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RESPONDING TO INCURSIONS OF AUSTRALIAN SUBTERRANEAN TERMITES IN NEW ZEALAND

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Abstract New Zealand has three species of native termites *Kalotermes brouni, Stolotermes ruficeps* and *S. inopinus*. In terms of destructive capability, these are of minor significance. Invasive Australian subterranean termites, specifically *Coptotermes acinaciformis* and *C. frenchii* hitchhiked into New Zealand unnoticed several decades ago, within utility poles, railway sleepers and wooden packaging. From 1940 to 1980, up to 50,000 properties in the North Island were inspected for invasive termites, with around 110 infested sites found and treated. One infested site located in the rural town of Otorohanga has persisted. *C. acinaciformis* was first reported from Otorohanga in 1990, with the termites entering the town during the 1950s via two imported utility poles. Initial response actions involved removal of the utility poles adjacent to infested properties and insecticide treatment. One nest was found within the poles, and this was destroyed. Further activity was detected between 1994 and 1998, despite treatment carried out after each incident. In 1999 options were explored to eliminate the increasing termite population, which had by now infested eight houses. A group of invited international and local experts met to overview the site and develop a strategy for elimination. As a result of the meeting a comprehensive response programme was implemented. This involved the placement of up to 300 Sentricon® bait stations and 200 wooden stakes at the site, inspection and removal of untreated hardwood utility poles in the area, placement of sticky traps up to 10 metres height on selected utility poles to monitor for alate flights, inspecting properties within the area for new activity, placing movement controls on termite host material, and liaising with the local community of 3000 to enable them to assist with identifying signs of termite activity. Bait stations were placed in November 1999 and active termites were found feeding within six bait stations one month after placement. By March 2000, three months after placement, termite activity had ceased. As of early 2005, regular monitoring and on-going inspection of bait stations have resulted in no further evidence of termite activity. Based on no *C. acinaciformis* being found, successful elimination at Otorohanga is scheduled to be announced in 2005.
Key Words *Coptotermes acinaciformis*, alates, elimination, Sentricon® bait stations, Otorohanga

INTRODUCTION

New Zealand has three species of indigenous termites *Kalotermes brouni* Frogatt (Isoptera: Kalotermitidae), *Stolotermes ruficeps* Brauer (Isoptera: Termopsidae) and *S. inopinus* Gay (Isoptera: Termopsidae) (Milligan 1984). These are not considered to be destructive. Indigenous termites do not form large colonies and usually affect only a small portion of any wooden structure.

Exotic termites were first reported entering New Zealand in the late 1930s (Clark, 1938; Miller, 1939). Colonies of *Glyptotermes breviconis* Froggatt (Isoptera: Kalotermitidae), *Kalotermes banksiae* Hill (Isoptera: Kalotermitidae), *Porotermes adamsoni* Froggatt (Isoptera: Termopsidae), *Coptotermes acinaciformis* and *C. frenchi* Hill (Isoptera: Rhinotermitidae) have all been confirmed from within New Zealand (Bain and Jenkin 1983). Infestations have mainly been found in the North Island. All species recorded have arrived from Australia, with the subterranean termite *C. acinaciformis* the most commonly recorded incursion. Various researchers (Kelsey 1944; Gay, 1967; Bain, 1983) have commented that all recorded infestations of Australian subterranean termites in New Zealand were introduced in rail or tramway sleepers or in wooden utility poles, and could be traced back to their original source. There is no suggestion that colonies of subterranean termites in New Zealand have resulted from alate flights.

As a means of detecting infestations, preventing spread and eliminating colonies between 1940 and 1980, up to 50,000 properties within the North Island were inspected for invasive termites, with around 110 infested sites found and treated (Ross, 2000). Treatment most often involved destruction of host material in which the termites lived, trenching around the site using insecticides such as Dieldrin and arsenic dusting in the termite runways. Treatment was, and still is, carried out at the government's expense.

Due to the number of termite incursions, New Zealand border controls were enhanced. Discussions were held between Australian and New Zealand forest authorities and controls were formulated to prevent termite importation. Controls included compulsory fumigation, creosote treatment of wood, and removal of all bark. Timber exports from Australia were prohibited unless these criteria had been met. Australian subterranean termites are now listed in New Zealand as unwanted organisms. Currently, all wooden material entering New Zealand is inspected and, if necessary, treatment is carried out at the border. The main risks now from Australia as far as termites go is from second-hand imported railway sleepers which are used for landscaping purposes. Fumigation at the port of entry is mandatory for these sleepers.

