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Long-term reduction in damage by rhinoceros beetle *Oryctes rhinoceros* (L.) (Coleoptera: Scarabaeidae: Dynastinae) to coconut palms at *Oryctes* Nudivirus release sites on Viti Levu, Fiji

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In 1972 to 1973 the non-endemic *Oryctes* Nudivirus (OrNV) was established at three sites on Viti Levu, Fiji, where the introduced rhinoceros beetle *Oryctes rhinoceros* was causing heavy damage to coconut crowns and frequently killing the palms. The establishment of OrNV, and its dissemination by adults, was followed by a marked reduction in the beetle population and damage. When re-surveyed 35 years later, damage was still at a low level. It is postulated that *Oryctes* Nudivirus is still helping to lower damage and manage *O. rhinoceros* populations at those sites.

Key words: Oryctes rhinoceros, *Oryctes* Nudivirus, coconut, Larvae, breeding site rhinoceros beetle.

INTRODUCTION

The rhinoceros beetle *Oryctes rhinoceros* (L.) (Coleoptera: Scarabaeidae: Dynastinae) is an important invasive pest of coconut palms ranging from the Middle East and South East Asia where it is endemic, to the South Pacific where it has been accidentally introduced into island groups such as Fiji (Bedford, 1976, 1980). An adult bores a hole into the heart or crown of the palm to feed on the sap, damaging the very immature fronds so that when they later unfurl they show characteristic V or wedge-shaped cuts, reducing photosynthetic area. Repeated or heavy attacks kill the growing point, causing the death of the palm. The decaying wood at the top of such dead standing palm poles, becomes a favoured breeding site, along with decaying logs and stumps, and cow dung, compost and sawdust heaps (Bedford, 1976, 1980, 1981, 2013).

A virus that infects *O. rhinoceros* was discovered in Malaysia and its history has been summarised (Huger, 2005). It has been included in the Nudivirus group and its name was abbreviated to Oryctes Nudivirus (OrNV) (Burand, 1998, Wang and Jehle, 2009). Infection is peroral, and it attacks the midgut and fat body of larvae and the midgut of adults, curtailing life span and fecundity, but infected adults act as vectors or "flying virus factories" (Huger, 2005) disseminating it by contaminating larvae or adults in breeding sites by defaecation, or other adults during mating. Safety testing showed it harmless to beneficial insects and vertebrates. The virus was released, and established, in a number of South Pacific and Indian Ocean countries where it was not endemic. Subsequently there has been a marked reduction in the beetle population and damage (references up to that time are summarized in Bedford, 1980). In more recent years, OrNV releases and subsequent reductions in damage have been noted in the following non-endemic locations: Andaman Islands

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Abbreviations: OrNV, Oryctes Nudivirus.

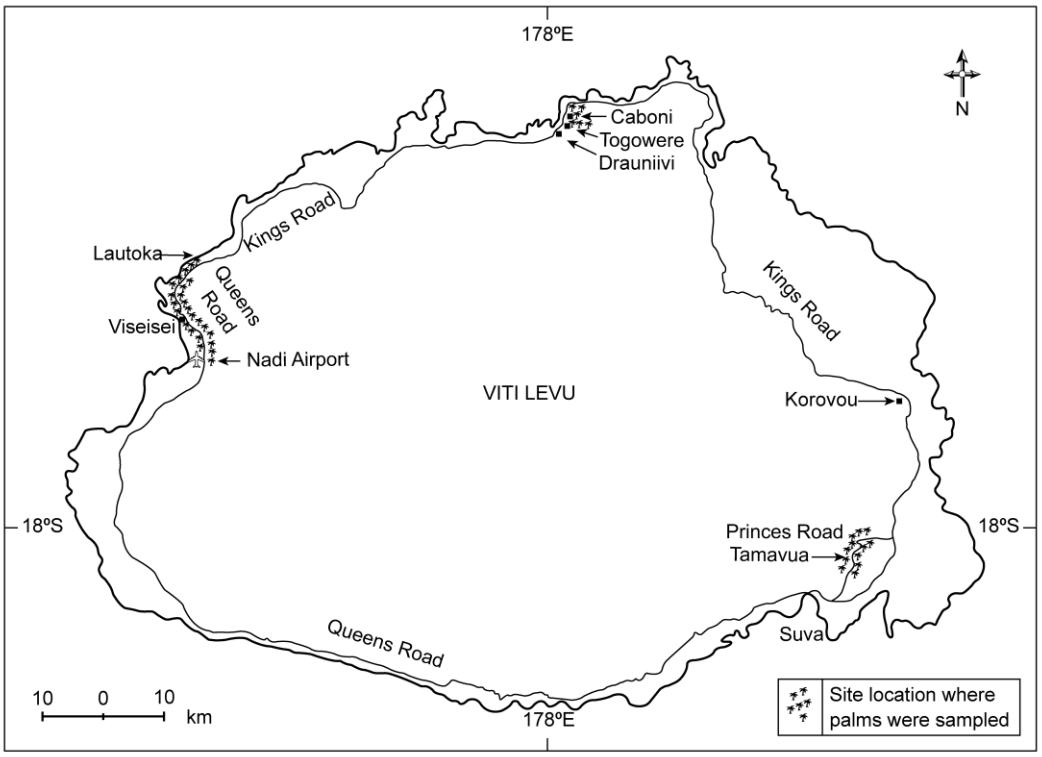

Figure 1. Map of Viti Levu, Fiji, showing locations of palm damage surveys (km = kilometres).

