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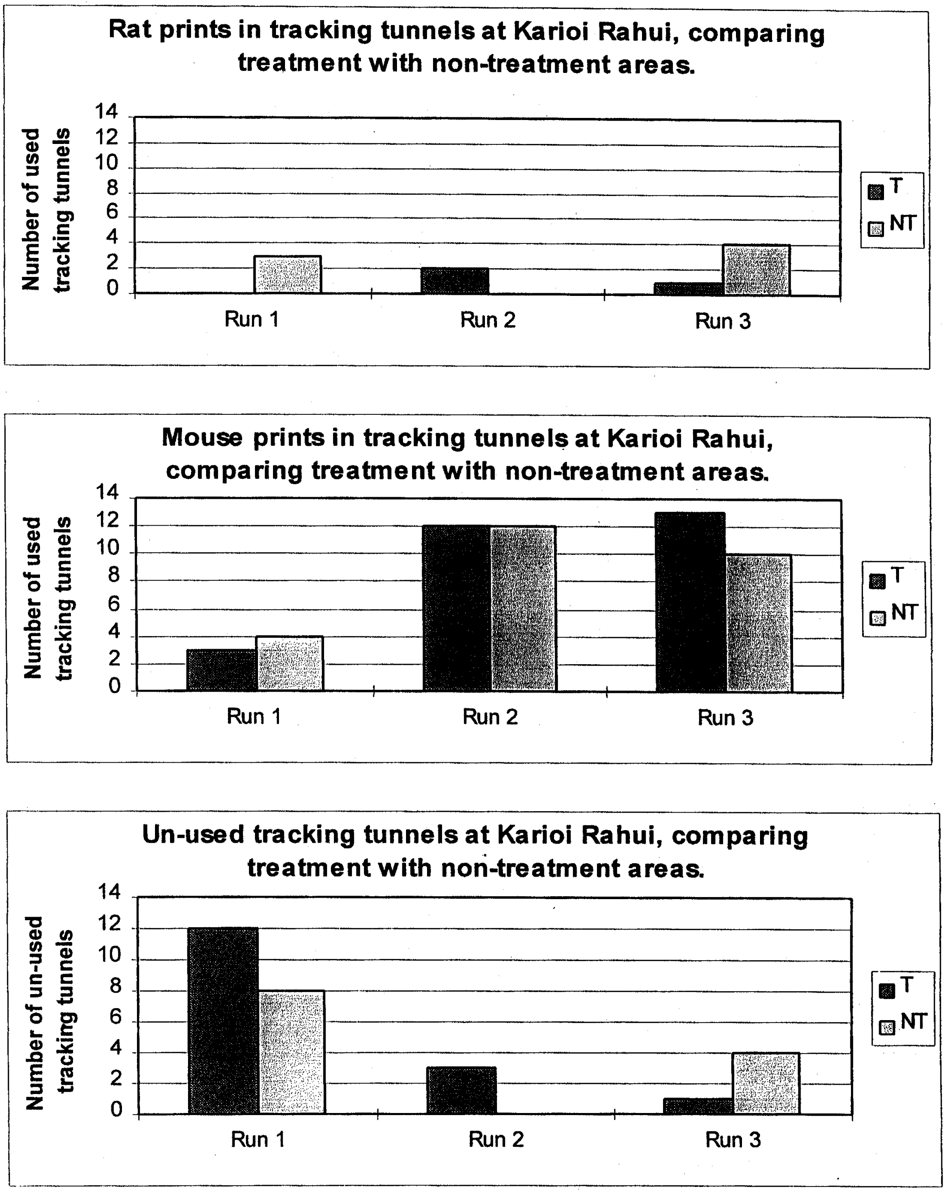

FIGURE 5. FREQUENCY OF RAT AND MOUSE PRINTS ON PAPERS FROM TRACKING TUNNELS SET IN TREATMENT AND NON-TREATMENT SITES AT KARIOI RAHUI, OHAKUNE. THREE EXPERIMENTAL TRIALS (RUNS) OF VARYING LENGTH WERE SET, AT TWO WEEK INTERVALS, USING 15 TUNNELS IN EACH SITE. (NOTE: THREE NIGHTS TRACKING FOR RUN 1, TWO NIGHTS TRACKING FOR RUNS 2 AND 3.)