Subterranean termites were first reported at the Otorohanga site in November 1990 when tenants reported to the local district council that winged insects were emerging from a doorjamb. The insects were subsequently identified as the Australian subterranean termite *C. acinaciformis*. The infestation was linked to two hardwood utility poles imported from Australia in the late 1950's (Fig. 1). Otorohanga is a rural town with around 3000 residents located south of Hamilton in the upper North Island of New Zealand. The site of the incursion is around 1 km south of the town centre and encompasses an area of approximately 3.5 hectares. Sealed roads and ditches bound three sides of the site while the fourth side is exposed to open pastureland. The site is a mixture of residential houses, trees, shrubs, fences, sheds, poles, general landscape materials, and swimming pools. The houses are mostly constructed from untreated native timber. The terrain is undulating with natural and built-up features.

Figure 1. *Coptotermes acinaciformis* nest found concealed within imported Australian utility pole.

Figure 2. Installation and removal of sticky alate trap from utility pole.

Initial actions on discovery of *C. acinaciformis* involved destruction of utility poles adjacent to infested properties, removal of host material, fumigation of wooden products with methyl bromide, and trenching around areas of known activity. However, treatment failed to eliminate the infestation and activity continued throughout the 1990s. As no formal research studies have been carried out on *C. acinaciformis* in New Zealand, it was not known if the infestation was primary or secondary. A delimiting survey carried out in March 1999 detected subterranean termite activity on eight properties in a concentrated area of 1.4 hectares south of the township. The infestation was causing considerable damage and impacting on power poles, residential homes, vegetation, fences, retaining walls, and landscaping timber. It was noted that the residents' property prices had reduced in value by up to 30% and that some buildings and trees were structurally unsafe.

The objective of this paper is to describe New Zealand's environment relative to termite incursions, and overview the response programme carried out to eliminate a colony of *Coptotermes acinaciformis* Froggatt (Isoptera: Rhinotermitidae) at a problematic site located in the North Island town of Otorohanga.

MATERIALS AND METHODS

A programme aimed at eliminating the population of *C. acinaciformis* was developed in late1999/early 2000 based on the results of the delimiting survey, an analysis of options, and the recommendations of a Technical Advisory Group (TAG) formed specifically to review the Otorohanga incursion. Criteria used in selection of treatments were linked to actual historic and current subterranean termite treatments used in eradication operations in New Zealand, chemical registration status in New Zealand, used in overseas subterranean termite control programmes though not registered in New Zealand, new treatments being researched overseas that might be suitable in a response programme, and technical soundness.

The methods chosen to achieve colony elimination were: placement of above-and below-ground Sentricon® bait stations at seven identified residential properties where activity was present; placement of wooden stakes at 21 properties not monitored by the bait stations; annual visual surveillance of wooden debris, trees and 28 residential properties; sticky traps on utility poles during the predicted alate flight season; inspection of all old untreated utility poles in the immediate Otorohanga area for activity; and placement of restrictions on the movement of host material out of the response area. It was recommended by the TAG to continue monitoring for residual *C. acinaciformis* activity for a period of five years after the last activity was detected before elimination could be declared.

Data Analysis

Placement of Bait Stations and Wooden Stakes. The baiting option appeared the most suitable for elimination at the Otorohanga site. Developed by Dow AgroScience, the bait stations concentrate termite feeding in specific locations. The active ingredient is hexaflumuron, which has been proven to prevent termites from moulting, resulting in death and eventual elimination of the colony (Su et. al., 1995). As the bait system was not registered for use in New Zealand, a temporary permit was organised for Otorohanga. During November 1999, a total of 285 below-ground and above-ground bait stations were placed at seven residential properties with known termite activity. Target sites included the exterior and interior of buildings, fences, decking and vegetation. To increase coverage at low cost wooden stakes were placed at 21 residential properties within the infested zone. The stakes (Monterey pine, *Pinus radiata*, at 350 mm length with a top width of 50 mm^2) were placed more or less in the corner of each residential property. Stakes were inserted into the ground so that no more than 30 mm was visible. Monitoring involved lifting and visually inspecting the wooden stakes every six months for evidence of subterranean termite activity.

