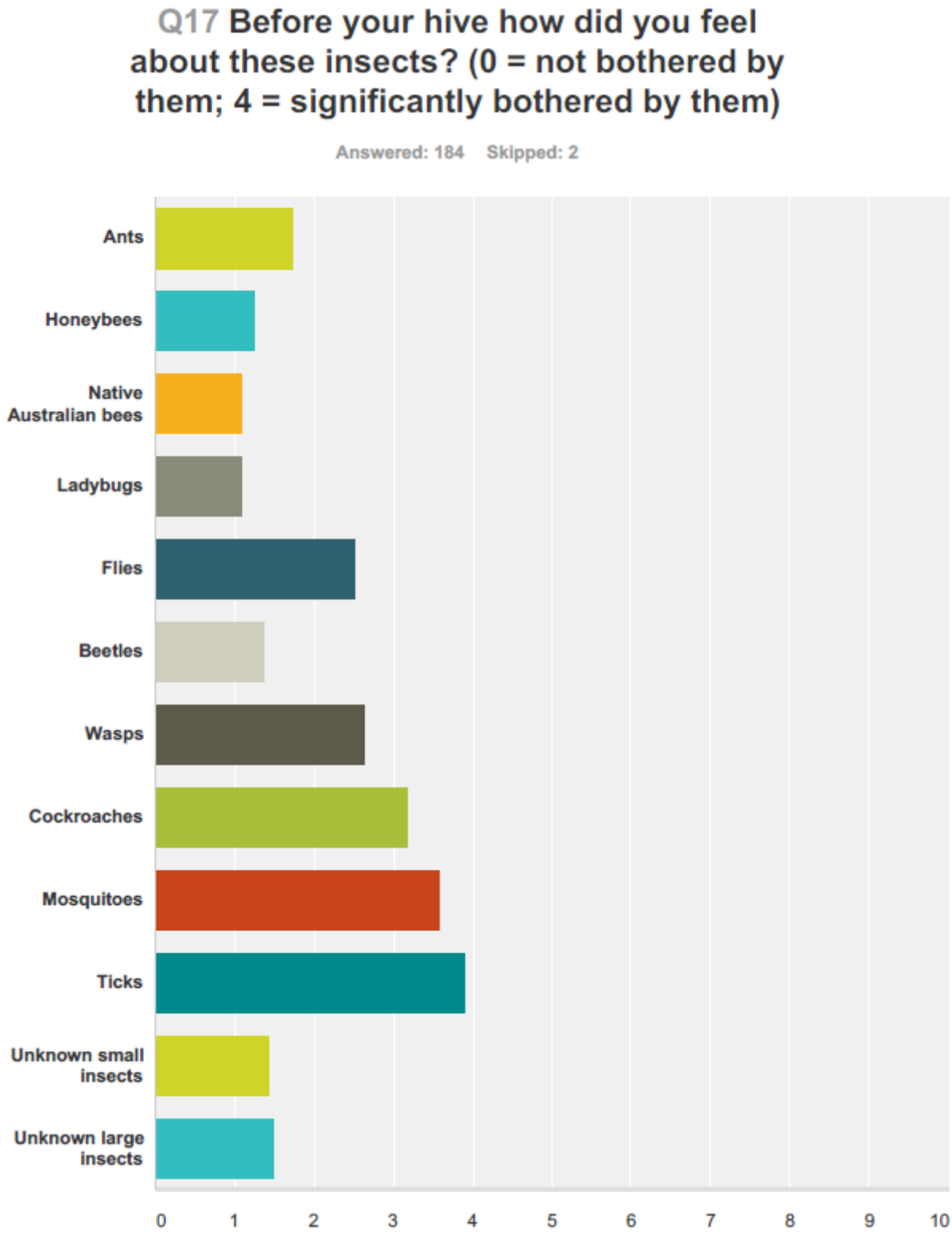
Answered: 185 Skipped: 1



Q16 Do you still use insecticides in your garden?