(India)(Jacob, 1996; Prasad et al., 2008); Maldives Islands (Zelazny et al., 1992); Minicoy Island (India) (Mohan and Pillai, 1993) and Oman (Sultanate) (Kinawy, 2004). Data on OrNV occurrence and effect in endemic regions has been provided for India (Gopal et al., 2001), Malaysia (Ramle et al., 2005) and the Philippines (Zelazny and Alfiler, 1991).

However, while it may be mentioned in various countries' Agriculture Department Annual Reports (e.g. Fiji), there have been no peer-reviewed studies of the status of *O. rhinoceros* populations or damage following OrNV establishment, in the Maldives since 1992, Mauritius since 1978, Fiji since 1976, Samoa since 1982, Tokelau Islands since 1977, and Tonga since 1981. So it may be asked: is OrNV still helping to manage rhinoceros beetle damage, or has damage resurged to levels which existed prior to its release? To explore this, in 2010 damage on the island of Viti Levu, Fiji, was re-surveyed at three locations where it had fallen markedly following OrNV release and establishment in the 1970's. This work is not a controlled trial but a follow up to those trial results published decades earlier (Bedford, 1976) and even then OrNV had begun spreading from release sites into control non-release sites. Following OrNV establishment, its incidence in adults was 68% at Tamavua, 66% between Nadi and Lautoka, and 57% at Caboni (Bedford, 1976). Occasional further releases of OrNV were made on this island from 1980 to 1982,1984 to 1986, 1988, 1999 to 2000 (Fiji Department of Agriculture – *O. rhinoceros* - Annual Research Reports for these years). On this island coconuts produced make an important contribution to food supply and security rather than being used for copra.

MATERIALS AND METHODS

Because of the difficulty or impossibility of counting beetles directly due to their cryptic behaviour and their inaccessibility due to palms reaching a height of up to 20 – 30 m, two types of damage surveys were done (Young, 1986), which give an index or indicator of the *O. rhinoceros* population. A rapid damage survey (RDS) scans a sample of palms, taken as randomly as possible, and scores them as damaged or not in the central 3-4 fronds, giving a percentage of palms with recent damage. A detailed damage survey (DDS) counts the number of fronds above the horizontal level in the crown, and the number damaged, in a palm sample, giving the percentage of fronds damaged at that location. As a new frond is considered to unfurl on the average every 3 – 4 weeks (Zelazny, 1987), with 10 – 17 fronds available in the DDS, this gives a palm's damage history for approximately the previous 40 – 68 weeks. The three locations used were: along the Nadi (airport) - Lautoka road (188 – 265 palms sampled, OrNV had spread here by mid-1973); Caboni (157 palms sampled, OrNV released April 1972); and Tamavua (on the outskirts of Suva, 54 palms sampled, OrNV released March 1972) (Figure 1). Extensive data was available at these locations from decades previously for comparison with current readings, and the aim was to have palm sample sizes as close as possible to the size of the original samples, and representative of a substantial proportion of the palms at each locality. For the Nadi-Lautoka road