Monitoring of Alate Flights. During the Australasian summer of 2001/02 a total of 53 alate traps were placed within the Otorohanga urban area in a 2 kilometre radius of the infested site. Forty four proprietary sticky traps were mounted on utility poles and accessed using a modified fibreglass telescopic pole (Figure 2). Traps were located at a minimum height of 2.5 metres above ground level and approximately 1.5 metres from the light source. A further 9 purpose- built light traps (6 x 12 volt and 3 x solar powered) were established in locations where utility poles were absent, such as under houses. Traps were established in December and removed in late February. Trap distribution was stratified according to identification of prime risk locations. Criteria used to define a risk location included history of previous infestation, records of alate flight and locations of suitable host material. All light pole traps were monitored daily. The traps were removed, visually inspected, and condition/catch data lodged. The inspection period was extended to 3 days for the under-house light traps and solar traps.

Inspection of Utility Poles. As a risk existed that other wooden utility poles in Otorohanga could be colonised by *C. acinaciformis*, all poles within a 2 kilometre radius of the infested site were identified. A visual inspection of 238 poles was completed looking for evidence of termite activity including mud trails, nests, cracks where alate flights occurred, and insects. Any cracks and fissure were scraped out and searched using a flashlight.

Visual Surveillance. A delimiting survey was carried out annually to assess the extent of activity. Inspection was carried out of the 28 residential properties in the infested area and all wooden structures within a 100 metre radius. Surveys involved external and internal inspection of buildings, timber in contact with the ground, trees and wooden structures, and the random ground inspection throughout the infested area using a probe or spade. Methods used included visual assessment, banging of timber for noise effects and drilling of a selection of trees.

Implementation of Controlled Area Restrictions. A controlled area was established at the 28 residential properties to restrict movement of host material from the infested area, to prevent the unwanted spread of termites. All residents and commercial operators were notified and regular monitoring was carried out to ensure compliance. Approximately 60 requests were received to remove restricted material, including vegetation and wooden host material. These were transported from the site by an approved operator and disposed of by burning.

RESULTS

Bait Stations

During the first bait station inspection (24 days after placement), active termite feeding was detected in three of the above-ground and two of the below-ground bait stations. The second inspection (55 days) detected further feeding activity in an additional four above-ground bait stations; termite feeding had also commenced on the hexaflumuron baits in the below-ground stations. At the third inspection (82 days), further feeding of the baits was observed. The caste ratio of termites had altered, with soldiers out-numbering workers, and mortality was also noted. At the fourth inspection in March 2000 (110 days), no evidence of any termite activity was observed in the bait stations or at any of the known infestation points. The only evidence of the termites was numerous body parts and dead termites in the inspected bait stations. Visual surveillance of the 3.4-hectare area did not detect any activity. Bait station monitoring continued on a regular basis and 32 inspections had been completed by February 2005. The last evidence of termite infestation was five years ago. The wooden monitoring stakes placed to complement the bait stations were inspected biannually. No termites were found at any stage within the stakes. As time progressed, a large number of the untreated stakes either deteriorated in the damp soil or were unrecoverable. A decision was made to remove all remaining stakes two years after placement.

Table 1. Bait Station Monitoring Results – November 1999 to May 2000.

PROPERTY NUMBER	NOV (16-19) Bait stations placed	DEC (13-15)	JAN (12-14)	FEB (16-18)	MARCH (17-19)	APRIL (13-15)	MAY (25-27)
1	45	X	X	X	X	X	X
2	45	√	√	√	X	X	X
3	28	X	X	X	X	X	X
4	47	X	X	X	X	X	X
5	43	X	√	√	X	X	X
6	38	√	√	√	X	X	X
7	39	√	√	√	X	X	X

KEY
√ – Active subterranean termites detected
X – No subterranean termite activity

Alate Trapping

No alate *C. acinaciformis* were captured within the Otorohanga trapping area.

The utility pole traps functioned effectively, were robust and fulfilled their design requirements. The traps were inspected daily but in most instances only required replacement after 3-4 days. Insect activity around the traps in the evening was generally weather dependent and ranged from moderate to intense. A wide range of insects was captured including winged ants (*Chelaner* sp.), moths (Noctuidae), flies (*Calliphora* sp., *Musca domestica*) and wasps (*Vespula germanica*). To confirm that residual termite activity was not present in the wider Otorohanga area, an additional 20 alate traps were placed during the summer of 2002/03. No alates were trapped.