5. Discussion

This study may be confounded by the presence of rats and mice in both the treatment and non-treatment sites, although rat density was apparently low in the treatment site. In another study, mouse numbers have been observed to increase (following initial declines) after poisoning, regardless of the toxin or poisoning method (aerial or bait stations) (Innes *et al.* 1995). In that work, the increase in mouse numbers was greater in sites where ship rats had been most effectively removed, implying that mice may survive better when inter-specific competition and predation from rats is reduced. This might explain our observation of high mouse presence in the treatment site at Karioi. Therefore, while the removal of possums and rats would be expected to have a benefit to invertebrate populations, predation pressure on invertebrates may be maintained by an increased abundance of mice, reducing the actual benefits of the poisoning operation to invertebrates.

Our invertebrates capture data tended to support the contention that rodents were still having an effect as predators in the treatment area. Both pitfall and malaise trap samples showed significant differences in the numbers of individuals in taxa which were collected in the treatment and non-treatment sites. However, the trends are not strongly defined, with some taxa occurring more frequently in the treatment area, and others more frequently in the non-treatment area. Araneae and Coleoptera >5 mm were scored more frequently in the non-treatment site in both pitfall and malaise samples, and adult Lepidoptera occurred more frequently in the treatment samples of both pitfall and malaise traps. Other taxa were recorded less consistently in the two trap types, and no real trend in terms of invertebrate abundance in one site or the other can be determined.

This situation may be the result of mice numbers not dropping because the poison bait stations were spaced too far apart relative to mouse home range size. Thus mice may still persist at densities sufficient to remain as significant predators of invertebrates. This scenario is supported by the ambivalent results from the statistical comparisons where significant differences occurred, but not necessarily with higher numbers in the treatment area, as one might expect if rodent predation was reduced by poisoning.

In order to establish an experiment in which the effects on invertebrates of rodent removal can be tested, rodent populations must be further reduced, and a poisoning regime which is effective on both mice and rats must be used. However, for research to be generally applicable, the poisoning programme and resulting changes in pest mammal abundance must represent the results of a typical poison operation. Creating an atypical situation, while showing the theoretical advantages for invertebrates if possums and all rodents were removed, would not tell us the actual benefits of mammal control operations in New Zealand.

The presence of rodents, especially mice, in the treatment site, and the small scale of the study, mean that we have not recorded data from which it is possible to gather evidence of the effect of rodent and possum removal on the abundance of invertebrates. Hence the pilot study was a trial of the methodology, and enables refinement of sampling methods for future work.

6. Recommendations for future research

Comparisons of invertebrate abundance and diversity between randomly selected treatment and non-treatment areas needs to be carried out in advance of the application of toxin—probably over two seasons. Further comparisons of invertebrate abundance and diversity between the treatment and non-treatment sites would be required for at least two years during toxin application (via poison bait stations which are accessible to all rodents as well as possums) followed by at least two years monitoring after the application of toxin. This will enable any changes in invertebrate numbers to be attributed to the reduction of pest mammals. The investigation of benefits of pest mammal control operations to invertebrates is therefore a long-term research project, requiring six years of work in the field.

In particular, it seems that longer sampling periods (perhaps six weeks) are required in beech forest to adequately sample large-bodied invertebrates using pitfall or malaise traps. Techniques such as "fences" which increase the catch area of pitfall traps or large diameter traps should be used. These have been shown to increase the proportion of larger beetles which are collected (Southwood, 1978).

New sampling methods may be required, especially if particular invertebrate species are found to be preferred in the diet of rodents and possums. Standardised techniques which involve manual searching should be used. The data yielded would be catch rates per unit effort. Pitfall and malaise trapping would need to be verified as methods which actually capture the invertebrate species which were found in rodent and possum diets.

Mammal species must be monitored using standard techniques throughout the invertebrate study, so changes in invertebrate density can be correlated with changes in mammal numbers. In addition, diet studies of rodents and possums will be required to ensure that the invertebrates sampled were actually prey items.

