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Brown marmorated stink bug (*Halyomorpha halys*) surveillance in the Bay of Plenty, New Zealand 2020–21

Puketapu A

July 2021

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Brown marmorated stink bug (*Halyomorpha halys*, BMSB) poses a serious and real risk to the New Zealand kiwifruit industry should it establish here. With continued border and post border detections in New Zealand, including in the Bay of Plenty (BoP), the risk of entry and establishment here remains high. Active surveillance for pests that are seemingly ‘knocking at our front door’ is important, especially if early eradication is to be feasible.

The Ministry for Primary Industries (MPI) currently manages the national BMSB surveillance programme here in New Zealand, with trapping and monitoring efforts established throughout New Zealand based on historical BMSB detection data and pathway risk. Alongside this, the New Zealand Institute for Plant and Food Research Limited (PFR) has established local BMSB surveillance networks in the Hawke’s Bay and Nelson regions with the support of New Zealand Apple and Pears Incorporated. These local networks feed into the national surveillance programme.

Following on from a 2019 BoP based pilot BMSB surveillance study and with continued support from Zespri and Kiwifruit Vine Health (KVH), 24 BMSB pheromone traps were established throughout the region in November 2020. This was the second year that the BoP was actively surveyed for BMSB. Traps were monitored fortnightly until late April 2021 by PFR staff.

The project aims for the 2020–21 surveillance project were:

1. To establish a BMSB trapping network to identify whether BMSB is present or enters the BoP during the active monitoring period and
2. To provide appropriate BMSB identification, trapping and monitoring training for kiwifruit industry members.

BMSB was not detected at any of the BoP trapping locations and stink bug detections in general were low across the surveillance network in 2020–21. Host plant species associations largely accounted for the stink bug species detected across the network for both trap and vegetation detections.

The knowledge extension activities delivered under this project were presented at the July 2021 KiwiNet meeting in Mt Maunganui. These were well received on the day and feedback received suggests that the training video was easy to understand and clear in terms of instructions. Further to this, participants agreed that the techniques and trapping materials demonstrated could be practically integrated into current kiwifruit orchard practice.

As this is the final year that the BoP surveillance network will be managed in this way, MPI has advised that the region will be included in the 2021–22 national surveillance programme but in a reduced capacity.

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1 Introduction

The brown marmorated stink bug (BMSB) (*Halyomorpha halys*) is the "kiwifruit industry's second most unwanted biosecurity threat" (KVH 2020). With continued border and post-border BMSB detections occurring nationwide and in the Bay of Plenty (BoP), New Zealand, the risk of establishment remains high. Early BMSB detection will be essential for successful pest eradication and mitigating negative economic, environmental and social impacts.

In order to detect biosecurity threats, like BMSB, surveillance networks are essential, particularly around high risk border entry points such as ports and transitional facilities (TFs). The Ministry for Primary Industries (MPI) oversees the national BMSB surveillance programme which operates on an entry risk basis associated with past detections and pathway risk. This sees much of the national trapping efforts concentrated in the main centres including Auckland, Wellington and Christchurch.

Alongside these national efforts, the New Zealand Institute for Plant and Food Research Limited (PFR) has managed three regional trapping networks in Nelson, the Hawke's Bay and the BoP. New Zealand Apples and Pears Incorporated has supported the Nelson and Hawke's Bay networks since 2018 and Zespri and Kiwifruit Vine Health (KVH) have funded the BoP network for the last 2 years. Data collected from these networks were shared with MPI and included in the national surveillance programme.

This is the second year that BoP has been included in the national BMSB surveillance programme, with 24 traps set at 12 locations across the region in November 2020 for the purposes of:

1. Establishing a BMSB trapping network to identify whether BMSB is present or enters the BoP during the active monitoring period and
2. To provide appropriate BMSB identification, trapping and monitoring training for kiwifruit industry members.

2 Materials and methods

2.1 BMSB surveillance network

The national BMSB surveillance programme focuses trapping efforts in and around high risk TFs in order to detect BMSB entering the country with incoming imported goods. MPI employs a risk-based approach when ranking TFs for inclusion in their surveillance programme. TFs are ranked based on the total number of prior BMSB detection events or the number of imports arriving from countries with existing BMSB populations, such as Italy and China.

Twenty-four BMSB pheromone traps (Figure 1) were established at 12 locations (two trapping sites per location, denoted as traps a and b) across the BoP from Tauriko (in Tauranga) to Whakatane. Traps were set in or around 10 TFs (locations 1, 3, 4, 5, 6, 7, 8, 9, 10 and 12, see Figure 2 and Table 1) and two kiwifruit (KF) orchards (locations 2 and 11). The decision to extend the BoP network in 2020–21 and negotiations around trap location were based on discussions with MPI, Zespri, KVH and PFR.

