An Annotated Bibliography on *Rhynchophorus ferrugineus* - A Pest of Coconut

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Introduction

The palm weevil *Rhynchophorus ferrugineus* F. is the most noxious pest of coconut. Its infestation, if not controlled in the early stage, proves fatal to the palm. The need for an annotated bibliography exclusively for this pest has been felt badly by both research and documentation workers. Earlier an attempt in this direction was made by Divakaran pillai, who listed 48 publications without annotations. [*Indian Cocon.* J.14(10): 1-4, 1984.]

In this communication international literature on the red palm weevil for the period till 1997 is included. The annotations are based on the abstracts/summaries furnished by the authors. Wherever this is not possible, abstracts have been prepared specially for the purpose.

The author places on record his heartfelt thanks to Dr. C. P. Radhakrishnan Nair who have gone through the manuscripts and suggested necessary modifications. He is extremely grateful to Dr. P.K. Koshy, Head, C.P.C.R.I. (RS) Kayangulam and Shri Jacob Mathew, Principal Scientist (Statistics) and Officer in charge of Library for their encouragement in the preparation of this bibliography

1 Abad, R.G. and Gallego, V.C. 1978. Chemical control of Asiatic palm weevil through the 'drill-pour-plug' method. Paper presented at the *Ninth Ann. Con. Pest Control Counc. Philipp.*, May 2-6, 1978, PICC, Manila.

Chemical control of Asiatic palm weevil (*Rhynchophorus schach* Oliv or *R. ferrugineus* Oliv.) was found to be effectively carried out using gamma BHC, diazinon, dimethoate and malathion, all at 1 percent concentration employing the drill-pour-plug (DPP) method.

The method involves: a) drilling of a hole a few inches above the point of weevil infestation at a depth of about 4-10 inches in a downward oblique direction; b) pouring of the insecticide solution into the drilled hole including the point of weevil entry at full capacity; and c) plugging the holes including the entry points with dried wood or any suitable material.

2 Abraham, V.A. 1971. Note on effective method of preventing entry of red palm weevil, *Rhynchophorus ferrugineus* Fabricius (Curculionidae : Coleoptera), into the stem of coconut palm through cut petioles. *Indian J. Agric. Sci.* 41 : 1130-1131.

The palm weevil grubs gained access into the stem by tunneling through the cut ends of petioles. If the leaves were cut leaving behind a petiole length of 120cm, the entry of the pest into the stem through cut ends of petioles could be avoided, as the grubs would not be able to make their way into the stem before the petiole dried up.

3 Abraham, V.A. 1971. Prevention of red palm weevil entry into coconut palms through wounds. *Mysore J. Agric. Sci.* 5 : 121-122.

Tar application alone did not prevent *Rhynchophorus ferrugineus* from laying eggs on wounds on coconut petioles but either BHC or BHC+tar was completely effective.

4 Abraham, V.A.; Abdulla Koya, K.M. and Kurian, C. 1975. Evaluation of seven insecticides for control of red palm weevil *Rhynchophorus ferrugineus* Fabr. *J. Plantn Crops.* 3(2) : 71-72.

Seven insecticides, viz., dichlorvos, phosphamidon, methyl-o-demeton, trichlorphon, parathion, malathion, and arprocarb, were tested in the laboratory in various concentrations for their effectiveness against the grubs of red palm weevil *Rhynchophorus ferrugineus*. Dichlorvos at 0.25%, methyl-o-demeton, phosphamidon, and arprocarb at 0.5 percent, trichlorphon and malathion at 1.0 percent and parathion at 2.0 percent gave 100 percent mortality on the seventh day. The three insecticides, with the lowest LC 90 values, dichlorvos, trichlorphon, and arprocarb, were tested in the field on naturally infested palms and trichlorphon gave the best results with 92 percent recovery of infested palms.

5 Abraham, V.A.; Abdulla Koya, K.M. and Kurian, C. 1989. Ingerated management of red palm weevil (*Rhynchophorus ferrugineus* F) in coconut gardens. *J. Plantn Crops* **16**(Suppl.) 159-162.

The red palm weevil, *Rhynchophorus ferrugineus* F., is a dreaded pest of the coconut palm, capable of killing the palm outright. Though different methods of management have been recommended against this pest, any single method has not been proved to be effective in combating the pest infestation. An integrated method of pest management

system was developed and tested in cultivators' gardens in Aleppey District. The schedules included adoption of plant and field sanitation, prophylactic method of filling all the leaf axils of palms with BHC + sand, curative chemical treatment, prevention of pest entry through cut ends of petioles and wounds and use of attractants. By adoption of all the proven methods of weevil control in an integrated manner the pest infestation could be brought down near to zero level and the gardens could be maintained free of fresh infestation.

6 Abraham, V.A. and Kurian, C. 1972. Preventive measures against red weevil in coconut palm. *Indian Fmg* 21 (9) : 39-43.

Wounds produced when green leaves were cut formed preferred egg-laying sites for *Rhynchophorus ferrugineus*; the grubs tunneled forwards the trunk as long as the petiole remained green. When leaves were cut to leave petioles 120 cm long 75 percent of them had dried before the grubs could reach the trunk. In another experiment, in which wounds were treated with 5 percent BHC dust and/ or tar, BHC treatment gave apparently complete prevention whereas tar alone was ineffective.