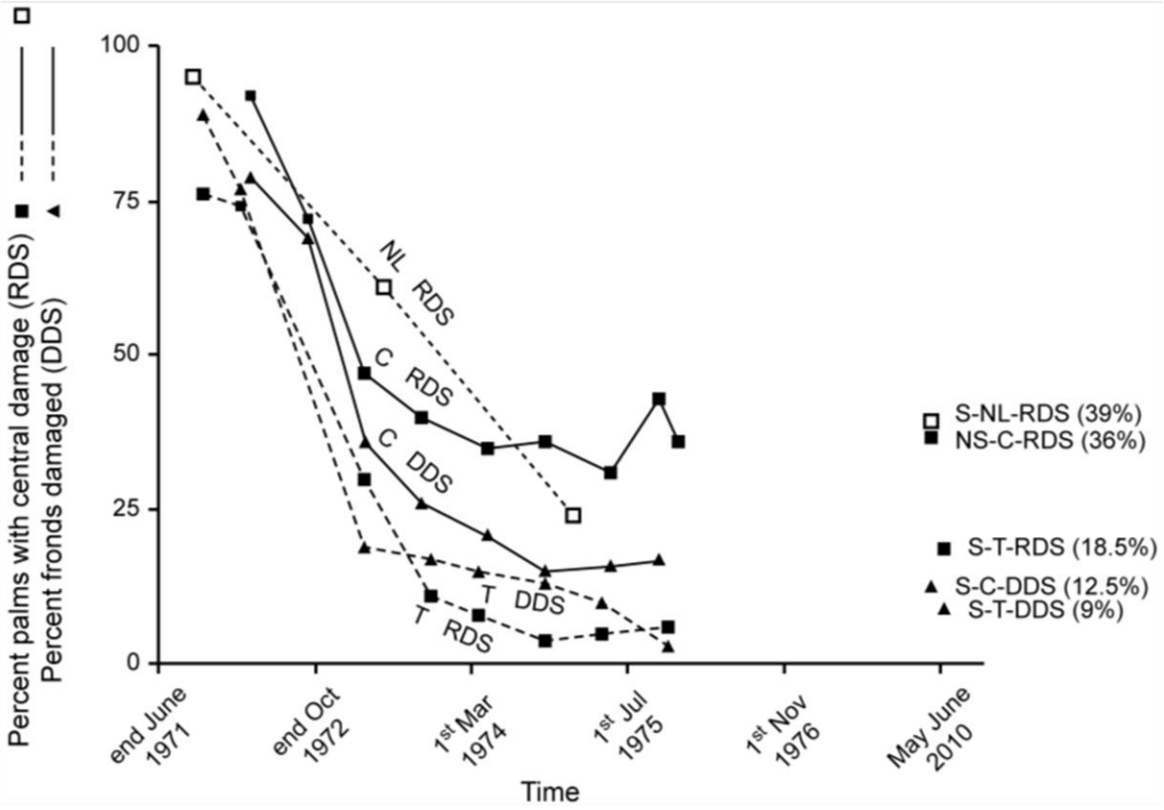

Figure 2. Change in palm damage at the 3 sites studied. C = Caboni, NL = Nadi – Lautoka Road, T = Tamavua, DDS = Detailed damage survey, RDS = Rapid damage survey, S = Significant difference $p < 0.05$, NS = No significant difference $p > 0.05$, and 2010 results are shown in brackets.

location, only a rapid damage survey was feasible. At Caboni it was found a large proportion of the original palms had been cut down so available palms up to a kilometre away had to be substituted to make up a sample representative of the location. For each location, the last old reading, and the 2010 reading were compared for significance by tests based on the normal distribution (comparing two percentages based on two large samples (Bailey, 1959: 38-40). Some rapid damage surveys were done at other locations on Viti Levu and give an impression of current damage but there are no previous readings at those locations for comparison.

RESULTS AND DISCUSSION

On the Nadi-Lautoka Road (Figure 2) damage is still well down, after 40 years, compared to the pre-OrNV level of 1971, but up marginally since February 1975. At Tamavua (Figure 2) damage in both types of survey was up (after 35 years), but still far below the level prior to OrNV release. Perhaps after the major drop-off in damage following OrNV establishment (at Nadi-Lautoka by natural spread by mid-1973) damage then fluctuates around a far lower level. At Caboni (Figure 2), interestingly there was no significant difference in the rapid damage survey from 34 years previously, and the detailed damage survey was even significantly down compared to what it had fallen to 34 years ago.

Rapid damage surveys at other locations (Figure 1) are: Nadi (from temple) along Back Road (and diverting to Nawaka) to airport - 11 palms damaged/162 sampled, 6.8% damaged; Drauniivi – 13/ 48, 27% damaged; Togowere - 13/69, 19% damaged; Vunitogoloa - 3/20, 17% damaged; Tailevu Hotel, Korovou - 1/22, 4.5% damaged; Verata – 1/33, 3% damaged.

By reducing the *O. rhinoceros* population and thus heavy damage and consequent killing of palms, OrNV indirectly reduces the number of breeding sites created and made available in the tops of the dead poles, thus reducing emergence of future generations of adults. A large rise in the number of breeding sites, from whatever cause, might lead to a rise in *O. rhinoceros* populations and damage, despite the presence of OrNV. The OrNV – *O. rhinoceros* – palms ecosystem is complex with numerous variables (Bedford, 2013). For simplicity the present study focused on damage as this is readily quantified and is the feature of concern with this pest. The OrNV genome may mutate and might be selected for less virulent forms so data on whether this might have occurred on Viti Levu, and on virus incidence, would be of interest, also data on the current situation of *O. rhinoceros* populations or damage on other parts of Fiji, preferably for comparison with data from previous years

at the same locations. Sometimes OrNV effectiveness may be queried, because fresh damage can always be found everywhere, as the pest never disappears entirely, so creating a subjective impression of ongoing damage, but the key consideration which needs to be recognised, is that the overall damage had become less, often much less, compared to previous levels, (and which then might fluctuate) as shown in the present work.

In summary, it is postulated that OrNV is still helping, many years after its establishment, to hold down and manage *O. rhinoceros* populations and damage on Viti Levu at the sites studied. Similar assessments should be undertaken in other countries where OrNV has been released and established.

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