4 *Neotermes rainbowi* (Hill)

Isoptera: Kalotermitidae
coconut termite, rainbow termite

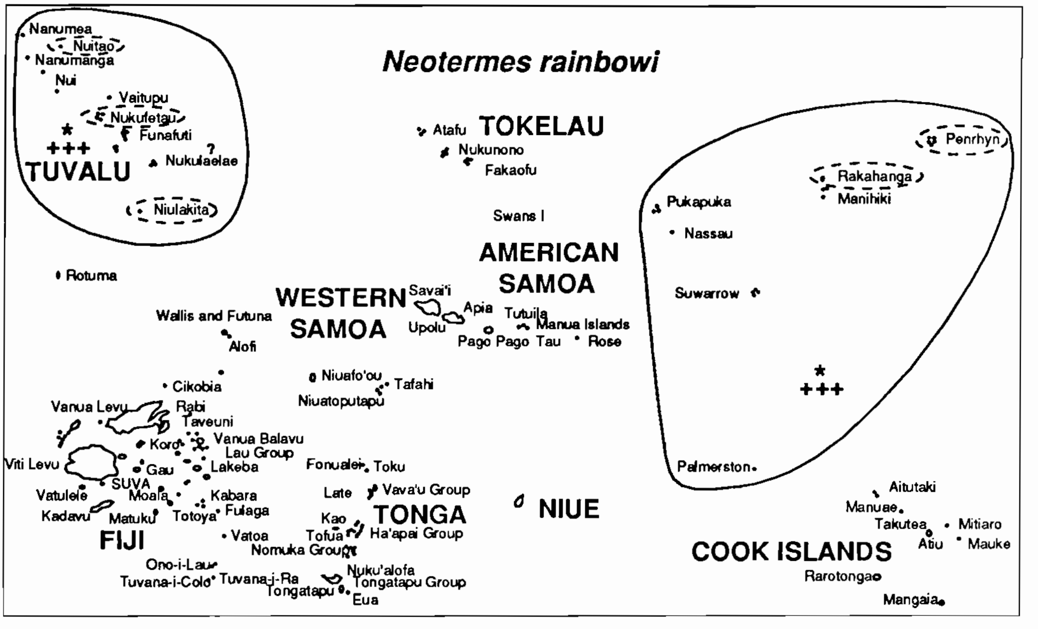

Figure 4.1 Distribution of *Neotermes rainbowi*

The coconut termite is known for certain only from two groups of small atolls in the central Pacific. The hollowing out that workers produce in the trunk of the living coconut palm leads, eventually, to the top snapping off in even mild wind.

It appears that destruction of infested coconut palms and stumps (which are all characteristically surface-marked by the termite) combined with, or perhaps replaced by individual treatment with appropriate entomopathogenic strains of fungi or nematodes, would greatly reduce losses and perhaps even lead to eradication.

There do not appear to be any suitable natural enemies that might be introduced for classical biological control.

Origin

N. rainbowi is known only from the central Pacific and presumably evolved there.

Distribution

The coconut termite has been recorded (Figure 4.1) from 5 (and possibly 6) of the 9 atolls comprising Tuvalu (Funafuti, Nanumanga, Nanumea, Nui, Vaitupu and ?Nukulaelae) (Hill 1926, Hopkins 1927, Lenz and Runko 1992). No information is available about the situation on the remaining 3 atolls (Nintao, Nukufetau and Niulakita) but it would be surprising (and most interesting) if *N. rainbowi* was not present, because these atolls are dispersed among infested ones. *N. rainbowi* is present on 4 and suspected on another 2 of the 6 atolls of the northern Cook Is (Manihiki, Nassau, Pukapuka, Suwarrow and ?Penrhyn, ?Rakahanga); and it is also present on Palmerston atoll, the most northerly of the southern Cook Is (Hoy 1978, Kelsey 1945). It is not recorded from the remaining 8 southern Cook Is, only two of which (Manuae, Takutea) are coral atolls. In 1988 *N. rainbowi* was observed in many palms on Pukapuka and Suwarow, but only in one very limited area of Nassau and not in palms elsewhere on the island, suggesting that it may have become established on the latter atoll in comparatively recent times (M. Lenz pers. comm. 1992).