7 Abraham, V.A. and Kurian, C. 1974. *Chelisoches moris* F. instar grubs of the red palm weevil *Rhynchophorus ferrugineus* Fabricius (Curculionidae : Coleoptera). *J. Plantn Crops.* I (suppl.) : 147-152.

Rhynchophorus ferrugineus F. is a serious pest of the coconut palm. No effective biological control agent of this pest has been reported so far. *Chelisoches moris* F., a species of earwig, is commonly met with on the crown of coconut palms infested by red weevil. Its life history and feeding habits on the eggs and early instar grubs of red palm weevil were studied. Eggs are laid in clusters. The average incubation period was 6.5 days. There were four nymphal instars and the average total nymphal period was 45.6 days. The adults lived for 66.8 days and the total life cycle lasted for 69-153 days. On an average one earwing in its life period consumed as many as 662.4 eggs or 633.5 early instar grubs.

8 Abraham, V.A. and Kurian, C. 1975. An integrated approach to the control of *Rhynchophorus ferrugineus* F. the red weevil of coconut palm. *Proc. 4th Sessn FAO Tech. Wkg Pty Cocon. Prod. Prot.Processg.* Kingston, Jamaica.

The pest could better be kept under check by integration of all the known methods of weevil control. A brief account of the hitherto known methods of red weevil was given.

9 Abraham, V.A.; Mathen, K. and Kurian, C. 1966. Aids to detect red weevil infestation in coconut palm. *Cocon. Bull.* 20: 148-152.

Different methods of entry of red weevil into the palm, the important symptoms manifested by the attacked palm and the detection of the pest infestation by an electronic amplifier were described in this article.

10 Abraham, V.A.; Pillai, G.B. and Kurian, C. 1974. Red palm weevil - A dreaded enemy of coconut palm. *Indian Fmrs'* Dig 7 (1) : 15-16, 20.

Symptomatology, nature of damage and different control measures were discussed.

11 Ahmad, M.N. and Ullah, M.H. 1951. Date cultivation in Punjab. *Punjab Fruit J.* Jan-April.

In Pakistan, authors have suggested some preventive and mechanical measures for the control of red palm weevil on date palms in West Punjab.

12 Anonymous. The red weevil of coconuts. Trop. Agriculturist 81 (4): 261-265.1933.

Recent experiments on th bionomics of *Rhynchophorus ferrugineus* have shown that oviposition begins 3-5 days after emergence, and eggs are laid daily for about 3-8 weeks. In records of 12 females, the number of eggs laid varied from 50-302. The pupal stage lasted 12-25 days in the laboratory.

13 Anonymous 1956. Red palm weevil. The hidden enemy that works from within. *Cocon. Bull.* 10 : 77-81.

Adult palms attacked by grubs of *Rhynchophorus ferrugineus* could be served by injecting into the infested area of the trunk 1000-1500 cc of 1% Pyrocon E. suspension. The application of 5% BHC or chlordane dust to the leaf axils of young palms may help to prevent attack.

14 Anonymous, 1971. An electronic device for the detection of red weevil infestations. *Leaf let no.* 41. Coconut Research Institute, Sri Lanka.

A simple electronic device, consisting of a low frequency amplifier and a simple gramophone magnetic pick up fitted with a long needle was developed to detect the larvae inside the stem. The needle is gently pressed into the stem of the palm. If the grubs are feeding, the sound will be amplified and may clearly be heard. With this instrument infestations may be detected in an early stage.

15 Antony, J. and Kurian, C. 1976. Save coconut from these pests. *Intensive agric.* 14(9) : 25-28.

Among the insect pests the key ones are the black beetle, the black headed caterpillar, the red weevil and the root eating white grubs and they are described.

16 Baloch, H.B.; Rustamani, M.A.; Khuro, R.D.; Talpur, M.A. and Hussain, T. 1995. Incidence and abundance of date palm weevil

in different cultivars of date palm. pp. 445-447. **In**: Proceedings of Pakistan Congress of Zoology. Vol. 12 eds. Ahamad, M and Shakoori, A.R. University of Karachi, Pakistan.

The incidence and abundance of *Rhynchophorus ferrugineus* on various cultivars of date palm was studied in Pakistan during 1988. The highest attack (21.41percent) was recorded for CV. Aseel, followed by Khurmo (14.5 percent), Hawawari (14.25 percent), Karbalain (10.25 percent) and Kupro (6.16 percent). Damage was positively correlated with infestation.

17 Banerjee, A. and Dangar, T.K. 1995. *Pseudomonas aeruginosa* a facultative pathogen of red palm weevil, *Rhynchophorus ferrugineus*. *World J. Micro. Biotech.* 11(6) : 618-620.