The traps were erected at each location following MPI guidelines to ensure trapping methods and data collected by all BMSB surveillance networks in New Zealand were comparable. Key guidelines included:

- all traps should be set in vegetation and spaced approximately 100 m apart.
- fruiting plants should be favoured for the erection of BMSB traps, especially those with a known association with BMSB or other stink bug species present in New Zealand, where and if possible (see Table 1). Host plant selections were made on a site-by-site basis and exceptions made where the risk associated with BMSB detections was deemed priority (see Table 1).
- for all TF locations, traps should be set in vegetation as close to the TF as possible and no further than 125 m away from the TF centre.

Trap location (GPS, physical address), host species, private land or business owner contact details and access information were entered into Survey 123 for ArcGIS, a mobile application customised for the national BMSB surveillance programme. All trap and vegetation search data (including beat samples) were entered into Survey 123 for ArcGIS during each monitoring event, including stink bug species, life stage and number of individuals detected. The central data bank was held by MPI.

BMSB pheromone trapping units consisted of a single Pherocon StinkBug STKY™ Dual Panel clear sticky trap and the dual component Pherocon (Trécé) high load (4x) BMSB lure (see Figure 1), as is current industry standard. Lures and traps were supplied by MPI.

The lure used in this trial contains high doses of murgantinol (known as PHER) and methyl 2,4,6 decatrienoate (known as MDT). The aggregation pheromone produced by male BMSB consists of a 3:5 mix of the two (cis and trans) stereoisomers, (3S,6S,7R,10S) -10,11-epoxy-1-bisabolene-3-ol and (3R,6S,7R,10S) -10,11-epoxy-1-bisabolene-3-ol) (Khrimian et al. 2014). MDT is an analogue of the aggregation pheromone for the brown-winged green stink bug (*Plautia stali*) (Khrimian et al. 2014, Weber et al. 2017), which is attractive to BMSB adults later in the growing season (Leskey and Nielsen 2018) and remains attractive to nymphs all season long. By combining the two components, MDT and PHER, a synergistic effect is evident, whereby more adults and nymphs are caught in traps baited with this dual pheromone complex compared with traps baited with each component alone

(Weber et al. 2017). It is now common for the two-component pheromone complex to be commercially marketed and sold in combination (Weber et al. 2017) as is the case with the Pherocon Trécé lures.

MPI advised that traps should be checked on a fortnightly basis, working to a 10 ± 3 working day guideline (see Table 2 for assessment dates), from early November through to mid-April 2021. Incidences where trap assessments fell outside of the 10 ± 3 working day guideline were discussed with MPI and data relating to these inspections were extrapolated for the national surveillance network based on these extended or shortened assessment periods.

All traps were set out in the field from 2–6 November 2020 and monitored through to April 2021, thereby encompassing the high-risk period for BMSB interceptions in New Zealand. Lures were refreshed at 3-monthly intervals and sticky panels replaced every 6 weeks or as required.

The BMSB lure compound contains aggregation pheromones that draw BMSB to the vicinity of the stimuli and not to the exact location. Morrison et al. (2016) documented that these aggregation lures elicit an ‘attract and arrest’ response in BMSB and that bugs can usually be found within 2.5 m of the pheromone stimuli. Hence, it is recommended that timed visual inspection and beating of vegetation around these lures is important for a more accurate indication of local stink bug population numbers (Astorga 2018).

Figure 1. A brown marmorated stink bug (*Halyomorpha halys*) pheromone trap set in a *Casuarina cunninghamiana* shelter belt in a kiwifruit (*Actinidia deliciosa*) orchard in the Bay of Plenty, New Zealand.

For this project, 5-min timed searches of vegetation within a 10-m radius of each trap were undertaken for stink bug presence during monitoring events and a single beat sample was undertaken for each trap (two traps per location). Collapsible beat sheets provided by MPI were placed into vegetation near the pheromone trap. The vegetation above the sheet was then struck three times with a beating stick and the resulting catch was assessed for stink bug presence. Vegetation search data were then entered into Survey 123 for ArcGIS. Vegetation and beat sampling data were combined for the purposes of this study.

Photos of all stink bug finds were entered into the Survey 123 for ArcGIS mobile application for identification purposes. All live stink bug specimens encountered within this study were collected for diagnostic purposes.

2.2 Knowledge extension activities

In projects such as this, that are pre-emptive in nature, knowledge exchange and extension is essential to enable policy makers, industry and other interested or potentially affected parties to make informed decisions. Knowledge extension has always been an important part of this project, with an emphasis on learning about current trapping and monitoring techniques and technologies and their use and practicality in New Zealand kiwifruit orchards.

A planned field day could not go ahead before the completion of the 2019–20 BoP surveillance project due to concerns around COVID-19 and national alert levels and guidelines at the time. Although this didn't go ahead as planned I attended and presented at several industry events in regards to BMSB identification and the BoP surveillance network including the Zespri Momentum conference (14 February 2020) and a KiwiNet meeting (20 February 2020) in Mt Maunganui. BMSB pheromone lures and traps were displayed at both meetings and trap monitoring procedures were explained to attendees.

