Descriptive analysis of Tb disease and surveillance data

July 2009 to June 2014

GF Mackereth

31 May 2015

Purpose

The purpose of this analysis was to inform the estimation of disease and testing under different strategy options. This paper describes disease incidence and livestock surveillance over a 5 year period.

Methods

TB Free provided annual data on herds, herd infection and clearance together with animal testing and disease data categorised by vector area status for the five year period 2009/10 – 2013/14. The data was categorised by year, "herd type" (beef, dairy and deer) and vector risk status. Data included the number of:

- Herds
- I herds 30 June
- Incident herds
- Period I herds
- Incident Herds infected by TB vectors
- Incident Herds infected by movement or grazing
- Incident Herds infected by recrudescence
- Incident Herds infected by splitting
- Incident Herds source of infection unknown
- Cleared I herds
- Primary Tests
- Primary test positive
- Serial tests
- Serial test-positive
- Parallel tested
- Reactors slaughtered
- Reactors with TB lesions at slaughter
- TB animals found at routine slaughter

The number of reactors with TB lesions that were condemned and the number of routinely slaughtered animals found with TB that were condemned was not provided. These values were estimated from the rate of condemnations observed from 2007 to 2014 (TB Free data Table 1).

TB Free provided information for all infected herds on the attributed source of infection. In the data provided infected herds were attributed a source of infection; vector, movement or grazing,

recrudescence, herd splitting, and unknown. The unknown herds were assigned one of the four sources based on the proportion of known sources in the herds area. It was assumed for example that unknown sources of infection in the vector free area were not vector related infections.

TB Free provided detailed information on the means by which incident herds in the vector free area (VFA) were detected.

Data on animals slaughtered by herd type per year in New Zealand was obtained from Industry for the 5 year period and from OSPRI (NAIT data) for the 2013-2014 year; cattle only (Table 2). Table 2 shows slaughter statistics by herd type as per NAIT and Industry data.

Initial descriptive analysis revealed that no herds were considered to have been infected by TB possums in a large number of vector control zones during the 5 year period. Accordingly, vector risk areas (VRAs) were grouped or divided into core VRAs and "suppressed" VRAs. The term "suppressed" was used to describe VRAs with little or no apparent transfer from TB possums to herds.

The analysis refers to six zones; the core and suppressed vector risk areas and the vector free areas in each Island.

Results

Disease statistics show no clear decline over the 5 years, but are not increasing

Disease statistics finished lower at the end of the period than the beginning, however a low year in 2011/12 and a high year in 2012/13 obscure any clear decline if it is present. Figure 1 shows disease statistics for the 5 year period.

Detection of infected animals is a rare event

Nationally, 3.6 animals with lesions were detected for every 100,000 animals tested, and 3 animals with lesions were detected per 100,000 routinely slaughtered (industry slaughter data). Table 3 shows the occurrence of disease, surveillance effort, livestock statistics, and detection rates; averaged for the 5 year period, as well as statistics for the 2013-14 year.

Disease is clustered in the core of the vector risk areas and in particular the South Island vector risk areas.

NAIT data available for 2013-14 allows slaughter detection rates to be examined with respect to vector risk area and island. Detection rates are dis-similar with respect to vector risk and island, showing a strong North Island to South Island gradient, and VFA to core VRA gradient. Table 4 shows the detection rates. Nationally the core VRA had 33 times the slaughter detection rate observed in the VFA, and the suppressed VRA had 3 times the detection rate observed in the VFA. Test detection rates show the same pattern, slightly less marked. Infected herd statistics are similarly clustered predominantly in the South Island core VRA (Table 6).

Half of all infected herds are infected directly by vectors

Figure 2 and Table 5 shows the estimated source of infection for incident herds for the 5 year period.

Nationally approximately half of incident infections were considered to be directly from vectors. Approximately a third were from movements, and the remainder from recrudescence of disease in previously infected herds, or from splitting of herds. Figure 2 shows that this pattern was very strong in the South Island and actually reversed in the North Island, where movement related infection was more common than vector infection. The findings were similar for both dairy and beef herds, although dairy show relatively more movement and recrudescent infection than beef.

We can propose that all infected herds directly or indirectly result from vector infection

The distribution of disease in the core VRA and the strong decline in gradient of infection as we move to the VFA supports the fundamental understanding of the epidemiology of bovine Tb in New Zealand; that vectors maintain TB and are a reservoir of infection for livestock. Given this assumption, the amount of indirect infection for every vector infection is of interest. Indirect infection levels provide a measure of the effectiveness of surveillance and disease control. Table 7 shows that for every vector infection in the North of South Island the number of indirect infections in that Island. Nationally for every vector infection there was one other herd infected; however in the North Island there were 4.5 other herds infected for every vector infection, and in the South Island there were 1.7 herds infected. This suggests that detection and movement control are effective in the South Island; importantly this is where the majority of vector infections occur.

Table 8 shows that for every incident vector infected herd there were in the country that year a total of 5 reactors and 2.8 routinely slaughtered animals found with lesions. Some of these animals would have been index cases infected by vectors, suggesting that indirect infections (livestock to livestock spread) was constrained to single digit figures.

Triennial testing is unrewarding in vector free areas

Table 5 shows that was an average of 17.4 incident herds detected per year in the VFA or 87 herds over the 5 years. TB Free provided detailed information on the means by which these herds were detected. Data was provided for 67 (76%) herds. Table 9 shows the means of detection of these herds; 41% were detected by slaughter surveillance, 26% by tracing, investigation, or post movement testing, and only 33% were detected by triennial testing, an estimated 29 herds or 6 herds per year. Table 10 shows the number of tests per annum in the VFA was 2,580,699.

The consequence of not testing in the VFA is low.

Tables 9, 10, 11 and 12 show how herds in the VFA are detected and calculate the estimated number detected by triennial testing in the VFA. This is low approximately 6 cattle herds per annum and no deer herds. The number of primary tests required to make these detections is shown in Table 12, averages 445,000 or 1.1 million dollars at $2.50 a test. The cost of a late detection of herds in the VFA (something that may happen if triennial testing is stopped) is shown in Table 12. Combining these data gives a saving of $5,750,000 in direct testing costs if triennial testing is stopped, allowing for the late detection of some infected herds ($180,000).

Over 7 million animals are examined for Tb (by test or at slaughter) each year

Tables 13 through 17 present testing or slaughter data by herd type and zone including:

- Testing and disease by herd type and zone
- Estimated slaughter statistics by herd type and zone
- Testing and disease statistics per primary test
- Detection rates at test and at slaughter per zone

- Disease animals per infected herd

The tables show that on average 4735900 animals were tested each year, 2,580,699 in the VFA. NAIT data for 2013-14 shows that 2,658,966 animals were slaughtered, 2,077,080 in the VFA.