Pseudomonas aeruginosa was identified as a facultative pathogen of red palm weevil. Intra-haemocoelic injection of the pathogen within larvae and pre-pupae was more effective at killing the insects [with a median lethal dose (LD_{50}) of $9x10^2$ to $2x10^3$ bacteria/ insect] than inoculation by force feeding (LD_{50} of 10^5 to $4x10^5$ bacteria/ insect) or by wading the insects in a suspension of the pathogen (LD_{50} of 10^5 to $2x10^5$ bacteria/insect). Injection of $3x10^3$ bacteria/insect killed 69 percent of larvae; small larvae were more susceptible (LD_{50} of $9x10^2$ bacteria/ larva) than either larger larvae (LD_{50} of 10^3 bacteria/larva) or prepupae (LD_{50} of $2x10^3$ bacteria/prepupa). The median time taken for the death of the small larvae following injection of P. aeruginosa was about 6 days but that following force feeding or wading was about 8 days. A secondary invader, *Serratia marcescens*, had no effect on the pathogenicity of *P. aeruginosa* but hastened death of larvae by about 3 days.

18 Bartlett, Alan C. and Rananavare, H.D. 1983. Karyotype and sperm of the red palm weevil *Rhynchophorus ferrugineus* Fabr. (Coleoptera Curculionidae). *Ann. Entomol. Soc.* Amer. 76(6) : 1011-1013.

The red palm weevil has a chromosome formula of 10A+Xyp. The karyotype of it consists of 22 metacentric chromosomes. Spermiogenesis was found in last-stage larvae, 2 week-old adults, and 4-week-old adults. The sperm of the red palm weevil are described.

19 Bokhari, U.G. and Abuzuhira, R. 1992. Diagnostic tests for red palm weevil, *Rhynchophorus ferrugineus* infested date palm trees. *Arab Journal of Scientific Research.* 10(3) : 93-104.

Physiological changes in date palms infested with *Rhynchophorus ferrugineus* were investigated in the field in Saudi Arabia. The rate of transpiration was increased and diffusive resistance and water potential were reduced in infested plants. It is concluded that any or all of these factors could be monitored to detect infestations of the pest, which otherwise irrevocably damages the plant before any symptoms are visible.

20 Brand, E. 1917. Coconut red weevil. Some facts and fallacies. *Trop. Agric.* 49(1) : 22-24.

The author offers several observations on *Rhynchophorus ferrugineus* in connection with a previous paper on this insect (The coconut Red weevil, *R. ferrugineus* by Henry G.M.(*Trop. Agric.*48(4) : 218-219. 1917).

He explains the essential differences in the habit of *R. ferrugineus* and of *Oryctes rhinoceros*. *R. ferrugineus* attacks the top, bottom or the middle of the tree in any stage of growth. The author has no faith in the use of carbon bisulphide as a means of destroying the grubs. Preventive measures are advocated. Covering of exposed wounds on the trunk with lime mortar is effective.

21 Burkill, I.H. 1917. *Scolia erratica*, Smith, a parasite of the red coconut-weevil (*Rhynchophorus ferrugineus*). *Gardens' Bull.* 1 (11-12) : 399-400.

The wasp *Scolia erratica*, which is distributed throughout Sikkim, Burma, Tenassarim, Sumatra and Java, may be regarded as a beneficial insect, since it preys on the grubs of the red weevil and black rhinoceros beetle, both of which attack coconut palms.

22 Buxton, P.A. 1920. Insect pests of dates and the date palm in Mesopotamia and elsewhere. *Bull. Ent. Res.*11: 287-303.

Reported that the weevil (*Rhynchophorus ferrugineus*) causes serious damage to date palms in Mesopotamia (Iraq). It is quite likely that the weevil is present in other Middle East countries also where date palms are grown in abundance.

23 Carton, P. 1926. Maladies et enemies de l' Arequier en In dochine. *Bull. Econ Indochine.*29 (179) : 352-356.

Very few serious pests of the Areca nut palm (*Areca catechu*) are recorded. Larvae of *Rhynchophorus ferrugineus*, Ol. occasionally construct zig-zag galleries in the trunk.

24 Cendana, S.M. 1963. The roles played by rhinoceros beetle and red palm weevil in the death of coconut trees in relation to the control of coconut beetles. pp.68-70. **In**: *Proc. Symp. Cadang-Cadang Coconut,* Sept. 3-5, 1962, Manila.

In the death of beetle-killed coconut trees, only two species of beetles are involved - the red palm weevil (*Rhynchophorus ferrugineus*) which is the killer and the rhinoceros beetle

(*Oryctes rhinoceros*) which is only an accessory. The successive generations of the palm weevil that feed on the crown eventually destroy the growing point of the palm completely and tree dies.

25 Copeland, E.B. 1931. *The coconut.* Macmillan and co. Ltd., London, pp. 68-113.

The known distribution of the pest *Rhynchophorus ferrugineus* was from India to the Philippines, and it is likely to reach upto New Guinea. The author also believed that the weevils visited the palms for oviposition only. The weevils could lay its eggs only in those palms where the soft tissues have been exposed in some way.

26 Cox, M.L. 1993. Red palm weevil, *Rhynchophorus ferrugineus*, in Egypt. *FAO Plant Port. Bull.* 41(1) ; 30-31.

The establishment of *Rhynchophorus ferrugineus* in Egypt was confirmed. The larvae were reported to be attacking the trunks and growing points of young date palm trees at Hussinia, Sharqiya region, Egypt. This is the first record reported from Africa; all previous records were reported from east of the Red Sea.