To ensure that these requirements were met in 2020–21 it was decided (via mutual agreement from KVH and PFR) that a training video outlining current BMSB surveillance activities be produced by PFR. The resulting video was intended to demonstrate how to set and monitor BMSB pheromone traps in the field and was to be used as a resource for training purposes should the kiwifruit industry ever need to use the traps. The video was filmed on 22 June 2021 and the final versions received on 14 July. The video was launched at the July 2021 KiwiNet meeting (23 July 2021, Trustpower Baypark, Truman Lane, Mt Maunganui, New Zealand) accompanied by a presentation that provided further information on the BoP surveillance network.

A questionnaire was also handed out to attendees at the KiwiNet meeting (Appendix 1) to allow Zespri and KVH to collect (anonymous) feedback on the training material provided (video) and the practicality of the surveillance methods for the kiwifruit industry. This information is summarised in Table 5 in the results section of this report.

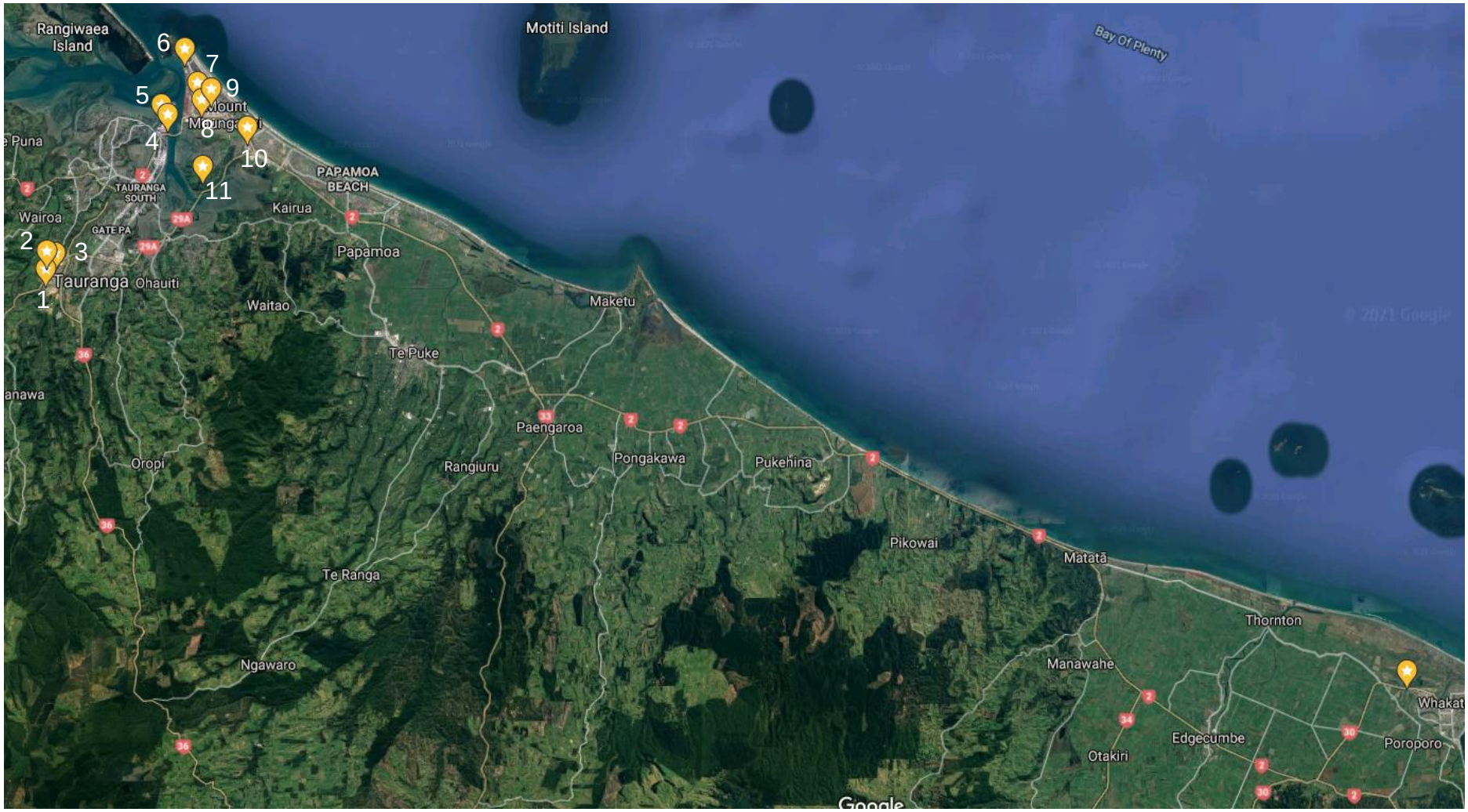

Figure 2. Map of the Bay of Plenty (BoP), New Zealand, showing 12 locations where brown marmorated stink bug (BMSB) (*Halyomorpha halys*) traps were set forming the 2020–21 BoP BMSB surveillance network.