Surveillance intensity per breakdown varies widely by zone and herd type

Figure 3 shows the relative contribution of testing and slaughter by herd type to the surveillance in each zone. Figure 4 shows the same surveillance statistics per herd by herd type. Figure 5 shows the amount of testing and slaughter surveillance per breakdown. This view of the data reverses the normal perception of surveillance being more intense in vector risk areas and in dairy herds. From a perspective of surveillance relative to breakdown risk there is more surveillance beef and in vector free areas.

Discussion

The core VRA could be targeted

The concept of rolling back VRA's to the core has the disadvantage of not suppressing the main source of TB in herds. The clustering of disease in the core of VRA provides an opportunity

to target the core with vector control and reduce both direct and indirect infections. This would have the benefit of reducing the need for widespread testing.

In much of the "VRA" there is no transmission from TB possums to livestock occurring. There are only a small number of herds believed to be infected by vectors each year, particularly in the North Island. Eliminating TB transmission to herds, particularly in the North Island and large parts of the VRA in the South island, could be an explicit objective of the programme.

Triennial testing could cease

For the whole country less than 1 in 1000 herds is infected, dropping to 3 in 10000 in the vector free area. Detection rates per test are very low and triennial testing is only detecting approximately 6 herds per annum. This challenges herd based testing programmes and points to the need for testing based on a known and specific risk.

In the design of testing programmes to detect disease by testing herds and testing animals within herds one must consider the proportion herds likely to be infected to determine how many herds to test ,and then the proportion of animals in infected herds to determine how many animals to test in those herds. Adjustments are made to the number of animals tested to account for the sensitivity of testing at the animal level, and adjustments are made to the numbers of herds tested to account for the sensitivity of testing at a herd level. Surveillance may be designed to give confidence it would detect disease if it is present at pre-determined design prevalence. A typical design prevalence for the number of animals within a herd to test is 1% prevalence. This random sampling paradigm is not appropriate for very rare diseases. The herd prevalence's observed in the last 5 years (2 in 10000 in the NI VFA) are so low that if random sampling the basis for detection then all herds would need to

be tested. Likewise the observed prevalence's within herd are so low that every animal would need to be tested to provide confidence of detection (Table 14 shows that nationally there are 1.1 Tb reactors for every period I herd that year and 0.52 Tb culls). Testing to detect 1 or 2 Tb animals within a herd requires nearly all animals to be tested to give confidence of detection.

Tb is now very rare in large parts of the country, and will become even rarer under some of the strategic options. Programmatic testing based on herd type will detect less and less TB animals.

An alternative paradigm would be to only test herds and animals with a demonstrable and reasonable risk of infection; that is target testing on sub populations at greater risk of TB infection. Testing purely to confirm herd freedom in the VFA could be unfunded.

The data is useful for economic analysis of scenario options

The herd disease statistics and animal disease statistics in relation to the number of incident vector infected herds in each Island (Table 7 and 8) could be used to extrapolate these statistics under different scenarios. If the expected number of incident vector infected herds was predicted under various scenario options then the indirect herd and animal disease statistics could be extrapolated from these tables. Incident vector infected herds could be estimated by adjusting for the % change in TB possums on pasture expected with possum control under different strategic options. Extrapolation into the future from these data would make an assumption that the relationships observed in these data will remain the same.

Disease data may underestimate disease

The analysis uses lesions at slaughter as the gold standard. It is acknowledged that lesions may not be detected in some TB animals.

Disclaimer

This paper is a concept paper, developed for the purpose of identifying approaches to the consideration of strategic options for the TB PMS. Any work presented here would naturally be re-worked as the approaches and strategic options are refined.

This report or document (the Report) is given by the author solely for the benefit of TB Free Ltd. The author does not make any warranty, express or implied, or assumes any legal liability or responsibility for use of the Report or its contents by TB Free Ltd or any other person or organisation.