27 El-Garhy, M.E. 1996. Field evaluation of the aggregation pheromone of the red palm weevil, *Rhynchophorus ferrugineus*, in Egypt. pp.1059-1064. **In**: *Brighton crop protection conference : Pest & diseases-1996.* Volume 3. Proceedings of an International Conference, Brighton, UK, 18-21 November 1996. farnham, UK, British Crop Protection Council

Rhynchophorus ferrugineus was first discovered in north-eastern Egypt in 1992 and has now become established as a primary pest of date palm in Egypt. Sizeable cavities are created in stem tissue by larval tunnelling, in which multiple generations may be completed. Even in advanced stages of infestation visible signs of stress are few and infestations are usually located by detection of exit holes. Experiments were carried out to examine the use of pheromone/food traps to determine seasonal variation of the abundance of adult *R. ferrugineus* and effectiveness of traps for monitoring populations. Pheromone/food traps were strapped to date palms 3m above ground to prevent vandalism and to be above off-shoots. More adults were captured during the warmer summer months than during the cooler winter months. The threshold for *R. ferrugineus* was found to be in the range 12-14°C with very low number of weevils being captured in December and January, the only month in which the average daily temperature fell below 14°C. Capture rates were highest in the months of April, May and June, which corresponds to the onset of warmer weather in Egypt. The higher capture rates during this period were probably due to the emergence of broods whose development was slowed by the cooler winter months. Twice as many female as male weevils were caught.

28 Dangar, T.K. 1997. Infection of red palm weevil, *Rhynchophorus ferrugineus*, by a yeast. *J. Plantn Crops* 25(2): 193-196.

Studies were undertaken with a view to detecting different natural pathogens of the pest red palm weevil (*R. ferrugineus*). During this study a yeast was isolated from the haemolymph of the natural pest population. The significance and potency of the yeast as a biocontrol agent were assessed.

29 Dangar, T.K. and Banergee, A. 1993. Infection of red palm weevil by microbial pathogens. pp. 531-533. **In**: *Advances in coconut research and development* (Eds.) Nair, M.K.;Khan, H.H.; Gopalasundaram, P. and Bhaskara Rao, E.V.V., Oxford & IBH Pub,New Delhi.

Screening of field-collected grubs and adults of red palm weevil revealed natural infection by bacterial and viral pathogens. As many as 211 bacteria were isolated from the early infected and moribund grubs. 166 isolates were tentatively identified as members of *Bacillus spp.*, *Serratia spp.* and coryneform group.

30 Defoliart, G.R. 1993. Hypothesizing about palm weevil and palm rhinoceros beetle larvae as traditional cuisine, tropical waste recycling, and pest and disease control on coconut and other palms-can they be integrated ? *Principles* 37 (1) : 42-47.

The potential for the use of larvae of *Rhynchophorus palmarum* and *R. ferrugineus* and other species of the genus for commercial sale as food are discussed.

31 Dhileepan, K. 1991. Insects associated with oil palm in India. *FAO Plant Prot. Bull.* 39(793) : 183-191.

Oil palm plantations and nurseries in India were surveyed from 1985 to 1990 and 54 species of insects associated with oil palm were identified. In oil palms in the main field rhinoceros beetle, *Oryctes rhinoceros* (L), and red palm weevil, *Rhynchophorus* ferrugineus (Oliver) were recorded as major pests.

32 Dhileepan, K. 1992. Insect pests of oil palm (*Elaeis guineensis*) in India. *Planter* 68(793) : 183-191.

Nature of damage and intensity of infestation by spindle bug, *Carvalhoia arecae* Miller & China, rhinoceros beetle, *Oryctes rhinoceros* L., red palm weevil *Rhynchophorus ferrugineus* Oliver, Coccoids, termites and other

defoliating insects are reported. Pest incidence in oil palm in relation to intercrops is also highlighted.

33 Ekanayake, U.B.M. 1962. Preventive measures in the control of the red weevil pest. *Ceylon Cocon. Plant Rev.* 3(2) : 45- 46.

It is observed that the best method of control is to prevent the red weevil from attacking young palms, that is, by taking proper preventive measures. It is stressed that the preventive measures stipulated below should form an integral part of the routine agricultural practices on all young coconut plantations.

Preventive measures: a) the trees should be kept healthy without wounds or cracks, as the pest lays its eggs in the wounds and cracks that appear on the stem, base of petiole and elsewhere; b) in each state, a regular survey of young palms up to 10 to 12 yr. of age should be carried out by trained labourers to detect the presence of the grubs of the red weevil.

34 Friederchs, K. 1913. Ueber den gegenwartigen stand der Be kampfung des Nashornkafers (*Oryctes rhinoceros* L.) in Samoea. *Tropenflanzer* 17: 538-56; 603-619.

The author recorded *Scolia erratica* Smith as a parasite of the larvae of *Rhynchophorus ferrugineus* F., in Singapore.

35 Ganapathy, T., Rajamanickam, K., Raveendran, T.S., Lourduraj, A.C.and Kennedy, F.J.S. 1992. Status of coconut cultivation in Pollachi tract. II Prevalence of pests and diseases. *Indian Cocon. J.* 23(3) : 4-6.