Table 1. Plant species used as hosts to erect brown marmorated stink bug (BMSB, *Halyomorpha halys*) pheromone traps for the 2020–21 Bay of Plenty (BoP), New Zealand BMSB surveillance network. Trapping locations included 10 high-risk transitional facilities (TFs) and two kiwifruit (KF) orchards.

Trap location & ID		Trap host plant species
Keahi Rise, Tauriko, Tauranga (TF)	1a	*Quercus* sp. (oak tree)
	1b	*Quercus* sp. (oak tree)
SH 29, Tauriko, Tauranga (KF)	2a	*Cryptomeria japonica* (Japanese cedar)
	2b	*Cryptomeria japonica* (Japanese cedar)
Poturi St, Tauriko (TF)	3a	*Agathis australis* (kauri)
	3b	*Agathis australis* (kauri)
Den Place, Sulphur Pt, Tauranga (TF)	4a	*Metrosideros excelsa* (pōhutukawa)
	4b	*Pittosporum crassifolium* (karo)
Sulphur Pt, Tauranga (TF)	5a	*Metrosideros excelsa* (pōhutukawa)
	5b	*Pittosporum crassifolium* (karo)
Port of Tauranga, Mt Maunganui, Tauranga (TF)	6a	*Metrosideros excelsa* (pōhutukawa)
	6b	*Metrosideros excelsa* (pōhutukawa)
Triton Ave, Mt Maunganui, Tauranga (TF)	7a	*Nerium oleander* (oleander)
	7b	*Pittosporum crassifolium* (karo)
Te Maire Rd, Mt Maunganui, Tauranga (TF)	8a	Pittosporum eugenioides (lemonwood)
	8b	*Metrosideros excelsa* (pōhutukawa)
Hewletts Rd, Mt Maunganui, Tauranga (TF)	9a	*Metrosideros excelsa* (pōhutukawa)
	9b	*Metrosideros excelsa* (pōhutukawa)
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10a	*Coprosma repens* (taupata)
	10b	*Metrosideros excelsa* (pōhutukawa)
Puwhariki Rd, Matapihi, Tauranga (KF)	11a	*Cryptomeria japonica* (Japanese cedar)
	11b	*Cryptomeria japonica* (Japanese cedar)
Mill Rd, Whakatane (TF)	12a	*Citrus limon* (lemon)
	12b	*Coprosma repens* (taupata)

Table 2. Brown marmorated stink bug (*Halyomorpha halys*) pheromone trap assessment dates for the surveillance network established in the Bay of Plenty, New Zealand. Trapping locations included 10 high-risk transitional facilities (TF) and two kiwifruit (KF) orchards.