Annual Surveillance and Inspection of Utility Poles

Five annual delimiting surveys were carried out at the site between 2000 and 2005, with no new *C. acinaciformis* activity detected. Additional evidence of termite activity was, however, found with the number of colonised properties increasing from seven to eleven. All the evidence found from 2001 onwards was classified as historical. Evidence included dried-out mud-covered termite runways, damaged timber, alate cracks in poles, and secondary nests. Utility pole inspection resulted in no termite activity being detected. A total of 238 poles were inspected.

In summary, despite intensive monitoring, there has been no new evidence of *C. acinaciformis* activity detected at the Otorohanga site since 18 February 2000. Results indicate that the population of *C. acinaciformis* was probably eliminated after consuming up to 950 mg of hexaflumuron during a 4-month period.

DISCUSSION

The continuing lack of termite activity at the Otorohanga site confirms that the integrated elimination programme implemented in November 1999 has been successful in exterminating the population of *C. acinaciformis*. Five years after termite activity and feeding were last observed in the bait stations no further activity has been found, despite intensive monitoring.

The use of bait stations as the main component of the elimination strategy succeeded where previous attempts over a 10 year period in the 1990s failed. Over 82 days in early 2000, the slowly acting toxin (hexaflumuron) placed in the bait stations would have been transferred throughout the colony by tropholaxis, leading to colony elimination. The bait stations had advantages over previously implemented methods in that they are non-destructive, do not rely on locating the main or secondary nests, and are environmentally safe and non-obtrusive to residents.

At the commencement of the revised programme in 1999, it was still believed that the infestation could be a primary colony. However, based on advice and further analysis, it was agreed that the original queen had perished, was succeeded by neotenics and that the infestation was a secondary colony dispersed throughout the monitored area of 3.4 hectares. This reasoning is supported in the literature by Bouillon (as cited in Krishna et al., 1970) who notes that reproductives are utilised when the founding pair dies a natural or accidental death As a queen dies, or approaches the end of its reproductive life, the colony may produce neotenics, which are usually formed from supplementary reproductives.

In New Zealand, functional neotenics have occurred in most colonies and appear to be the means by which the colonies grow (Ratcliffe et al., 1952; as cited in Lenz and Barrett, 1982). Based on the research of Lenz and Barrett (1982) it is believed that the *C. acinaciformis* infestation in Otorohanga continued due to the formation of neotenics within the colony, and not through alate flights or an aged queen. It is probable that the original colony in Otorohanga was established by alates in Australia, with the subterranean termites being introduced into New Zealand in timber as an incipient colony.

The inability to trap alates after activity had ceased was not unexpected. Lenz and Barrett (1982) notes that it is unlikely that a pioneer colony of *Coptotermes* would be able to achieve an essential feature of nuptial flights, i.e. area saturation with alates over a very short period. The relatively few alates dispersed from the pioneer nest in Otorohanga would have had only a remote chance of pairing, let alone establishing a new colony. The close synchronisation of nupital flights depends on fine-tuning the seasonal cycle of development so that alate formation coincides with optimal weather conditions for flight and colony foundation. It may well be that the alien environment of Otorohanga did not provide the cues needed to synchronise the production or release of alates. Hadlington and Marsden (1998) note that in Australia the majority of alates die, becoming food for birds, spiders and so on, further adding to the problems of colony formation within a new environment. Trapping at Otorohanga confirmed that no additional colonies of termites had established in the area despite alate flights being observed in the 1990s.

Otorohanga, being a small town with a population of around 3000, became involved in response actions as residents supported the objective of elimination. As the programme progressed a key success feature became the public relations. The alate traps placed throughout the township increased the amount of public and media attention, which in turn raised the level of residential support. Because of the failure of previous treatments, distrust had been built up within the community towards elimination attempts. To overcome the risk of support being withdrawn, regular reports were mailed to residents, public meeting were held in Otorohanga, a liaison person was made available to discuss concerns, and media statements were made at timely intervals.

The attributes which made this programme successful include the rigorous technical analysis of implemented strategies, the level of commitment and leadership shown during the programme by team members, readily available operational field capability, community support, and communication. The lessons learnt through the mistakes made in the past, and experimentation with the termite-elimination treatments carried out at Otorohanga will provide valuable data for New Zealand in future actions against exotic termite incursions.

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