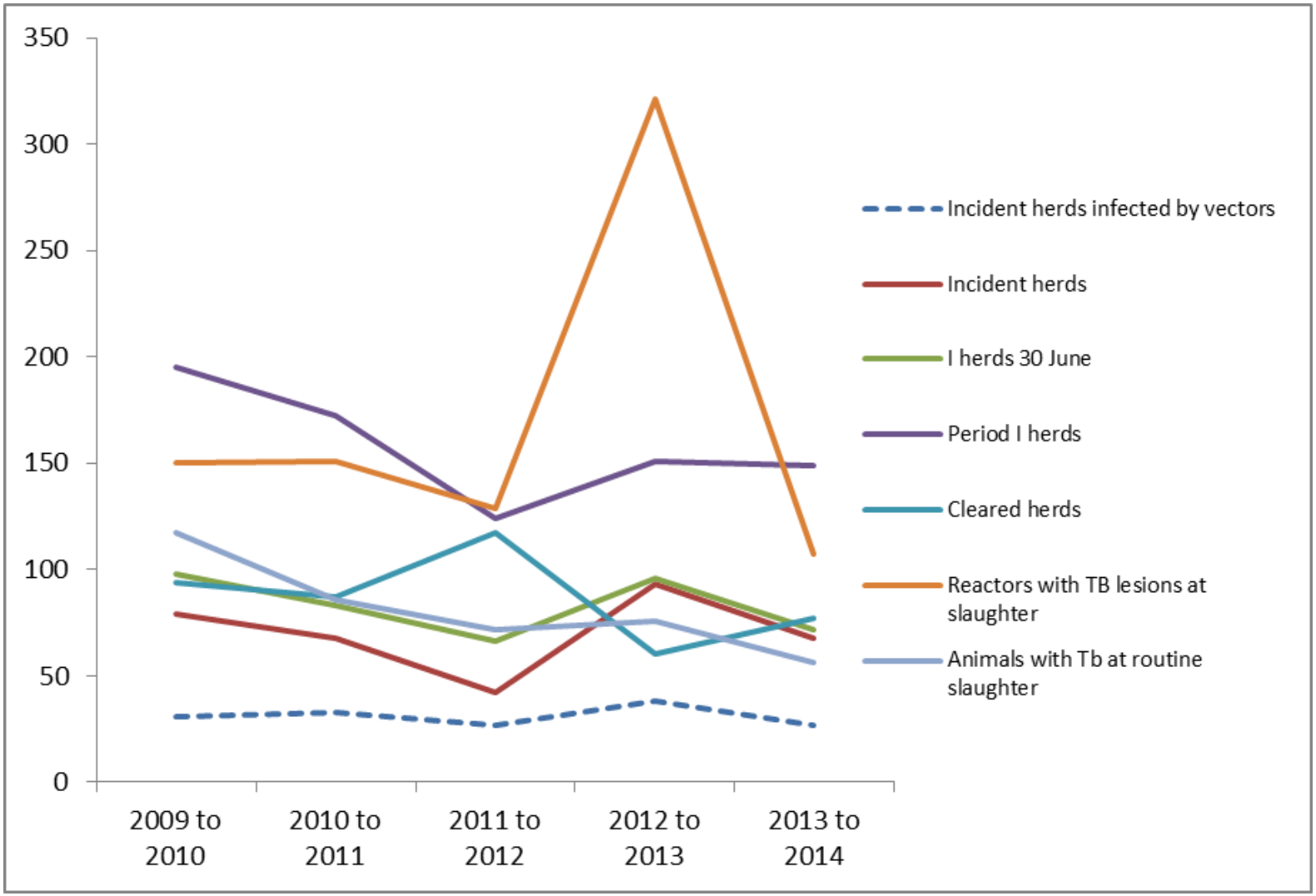

Figure 1 Figure of disease statistics by year

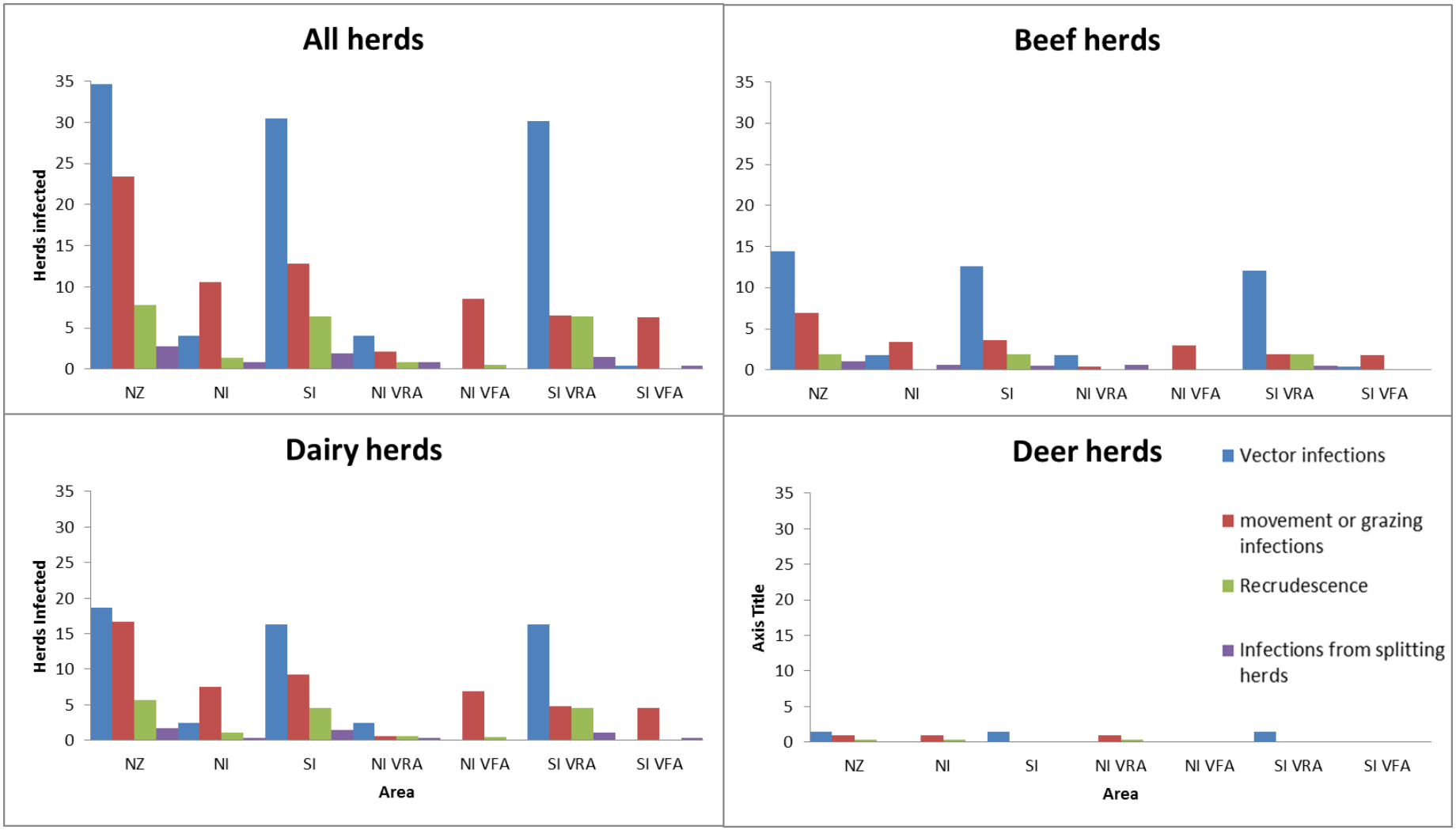

Figure 2 Estimated source of infection by area and herd type 5 year average

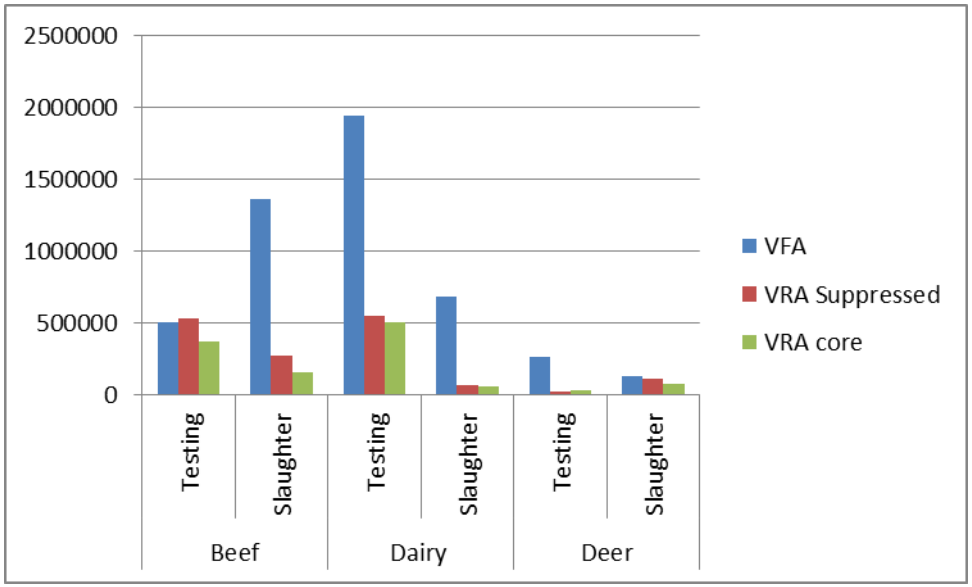

Figure 3 Figure showing testing and slaughter statistics by vector zone annually

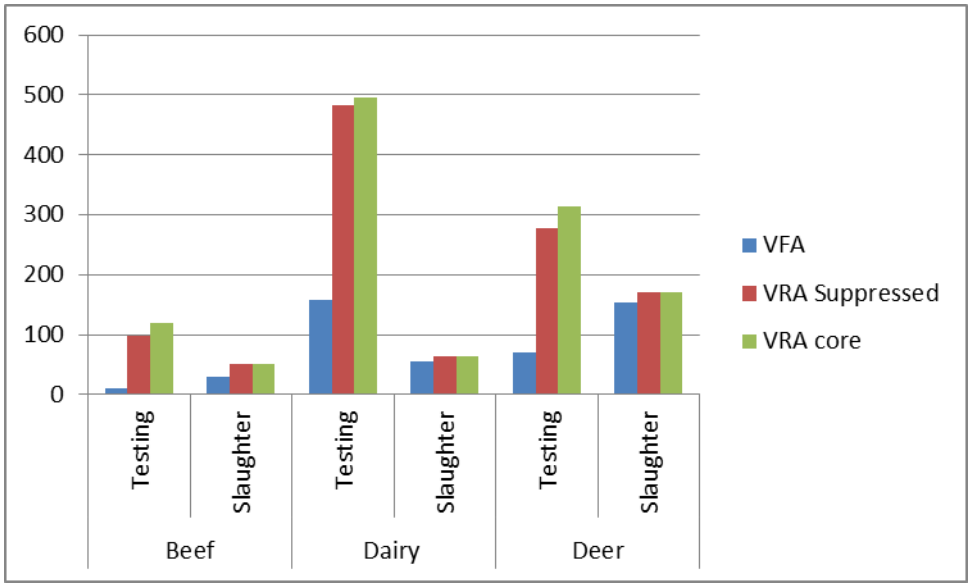

Figure 4 Figure showing tests and slaughter per herd by vector zone

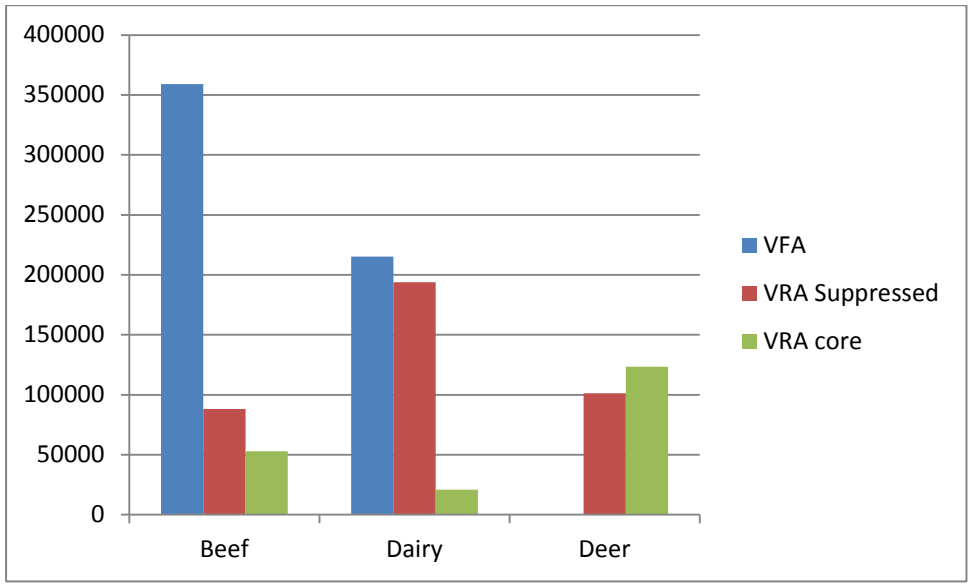

Figure 5 Amount of testing and slaughter surveillance per breakdown (by any means)

Nb no breakdowns occurred in deer VFA

Table 1 Condemnation rates by herd type from 2007- 2014 (TB Free data)

Herd type	% Reactors with TB condemned	% Culls with TB condemned
All herds	18.0%	15.6%
Beef	15.1%	16.4%
Dairy	19.8%	22.2%
Deer	7.1%	0.0%

Table 2 Table of slaughter statistics (Industry sources and NAIT)

Herd type (slaughtered from)	Beef		Dairy		Deer
	Industry sources	NAIT	Industry sources	NAIT	Industry sources
2009-2010	1614971		769223		384701
2010-2011	1588261		789333		414512
2011-2012	1515386		702297		406781
2012-2013	1510334	1282818	861764	7070345	430989
2013-2014	1480198	1700215	893588	826543	420392
5 year total	7709150		4016205		2057375
Annual average	1541830		803241		411475
TB Free herds 5 year total	264720		70134		15161
Estimated average number of herds (TB Free data)	52944		14027		3032
Average animals slaughtered per herd type	29		57		136

Table 3 National disease, surveillance and livestock statistics 5 year average and 2013-14 year

Herd type	All		Beef		Dairy		Deer	
Disease statistic	5 year average	2013/14	5 year average	2013/14	5 year average	2013/14	5 year average	2013/14
Incident herds infected by vectors	35	27	14	7	19	20	1	0
