The OPRAtive Word

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SEXAVA PESTS OF OIL PALM

Bill W. Page

Segestes decoratus; adult female

INTRODUCTION

The principle insect pests of oil palm are a group of Tettigoniidae (*long horned grasshoppers*) belonging to the tribe Sexavae. These tettigoniids are often called treehoppers, katydids or long-horned grasshoppers, however in PNG they are usually known under the collective name of sexava. These pests account for more than 80% of the reports of pest damage to oil palm and can be of considerable importance with regard to yield losses and inputs for monitoring and control. Like most of the pests of oil palm, sexava originated as a pest of coconut and, because of this, research efforts on the pest began in PNG from 1932 onwards. Sexava outbreaks on oil palm during the late 1970's prompted research within the oil palm industry.

SPECIES INVOLVED

Sexava are known to occur on the New Guinea mainland, as far as Halmahera and Talaud islands to the North West of the mainland, and on many of the Papua New Guinea islands.

Although there are ten known species of sexava in PNG that can be economically important on coconut, only four are known to cause damage to oil palm because of the distribution of the industry. The four species found within the oil palm growing areas are:

Segestidea defoliaria; adult female, green

Segestidea defoliaria; adult male, brown

1. *Segestes decoratus* Redtenbacher, which occurs on mainland PNG and in West New Britain Province (*WNBP*). In the Talasea and Kimbe areas of WNBP only females of this species occur and they reproduce parthenogenetically. Males occur in the population found at the eastern end of the island around Cape Gloucester.

2. *Segestidea defoliaria defoliaria* Uvarov. Found in East and West New Britain Provinces.

3. *Segestidea novaeguineae* Brancsik. Found on mainland PNG (*e.g. Madang, Morobe, Eastern Highlands and Oro Provinces*).

4. *Segestidea gracilis gracilis* C. Willemse. Found on New Ireland.

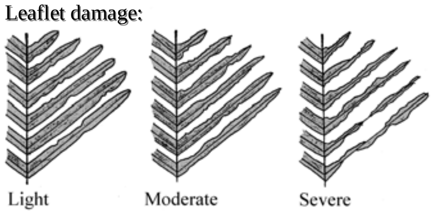
Other species of sexava have the potential to become pests of oil palm if the industry expands into other parts of PNG (*e.g. Sexava nubila Stål if planting is done in East Sepik Province*).

FOOD PLANTS AND DAMAGE

Sexava feed on a wide variety of native and exotic palms in addition to coconut (*Cocos nucifera*) and oil palm (*Elaeis guineensis*). Other monocotyledons such as *Pandanus* spp., *Musa* spp. (*banana*) and *Heliconia* spp. can also be eaten. Coconut is the preferred food plant of the different sexava species.

Loss in yield is caused by the reduction of photosynthetic area when large numbers of sexava eat the leaves of the oil palms. This is when there is an upsurge in the population within an area, called an outbreak, due to factors described below. Leaf damage is estimated by looking at the overall effect of the defoliation and is classed as light, moderate and severe according to the general level of eating. Unless there are parasites in the area, light damage usually leads on to moderate and severe damage, so the occurrence of overall light damage may trigger chemical control. Moderate and severe damage can lead to over 50% loss in fresh fruit bunch yield and can affect the palms over the following two to five years because of the recovery time and the shock produced by the damage causing a strong male phase of inflorescences two years after the damage has occurred.

Leaflet damage:



BIOLOGY

Adult sexava, in general, have comparatively long wings. They are, however poor fliers, mostly using their wings for gliding down from the palms or for short hopping/flying movements when disturbed. There are two colour forms, green and brown, the former being most prevalent. The females have long ovipositors for pushing into the ground when egg laying. They have the capacity to lay up to 50 eggs in

Segestidea novaeguineae; adult female

Segestidea gracilis gracilis; adult male

one go from the ovary (*25 ovarioles per paired ovary*). This does not happen since the eggs are comparatively large for their body size so can only be laid in batches up to 14 at a time. By

Sexava female genitalia

Sexava male genitalia

examining the ovaries of sexava from the field it has been shown that the females are capable of laying up to 100+ eggs (*each ovariole producing 2+ eggs*).