The coconut termite has also been reported from Rotuma, the main (high) island of the 9-island Rotuma group (Fiji) (Maddison 1987, quoting from Swaine (1971)), but the facts that this termite attacks cocoa and citrus as well as coconuts and that the characteristic channels in the bark (see later) have not been recorded, raises doubts about the identity of the species involved and the situation is currently under investigation (M. Lenz pers. comm. 1992).

The genus *Neotermes* is in need of taxonomic revision. It is widely distributed in the south Pacific, with several described and undescribed species, but *N. rainbowi* is the only one known to attack the living wood of the coconut tree (Hopkins 1927, Thomson 1969). The most closely related species are said to be *N. samoanus* from Western Samoa, Solomon Is and Vanuatu; and *N. sarasini* from New Caledonia (Hill 1942). The report of *N. rainbowi* from Western Samoa (Maddison 1987) has proved to be a misidentification of *N. samoanus* (Gay in Lenz 1980).

The coconut termite was reported in Tuvalu in 1896 (Rainbow 1896-97) and in Cook Is about 1904 (Given 1964). Suwarrow (Cook Is) supported a copra estate in the 1920's and 1930s 'until the island became infested with termites and the export of copra was prohibited' (Stanley 1986) or until 'the ravages of termites made it necessary to prohibit the export of copra' (Douglas and Douglas 1989). It is certainly not at all clear that the atoll was uninfested before the estate was established.

Although it has not previously been reported from the three atolls comprising Tokelau, it was recorded as present but unimportant in the 1992 SPC survey (K. Kirifi, June 1992). The identity of the termite requires confirmation, since blown off tops do not occur, and the termites are normally observed in fallen or dead coconut trunks and the damage done is very minimal (K. Kirifi pers. comm. 1992).

Life Cycle

The Kalotermitidae, to which *Neotermes rainbowi* belongs, are primitive termites, many of which attack living trees and are termed live-wood termites. Hollows, where wood has been eaten out, are filled with faecal material which is earth-like in appearance and tunnels are constructed of carton-like material.

After a nuptial flight, founding pairs shed their wings and enter suitable wood through tree wounds or cracks; or they may chew a tunnel into soft wood. There mating occurs and the female (still accompanied by the male) lays a batch of eggs to produce workers and a small proportion of soldiers. When the first progeny mature they feed and tend the king and queen and, with further egg laying, the colony starts to grow in size. Kalotermitid termites are able to replace injured kings and queens with supplementary reproductives to maintain the colony. Average colony life is probably more than 20 years.

Pest status

Although there is little evidence that the presence of the coconut termite affects the nut yield of mature trees, structural damage to the palm trunks makes them subject to windthrow (Plate 1, Figs 7, 8), even at the low velocities of the steady tradewinds. On the other hand, the yield of young palms is reduced, or they may be destroyed before reaching bearing age (Given 1964). Nuts and fronds, whether fallen or on the tree, are not infested. Although it was reported to Given (1964) by an island inhabitant that *N. rainbowi* attacks all woody trees on Suwarrow (Cook Is) except *Cordia subcordata*, it is highly probable that the termite mainly concerned was a species other than *N. rainbowi*. Twice only in detailed searches on Vaitupu (Tuvalu) was *N. rainbowi* found in other than living coconut palms or stumps. These occasions were when *N. rainbowi* was found some 40cm below ground level in a few palm fence posts and in a woody shrub which had parts of its stems and roots hollowed out. In each case the termites had constructed tunnels into the soil. By contrast, colonies in living palms were never found to have tunnels leading to the soil (Lenz and Runko 1992).