A survey was carried out in coconut groves in Coimbatore, Tamil Nadu, India, to determine the pests and diseases infesting the trees. The scarabaeid *Oryctes rhinoceros* was observed in *97 percent of the groves surveyed*, and *Opisina arenosella* and *Rhynchophorus ferrugineus* were observed in 6 and 34 percent of the groves, respectively.

36 Ganeswara Rao, A ; Ramamohana Rao, P.; Ramamohana Rao, T. and Laxminarayana, K. 1989. Studies on the effect of root feeding of systemic insecticides in the control of red palm weevil, *Rhynchophorus ferrugineus* Fab. in coconut. *Indian Cocon. J.* 19(9) : 12-16.

Relative effectiveness of root feeding of seven insecticides was assessed. None of the insecticides except monocrotophos @ 10ml/palm diluted with equal quantity of water was found to give optimum lethal dose. The cost of the treatment was worked out and merits of root feeding method are also discussed.

37 Ganeswara Rao, A ; Laxminarayana, K. and Ramamohana Rao, P. 1980. Administration of systemic insecticide through root - A new method of control of red palm weevil, *Rhynchophorus ferrugineus* Fab., in coconut. *Indian Cocon. J.* 11(2) : 5-6.

Rhynchophorus ferrugineus Fab. the most destructive pest of coconut palm has been described in this paper. A method for root application of suitable pesticides was furnished.

38 Ghosh, C.C. 1911. Life history of Indian insects. 3. The rhinoceros beetle (*Oryctes rhinoceros*) and the red palm weevil (*Rhynchophorus ferrugineus*). Mem. *Dep. Agri.Indian Ent.* Ser. 2 : 193-204.

The life history of the pest has been discussed.

39 Goonewardena, H.F. and Velu, M.S. 1958. The red palm weevil *Rhynchophorus ferrugineus* Ol. in Ceylon. I. Introduction, distribution and life history. *Ceylon Cocon. Quart.* 9(1/2) : 20.

The authors recorded a flight range of 1/2 - 3/4 miles for R. *ferrugineus* in Ceylon.

40 Gopinadhan, P.B. 1993. Natural occurrence of cytoplasmic polyhedrosis virus of red palm weevil in Kerala. pp. 527-530. **In**: *Advances in coconut research and development.* (Eds.) Nair, M.K.; Khan, H.H.; Gopalasundaram, P. and Bhaskara Rao, E.V.V. Oxford & IBH publishing co.. New Delhi.

The diseased larvae, pupae and adults of red palm weevil, *Rhynchophorus ferrugineus* F. collected from infested coconut palms in Trivandrum, Aleppey and Kottayam districts of Kerala, when further reared under laboratory conditions yielded an effective promising entomopathogen of cytoplasmic polyhedrosis virus origin(CPV). The disease is present throughout the period, in varying intensities, infective to all stages and the adults are more vulnerable. The CPV manifested its symptoms on pupae and adults as malformed and wrinkled, the eggs laid by diseased adults did not hatch.

41 Gopinadhan, P.B.; Mohandas, N. and Vasudevan Nair, K.P. 1990. Cytoplasmic polyhedrosis virus infecting red palm weevil of coconut. *Curr. Sc.* 59(11) : 577-580.

A highly potent cytoplasmic polyhedrosis virus (CPV) has been detected for the first time in Kerala in life stages of the red palm weevil, *Rhynchophorus ferrugineus* F., which infests coconut. The pathogen infects all the life stages of the pest, including the adult. Infection in the late grub stage resulted in malformed adults and suppressed the insect population drastically. The midgut of infected insects was enlarged and filled with thousands of polyhedral inclusion

bodies (PIBs) visible under a light microscope. Electron microscopic studies revealed characteristic surface projections of viral bodies characteristic of CPV.

42 Green, E.E. 1906. *Rhynchophorus ferrugineus. Trop. agric.* 27

In Ceylon the author advocated the control of the rhinoceros beetle *Oryctes rhinoceros*. L., which considerably helped to reduce the number of injured palms, in which red palm weevils were likely to lay their eggs and breed. In addition to the above, he suggested a regular survey of young palms, upto ten or twelve years of age, by expert labourers, who could detect the presence of the weevils larvae in the earlier stages of attack. The infested portions along with different stages of the weevil were advised to be carefully excavated, leaving back only the healthy tissues, which were to be tarred and plastered with cement concrete.

43 Gunawardena, N.E. 1994. Terpenes as potential semichemical for coconut pest, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae): an electroantennogram assay. *Journal of the Natural Science Council of Sri Lanka* 22 (1) : 35-42.

Electroantennogram (EAG) response of male and female *Rhynchophorus ferrugineus* to sixteen terpenes were determined. The chemoreceptivity of *Rhynchophorus ferrugineus* was sensitive to the size and the position of the oxygen function, degree of unsaturation and the arrangement of olefinic bonds in the molecules.

44 Gunawardena, N.E. 1994. Steam volatiles of coconut bark: chemical investigations and electroantennogram responses of the coconut pest, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) *Journal of the Natural Science Council of Sri Lanka* 22 (3) : 231-238.