Location	Trap ID	Trap assessment dates											
		Assess. 1	Assess. 2	Assess. 3	Assess. 4	Assess. 5	Assess. 6	Assess. 7	Assess. 8	Assess. 9	Assess. 10	Assess. 11	Assess. 12
Keahi Rise, Tauriko, Tauranga (TF)	1a	19/11/20	4/12/20	17/12/20	20/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
	1b	19/11/20	4/12/20	17/12/20	20/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
SH 29, Tauriko, Tau (KF)	2a	19/11/20	4/12/20	17/12/20	20/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
	2b	19/11/20	4/12/20	17/12/20	20/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
Poturi St, Tauriko (TF)	3a	19/11/20	4/12/20	17/12/20	20/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
	3b	19/11/20	4/12/20	17/12/20	20/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
Den Place, Sulphur Pt, Tauranga (TF)	4a	19/11/20	4/12/20	17/12/20	22/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
	4b	19/11/20	4/12/20	17/12/20	22/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
Sulphur Pt, Tauranga (TF)	5a	19/11/20	4/12/20	18/12/20	22/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
	5b	19/11/20	4/12/20	18/12/20	22/12/20	14/01/21	29/01/21	11/02/21	25/02/21	10/03/21	25/03/21	7/04/21	21/04/21
Port of Tauranga, Mt Maunganui, Tauranga (TF)	6a	19/11/20	4/12/20	18/12/20	23/12/20	13/01/21	29/01/21	11/02/21	25/02/21	11/03/21	25/03/21	7/04/21	21/04/21
	6b	19/11/20	4/12/20	18/12/20	23/12/20	13/01/21	29/01/21	11/02/21	25/02/21	11/03/21	25/03/21	7/04/21	21/04/21
Triton Ave, Mt Maunganui, Tauranga (TF)	7a	19/11/20	4/12/20	18/12/20	22/12/20	13/01/21	29/01/21	12/02/21	25/02/21	11/03/21	25/03/21	7/04/21	21/04/21
	7b	19/11/20	4/12/20	18/12/20	22/12/20	13/01/21	29/01/21	12/02/21	25/02/21	11/03/21	25/03/21	7/04/21	21/04/21
Te Maire Rd, Mt Maunganui, Tauranga (TF)	8a	19/11/20	4/12/20	18/12/20	22/12/20	14/01/21	29/01/21	12/02/21	25/02/21	11/03/21	25/03/21	7/04/21	21/04/21
	8b	19/11/20	4/12/20	18/12/20	22/12/20	14/01/21	29/01/21	12/02/21	25/02/21	11/03/21	25/03/21	7/04/21	21/04/21
Hewletts Rd, Mt Maunganui, Tauranga (TF)	9a	19/11/20	8/12/20	18/12/20	22/12/20	14/01/21	29/01/21	12/02/21	26/02/21	11/03/21	25/03/21	7/04/21	21/04/21
	9b	19/11/20	8/12/20	18/12/20	22/12/20	14/01/21	29/01/21	12/02/21	26/02/21	11/03/21	25/03/21	7/04/21	21/04/21
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10a	19/11/20	7/12/20	18/12/20	23/12/20	13/01/21	29/01/21	12/02/21	26/02/21	10/03/21	25/03/21	7/04/21	22/04/21
	10b	19/11/20	7/12/20	18/12/20	23/12/20	13/01/21	29/01/21	12/02/21	26/02/21	10/03/21	25/03/21	7/04/21	22/04/21
Puwhariki Rd, Matapihi, Tauranga (KF)	11a	19/11/20	7/12/20	17/12/20	23/12/20	13/01/21	29/01/21	12/02/21	26/02/21	10/03/21	25/03/21	7/04/21	22/04/21
	11b	19/11/20	7/12/20	17/12/20	23/12/20	13/01/21	29/01/21	12/02/21	26/02/21	10/03/21	25/03/21	7/04/21	22/04/21
Mill Rd, Whakatane (TF)	12a	20/11/20	7/12/20	18/12/20	23/12/20	15/01/21	30/01/21	12/02/21	27/02/21	11/03/21	26/03/21	12/04/21	23/04/21
	12b	20/11/20	7/12/20	18/12/20	23/12/20	15/01/21	30/01/21	12/02/21	27/02/21	11/03/21	26/03/21	12/04/21	23/04/21

3 Results

Due to the nature of the stink bug capture data (sparse and few data points) (Tables 3 and 4), statistical analysis was not feasible and hence observational data only are presented in this report. Data were separated into two categories: pheromone trap and vegetation search detections.

BMSB was not detected at any of the trapping locations across the BoP surveillance network.

Monteithiella humeralis (pittosporum shield bug) was the dominant stink bug species across the network and surveillance, accounting for 98.3% of total stink bug detections (Tables 3 and 4). The *Glaucias amyoti* (Australasian green stink bug) specimens detected in November 2020 (trap catch) and February 2021 (vegetation search) (Tables 3 and 4) were the only other stink bug species encountered besides *M. humeralis*.

No stink bugs were detected at the two kiwifruit orchards (locations 2 and 11) and several of the TF trapping sites (locations 3, 6, 7, 8 and 9).

All *M. humeralis* individuals detected across the monitoring period were encountered on their primary host plant *Pittosporum crassifolium* (Tables 3 and 4).

Both adult and immature (nymphal) stink bugs were detected on the sticky panels. Vegetation searches accounted for 91.5% of total stink bug detections (Table 3).

Stink bug detections were more frequent in January and February than other months included in the assessment period (see Tables 3 and 4, and Figure 3).

With over 40 attendees at the July 2021 KiwiNet meeting, which included several industry representatives from Fruitfed Supplies (PGG Wrightson Ltd), New Zealand Avocado, Seeka Ltd, Horticulture NZ, NZ Wine, Zespri and KVH, 32 feedback forms were completed. Feedback from the two multichoice questions is included in Table 5a and written comments are summarised in Table 5b.

Table 5a shows that those in attendance at the KiwiNet meeting agreed that the training video was easy to follow and understand and that the techniques demonstrated could be practically integrated into current orchard practices.

There were five common themes identified in responses to Question 2 (Table 5b) in regards to the practicality of integrating BMSB monitoring techniques into current orchard practice: grower/industry buy-in/interest; availability of trapping materials; trapping methods; feedback on the training video; and further suggestions.

Table 3. Pentatomidae (stink bug) trap catches associated with brown marmorated stink bug (*Halyomorpha halys*) pheromone traps established as part of a surveillance network in the Bay of Plenty, New Zealand. Data have been sorted by stink bug detection date. Trapping locations included 10 high-risk transitional facilities (TFs) and two kiwifruit (KF) orchards.