In 1941 a hurricane caused 90% loss of palms on Suwarrow and damage must also have been extensive on Pukapuka since, in 1978, there was 'little evidence of any palms older than approximately 40 years' (Hoy 1978). Around the villages on Pukapuka where the ground is clear of other vegetation relatively few infested palms were found in 1978, whereas further away where ground cover was denser, and especially where pandanus was plentiful, levels of infestation were higher — often somewhat less than one palm in fifteen but occasionally rising to one palm in three (Hoy 1978). However, almost all healthy looking 9 year old palms receiving fertiliser at the time of planting were infested (Lenz 1988).

Attacked palms are readily recognised from the very early stages of infestation, a situation apparently unique amongst termites. At first, a few holes and grooves filled with chips of bark appear on the surface of the trunk. Later, a net-like pattern of grooves and channels is produced to the full depth of the bark (Plate 1, Fig. 9) and these are covered with chips of wood and bark mixed with faecal material. In the northern Cook Is this network commences near the base of the tree, close to where the bark forms a collar over the uppermost roots, and eventually extends upwards one or two metres with the expansion of the termite colony (Lenz 1988). In Tuvalu, the attack on the bark characteristically occurs at levels of 1 to 3 m and extends upwards as the colony expands, so that many square metres of bark become marked (Plate 1, Figs 7, 8) (Hopkins 1927, M. Lenz pers. comm. 1992, Rainbow 1896-97). The function of the channels is unknown but may possibly be related to moisture control, temperature regulation or, perhaps, conditioning of the underlying woody tissues. Whatever its function it is a striking tell-tale sign of the presence of a termite colony (Plate 1, Fig. 9). Very different channels, presumably caused by some other insect are occasionally seen higher up the trunk (M. Lenz pers. comm. 1992). As attack proceeds, large cavities are eaten out of the trunk, often extending to the surface of the palm. Portion of this space is filled with a soft moist honeycomb of faeces and debris. It is at this level that the top snaps off. The stilt roots or branches of nearby *Pandanus* are sometimes hollowed out without invasion of the main trunk (Hoy 1978) and, on Suwarrow, a few eaten out palm roots were observed (Lenz

1988). In Cook Is (Suwarrow, Pukapuka), but not in Tuvalu, it was evident that colonies were able to move from their original infestation through roots and soil to neighbouring palms (Given 1964, Lenz and Runko 1992).

The inhabitants of the atoll islands infested with *N. rainbowi* are very heavily dependent on nut production, not only as a major component of human and domestic animal diet, but as a principal source of income from copra production. The coconut termite is thus of crucial economic and social importance.

In Tuvalu, but not in Cook Is, there is a relatively abundant undescribed species of *Nasutitermes*, which builds dark-coloured galleries on the surface of palm trunks and other vegetation, often reaching the crown. This species is unable to penetrate the hard outer wood of coconut palm, unless this is damaged, such as by the deep access steps cut into palms to facilitate climbing for toddy collection. Tunnels made by *N. rainbowi* may also provide entry. There is no evidence that *Nasutitermes* n. sp. is of economic importance (Lenz and Runko 1992).

Control Measures

These have involved the removal and burning of infested palm wood and the use of chemicals. However, chemicals such as arsenic, lindane, dieldrin and phostoxin (Hoy 1978), which are effective if properly applied, are no longer recommended on residue, cost and environmental grounds (Lenz 1988). The destruction of infested material requires considerable physical effort and, unless carried out systematically, probably does little more than depress the steady increase in the number of trees infested. On the other hand, results can be striking if destruction of infested palms is carried out effectively. Thus, clear felling in a palm regeneration program on Vaitupu carried out in the late 1970s and early 1980s reduced infestations to very low levels. Only 4 of 1155 re-planted palms inspected in 1992 were infested with *N. rainbowi* although infestations were common in some other untreated areas. By comparison, 190 had surface infestations by the economically harmless *Nasutitermes* n. sp. (Lenz and Runko 1992). Recently, experiments in Tuvalu involving injection into the termite colonies of specially selected strains of the fungus *Metarhizium anisopliae* or of an entomopathogenic nematode, *Heterorhabditis* sp. have given very promising results (Lenz and Runko 1992).