Male sexava have the ovipositor missing and therefore the body looks a lot shorter. The males also tend to be smaller overall than the females. Unlike the females, the male sexava have an adaptation to the base of both forewings where they are overlapping and have a sound producing device which produces a loud noise when the two forewings are rubbed together (*called stridulation*). On average, but according to species and sex, adults will live for approximately 80 days with a range of 4-110. Females have a pre-oviposition period of approximately 30-50 days from moulting, including a period of 10-30 days before mating takes place.

The eggs, which are comparatively large with a thick outer casing, are mostly laid in the ground either singly or in pairs. A female will lay up to 14 eggs in one session on the ground. Eggs can also be found in the butts of old fronds, the roots of epiphytes and in the accumulated matter in the crown. These positions make the eggs a lot more susceptible to egg parasitoids. The eggs can take anything from 50 days to 8+ months from laying to hatching due to highly variable periods of developmental quiescence (*diapause*).

There are generally 6-7 nymphal instars and, like the adults, the nymphs (*after the 2nd instar*) can have green or brown forms. Between hatching and moulting to adult, the nymphal stages take about 105 days with the female taking slightly longer to develop. Thus the period from hatching until oviposition for the females is approximately 145 days (*over 5 months*) The length of the overall life cycle is very much dependant on the length of time that the eggs are in diapause. However the approximate period for a full cycle with a minimum egg diapause would be 195 days (nearly 7 months).

CURRENT KNOWLEDGE

BEHAVIOUR

Sexava are primarily nocturnal, hiding during the day and then becoming active and feeding during the night. Because sexava like to hide in the shade during the day, they are not often found resting on young oil palms which are too open for them (unless associated with adjacent infested older palms when the sexava will move onto the young palms at night). As sexava are poor flyers, their mobility is restricted and therefore an outbreak may spread very slowly with adults and nymphs moving from palm to palm via touching fronds, young nymphs hatching from the ground and searching for a palm to climb, or females coming down to the ground to lay eggs and then moving to another palm to ascend to continue feeding. When there is severe damage, sexava will move on to find fresh fronds on nearby palms sometimes producing a "front" of more concentrated grasshoppers. Outbreaks of sexava do not suddenly appear. The damage in an area will build up over several months because of the slow development of these pests; a factor important in the monitoring and reporting of outbreaks.

Sexava male stridulation

The period when females have to come out of the palm crowns to lay there eggs in the ground and when newly hatched nymphs have to find their way up palms for food are a particularly vulnerable stage where predation takes place. Not surprisingly, these activities take place at night.

Sexava egg

EGG DIAPAUSE

Studies by OPRA have shown that *S. decoratus* eggs can have two periods of arrested development (*diapause*):

1. An initial diapause which is highly variable and pre-determined. Such a diapause may last from 16 days to over 8 months and ensure that eggs laid, even in large numbers at the same time, can hatch over long periods. This would be ideal for grasshoppers in a tropical rainfall situation as they would be able to take advantage of continuously available food where, in general, new foliage is appearing all the time.
2. A late diapause where embryos can develop up to close to hatching and then hold up hatching if conditions are not conducive. This would be ideal for situations of drought where fresh, suitable foliage might not be available for the early instars (*unopened spears in the case of oil palm*).

It is thought that *S. defoliaria*, *S. gracilis* and *S. novaeguineae* eggs may also have two diapauses.

OUTBREAKS/UPSURGES

In a field situation, eggs in the ground subjected to intermittent rain might be expected to go through their initial diapause, hatching at different times over 8+ months, but do not go into late diapause. In severe dry seasons, eggs will go through their initial diapause, develop, and then go into a late diapause, the numbers nearly ready to hatch building up over time as individual eggs reach a late embryonic stage. The longer the dry period the greater the number of eggs waiting to hatch. When suitable rain comes, the eggs will hatch en masse and cause subsequent outbreaks. Usually, but depending on the numbers of eggs in late diapause, the subsequent outbreak will be noticed during that generation, but it may take another generation or more to reach damaging numbers according to the conditions. The above is however a simplified version of what may happen since during a "normal" dry season there may be periods with no rain that could put the eggs developing at that time into late diapause. A shower of rain may then stimulate their hatching. The affect could therefore be surges of egg hatching during the dry season.

CONTROL

PHYSICAL

Sexava adults and nymphs can be hand collected from affected areas, particularly from young palms. This is good method when infestation levels are comparatively low.