In this study invertebrates were generally not sorted to species level. Thus differences in species diversity may not have been apparent between samples because so many taxa were lumped together. Future work needs to compare changes in diversity (species composition) between sites as well as biomass.

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8. Acknowledgements

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Appendix 1

MALAISE TRAP SAMPLES, ORIGINAL FREQUENCY SCORES

All taxa, two week samples for malaise trap samples. T=treatment, NT=non-treatment

SAMPLE	DATE	Lithobiomorpha	Araneae	Opilionidae	Pseudoscorpionidae	Collembola	Cellatoblatta vulgaris	Isoplectron (gold stripe)	Gymnoplectron tuartii	Hemideina	Cricket	Staphylinidae	Coleoptera - large (>5mm)	Coleoptera - small (<5mm)	Coleoptera larvae	Saphobius squam.	Odontria	Cerambycidae	Brown Chrysomelidae?	Lepidoptera	Lepidoptera larvae	Calliphoridae	Tachinidae	Hoverfly?	DIPT: assorted small dark	DIPT: various large, slender (>5mm)	DIPT: Large brown, orange wing	DIPT: various small (<5mm)	DIPT: brown hairy & large hairy	DIPT: stripy housefly?	DIPT: yellow abdomen	DIPT: large, like yellow thorax Drosoph	DIPT: Small brown, yellow wing	DIPT:Yellow thorax drosoph	DIPT: yellow body, spotted wing	Hymenoptera - small	Ichnumonidae (large)	Apidae	Pompillidae	Winged termite/ant?	?Bee?	Vespula vulgaris	Hemiptera	Psocoptera?	? like Psocoptera?	Mayfly	Lacewing	Cranefly	Small Cranefly (<10mm)	Robberfly	Robberfly - small
1M.T1	17/3/98		6		1	13	5			1		3	7	12					15	5		36	2		9	34	4	421	2				4	15	6	58	15	3						8	1			2		7	
1M.T2	17/3/98		8			12		1				1		39			1		28	12		21	2		13	61		345						11		88	52		2	1	10		3	20				4		1	
1M.T3	17/3/98		9		1							3	2	31					120	9	1	79	2	3	18	113	5	221	10	13		1		101	3	41	70		2		18		3				1	4	75	1	
1M.T4	17/3/98		4			8			1			6	4	62					8	7	1	6	1		5	36	11	221		8				13	2	35	10		1	1			1		1			1		1	
1M.T5	17/3/98		7									4	11	22			2		29	31		42			16	93	7	622	12	8			12	31	5	240	79		3		12	1	3					10		1	
	total		34		2	33	5	1	1	1		17	24	166			3		200	64	2	184	7	3	61	337	27	1830	24	29		1	16	171	16	462	226	3	8	2	40	1	10	28			1	21	75	11	
1M.NT1	17/3/98		7		1	36	1					4	14	17			1		13	11	1	56	5		13	46	8	584						17	5	59	19		1		32		1	13			1	6		1	
1M.NT2	17/3/98		9	1	1	7	1					3	2	22				2	17	14		30		1	32	92	3	268		16				36	6	121	78				13	1	3		3		1	7		4	
1M.NT3	17/3/98		12						1		2	6		63				1	96	10	1	30	2	4		239		563	1	20	4			106	4	195	64				19	1	8	9	1			12	90	2	
1M.NT4	17/3/98		14	1								3	10	20	1			1	36	5		17	3		17	88		363	3	23				37	9	139	26		1	4	14		5	10		1		9		1	
1M.NT5	17/3/98		8				2		1			1		16			1		9	3	1	11			12	72		249	6	10				26	3	118	59		1		8		1		1			7			
	total		50	2	2	43	4		2		2	17	26	138			2	4	171	43	3	144	10	5	74	537	11	2027	10	69	4			222	27	632	246		3	4	86	2	18	32		1	2	41	90	8	
2M.T1	4/01/98		10		1	19	2	1	1			3		17						1	1	17	1		4	81	2	488	1	3				26		87	24		1				1	18				3	20	2	
2M.T2	4/01/98		5	1		4						10	4	49						11	1	9			4	75	3	462		11				16		150	68		1	1	16	2	1	22	1		1	7	53		7
2M.T3	4/01/98		4		1	3			1			5	1	15					11	24		85			18	138	6	214	8	25		4		73	1	51	28		3		6	2	6					2	124	2	
2M.T4	4/01/98		6	2		25						6		21		1	1		2	7		3			3	66		242	1	4				7		77	11		1		5	1	2	12	1			4	29		
2M.T5	4/01/98		12	1		7			2			4	1	15			2		4	37		29	1		23	273	3	1624	7	11				35	2	664	32		5		25	6	3	48	1			7	46		
	total		37	4	2	58	2	1	4			28	6	117		1	3		17	80	2	143	2		52	633	14	3030	17	54		4		157	3	1029	163		11	1	52	11	13	100	3		1	23	272	4	7
2M.NT1	4/01/98		8	1		34						2		15						9		57			7	199	3	484	2	5				17		172	17		1		13	2	1	16	1			9	22	2	
2M.NT2	4/01/98		1			10						2	1	19	1		1		7	9		23	2		10	140	1	257	1	13				27	1	160	70		3		13	2	2	17				10	45	1	
2M.NT3	4/01/98	1	8			3					1	10	1	10					13	10		28			23	224	2	551		9				54	1	241	66		7		14	2	4	18	4			8	72	1	8
2M.NT4	4/01/98		9			11	4						5	24					3	5	3	7	1		8	176		623		8				34	4	309	27		2	1	36	2	2	17	3			6	52		
2M.NT5	4/01/98		6	2	1		1					3		13					4	5		7			9	129		417	3	12				4	3	241	27		6		11	1		7	1			6	69		
	total	1	32	3	1	58	5				1	17	7	81	1		1		27	38	3	122	3		57	868	6	2332	6	47				136	9	1123	207		19	1	87	9	9	75	9			39	260	4	8