Incident herds (all sources)	70	68	24	22	43	46	1	0
I herds 30 June	83	72	29	21	49	48	4	3
Period I herds	158	149	59	46	91	98	7	5
Cleared I herds	87	77	34	21	49	77	4	2
Reactors with TB lesions at slaughter	172	107	49	21	119	86	3	0
Estimated Reactors condemned	31	19	7	3	24	17	0	0
Animals with Tb at routine slaughter	81	56	58	45	19	11	0	0
Estimated condemned at routine slaughter	13	9	9	7	4	2	0	0
Surveillance statistic								
Primary tests	4735900	4448168	1417641	1288703	2990250	2913804	328009	245661
Primary test positive	8936	10157	854	981	5623	7369	2461	1818
Reactors slaughtered	1121	997	180	120	647	654	295	223
Serial tests	8564	9780	750	933	5475	7195	2341	1663
Serial test positive	536	455	54	50	351	326	131	79
Parallel tests	33165	44079	4905	4806	28286	39273	na	na
Parallel test positive	170	169	24	22	146	147	na	na
Herd testing visits (estimated minimum)	20059		10501		7570		1988	
Livestock statistic								
Herds	70003	70170	52944	53070	14027	14490	3032	2610
Animals slaughtered (NAIT adjusted for unknown herd type)				1784752		825423		sparse data
Animals slaughtered (Industry sources)	2756546	2729447	1541830	1545499	803241	829766	411475	354182
Detection rate								
Animals tested for every reactor with lesions detected	27598	41572	28814	61367	25128	33881	96473	No detection
Animals routinely slaughtered for every TB detection (industry slaughter data)	33864	48740	26768	34344	41835	75433	No detection	No detection
Detections per 100,000 tests	3.6	2.4	3.5	1.6	4.0	3.0	1.0	No detection
Detections per 100,000 routine slaughter examinations (industry slaughter data)	3.0	2.1	3.7	2.9	2.4	1.3	No detection	No detection

Table 4 Animal disease detection rates per 100,000 slaughtered and per 100,000 tested with respect to vector risk and island