Trapping location	Trap id	Sample date	Specimen species	# of specimens	Life stage	Sample host	Host phenology
Keahi Rise, Tauriko, Tauranga (TF)	1a	19/11/20	*Glaucias amyoti*	1	Adult	*Quercus* sp.	Vegetative growth
Den Place, Sulphur Pt, Tauranga (TF)	4b	29/01/21	*Monteithiella humeralis*	1	Adult	*Pittosporum crassifolium*	Ripening fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	25/03/21	*M. humeralis*	8	Nymphs	*P. crassifolium*	Ripening fruit

Table 4. Pentatomidae (stink bug) detections in vegetation located within 10 m of a single brown marmorated stink bug (*Halyomorpha halys*) pheromone trap. Data have been sorted by stink bug detection date. Trapping locations included 10 high-risk transitional facilities (TFs) and two kiwifruit (KF) orchards.

Trapping location	Trap id	Sample date	Specimen species	# of specimens	Life stage	Sample host	Host phenology
Sulphur Pt, Tauranga (TF)	5a	19/11/20	*Monteithiella humeralis*	1	Adult	*Pittosporum crassifolium*	Immature fruit
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10b	7/12/20	*M. humeralis*	1	adult	*P. crassifolium*	Immature fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	17/12/20	*M. humeralis*	2	adult	*P. crassifolium*	Ripening fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	22/12/20	*M. humeralis*	6	5 adults, 1 nymph 1 egg raft (15 eggs total)	*P. crassifolium*	Ripening fruit
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10b	13/01/21	*M. humeralis*	10	nymphs	*P. crassifolium*	Ripening fruit
Sulphur Pt, Tauranga (TF)	5a	14/01/21	*M. humeralis*	1	nymph	*P. crassifolium*	Ripening fruit
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10b	29/01/21	*M. humeralis*	1	adult	*P. crassifolium*	Ripening fruit
Sulphur Pt, Tauranga (TF)	5a	11/02/21	*M. humeralis*	2	adults	*P. crassifolium*	Ripening fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	11/02/21	*M. humeralis*	2	1 adult, 1 nymph	*P. crassifolium*	Ripening fruit
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10a	12/02/21	*M. humeralis*	2	1 adult, 1 nymph	*P. crassifolium*	Ripening fruit
			Glaucias amyoti	1	nymph		
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10b	12/02/21	*M. humeralis*	23	4 adults, 19 nymphs	*P. crassifolium*	Ripening fruit
Sulphur Pt, Tauranga (TF)	5b	25/02/21	*M. humeralis*	1	adult	*P. crassifolium*	Ripening fruit
Sulphur Pt, Tauranga (TF)	5a	25/02/21	*M. humeralis*	1	adult	*P. crassifolium*	Ripening fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	25/02/21	*M. humeralis*	16	nymphs	*P. crassifolium*	Ripening fruit
Bayfair Reserve, Russely Dr, Mt Maunganui, Tauranga (TF)	10a	26/02/21	*M. humeralis*	2	adults	*P. crassifolium*	Ripening fruit
Sulphur Pt, Tauranga (TF)	5a	10/03/21	*M. humeralis*	2	adults	*P. crassifolium*	Maturing fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	10/03/21	*M. humeralis*	7	4 adults, 3 nymphs 1 x egg raft (15 eggs total)	*P. crassifolium*	Maturing fruit
Sulphur Pt, Tauranga (TF)	5a	10/03/21	*M. humeralis*	1	nymph, 1 egg raft (14 eggs total)	*P. crassifolium*	Maturing fruit
Sulphur Pt, Tauranga (TF)	5a	25/03/21	*M. humeralis*	1	nymph	*P. crassifolium*	Maturing fruit
Sulphur Pt, Tauranga (TF)	5b	25/03/21	*M. humeralis*	2	adults	*P. crassifolium*	Ripening fruit
Sulphur Pt, Tauranga (TF)	5b	07/04/21	*M. humeralis*	1	adult	*P. crassifolium*	Ripening fruit
Sulphur Pt, Tauranga (TF)	5a	07/04/21	*M. humeralis*	2	adults	*P. crassifolium*	Maturing fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	07/04/21	*M. humeralis*	8	6 adults, 2 nymphs	*P. crassifolium*	Maturing fruit
Den Place, Sulphur Pt, Tauranga (TF)	4b	14/01/21	*M. humeralis*	2	nymphs	*P. crassifolium*	Maturing fruit