Steam volatiles of young coconut (*Cocos nucifera*) bark were analysed by combined gas chromatography - mass spectrometry (GC -MS). Among the large number of components present were ethanol-1 (2-hydroxy-5-methyl), 4-hydroxy-3-methoxybenzaldehyde, acetophenone, phenol, xylene, nonanal, decenal, diethylene glycol, nonanoic acid and α-ionone. Electroantennogram (EAG) responses of the isolated antennae of adult male and female *Rhynchophorus ferrugineus* to the total steam distillate and its 2 column fractions, and the individual constituents were recorded.

45 Gunawardena, N.E. and Bandarage, U.K. 1995. 4-Methyl - 5-nonanol (ferrugineol) as an aggregation pheromone of the coconut pest, *Rhynchophorus ferrugineus* F. (Coleoptera: Curculionidae): synthesis and use in a preliminary field assay. *Journal of the National Science Council of Sri Lanka* 23(2): 71- 79

4-Methyl-5-nonanol(ferrugineol), the more attractive component of the aggregation pheromone of *Rhynchophorus ferrugineus* was synthesized by a Grignard reaction with butyl magnesium bromide and 2-methyl-1-pentanol. At a release rate of 0.38 ± 0.08mg synthetic ferrugineol/day from capillaries suspended in bucket traps filled with soap water, significantly more weevils were caught compared to a control trap (0.23 ± 0.04 weevils and 0.00 weevils/trap/day, resp.) in the field. Significant differences were not observed between male and female trap catches using ferrugineol as a bait (0.12 ± 0.02 and 0.11 ± 0.01/trap/day,resp.). Ferrugineol remained attractive to weevils for at least 60 days.

46 Gunawardena, N.E. and Herath, H.M.W.K.B. 1995. Enhancement of the activity of ferrgineol by N-pentanol in an attractant baited trap for the coconut pest, *Rhynchophorus ferrugineus* F. (Coleoptera: Curculionidae): synthesis and use in a preliminary field assay. *Journal of the National Science Council of Sri Lanka* 23(2):81-86.

Rhynchophorus ferrugineus were used to improve 4-methyl-5-nonanol (ferrugineol) baited trap. In a Y-shaped olfactometer choice test, 68 percent of weevils selected the ferrugineol baited arm.n-Propanol and n-pentanol elicited responses in 80 and 79 percent of weevils, resp. Combinations of n-pentanol:ferrugineol (1:1) and n-propanol:ferrgineol (1:1) did not show increased activity (80 and 82% selection, resp.). In a field assay, n-propanol and n-pentanol baited traps caught no weevils whereas ferrugineol caught a mean number of 0.42 weevils/trap/day. Combinations of ferrugineol with 5 alcohols (n-propanol, n-butanol, n-pentanol, n-hexanol and n-nonanol) were field- tested as baits for possible enhancement of the activity of the ferrugineol. A significantly higher catch of 0.85 weevils/day/trap, was obtained with ferrugineol and n-pentanol.

47 Gunawardena, N.E. and Kern, F. 1994. Electroantennogram response of the coconut pest, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) to alcohols. *Journal of the National Science Council of Sri Lanka* 22 (1) : 25-33.

The coconut pest *Rhynchophorus ferrugineus* shows short range attraction to coconut sap, whose volatile constituents consist mainly of short chain alcohols. In this study, electrophysiological responses of male and female antennae to four alcohols in coconut sap, *viz.* ethyl, n-propyl, n-butyl and n-pentyl alcohols were recorded. Pentanol, which constitutes a major portion of the coconut sap, elicited the greatest response in the

antennae of *both male and female R. ferrugineus* (EAG/EAGmax = 0.85 SD,+0.16) and this response was significantly different from that of the control as well as those of the ethanol and n-butanol (EAG/EAGmax = 0.24 and 0.32 respectively). n-Propanol also had high EAG potency with EAG/EAGmax = 0.52, SD ± 0.15 which was not significantly different (P>0.05 ANOVA, Scheffe's test) from that of n-pentanol. To compare the activities of the above alcohols with C6 to C10 n-alcohol EAGs of hexanol up to decanol were also recorded under the similar conditions. Results showed that the activity of pentanol was still the highest in the series, while that of hexanol (EAG/EAGmax = 0.83 SD,± 0.16) was not significantly different from it. Heptanol elicited moderate activity (EAG/EAGmax = 0.52, SD± 0.15) which did not differ significantly from those of propanol, pentanol and hexanol. Other alcohols at the higher end of this series *viz*, octanol and nonanol had lesser EAG potencies (EAG/EAGmax=0.35,SD±0.13 and 0.25, SD±0.09,resp.) which were not significantly different from that of the control(EAG/EAGmax=0.16, SD± 0.06). The lowest EAG response of EAG/EAGmax=0.19(SD±0.05) was shown by decanol and this response was also close to that of the control.

48 Gunawardena, N.E. and Swarnakanthi, M.N.A. 1995. Behavioural and electrophysiological responses of the coconut pest, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) to host, non host and alternate host plant volatiles. Journal of the *National Science Council of Sri Lanka* 23(2): 63-70.

