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BIOLOGICAL CONTROL OF THE RHINOCEROS BEETLE (*ORYCTES RHINOCEROS*) IN THE SOUTH PACIFIC BY BACULOVIRUS

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ABSTRACT

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A baculovirus, originally discovered in Malaysia, attacks both the larval and adult stages of *Oryctes rhinoceros* (L.), a serious pest of the coconut palm in the South Pacific. Infection is peroral. The virus multiplies in the digestive system and other organs. Dying larvae contaminate breeding sites with virus. Infected adults cease egg laying, but live for several weeks during which time they disperse, visiting breeding sites and spreading the disease to larvae and other beetles. Safety tests showed the virus to be without apparent harmful effect on vertebrates. It can be conveniently propagated in larvae in the laboratory and stored. Various methods have been used to release the virus in South Pacific countries. The most economical and effective method was found to be the release of infected adults. Larvae and adults may be mass-reared for this purpose if necessary. Establishment of the virus has been successful at many sites in Fiji, the Samoas, Tonga, Tokelaus, Wallis Island, Papua New Guinea and Mauritius and has been followed by a fall in the beetle population. This is reflected in marked reductions in beetle damage to palms, which have been recorded in many localities 1—1.5 years after establishment.

INTRODUCTION

The rhinoceros beetle *Oryctes rhinoceros* L. occurs throughout southeast Asia, and was accidentally introduced into the following South Pacific countries: Western Samoa (1909), American Samoa (possibly 1912), Fiji (1952), Tonga (1961), Tokelau Islands (1963), Wallis Island (1931), Palau (about 1942) and Papua New Guinea (about 1942). Adults fly to the central crown of the coconut palm, crawl down the axil of a young frond and then bore through the heart of the palm into the unopened fronds, which unfold later, revealing tattering and V-shaped cutting of the leaflets. These attacks reduce yield, kill both young and old palms if heavy and repeated and provide entry points for lethal secondary attacks by other pests and diseases. As a consequence, the attacks discourage farmers from replanting. The eggs are laid and the larvae develop and pupate in the tops of dead

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standing palms, decaying trunks of coconut and other wood, and heaps of sawdust, compost, manure and other decomposing vegetable matter. *Oryctes* biology, ecology and control have recently been reviewed (Bedford, 1980).

A baculovirus was originally discovered in Malaysia and described as *Rhabdionvirus oryctes* (Hüger, 1966), and was found subsequently in Indonesia and the Philippines (Zelazny, 1977a). It was not endemic in beetle populations in any territory in the South Pacific. It multiplies in the larval fat body and intestinal epithelium of larvae and adults. Infected adults become flying virus reservoirs which can defaecate infective virus into the species-specific habitats (Hüger, 1973). Third instar larvae fed with virus die 15—22 days after infection and the cadavers contain much virus material. Laboratory-bred adults, when infected, live for about 24 ± 1.6 days while similar adults, uninfected, live for about 70 ± 7 days and infected females stopped egg laying by the second week after inoculation (Zelazny, 1972, 1973). Safety testing with purified virus showed no pathogenicity to 8 tissue cultures (2 human and 2 pig cell cultures and 1 each from mouse, hamster, fish and calf) or to various organs of mice up to 60 days after inoculation (FAO, 1978). Further pathogenicity studies on adult pigs confirmed the safety of the virus toward vertebrates (Gourreau, et al., 1979).

Baculovirus was first released in Western Samoa in 1967 (Marschall, 1970) and its spread through the beetle population there resulted in a marked and widespread fall in beetle damage to palms. Similar results were obtained following its release in Tonga (Young, 1974), Wallis Island, American Samoa, Tokelau Islands and Mauritius (summarized in Bedford, 1980). More recently it has been released in Papua New Guinea (Gorick, 1980). The present paper refers particularly to Fiji.

MATERIALS AND METHODS

The virus is mass produced by allowing large numbers of larvae to feed on virus-contaminated rotted sawdust. As the larvae die from the disease the cadavers filled with virus material are removed and transferred to a deep freezer where they may be stored indefinitely (Bedford, 1976a). Virus was originally released by placing macerated virus-killed larvae in artificial compost heaps covered with decaying coconut logs. These were visited by individuals of the wild beetle population which became infected. This method was superseded by placing live and dead infected larvae in sawdust under lengths of split coconut log, which again infected visiting beetles. This method was in turn replaced by the release of laboratory-infected adults, which may be field-caught, or, more economically, mass-reared (Bedford, 1976b), to carry the infection directly into the wild population. Virus establishment is confirmed by collecting larvae or adults from natural breeding sites, or adults from ethyl chrysanthemumate attractant traps, for bioassay, histological examination, or other tests (Bedford, 1981; Young and Longworth, 1981).

The most convenient method for observing the effect of virus in the field is to monitor the change in beetle damage to palms over time. In detailed surveys, samples of 20—30 palms were paint-numbered at various sites. Periodically, the number of fronds above the horizontal level was counted in the crown of each palm and also the number of fronds which showed beetle cuts. Results were expressed as percentage of fronds damaged for the palms at one site, or a group of sites combined (Bedford, 1976a). A more rapid type of survey is also available which shows percentage of palms with recent damage to the central crown at a site (Young, 1974; Bedford, 1980).