CULTURAL

Movement into palms from uncultivated areas can be reduced by removing natural host plants (*coconut, Heliconia spp. etc.*) from the vicinity of the oil palms.

Preference for shade means that it is important that oil palms are kept well pruned and kept free of old fronds that tend to hang down from the central cluster.

BIOLOGICAL

Egg parasitoids

A number of parasitoids are known from sexava eggs, mostly parasitic wasps (Hymenoptera). The latter can lay one egg into an egg of sexava which then clones into different numbers of larvae which feed inside the eggs and ultimately kill the host embryo. Two species have been recognised as being particularly efficient parasites of sexava eggs and can be used to help manage sexava build-ups: *Leefmansia bicolor*, which produces around 25 wasps per egg and *Doirania leefmansi* which produces around 250 per egg. The latter species has been shown to be able to find and parasitize eggs up to 2cm in the ground and also kill well developed embryos. *L. bicolor* and *D. leefmansi* can be reared in sexava eggs under laboratory conditions and then released into oil palm growing areas where low-level sexava populations are present. This helps to manage outbreaks. It is thought that the pressure of egg parasitism causes sexava to lay their eggs in the ground instead of up in the crown and the butts of old fronds where the eggs can be more easily found by the parasitic wasps.


Doirania leefmansi in sexava egg

Stichotrema

The Strepsipteran parasite *Stichotrema dallatorreanum* is found in the sexava pests *Segestidea novaeguineae*, *Sexava nubila* and *Segestes decoratus* on the mainland of PNG where they are known to suppress the build up of outbreaks. OPRA found that the *Stichotrema* occurring around Popondetta, in the host *Segestidea novaeguineae*, appeared to be reproducing parthenogenetically thus excluding the complicated male life cycle (through ants). Because this parasite did not occur on the islands of New Britain and New Ireland, large numbers of sexava from the islands were infected and released into the oil palm growing areas. There is now a good reservoir of the parasite in *S. defoliaria* in West New Britain.


Stichotrema in *S. defoliaria*


Stichotrema in *S. decoratus*

In areas where the parasite occurs, the light damage, which would normally lead to moderate and severe damage, stays the same over several months showing that outbreaks are suppressed. There is also a considerable reduction in sexava numbers at the time when a large proportion of the *Stichotrema* produce first instar larvae. This is because once *Stichotrema* produce their first instar larvae (*an estimated 750,000*) they die and kill their host in the process. Also sexava deaths occur before this when there is multi-parasitism and the host cannot cope with the parasite load. *Stichotrema* also severely affect the production of eggs by sexava, usually no eggs are produced.

By redistributing *Stichotrema* from known reservoirs it is hoped that there will be a considerable reduction in upsurges of sexava, thus reducing the costs of chemical control and monitoring and reporting. It should be noted, however, in severe dry seasons when the sexava eggs all stay in late diapause and the nymphs and adults die back on the palms, that the hosts available to *Stichotrema* could become scarce which would then tend to restrict the parasite to wetter areas where the hosts are still hatching from eggs during the dry season.

BIODIVERSITY MANAGEMENT

In order to ensure good biodiversity within smallholder blocks and plantations and to help sustain the beneficial insects, controlled, targeted usage of herbicides and insecticides is recommended. It is also recommended that the planting and/or the encouragement of suitable flowering weeds is carried out to help increase the feeding and resting sites of the beneficial species of predators and parasitoids (*i.e. the adults of the egg parasitoids*).

CHEMICAL

The control methods described above can help considerably to suppress upsurges of sexava. However when eggs, that are ready to hatch, accumulate in the ground due to late diapause during a long dry period (*particularly an El Nino event*) there can be mass hatches which the parasites and other biocontrol methods are often unable to deal with straight away, so chemical control is required. This is done in palms with the petiole of the oldest frond at least one metre above ground level. Below that height trunk injection cannot be used and handpicking is the alternative.

By monitoring an outbreak, the area in which damage is occurring can be delineated based on


S. defoliaria nymph

leaf damage. This allows the precise targeting of a systemic insecticide using trunk-injection in the area where damage is occurring. 10ml of methamidophos is applied per tree into a single 1.5cm diameter hole, 15cm deep and drilled at a 45° angle into the trunk, 1m above ground. The hole is plugged to avoid infections getting into the palm and any dangers of external contamination. The work should be done by well trained control teams. The effectiveness of methamidophos lasts for up to 60 days, thus controlling nymphs that are hatching from the ground during that period.