Stembark distillates of the typical and aurancica varieties of coconut (*Cocos nucifera*) (host plant), and of *Terminalia catappa Albizia amara* (non host plants), and *Areca catechu* and *A. concinna* (alternate hosts) were subjected to electrophysiological and behavioural assays to compare attractiveness to the coconut pest *Rhynchophorus ferrugineus*. In the electroantennogram (EAG) assay, the steam distillates of *C.nucifera* form auranacica elicited the highest response of 79.1percent (relative to standard) and the form typical (young bark) 55.6 percent, both values being significantly different from those of T. catappa and Albizia amara (10.9 and 5.9 percent, resp.). EAGs of old bark(51.4 percent) steam distillate of *C.* nucifera form typical did not differ significantly from that of the young bark distillates (55.6 percent). The two alternate hosts, *Areca catechu* and *A. concinna* showed moderate EAG activities (29.4 and 25.9%,resp.). In a behavioural assay using an olfactometer, the steam distillates of host palms were more attractive than those of the non hosts, *C.nucifera* form *aurancica* was more attractive (79.9 percent attrac. Pation to the baited arm) than typical. Between young and old palms of *C. nucifera* form typical, no significant difference in the behavioural activity was observed. The alternate hosts showed moderate activity.

49 Hallet, R.H.; Gries, G.; Gries, R.; Borden, J.H.; Czyzewska, E.; Oehlschlager, A.C.; Pierce, H.D.; Angerilli, N.P.D. and Rauf, A. 1993. Aggregation pheromones of two Asian palm weevils, *Rhynchophorus ferrugineus* and *R. vulneratus*. Naturwissenschaften 80 : 328-331.

Reported for the first time the identification, antennal perception, and behavioural activity of two male-produced pheromones for *R. ferrugineus and R. vulneratus*. Lack of pronounced differences in pheromonal production and response reopens the question as to whether *R. ferrugineus* and *R. vulneratus* are distinct species.

50 Henry, G.M. 1917. The coconut red weevil, *Rhynchophorus ferrugineus*. *Trop. Agric. Peradeniya*, 48 (4) : 218-219.

Besides coconut, the pest attacks *Areca catechu and Caryota urens* which probably constitute secondary hosts of the weevil. The mechanism of infestation and the life cycle of the insect are described. No parasitic or predatory enemies have been found in Ceylon. Trapping the adult weevil with baits of fermenting kitual palm wood might be an effective means of control. Phytosanitary measures are advocated. *Oryctes rhinoceros* attack should be eliminated and bark of the palm should be protected from injury.

51 Jacques, C. 1930. Maladie des cocotiers. *Rev. agric. Nouv. Caledonie*. pp. 29-36.

In reply to a letter describing injury to coconut trees in New Caledonia, the author states that the damage is due to a weevil, probably *Rhynchophorus ferrugineus*, F., and that the only method of control is to destroy infested trees, to eradicate all banana plants (in the decaying trunks of which both larvae and adults of *R. ferrugineus* may be found) and to practise clean cultivation.

52 Kirthisinghe, J.K.F. 1966. Pest control in coconut cultivation. *Ceylon Cocon. Plant Rev.* 4(2) : 34-38.

A brief account is given on the main pests and diseases of the coconut palm in Ceylon and their control. The weevil *Rhynchophorus ferrugineus* is now being controlled by injecting the trunks with demetonmethyl.

53 Kloft, W.J.; Kloft, E.S.; Kanagaratnam, P. and Pinto, J.L.J.G. 1986. Studies on the use of radioisotopes for the control of the red palm weevil, *Rhynchophorus ferrugineus* F. by the sterile insect technique. I.

Preliminary investigations on the detection of radiolabelled weevils. *Cocos* 4: 11-17.

Preliminary radioecological investigations were carried out and a technique for labelling red palm weevil with radioisotopes emitting radiation was developed. The weevils were tagged by inserting pieces wire of radioactive Iridium, 192 Ir into the flight muscles with a flight carrousel. It was shown that tagging in this manner did not affect the ability of weevils to fly.The distances upto which marked weevil could be located were estimated. At a distance of 18m, the activity was reduced to approximately 30-40 percent. Thus it is possible to detect labelled weevils at a considerable long distance.

54 Kloft, W.J.; Koerner, J. and Wolfram, E. 1986. Studies on the use of radioisotopes for the control of the red palm weevil, *Rhynchophorus ferrugineus* F. by the sterile insect technique. II. Technique for tagging insects with precise lenghts of radioactive Iridium, 192Ir wire. *Cocos* 4 : 19-22.

Special apparatus was designed for the measurement, handling, and insertion of precise lengths of radioactive Iridium, 192Ir wire into the body of an insect. The construction and use of this apparatus is described.

55 Kunjan Pillai, N. 1919. Coconut: The wealth of Travancore *Agric. J. India* 15(4) : 608-628.

This paper dealing with the uses and possibilities of coconut cultivation, mentions the following pests as occurring in Travancore: *Oryctes rhinoceros*, *Rhynchophorus ferrugineus* and a limacodid moth, *Contheyla rotunda*, Hmps.