Values	NZ	NI	SI	VFA	VRA	VRA Suppressed	VRA core	NI VRA	NI VFA	SI VRA	SI VFA
Detection rate per 100000 animals slaughtered	3.06	0.33	7.13	0.38	12.65	1.06	9.47	0.25	0.34	21.52	0.44
Detection rate per 100000 animals slaughtered - beef	3.22	0.22	7.64	0.26	12.57	0.80	10.16	0.21	0.23	22.51	0.33
Detection rate per 100000 animals slaughtered - diary	2.32	0.51	5.23	0.58	10.90	1.48	25.98	0.41	0.52	16.44	0.71
Detection rate per 100000 animals slaughtered - deer	1.12	0.11	1.88	0.07	3.91	20.76	17.46	0.00	0.14	5.79	0.00
Detection rate per 100000 tests	3.62	2.00	5.36	2.37	5.12	1.40	9.78	0.70	2.69	8.01	1.86
Detection rate per 100000 tests beef	3.47	1.05	5.98	2.09	4.24	2.05	7.42	0.94	1.20	6.89	3.57
Detection rate per 100000 tests dairy	3.98	2.52	5.74	2.61	6.50	0.62	12.86	0.56	3.14	10.07	1.66
Detection rate per 100000 tests deer	1.04	0.00	1.41	0.00	1.76	2.13	1.25	0.00	0.00	2.42	0.00
Detection rate ratio tests/slaughter	1.2	6.1	0.8	6.3	0.4	1.3	1.0	2.8	7.9	0.4	4.2
Detection rate ratio tests/slaughter beef	1.1	4.7	0.8	7.9	0.3	2.6	0.7	4.5	5.2	0.3	10.8
Detection rate ratio tests/slaughter dairy	1.7	4.9	1.1	4.5	0.6	0.4	0.5	1.3	6.0	0.6	2.4
Detection rate ratio tests/slaughter deer	0.9	0.0	0.7	0.0	0.5	0.1	0.1	0.0	0.0	0.4	0.0

Notes rates per 100,000 slaughtered are based on NAIT slaughter data for 2013-14 for beef and dairy as it is available by vector risk status and island. National slaughter estimates for deer were used as NAIT data was sparse. Deer slaughter estimates were estimated for each area on the basis of number of herds in that area. So this statistic for deer should be treated with caution.

Table 5 Table of estimated source of infection by herd type and zone – average for 5 years

Values	NZ	NI	SI	VFA	VRA	NI VRA	NI VFA	SI VRA	SI VFA
Herds with known sources of infection – all herds	34.8	4.1	30.7	0.4	34.4	4.1	0.0	30.3	0.4
Beef herds with known sources of infection	14.4	1.8	12.6	0.4	14.0	1.8	0.0	12.2	0.4
Dairy herds with known sources of infection	18.8	2.4	16.4	0.0	18.8	2.4	0.0	16.4	0.0
Deer herds with known sources of infection	1.4	0.0	1.4	0.0	1.4	0.0	0.0	1.4	0.0
Estimated herds infected from vectors – all herds	23.3	10.6	12.7	14.8	8.5	2.1	8.5	6.5	6.3
Estimated herds infected from vectors -beef	7.0	3.4	3.6	4.8	2.2	0.4	3.0	1.8	1.8
Estimated herds infected from vectors -dairy	16.9	7.5	9.4	11.4	5.5	0.6	6.9	5.0	4.5
Estimated herds infected from vectors- deer	1.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Estimated herds infected from movement or grazing	7.6	1.4	6.2	0.5	7.2	0.9	0.5	6.2	0.0
Estimated herds infected from movement or grazing beef	1.9	0.0	1.9	0.0	1.9	0.0	0.0	1.9	0.0
Estimated herds infected from movement or grazing dairy	5.4	1.1	4.3	0.5	4.9	0.6	0.5	4.3	0.0
Estimated herds infected from movement or grazing deer	0.4	0.4	0.0	0.0	0.4	0.4	0.0	0.0	0.0
Estimated Incident Herds due to recrudescence – all herds	2.8	0.9	1.9	0.4	2.5	0.9	0.0	1.6	0.4
Estimated Beef Incident Herds due to recrudescence	1.1	0.6	0.5	0.0	1.1	0.6	0.0	0.5	0.0
Estimated dairy Incident Herds due to recrudescence	1.7	0.3	1.4	0.3	1.3	0.3	0.0	1.1	0.3
Estimated Deer Incident Herds due to recrudescence	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Estimated Incident Herds due to splitting – all herds	34.8	4.1	30.7	0.4	34.4	4.1	0.0	30.3	0.4
Estimated Beef Incident Herds due to splitting	14.4	1.8	12.6	0.4	14.0	1.8	0.0	12.2	0.4
Estimated Dairy Incident Herds due to splitting	18.8	2.4	16.4	0.0	18.8	2.4	0.0	16.4	0.0
Estimated Deer Incident Herds due to splitting	1.4	0.0	1.4	0.0	1.4	0.0	0.0	1.4	0.0

Table 6 Table of disease occurrence (average of 5 years)

Values	NZ	NI	SI	VFA	VRA	NI VRA	NI VFA	SI VRA	SI VFA
Herds	70003.0	48795.0	21208.0	57067.2	12935.8	6048.4	42746.6	6887.4	14320.6
Beef herds	52944.0	37207.0	15737.0	42975.6	9968.4	4890.4	32316.6	5078.0	10659.0
Dairy herds	14026.8	10278.2	3748.6	11889.0	2137.8	888.4	9389.8	1249.4	2499.2
Deer herds	3032.2	1309.8	1722.4	2202.6	829.6	269.6	1040.2	560.0	1162.4
I herds 30 June	83.0	16.0	67.0	16.2	66.8	6.0	10.0	60.8	6.2
Beef I herds 30 June	29.2	7.6	21.6	4.4	24.8	4.4	3.2	20.4	1.2
Dairy I herds 30 June	49.2	8.4	40.8	11.4	37.8	1.6	6.8	36.2	4.6
Deer I herds 30 June	4.6	0.0	4.6	0.4	4.2	0.0	0.0	4.2	0.4
Incident herds	70	18.4	51.6	17.4	52.6	8	10.4	44.6	7
Beef incident herds	24.4	5.8	18.6	5.2	19.2	2.8	3	16.4	2.2
Dairy incident herds	42.8	11.2	31.6	12.2	30.6	3.8	7.4	26.8	4.8
Deer incident herds	2.8	1.4	1.4	0	2.8	1.4	0	1.4	0
Period I herds	158.2	34.6	123.6	36.0	122.2	12.8	21.8	109.4	14.2
Period I herds Beef	59.4	16.4	43.0	12.0	47.4	8.6	7.8	38.8	4.2
Period I herds Dairy	91.2	18.0	73.2	23.4	67.8	4.2	13.8	63.6	9.6
Period I herds Deer	7.6	0.2	7.4	0.6	7.0	0.0	0.2	7.0	0.4

Table 7 Herd disease statistics observed in the same year for every incident herd infected by vectors in the same island(s)