All taxa, month totals for malaise trap samples. T=treatment, NT=non-treatment

month total	all taxa	Litho	Aran	Opil	Psued	Collem	Cellatob	Isoplec	Gy tu	Hemidein	Crick	Staph	Coleopt lrg	Coleopt sm	Coleopt larv	SS	Odont	Cerambyc	Chrys	Lepid	Lepid larv	Calliph	Tach	Hoverf	DIPT:sm d	DIPT:lrg	DIPT: lrg bow	DIPT: sml	DIPT:hairy	DIPT:stripy	DIPT:yell abd	DIPT:lrg y dros	DIPT:sml byw	DIPT:y Drosop	DIPT: ybsw	Hymenop	Ichnumon	Apidae	Pomp	Termite?	Bee?	Vespula	Hemipt	Psocopt	like Psocopt	Mayfly	Lacewing	Cranefly	Cranefly sml	Robberfly	Robberfly sml
	T	0	71	4	4	91	7	2	5	1	0	45	30	283	0	1	6	0	217	144	4	327	9	3	113	970	41	4860	41	83	0	5	16	328	19	1491	389	3	19	3	92	12	23	128	5	0	2	44	347	15	7
	NT	1	82	5	3	101	9	0	2	0	3	34	33	219	2	0	3	4	198	81	6	266	13	5	131	1405	17	4359	16	116	4	0	0	358	36	1755	453	0	22	5	173	11	27	107	14	1	2	80	350	12	8

Taxa larger than 5mm, month totals for malaise trap samples. T=treatment, NT=non-treatment

taxa>5mm	Taxa	Araneae	Opilionidae	Blattodea	Orthoptera	Staphylinidae	Coleoptera - large (>5mm)	Larvae (Coleopt. & Lepidopt.)	Lepidoptera (adult)	Hemiptera	Ephemeroptera	Neuroptera	Tipulidae	
site total	T	71	4	7	8	45	36	4	144	23	0	2	391	735
site total	NT	82	5	9	5	34	40	7	81	27	1	2	430	723

Appendix 2

PITFALL TRAP SAMPLES, ORIGINAL FREQUENCY SCORES

Taxa larger than 5mm, month totals for pitfall trap samples. T=treatment, NT=non-treatment.