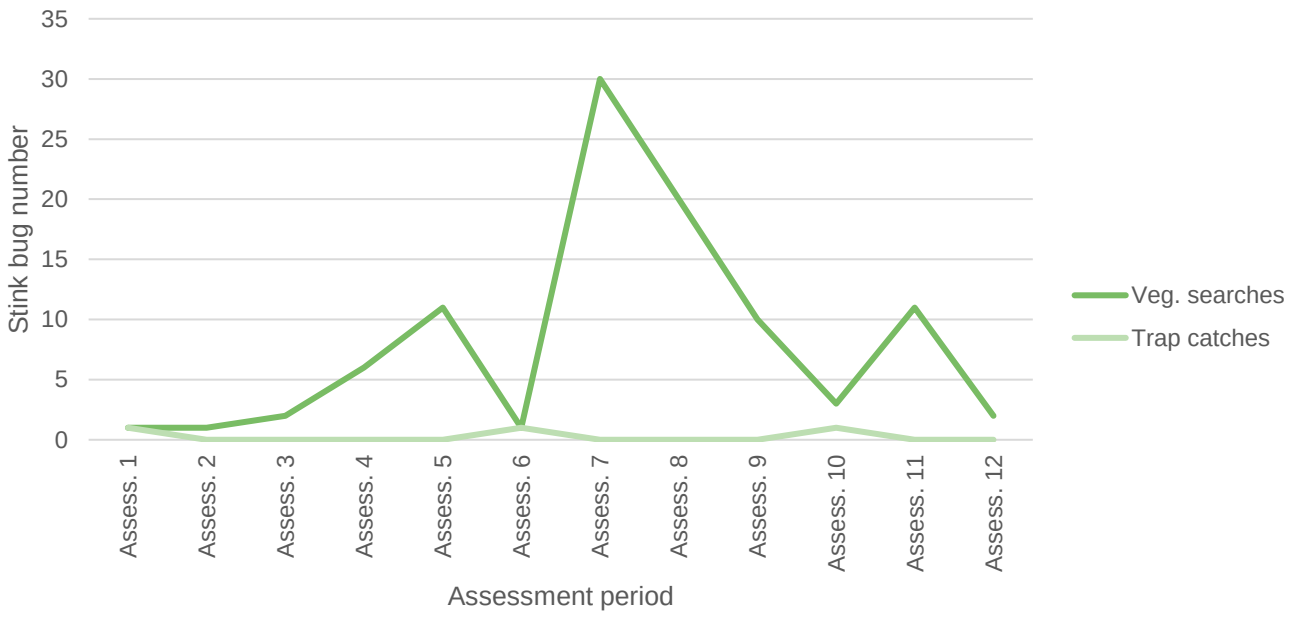

Figure 3. Number of Pentatomidae (stink bug) detections on brown marmorated stink bug (BMSB) (*Halyomorpha halys*) pheromone trapping units or on vegetation located within 10 m of each trap (excluding egg raft detections). These traps were established as part of a BMSB surveillance network established in the Bay of Plenty, New Zealand. Data have been sorted by stink bug assessment period.

Table 5a and 5b: Feedback (anonymous) collected from attendees at the 23 July 2021 KiwiNet meeting, held at Trustpower Baypark, Truman Lane, Mt Maunganui, New Zealand, in regards to knowledge extension activities provided on the day. These included a PowerPoint presentation outlining the functioning of the Bay of Plenty arm of the national brown marmorated stink bug (*Halyomorpha halys*, BMSB) surveillance network and a training video prepared by The New Zealand Institute for Plant and Food Research Ltd staff demonstrating how to set and monitor BMSB pheromone traps in the field. The questionnaire (Appendix 1) was handed out to attendees at the KiwiNet meeting. With over 40 people in attendance, 32 feedback forms were received. Table 5a shows the results for the two multichoice questions and Table 5b shows summarised written feedback.

Table 5a Question	Feedback responses
1: Did you find the training video easy to follow and understand?	Very Easy: 29 Easy: 3 Somewhat easy: 0 Neither easy or difficult: 0 Somewhat difficult: 0 Difficult: 0 Very difficult: 0
2: Do you think that the trapping materials and methods shown today could be practically integrated into current kiwifruit growing systems?	Strongly agree: 15 Agree: 17 Neither agree nor disagree: 0 Disagree: 0 Strongly disagree: 0

Table 5b Question	Feedback responses
2: Do you think that the trapping materials and methods shown today could be practically integrated into current kiwifruit growing systems?	Grower/industry buy-in/interest: Grower buy-in and awareness of the BMSB and monitoring activities might be a barrier for adoption of these practices Already interest from many growers for traps to be placed in kiwifruit orchards for the last two years Many growers will adopt these techniques
	Availability of trapping materials: Retailers and MPI need to make traps available if needed Costs and availability might impede use and trapping efforts Are screws and washers included in the trapping packs? Some growers may not want to fund the beat sheet, are there any other options for this? Will a tarp or a cardboard sheet suffice?
	Trapping methods: Simple and practical methods Need to look at considerations for growers with artificial shelters Screws and large washers are a good option, as they're strong and will ensure that the traps remain in place Require further information in regards to trap placement and frequency
	Feedback on the video: Clear and easy to follow the video Great alternative to training in person Easy to follow instructions and very clear to understand More bullet points in the video
	Further suggestions: Centralised data recording system Can the video be integrated into the biosecurity workshops for growers in November?
3: Are there any other training activities you would like to see in regards to BMSB monitoring techniques?	Fun activities: quiz on trapping and monitoring techniques, find the BMSB explore/search, BMSB identification Workshops: small group sessions and training days that include: an introduction to BMSB, BMSB in a kiwifruit context and trapping and monitoring activities Make the training video available and accessible on multiple affiliated industry websites and email it industry wide BMSB identification: BMSB vs. New Zealand examples, a model of BMSB made with identifying features, physical samples of BMSB Biosecurity messaging, awareness and activities be conveyed to schools and into tertiary education Specific advice on orchard trap placement, importance of trapping and surveillance and practical implementation Information on the use of sacrificial crops and netting as potential control options for BMSB