Attempts at biological control

There have been no attempts at classical biological control of *N. rainbowi*, nor apparently any against other termite species.

Natural enemies

The most important natural enemies of termites are non-specific invertebrate and vertebrate predators and entomopathogenic fungi. A few ectoparasitic mites and endoparasitic flies (belonging to the families Calliphoridae, Conopidae or Phoridae) are occasionally referred to in the extensive literature on termites; also nematodes, mermithid worms, gregarines, microsporidia, protozoa and fungi (Ernst et al. 1986, Snyder 1956, 1961, 1968). They appear to produce important mortality only in weak colonies, whose decline is thereby accelerated. None of these organisms normally appear to cause sufficiently high or widespread mortality to show promise for classical biological control.

Winged reproductives on their colonising flight are eaten in large numbers not only by ants, dragonflies and other predatory insects, but also by birds, lizards, snakes and frogs. In Australia, workers and soldiers are preyed upon by ants, several marsupials (including the echidna) and many lizards (Watson and Gay 1991). Ants are almost certainly the major predators. Indeed, about one third of the world-wide references assembled on termite predators by Ernst et al. (1986) and Snyder (1956, 1961, 1968) refer to ants.

Termite colonies often harbour a specialised fauna of arthropods, known as termitophiles. Some of these are predators on eggs and young termites, others are scavengers feeding on nest debris and many provide secretions in return for being fed by worker termites. Nothing is known of termitophiles of *N. rainbowi*, but there is little likelihood that any could be exploited.

The only published report of natural enemies of *N. rainbowi* is the attack on young termites on Suwarrow (Cook Is) by meat ants (Given 1964). However, M. Lenz (pers. comm. 1992) has also observed ant attack on both Cook Is and Tuvalu when tunnels were broken open.

Comment

It is probable that many reports of the presence of *N. rainbowi* are due to its being confused with other termite species. On Vaitupu, of the other four termite species present, this would mainly be with *Nasutitermes* n. sp., but also possibly with *Prorhinotermes inopinatus* (Lenz and Runko 1992). Unless the characteristic channels in the bark are evident and unless hollowed out stumps containing termites are present, considerable doubts must be held until there is a positive identification by a termite specialist.

It is postulated that the presence of *N. rainbowi* galleries in the soil in the Cook Is, but their absence in Tuvalu is due to the presence in the latter group of atolls (but not in the former) of an effective subterranean competitor in the form of *Nasutitermes* n. sp.. This species is smaller in size, but more agile, agressive and numerous and, in encounters, is more likely to be victorious. It prefers to found its colonies at the base of palms and extend its feeding territory by means of subterranean galleries connecting several palm trees. From its position on the outside of the trunk it is able to invade exposed *N. rainbowi* galleries when the top of the palm is blown off. The older such stumps are, the more restricted become the portions occupied by *Neotermes* and the more extensive those by *Nasutitermes* (Lenz and Runko 1992).

There are a number of interesting unresolved problems concerning the origin and distribution of *Neotermes rainbowi*. The answers, if available, might have a direct bearing upon possible long term measures to reduce its abundance. If the currently held view is valid that the Polynesians brought the coconut with them when they migrated into the Pacific some 4000 years or so ago, the voyagers may also have had termites as fellow travellers — either *N. rainbowi* or a species that must have rapidly evolved into it. Alternatively, pairs of as yet unmated reproductives may have been carried to the atolls in storm winds from afar (but from where?). Of course, such pairs would only have been able to initiate colonies once coconut palms had been established. Further, no specific external area of origin for *N. rainbowi* appears credible at the moment. Another difficulty with this means of dispersal is that recorded distances flown by reproductives of most species is no more than a few kilometres (Nutting 1969). Nevertheless 19 alates of *Reticulitermes virginicus* were trapped by aeroplane over Louisiana at altitudes from 20 to 30,000 feet (Glick 1939), so longer distance dispersal cannot be entirely ruled out. It is relevant that nuts and palm fronds are not infested so that, if carried by canoe, colonies must have been in substantial (and thus heavy) portions of coconut trunk. It seems unlikely that termites could survive the long periods of immersion in salt water required for floating logs containing exposed termite colonies to be carried from one atoll to another far away. Of course, it is possible that *N. rainbowi* evolved as a species associated with other woody vegetation, including *Pandanus* roots and stems prior to the introduction of the coconut into the Pacific, and that it then transferred its main attention to the latter (M. Lenz pers. comm. 1992). Infested *Pandanus* roots would be more readily transported by canoe than colonies in coconut logs and there is some evidence that roots were transported as planting material. The ease with which Kalotermitidae (and presumably *N. rainbowi*) can produce supplementary reproductives from immature termites means that new colonies could be established from a small group of workers and immatures.