RESULTS

In Fiji, virus release began in 1970 using the three methods as they evolved. Its establishment at various localities was confirmed. Detailed damage surveys before release and afterwards at intervals, showed that in many localities beetle damage fell significantly 12—18 months after establishment (Fig. 1), whilst the appearance of the palms improved (Fig. 2). The effect was particularly noticeable in areas where high levels of damage existed before virus release.

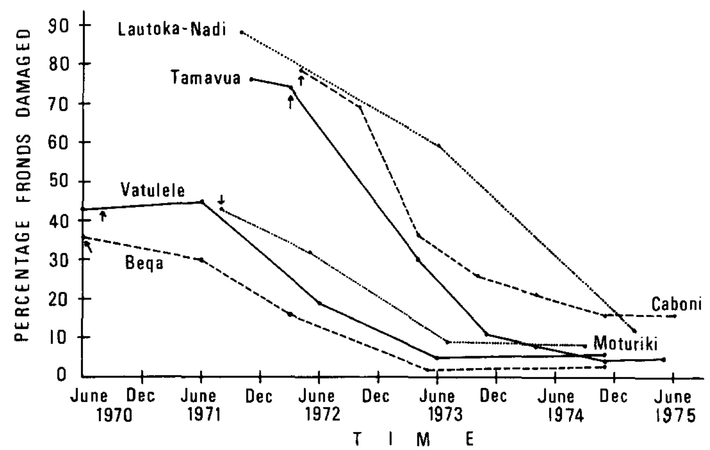

Fig. 1. Effect of baculovirus on palm damage by *Oryctes rhinoceros* at localities in the Fiji Islands. Arrows indicate time of virus introduction. Virus had spread naturally into the Lautoka-Nadi area by mid-1973.

DISCUSSION AND CONCLUSIONS

The use of virus is easily integrated into control programmes which may use additional methods against *O. rhinoceros*. Latch (1976), in Tonga,

Fig. 2. Group of palms at Waisomo, Beqa Is., photographed (above) in March 1971, and (below) April 1982. Note replacement of damaged fronds by healthy ones.

showed that the fungus *Metarrhizium anisopliae* can be mass produced saprophytically on oat grains and applied as a microbial pesticide to the surface of breeding sites such as sawdust heaps. After 3 months, most *O. rhinoceros* larvae are killed, and the spores remain viable in the breeding sites for at least 24 months. Decaying coconut logs may be concealed from *O. rhinoceros* by cover crops. Fresher logs may be removed for charcoal-making or timber. In general, virus reduces the beetle population and hence damage, to a considerably lower level than occurred before its release. A persistent but reduced beetle population is of course needed in the field to maintain and propagate virus under natural conditions and for this a certain number of natural breeding sites has to be always present, which will lead to a certain level of damage.

O. rhinoceros "escaped" from its virus when it was first introduced into the South Pacific early this century and the subsequent introduction of the virus from the late 1960's onwards, may have tended to restore the situation to what happens in regions where both co-existed before e.g., Malaysia. However, to confirm this would require a thorough study of the various palm–beetle—virus ecosystems in Malaysia, a task for the future.

In some localized places, if a greater than usual number of breeding sites is created, e.g., by felling of palms, or hurricanes, the beetle population may build up again in the "outbreak" areas and cause an increase in damage to palms in the vicinity, despite the presence of virus. This raises the question of whether any benefit is gained by releasing additional virus. On a group of isolated islets in the Tokelaus, Zelazny (1977b) trapped and killed female beetles, destroyed larvae collected from breeding sites and released about 20 virus-infected male beetles/week for 20 months. In detailed surveys the percentage of fronds damaged above horizontal fell from 6.5 to 1.9. Damage was thus low to begin with and it is not clear to what extent the 4.5% fall in damage was due to virus re-release or the other control methods applied, or whether it was commensurate with the effort expended.

Young and Longworth (1981) resurveyed Tongatapu in 1978, where no further virus had been released since its establishment in 1971. They found that although damage was common in villages and on isolated palms, the plantation areas were little affected by the beetle overall. The incidence and distribution of virus and abundance of beetles had stabilized at levels similar to those of 1972. They thus made no recommendation for virus re-release. However, it must be borne in mind that *M. anisopliae* established in sawdust heaps around sawmills (Latch, 1976) may have contributed to holding down beetle numbers. Marschall and Ioane (1981) re-released virus beetles at 6 sites in Western Samoa where damage was still high and obtained a reduction in numbers of beetles caught subsequently in attractant traps, but data they presented showed a significant reduction in damage at only one of the 6 sites. These three reports indicate that the question of the benefit to be gained from virus re-release is not yet resolved. In view of the complexity and diversity of the beetle—palm ecosystem and the occurrence of beetle movement between sites, the effect of re-release may vary considerably from one site to the next.

Over the long term, attenuation of the virus with consequent weakening of its controlling effect and the evolution by natural selection of virus-resistant strains of *O. rhinoceros* (paralleling the relation between myxomatosis and rabbits) cannot be ruled out. Several different strains of virus, of varying virulence, have been found in the Philippines (Zelazny, 1977a), and these could be tried in the South Pacific if necessary.

Virus may also be useful in control of the related dynastid rhinoceros beetle *Scapanes australis*, a serious pest of young palms in the Solomon Islands and Papua New Guinea, since experiments have shown larvae of this species to be susceptible (Bedford, 1973).

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