Taxa	T	NT
Endodontidae	4	3
Amphipoda	116	109
Isopoda	19	14
Diploda & Chilopoda	67	59
Araneae	316	342
Opilionidae	22	18
Blattodea	3	1
Orthoptera	52	87
Larvae (Lep., Dipt. & Coleopt.)	21	69
Carabidae	44	18
Staphylinidae	15	53
Coleoptera>5mm (ex Carabids)	4	7
Neuroptera	0	1
Lepidoptera (adult)	1	0
TOTAL	684	781

All taxa, month totals for pitfall trap samples. T=treatment, NT=non-treatment

	T	NT
Endod	1	0
Otoconc	1	1
Plan	1	0
worms	4	2
Amph	116	109
Sphar	4	9
Phil	2	3
SlaB	13	2
Diplod	3	2
Dimer	1	2
Jul	55	50
Icosid	7	2
Litho	0	1
Corm	1	2
Aran	316	342
Acar	197	162
Opil	22	18
Psued	11	17
Collem	507	602
Cellato	3	1
Rhap	7	10
Zeland	0	1
Weta	45	76
Coleop	110	92
Col. lar	1	8
Car1	28	12
Car2	8	5
Mepl	8	1
Stap	11	49
Qued	4	4
Odont	3	4
SS	298	105
Cucu	0	1
choc	1	2
Lep larv	16	61
Dipt?	606	83
Dipt larv	4	0
Apt dipt	55	1
Callip	84	2
Tach	7	0
Hymen	97	93
Form	48	166
Ich	2	3
Pomp	3	1
Hemip	7	1
Lace	0	1
Snail	2	2
thing	1	0
Rhyp	1	0
Lep	1	0
	2723	2111

All taxa, two week samples for pitfall traps. T=treatment, NT=non-treatment

TREATMENT/NON-TREATMEN	1T	1NT	2T	2N
Endodontidae	1		0	0
Otoconcha dim.	1	1	0	0
Planeria	1	0	0	0
worms	4	1	0	1
Amphipoda	74	78	42	31
Sphaerillo	2	3	2	6
Philoscia	2	3	0	0
Slater B	6	1	7	1
Dipoloda - unknown	3	2	0	0
Dimerogonus	1	1	0	1
Julida	27	34	28	16
Icosidesmus	5	0	2	2
Lithobiomorpha?	0	1	0	0
Cormocephalus rubiceps?	0	1	1	1
Araneae	169	166	147	176
Acarinae	107	70	90	92
Opilionidae	16	8	6	10
Psuedoscorpionidae	9	10	2	7
Collembola	255	361	252	241
Cellatoblatta vulg.	2	1	1	0
Rhaphid/Gymnoplec. tuarti	4	7	3	3
Zelandrosandrus	0	1	0	0
Weta nymph	21	39	24	37
Coleoptera - small unident	79	65	31	27
Coleoptera larvae	0	4	1	4
Carabid 1	17	8	11	4
Carabid 2	4	2	4	3
Mecyclothorax plac.	6	0	2	1
Staphylinidae	9	37	2	12
Quedius tinctellus	4	4	0	0
Odontria	1	4	2	0
Saphobius sqam.	208	56	90	49
Cucujidae?	0	1	0	0
choc chip/wheel arch beetle	0	2	1	0
Lepidopt larvae	12	52	4	9
Diptera - small unident	150	63	456	20
Dipteran larvae	2	0	2	0
Wingless fly	11	0	44	1
Calliphoridae	34	0	50	2
Tachinid fly	4	0	3	0
Hymenoptera - small unident.	51	35	46	58
Formicidae (incl Huberia brouni)	29	113	19	53
Ichnumonidae	1	1	1	2
Pompilidae	2	1	1	0
Hemiptera	5	1	2	0
Lacewing	0	1	0	0
Snail			2	2
"thing" (Mike's drawing)			1	0
Rhypodes			1	0
Lepidoptera			1	0
TOTAL	1339	1239	1384	872