For every incident vector infected herd in the same Island there were in this	NZ	NI	SI	VFA	VRA	NI VRA	NI VFA	SI VRA	SI VFA
zone n I herds at 30 June	2.4	3.9	2.2	0.5	1.9	1.5	2.4	2.0	0.2
herd type and zone n Beef I herds at 30 June	2.0	4.2	1.7	0.3	1.8	2.4	1.8	1.7	0.1
herd type and zone n Dairy I herds at 30 June	2.6	3.5	2.5	0.6	2.0	0.7	2.9	2.2	0.3
herd type and zone n Deer I herds at 30 June	3.3	0.0	3.3	0.3	3.0	0.0	0.0	3.0	0.3
zone n incident herds	2.0	4.5	1.7	0.5	1.5	1.9	2.5	1.5	0.2
herd type and zone n Beef incident herds	1.7	3.2	1.5	0.4	1.4	1.6	1.7	1.3	0.2
herd type and zone n Dairy incident herds	2.3	4.7	1.9	0.6	1.6	1.6	3.1	1.6	0.3
herd type and zone n Deer incident herds	2.0	0.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0
zone n Period i herds	4.5	8.4	4.0	1.0	3.5	3.1	5.3	3.6	0.5
herd type and zone n Period Beef I herds	4.1	9.1	3.4	0.8	3.4	4.8	4.3	3.2	0.3
herd type and zone n period Dairy I herds	4.8	7.6	4.5	1.2	3.6	1.8	5.8	3.9	0.6
herd type and zone n Period Deer I herds	5.4	0.0	5.3	0.4	5.0	0.0	0.0	5.0	0.3
zone n Cleared I herds	2.5	4.3	2.3	0.6	1.9	1.4	2.9	2.0	0.3
herd type and zone n cleared beef I herds	2.3	4.6	2.0	0.5	1.8	2.0	2.6	1.8	0.3
herd type and zone n cleared dairy I herds	2.6	3.9	2.4	0.7	1.9	0.9	3.0	2.1	0.3
herd type and zone n cleared deer I herds	3.1	0.0	3.0	0.1	3.0	0.0	0.0	3.0	0.0
zone n estimated herds infected from vectors	1.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0
herd type and zone n estimated herds infected from vectors - beef	0.4	0.4	0.4	0.0	1.0	1.0	0.0	1.0	0.0
herd type and zone n estimated herds infected from vectors - dairy	0.5	0.6	0.5	0.0	1.0	1.0	0.0	1.0	0.0
herd type and zone n estimated herds infected from vectors - deer	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
zone n estimated herds infected from movement or grazing	0.7	2.6	0.4	0.4	0.2	0.5	2.1	0.2	0.2
herd type and zone n estimated herds infected from movement or grazing beef	0.2	0.8	0.1	0.1	0.2	0.2	1.7	0.1	0.1
herd type and zone n estimated herds infected from movement or grazing dairy	0.5	1.8	0.3	0.3	0.3	0.2	2.9	0.3	0.3
herd type and zone n estimated herds infected from movement or grazing deer	0.0	0.2	0.0	0.0	0.7	0.0	0.0	0.0	0.0
zone n estimated Incident Herds due to recrudescence	0.2	0.3	0.2	0.0	0.2	0.2	0.1	0.2	0.0
herd type and zone n estimated Beef Incident Herds due to recrudescence	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.2	0.0
herd type and zone n estimated Dairy Incident Herds due to recrudescence	0.2	0.3	0.1	0.0	0.3	0.2	0.2	0.3	0.0
herd type and zone n estimated Deer Incident Herds due to recrudescence	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0
zone n estimated Incident Herds due to splitting	0.1	0.2	0.1	0.0	0.1	0.2	0.0	0.1	0.0
herd type and zone n estimated Beef Incident Herds due to splitting	0.0	0.1	0.0	0.0	0.1	0.3	0.0	0.0	0.0
herd type and zone n estimated Dairy Incident Herds due to splitting	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0
herd type and zone n estimated Deer Incident Herds due to splitting	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8 Animal TB statistics observed in the same year for every herd infected by vectors in the same island(s)

For every incident vector infected herd there were in the same Island n	NZ	NI	SI	VFA	NZ VRA	NI VRA	NI VFA	SI VRA	SI VFA
Reactors with TB slaughtered	4.9	11.8	4.0	1.8	3.2	1.5	10.4	3.5	0.6
Reactors with TB slaughtered -beef	1.4	4.2	3.3	0.3	2.8	2.1	2.1	2.9	0.6
Reactors with TB slaughtered -dairy	3.4	17.4	4.7	1.5	3.6	0.9	16.4	4.1	0.7
Reactors with TB slaughtered -deer	2.4	0.0	2.4	0.0	2.4	0.0	0.0	2.4	0.0
TB culls	2.3	1.3	2.5	0.2	2.3	0.1	1.1	2.4	0.1
TB culls - beef	1.7	1.3	4.4	0.1	3.9	0.2	1.1	4.4	0.1
TB culls - dairy	0.6	1.1	1.0	0.1	0.8	0.1	1.0	0.9	0.1
TB culls - deer	3.3	0.0	3.1	0.1	3.1	0.0	0.0	3.1	0.0
Reactors with TB condemned (estimated)	0.9	2.1	0.7	0.3	0.6	0.3	1.9	0.6	0.1
Reactors with TB condemned– beef (estimated)	0.2	0.6	0.5	0.0	0.4	0.3	0.3	0.4	0.1
Reactors with TB condemned– dairy (estimated)	0.7	3.4	0.9	0.3	0.7	0.2	3.3	0.8	0.1
Reactors with TB condemned– deer (estimated)	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.2	0.0
TB culls condemned (estimated)	0.4	0.2	0.4	0.0	0.3	0.0	0.2	0.3	0.0
TB culls condemned- beef (estimated)	0.3	0.2	0.7	0.0	0.6	0.0	0.2	0.6	0.0
TB culls condemned– dairy (estimated)	0.1	0.2	0.2	0.0	0.2	0.0	0.2	0.2	0.0
TB culls condemned– deer (estimated)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9 Table of means of detection for incident herds in the VFA

VFA incident herds means of detection	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Grand Total
Programmed triennial testing	4	5		6	7	22 (33%)
Slaughter surveillance	8	4	1	9	5	27 (41%)
Testing because of investigation & tracing or post movement tests	1		3	11	2	17 (26%)
Total	13	9	4	26	14	66

Table 10 Table of means of detection for incident herds in the VFA herd type

Means of herd detection in VFA cattle	**All herd types**	Beef Breeding	Meat Production	Milk Production	Long-Term Grazing
Triennial testing	22	2	0	20	
Slaughter surveillance	27	3	9	14	1
Testing because of investigation & tracing	14	1	9	3	1
Post-movement testing from known risk herds	3		1	2	
Total	66 of 87	6	19	39	2
Estimated number detected by triennial testing	29 or 6 per year				

Table 11 Disease and cost of a breakdown (per comm. Jane Sinclair)

Outbreak size	TB animals	Cost	Frequency
Common	1	$15,000	0.7
Average	14	$45,000	0.275
Worst case	50	$360,000	0.025
Weighted average	6	$31,875	1