By confining the insecticide to the palm, there is no impact on non-target organisms.

RECOMMENDATIONS FOR THE TIMING OF CONTROL

Before control is recommended the presence of egg parasitoids and *Stichotrema* should be monitored, as good levels of parasitism may indicate that there is a chance of natural control taking place. It is particularly important to monitor for the presence of *Stichotrema* and whether they are suppressing the sexava population. Chemical control in an area with *Stichotrema* will effectively kill the parasite in that area as well. The egg parasitoids are not killed but are affected because of a reduction of eggs to parasitize.

If an outbreak from a mass hatch after a severe dry season is discovered early, the sexava population will consist of only two or three stages of nymphs that, because no egg laying is taking place, may only have to be controlled by trunk injection once. In addition to checking the ground below palms for eggs, it is possible by dissection to tell whether adults have already started laying eggs, and if they haven't, then only one trunk injection may be necessary. If adults have been laying eggs, a second trunk injection will be necessary to catch emerging nymphs. The timing of the second control may depend on the proportions of eggs in early diapause and whether eggs go into late diapause or not, because if eggs are in diapause much of the subsequent hatching may be missed by controlling early (*e.g. at 12 weeks after the first injection*). The second trunk injection should therefore be delayed as long as possible to maximise the control of hatching nymphs but the levels of recent damage should also be taken into account. Delaying the second trunk injection may also avoid having to do a third injection.

Sexava damage in oil palm

If there has been a mass hatch and a good proportion of the sexava have been allowed to lay eggs before control, or if preset times of control by trunk injection are required for logistical reasons then, based on known efficacy of the insecticide, egg development and nymphal growth times, a second trunk injection can be done four months after the first and a third injection four months after that. This should, in effect, control virtually all nymphs hatching, taking into account the initial diapause periods. However, if there has been a mass hatch and the sexava are controlled before egg laying, this method is not recommended as only one trunk injection should be required.

Sexava damage to oil palm fronds

Release of egg parasitoids should be avoided after a mass hatch as there would be few eggs in the ground to parasitize. Likewise the release of *Stichotrema* should be avoided during a severe dry season as the only sexava population present might be in the form of eggs. After a severe dry season *Stichotrema* may have to be redistributed from higher rainfall areas where they have survived.

IMPORTANCE OF MONITORING AND REPORTING

The worst scenario for continual outbreaks in an area (*so called "hot spot"*) is when there has been a mass hatch of eggs after a severe dry season and then the upsurge of sexava is not monitored or reported before egg laying from that generation begins. There can then be very large numbers of eggs deposited in the ground (often hundreds of thousands, even millions) which will hatch over the next 50 days to 8+ months, sometimes with surges in numbers because of mini dry periods. Early hatching nymphs from these, if not controlled, could also reach adult and lay eggs themselves. There is then a situation where large numbers of eggs could be hatching after the first and second controls have lost their efficacy. Only a third control would break this cycle.

The most vulnerable time for sexava with regard to being able to control the majority of the population is when there is a mass hatch after a severe dry season. This is the only time that the population in an area is synchronised and therefore it is essential after a severe dry season to monitor carefully and regularly for several months after the rains begin for any signs of damage so that expert monitory and advice on control can be sought. As long as there has been no egg laying in the area, only the one control is necessary and this should hit most of the population in an area and re-occurrence should not happen.

It is very important that monitoring and reporting of sexava damage is carried out by the smallholder or harvesters, pruners and supervisors, who are all in the oil palm blocks regularly. The sooner reports are made the less chance there is of an outbreak taking hold and causing damage over many months.

TREATMENT AUTHORISATION

The PNG Department of Environment and Conservation (DEC) approves the importation of methamidophos into PNG under the strict conditions that: a) it is for the sole purpose of controlling oil palm pests by trunk injection, b) that the treatment is carried out by supervised and trained treatment teams, and c) that the treatment is in strict accordance with authorised PNG OPRA recommendations.

For Further Information Contact:

Senior Entomologist
Papua New Guinea Oil Palm Research Association Inc.
P.O. Box 97, Kimbe, West New Britain Province, Papua New Guinea
Tel: +675 9854009 ▫ Fax: +675 9854040 ▫ Email: info@pngopra.org.pg