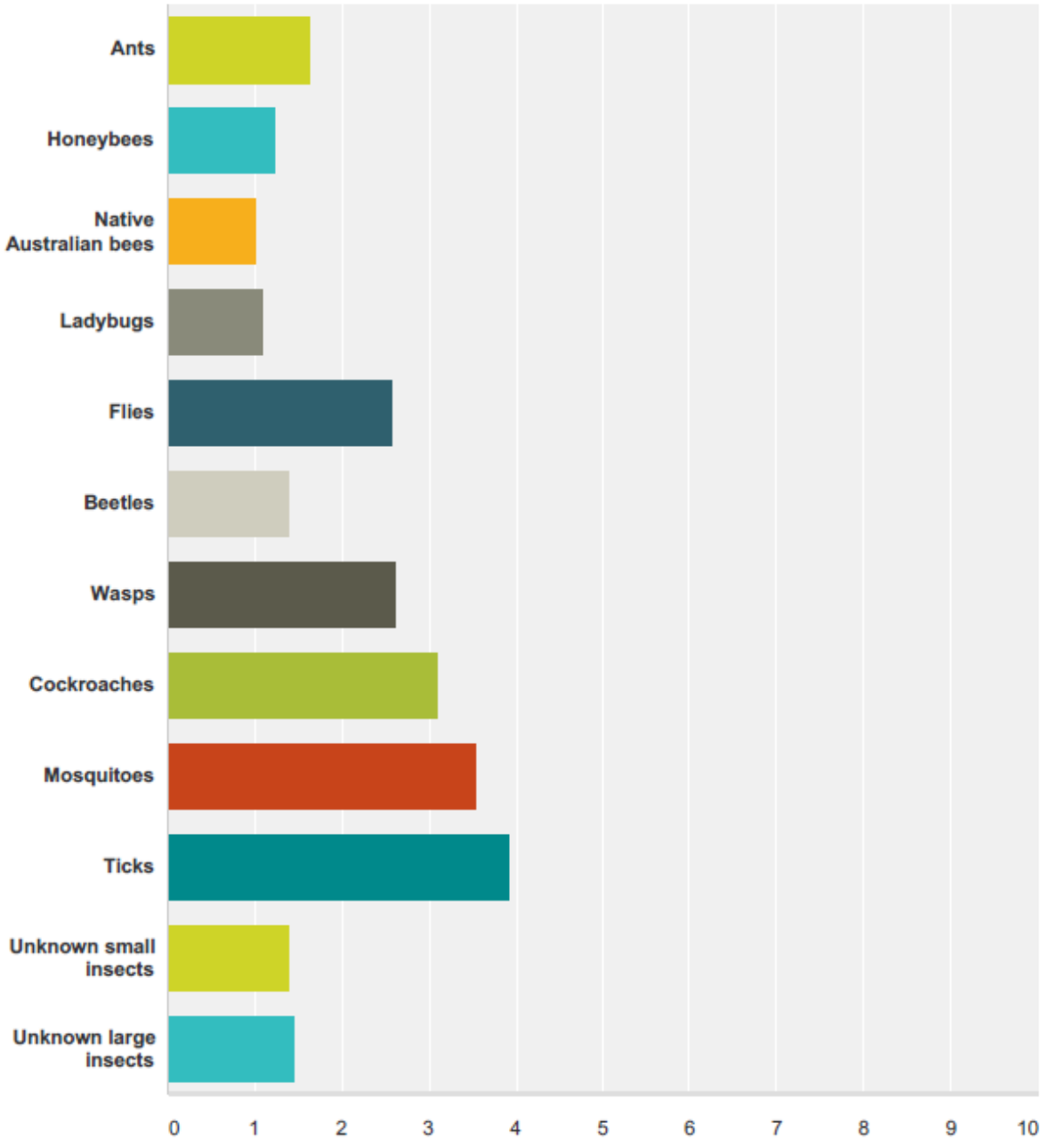
Answered: 181 Skipped: 5

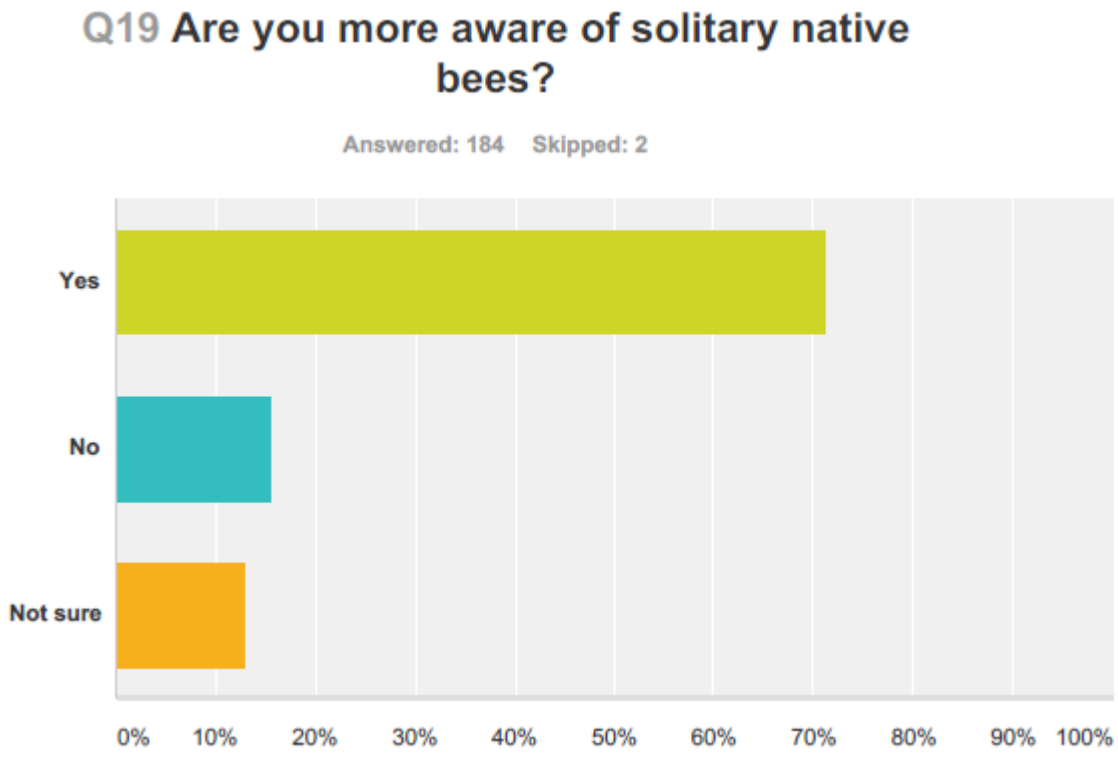



Q17 Before your hive how did you feel about these insects? (0 = not bothered by them; 4 = significantly bothered by them)
Answered: 184 Skipped: 2
Ants
Honeybees
Native Australian bees
Ladybugs
Flies
Beetles
Wasps
Cockroaches
Mosquitoes
Ticks
Unknown small insects
Unknown large insects
0
1
2
3
4
5
6
7
8
9
10

Q18 Now you have your hive how do you feel about these insects? (0 = not bothered by them; 4 = significantly bothered by them)

Answered: 181 Skipped: 5




Q19 Are you more aware of solitary native bees?
Answered: 184 Skipped: 2
Yes
No
Not sure
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%