Table 12 Tests and costs per breakdown detected by triennial test in the VFA

Year	All	Beef	Dairy	Deer*
a) 5 years triennial tests	12903493	2538975	9688349	676169
b) 2013-2014 triennial tests	2379972	413769	1866664	99539
c) % Triennial testing	98%	98%	98%	98%
d) Herds detected by triennial testing	29	2	27	0
e) Triennial tests per detection (b*c)/d	444948	1269488	358828	600000
Cost of triennial testing per detection at $2.5 a test (e*2.5)	$1,112,370	$3,173,719	$897,069	$1,500,000
Cost of 2013-2014 triennial testing at $2.5 (b*2.5)	$5,949,929	$1,034,422	$4,666,660	$248,847
Annual cost of not testing (cost of late detection of outbreaks at a weighted average of $31,875	$191,250			

*Deer at $2.5 a test is an underestimate

Table 13 Testing and disease by herd type and zone

Average over 5 years	NZ	NI	SI	VFA	VRA	NI VRA	NI VFA	SI VRA	SI VFA
Primary Tests	4735900	2445239	2290661	2580699	2155202	852464	1592775	1302738	987923
Primary Tests Beef	1417641	722103	695538	507795	909846	404622	317481	505224	190314
Primary Tests Dairy	2990250	1636000	1354250	1937670	1052580	395385	1240615	657195	697055
Primary Tests Deer	328009	87137	240873	135234	192776	52456	34680	140319	100554
Primary test positive	8936	2690	6246	4420	4516	1055	1636	3462	2785
Primary test positive Beef	854	236	618	371	483	86	150	396	222
Primary test positive Dairy	5623	1551	4072	3161	2462	333	1218	2130	1943
Primary test positive Deer	2461	905	1556	888	1573	638	268	936	620
Serial tests	8564	2551	6013	4324	4240	1004	1547	3236	2777
Serial tests Beef	750	213	538	344	406	76	136	330	207
Serial tests Dairy	5475	1477	3998	3133	2342	323	1153	2019	1979
Serial Tests Deer	2341	864	1477	847	1494	607	257	887	590
Serial test-positive	536	105	431	219	318	40	65	278	153
Serial test-positive Beef	54	11	43	20	34	3	7	31	13
Serial test-positive Dairy	351	57	295	149	202	9	48	194	101
Serial test-positive Deer	131	38	93	50	82	28	10	54	40
Parallel tested	33165	11297	21868	15644	17521	2311	8986	15210	6658
Parallel tested Beef	4905	1397	3507	2082	2822	780	617	2042	1465
Parallel tested Dairy	28286	9925	18360	13561	14724	1556	8369	13168	5192
Parallel tested Deer	0	0	0	0	0	0	0	0	0
Parallel test positive	170	50	120	76	94	8	42	86	34
Parallel test positive Beef	24	3	21	7	16	2	1	15	6
Parallel test positive Dairy	146	47	99	69	77	6	41	71	28
Parallel test positive Deer	0	0	0	0	0	0	0	0	0
Reactors slaughtered	1121	292	829	391	730	95	197	635	195
Reactors slaughtered Beef	180	36	144	55	125	14	22	111	33
Reactors slaughtered Dairy	647	179	468	248	398	23	156	375	92
Reactors slaughtered Deer	295	77	218	88	207	59	19	148	70
Reactors with TB at slaughter	172	49	123	61	110	6	43	104	18
Reactors with TB at slaughter Beef	49	8	42	11	39	4	4	35	7
Reactors with TB at slaughter Dairy	119	41	78	51	68	2	39	66	12
Reactors with TB at slaughter Deer	3	0	3	0	3	0	0	3	0
TB culls	81	5	76	8	74	1	5	73	3
TB culls - beef	58	2	55	4	54	0	2	54	2
TB culls - diary	19	3	17	4	15	0	2	15	2
TB culls - Deer	5	0	4	0	4	0	0	4	0
Estimated TB reactors condemned	31	9	22	11	20	1	8	19	3
Estimated TB reactors condemned beef	7	1	6	2	6	1	1	5	1
Estimated TB reactors condemned Dairy	24	8	15	10	14	0	8	13	2
Estimated TB reactors condemned deer	0	0	0	0	0	0	0	0	0
Estimated TB culls condemned	13	1	12	1	11	0	1	11	0
Estimated TB culls condemned beef	9	0	9	1	9	0	0	9	0
Estimated TB culls condemned dairy	4	1	4	1	3	0	1	3	0
Estimated TB culls condemned deer	0	0	0	0	0	0	0	0	0

Table 14 Estimated slaughter statistics per zone and herd

Average over 5 years	NZ	NI	SI	VFA	VRA	NI VRA	NI VFA	SI VRA	SI VFA
Herds	70003	48795	21208	57067	12936	6048	42747	6887	14321
Beef herds	52944	37207	15737	42976	9968	4890	32317	5078	10659
Dairy herds	14027	10278	3749	11889	2138	888	9390	1249	2499
Deer herds	3032	1310	1722	2203	830	270	1040	560	1162
All herds Nait 2013-14 slaughter data (adjusted)	2658966	1590852	1068114	2077080	581886	242646	1348206	339240	728874
Beef Nait 2013-14 adjusted data on slaughtered animals (adjusted)	1789279	1066710	722415	1359645	429480	191413	875297	238067	484348
Dairy Nait 2013-14 adjusted data on slaughtered animals (adjusted)	827517	509917	317600	688070	139447	48212	461705	91235	226365
Industry estimate 5 year average pro-rata by herd numbers Deer	411475	177742	233733	298897	112578	36585	141157	75993	157740
Estimated animals slaughtered per herd	38.0	32.6	50.4	36.4	45.0	40.1	31.5	49.3	50.9
Estimated animals slaughtered per herd Beef	33.8	28.7	45.9	31.6	43.1	39.1	27.1	46.9	45.4
Estimated animals slaughtered per herd dairy	59.0	49.6	84.7	57.9	65.2	54.3	49.2	73.0	90.6
Estimated animals slaughtered per herd deer	135.7	135.7	135.7	135.7	135.6	135.5	135.7	135.7	135.7
Nait 2013-14 data on slaughtered animals (unadjusted)	2658966.0	1511665.0	1014947.0	1973690.0	552922.0	230568.0	1281097.0	322354.0	692593.0
Nait 2013-14 data on slaughtered animals Beef unadjusted	1700215.0	1013613.0	686456.0	1291967.0	408102.0	181885.0	831728.0	226217.0	460239.0
Nait 2013-14 data on slaughtered animals Diary unadjusted	786326.0	484535.0	301791.0	653820.0	132506.0	45812.0	438723.0	86694.0	215097.0
Nait 2013-14 data on slaughtered animals Deer unadjusted	40217.0	13517.0	26700.0	27903.0	12314.0	2871.0	10646.0	9443.0	17257.0