Another question is what are the features of the widely dispersed atolls (none of which has ever had a land connection with its neighbours) which permit *N. rainbowi* to survive there, but apparently not on other atolls or on high islands no further away (see Figure 4.1). Is it *N. rainbowi's* ability to survive (or even require) such factors as salt spray or, more likely, could it be the lack of competition on atolls with their very limited diversity of other animals? However, there appears to be little competition for space once access has been gained to the woody stem of the living palms.

It is considered that the atolls where *N. rainbowi* occurs did not have a native ant fauna (R.W. Taylor pers. comm. 1992), although it is probable that the majority now have a range of exotic tramp species. The distribution of such species is unlikely to be uniform and it is to be expected that the larger, high islands will have more such species than atolls. The only published record for those atolls infested with *N. rainbowi* appears to be for Palmerston (Cook Is), where five species are listed (Taylor 1967) so, at the moment there is no basis for comparison. There is, however, a record from Fakaofo (Tokelau) from 1924 of the presence of 12 species of introduced ants belonging to 9 genera (Wilson and Taylor 1967) and, doubtless, additional species would have arrived since then. However, there is no indication that the higher number there than in Palmerston has any significance in relation to the occurrence of *N. rainbowi*.

If it is postulated that ants could be a major factor in preventing the spread of *N. rainbowi* to additional islands, which species are likely to be involved and could these be introduced to infested islands to reduce, or possibly even eliminate, the coconut termite? The main attack by ants on termites appears to be on reproductives after colonising flights, on workers foraging away from their nests, or when nests or galleries are broken open. If ants were effective in eliminating established colonies, their great abundance and diversity in Australia would surely ensure that termites would have difficulty in surviving, whereas this is certainly not so. It must, thus, be concluded that termites, at least in established colonies, can generally defend themselves effectively against attack by ants.

Even if ants were believed to be effective in destroying termite colonies, in recent years the attitude of those concerned with the conservation of native fauna has firmed strongly against the introduction of non-specific predators, such as ants, that have the capacity to attack, and perhaps eliminate, non-target fauna: most, perhaps all, tramp ants fall into this category. Furthermore, the tramp ants now in the Pacific are, themselves, almost all pests or potential pests. This is because many bite or sting, invade dwellings and foodstuffs and foster outbreaks of aphids and scales for the honeydew they produce. The appearance of additional tramp species is generally regarded as a disaster, for example the unintentional introduction of *Wasmania auropunctata* into New Caledonia (Fabres and Brown 1978).

To pursue this argument further and to investigate whether there could, indeed, be any merit in the introduction of one or more ant species, it would be essential to evaluate the situation on atolls where the species in question either did, or did not, occur and also to include atolls where *N. rainbowi* did, or did not, occur. Very significant logistic problems and costs would be involved.

With the present state of knowledge, there seems little doubt that further development of environmentally safe control methods, such as the use of entomopathogenic fungi or nematodes is the best use of available resources. Also, in view of the tell-tale channels on the trunk surface, the option would appear to exist of eradicating *N. rainbowi* by a well-planned colony treatment operation, supplemented with, or if appropriate replaced by, destruction of infested palms and palm stumps.