4 Discussion

In the event that BMSB should establish in New Zealand, the national kiwifruit industry is likely to face several challenges, including: potential limits to export markets, the disruption of current management systems with a need for increased chemical use, and associated issues with exceeding international minimum residue levels (MRLs). With this, it is likely that production costs would increase, particularly those related to labour and crop protection. The New Zealand kiwifruit industry is well aware of the threat posed by BMSB and is active in supporting research initiatives and awareness campaigns concerning this pest, including the second year of the BoP BMSB surveillance network.

The risks associated with BMSB establishment in the BoP remain high. Early detection is essential for successful pest eradication and mitigating economic impacts, and in the case of BMSB offers the most sustainable solution to control this pest should it arrive in New Zealand. Efficient and widespread surveillance is a primary requirement to elicit eradication responses and hence should be a priority for high risk and high impact biosecurity threats such as BMSB.

This was the second year that the surveillance network was active in the BoP, with traps established in early November 2020 and monitoring occurring every fortnight until mid-April 2021. BMSB was not detected by any traps or monitoring activities associated with the BoP surveillance network this year.

Stink bug detections were low across all BoP locations and no stink bugs were detected at the two kiwifruit orchards (locations 2 and 11) and several of the TFs (locations 3, 6, 7, 8 and 9) across the monitoring period. Although BMSB was not detected by this surveillance network, a live BMSB adult was discovered by staff at a TF included as a trapping location in the BoP network. The insect was discovered in a container that had recently arrived from Japan, and was dealt with accordingly by facility staff and MPI. Incidences such as this reaffirm the risk associated with this pest here in New Zealand and the BoP.

It is evident that host plant associations and presence at or near the trapping locations influenced stink bug detections, and this holds true across the 2 years that the BoP network was active (2019–20 data not included in this report). In 2020–21 all host plants associated with trap catches and vegetation detections were known hosts of stink bugs present in New Zealand, except for location 1 (on *Quercus* sp.). *Monteithiella humeralis* (pittosporum shield bug) was the most commonly encountered species across the network in 2020–21 owing to the presence of their primary host (*P. crassifolium*) at or near the trapping locations. This differed from the 2019–20 insect detections, in which a wider range of stink bug species was encountered, including *Nezara viridula* (green vegetable bug), *Cuspicona simplex* (green potato bug), *Dictyotus caenosus* (brown shield bug) and the predatory species *Cermatulus nasalis* (brown soldier bug). This was a result of the wider range of known stink bug host plants present in the trapping vicinity that year (2019–20 data not included in this report)

Sticky panel interceptions were low in 2020-21 (three) compared with the previous year (eleven, data not included in this report) possibly due to the nature of the host plants included in the network and a shift to more industrial locations this year.

Stink bug detections were most frequent during January and February across the two active years of the BoP surveillance network (2019–20 data not included in this report) which follows general trends for Pentatomidae phenology in New Zealand.

The knowledge extension and training activities delivered under this project were well received by attendees at the KiwiNet meeting held in late July 2021. Feedback received on the day suggests that

the training video was easy to understand and clear in terms of instructions. Further to this, participants agreed that the techniques and trapping materials demonstrated could be practically integrated into current kiwifruit orchard practice. The questionnaire also identified possible barriers to adoption, gaps in industry/grower knowledge in regards to BMSB and possible future training activities.

The Zespri and KVH funded BoP BMSB surveillance network has provided opportunities for scientists, kiwifruit growers, industry partners and support services to become familiar with current BMSB pheromone trapping and monitoring technologies and techniques. This could prove invaluable should BMSB ever establish in New Zealand.

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- All private land and business owners and the Tauranga City Council for allowing regular access to their properties for the duration of this study. We appreciate your willingness to support a regional, and ultimately national, initiative aimed at protecting New Zealand from a serious biosecurity threat.

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Appendix 1 – KiwiNet meeting questionnaire

BMSB trapping and monitoring survey

1: Did you find the training video easy to follow and understand?

Very easy ○ ○ ○ ○ ○ ○ ○ Very difficult

2: Do you think that the trapping materials and methods shown today could be practically integrated into current kiwifruit growing systems?

○ Strongly agree ○ Agree ○ Neither agree nor disagree ○ Disagree ○ Strongly disagree

Comments:

3: Are there any other training activities you would like to see in regards to BMSB monitoring techniques?

Thank you for your feedback.

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