Table 15 Table of test statistics per 100,000 primary tests

Average over 5 years	NZ	NI	SI	VFA	VRA	NI VRA	NI VFA	SI VRA	SI VFA
Primary test positive	189	110	273	171	210	124	103	266	282
Primary test positive Beef	60	33	89	73	53	21	47	78	116
Primary test positive Dairy	188	95	301	163	234	84	98	324	279
Primary test positive Deer	750	1039	646	657	816	1215	772	667	617
Serial tests	181	104	263	168	197	118	97	248	281
Serial tests Beef	53	29	77	68	45	19	43	65	109
Serial tests Dairy	183	90	295	162	223	82	93	307	284
Serial Tests Deer	714	991	613	626	775	1157	740	632	587
Serial test-positive	11	4	19	8	15	5	4	21	16
Serial test-positive Beef	4	1	6	4	4	1	2	6	7
Serial test-positive Dairy	12	3	22	8	19	2	4	29	14
Serial test-positive Deer	40	44	39	37	42	53	29	38	39
Parallel tested	700	462	955	606	813	271	564	1168	674
Parallel tested Beef	346	193	504	410	310	193	194	404	770
Parallel tested Dairy	946	607	1356	700	1399	394	675	2004	745
Parallel tested Deer	0	0	0	0	0	0	0	0	0
Parallel test positive	4	2	5	3	4	1	3	7	3
Parallel test positive Beef	2	0	3	1	2	0	0	3	3
Parallel test positive Dairy	5	3	7	4	7	2	3	11	4
Parallel test positive Deer	0	0	0	0	0	0	0	0	0
Reactors slaughtered	24	12	36	15	34	11	12	49	20
Reactors slaughtered Beef	13	5	21	11	14	3	7	22	17
Reactors slaughtered Dairy	22	11	35	13	38	6	13	57	13
Reactors slaughtered Deer	90	89	90	65	107	112	54	105	69

Table 16 Animal disease detection rates per 100,000 slaughtered and per 100,000 tested

Values	NZ	NI	SI	VFA	VRA	VRA Suppressed	VRA core	NI VRA	NI VFA	SI VRA	SI VFA
Detection rate per 100000 animals slaughtered	3.06	0.33	7.13	0.38	12.65	1.06	9.47	0.25	0.34	21.52	0.44
Detection rate per 100000 animals slaughtered - beef	3.22	0.22	7.64	0.26	12.57	0.80	10.16	0.21	0.23	22.51	0.33
Detection rate per 100000 animals slaughtered - diary	2.32	0.51	5.23	0.58	10.90	1.48	25.98	0.41	0.52	16.44	0.71
Detection rate per 100000 animals slaughtered - deer	1.12	0.11	1.88	0.07	3.91	20.76	17.46	0.00	0.14	5.79	0.00
Detection rate per 100000 tests	3.62	2.00	5.36	2.37	5.12	1.40	9.78	0.70	2.69	8.01	1.86
Detection rate per 100000 tests beef	3.47	1.05	5.98	2.09	4.24	2.05	7.42	0.94	1.20	6.89	3.57
Detection rate per 100000 tests dairy	3.98	2.52	5.74	2.61	6.50	0.62	12.86	0.56	3.14	10.07	1.66
Detection rate per 100000 tests deer	1.04	0.00	1.41	0.00	1.76	2.13	1.25	0.00	0.00	2.42	0.00
Detection rate ratio tests/slaughter	1.2	6.1	0.8	6.3	0.4	1.3	1.0	2.8	7.9	0.4	4.2
Detection rate ratio tests/slaughter beef	1.1	4.7	0.8	7.9	0.3	2.6	0.7	4.5	5.2	0.3	10.8
Detection rate ratio tests/slaughter dairy	1.7	4.9	1.1	4.5	0.6	0.4	0.5	1.3	6.0	0.6	2.4
Detection rate ratio tests/slaughter deer	0.9	0.0	0.7	0.0	0.5	0.1	0.1	0.0	0.0	0.4	0.0

NB rates per 100,000 slaughtered are based on NAIT data for 2013-14 for beef and dairy and national slaughter estimates for deer applied to each area on the basis of number of herds in that area. So this statistic for deer should be treated with caution.

Table 17 Total diseased animals observed in a zone for every I herd or period I herd

Values	Total	NI	SI	VFA	VRA	VRA Suppressed	VRA core	NI VRA	NI VFA	SI VRA	SI VFA
Reactors with lesions at slaughter in a zone for every period I herd in that zone	1.10	0.90	1.20	1.13	1.08	0.60	1.26	0.48	1.02	1.16	1.51
Reactors with lesions at slaughter in a zone for every period I herd in that zone beef	0.96	0.48	1.18	0.93	0.97	0.56	1.35	0.46	0.49	1.09	1.89
Reactors with lesions at slaughter in a zone for every period I herd in that zone dairy	1.21	1.08	1.28	1.20	1.21	0.52	1.30	0.52	1.15	1.26	1.41
Reactors with lesions at slaughter in a zone for every period I herd in that zone deer	0.53	0.00	0.55	0.00	0.59	1.33	0.25	0.00	0.00	0.59	0.00
TB culls in a zone for every period I herd in that zone	0.52	0.10	0.75	0.14	0.72	0.24	0.90	0.05	0.11	0.81	0.26
TB culls in a zone for every period I herd in that zone beef	1.12	0.15	1.56	0.32	1.35	0.19	2.46	0.05	0.26	1.69	0.44
TB culls in a zone for every period I herd in that zone dairy	0.19	0.07	0.27	0.10	0.27	0.15	0.28	0.05	0.07	0.29	0.20
TB culls in a zone for every period I herd in that zone deer	0.72	1.00	0.71	0.33	0.76	1.00	0.65	0.00	1.00	0.76	0.00
Reactors with lesions at slaughter in a zone for every incident I herd in the zone	2.5	3.0	2.4	4.0	2.1	1.2	2.5	0.8	5.2	2.4	2.6
Reactors with lesions at slaughter in a zone for every incident I herd in the zone beef	2.0	1.4	2.2	2.1	2.0	1.2	2.8	1.4	1.4	2.1	3.1
Reactors with lesions at slaughter in a zone for every incident I herd in the zone dairy	2.9	4.5	2.5	5.0	2.3	1.1	2.4	0.6	7.2	2.5	2.4
Reactors with lesions at slaughter in a zone for every incident I herd in the zone deer	1.2	0.0	2.4	0.0	1.2	1.3	1.0	0.0	0.0	2.4	0.0
TB culls in a zone for every incident I herd in the zone	1.2	0.3	1.5	0.5	1.4	0.5	1.8	0.1	0.6	1.6	0.5
TB culls in a zone for every incident I herd in the zone beef	2.4	0.4	3.0	0.7	2.8	0.4	5.0	0.1	0.7	3.3	0.7
TB culls in a zone for every incident I herd in the zone dairy	0.5	0.3	0.5	0.4	0.5	0.3	0.5	0.1	0.4	0.6	0.3
TB culls in a zone for every incident I herd in the zone deer	1.6	0.1	3.1	0.0	1.6	1.0	2.6	0.0	0.0	3.1	0.0