56 Kurian, C. 1961. Biological control of insect pests of coconuts. pp. 157-166. **In**: *Proc. 1st Sessn FAO Tech. Wkg Pty Cocon. Prod. Prot. Processg* Trivandrum.

The biology and feeding habits of parasites and predators of major pests of coconut *viz. Oryctes rhinoceros, Nephantis serinopa*, Rhynchophorus ferrugineus, and *Leucopholis coneophora* were given.

57 Kurian, C. 1961. Destructive pests of coconut other than the rhinoceros beetle. pp. 137-152.**In**: *Proc. 1st Sessn FAO Tech. Wkg Pty Cocon. Prod. Prot. Processing* Trivandrum.

A brief review of the more important work done in India and abroad was given. The distribution and incidence of Nephantis, chemical and biological control of this destructive caterpillar; a similar account of the most deadly red weevil, the not so serious cockchafer and an account of the other miscellaneous pests from India were the main features of this article.

58 Kurian, C. 1976. Red palm weevil, *Rhynchophorus ferrugineus* F. pp.160-191. **In**: *Guide to tropical diseases, pests and weeds.* Institute for Phytopathology, Germany.

Synonyms, common names, geographical distribution, host plants, symptoms, economic importance, morphology, similarities to other pests, life-cycle, ecology, natural enemies and control including sanitary methods, integrated control and chemical control were given.

59 Kurian, C.; Abraham, V.A. and Ponnamma, K.N. 1984. Attract ants, an aid in red palm weevil management. pp.581-585.**In**:*Placrosym V.*

The red palm weevil (*Rhynchophorus ferrugineus* F.) is an enemy of young coconut palms. It bores into the tissues and ultimately kills the palm. Being a hidden enemy, timely detection is necessary for effecting control. Traps and attractants, by which adults can be trapped and killed, have proved to be effective components of integrated pest management. Log traps consisting of tender coconut stems, 50cm long and spilt longitudinally were found to be superior to metal traps. The cut surfaces were treated with candidate attractants. Macerated fruits, molasses (jaggery from sugarcane) and toddy, singly or in combination, were the test materials. Along with these, yeast and/or acetic acid was mixed to ascertain whether the same will enhance the attractiveness. Out of sixteen combinations tested in the field, logs treated with coconut toddy + yeast + acetic acid were the best, followed by coconut toddy + acetic acid, pineapple + molasses + yeast, pineapple + molasses, and molasses+yeast. The use of coconut log traps treated with the above combination is recommended as one of the effective components of integrated pest management.

60 Kurian, C and Mathen, K. 1964. Insects of major importance other than the rhinoceros beetle. pp.331-334. **In**: Proc. *2nd Sessn FAO Tech. Wkg Pty Cocon. Prod. Prot. Processing Colombo. Ceylon*, 31 Nov-8 Dec. 1964.

Ecological studies and biological control of *Nephantis serinopa*, symptomatology studies, detection of red weevil attack and chemical control of this pest, field control of cockchafer using contact insecticides and notes on the lace wing bug *Stephanitis typicus* and the termite *Odontotermes obesus* were included in this paper.

61 Kurian, C and Mathen, K. 1965. Black beetle and red weevil *Cocon. Bull.* 19 : 153-159.

Appearance, life cycle, symptoms and preventive and curative methods of control of rhinoceros beetle and red weevil were discussed.

62 Kurian, C and Mathen, K. 1971. Red palm weevil- Hidden enemy of coconut palm. *Indian Fmg.* 21 (1) : 29-31.

The life history of *Rhynchophorus ferrugineus* and symptoms of infestation on coconut were described. Preventive and control measures including plant and field sanitation, trapping and periodic filling of leaf axils with a mixture of BHC dust and sand were explained. Existing infestation may be controlled by injection of carbaryl or Pyrocon-E suspension after plugging all holes in the stem.

63 Kurian, C. and Pillai, G.B. 1964. Biological control of the pests of coconut - A resume. Paper presented *Entomol. Res. Workers Conf. IARI.* New Delhi.

This is resume of work done so far on the biological control of the rhinoceros beetle, leaf-eating caterpillar, the red palm weevil and the cockchafer beetle. Studies on pathogenic microbial organisms, insect parasites and predators associated with various stages of these major pests were discussed.

64 Kurian, C. and Pillai, G.B. 1964. Pests of coconut and how to fight them. Paper presented at *Plant Prot. Semnr,* Kerala. 49-54.

The losses caused by various pests and different aspects of control of rhinoceros beetle, leaf-eating caterpillar, red palm weevil, cockchafer and some minor pests were discussed.

65 Kurian, C. and Pillai, G.B. 1968. Methods of control of the pests of coconut palm - A resume. Paper presented at *Plant Prot. Semnr,* Goa

Different aspects of control of rhinoceros beetle, leaf-eating caterpillar, red palm weevil, cockchafer and some minor pests were discussed.

66 Kurian, C. Pillai, G.B, Antony, J.; Abraham, V.A. and Natarajan, P. 1983. Biological control of insect pests of coconut - A review. pp. 361-375. **In**: *Coconut Research and Development* (ed) N.M.Nayar. Wiley Eastern, New Delhi

No biological agent other than *Chelisoches moris* F. has been reported on red palm weevil in India. The scope of the biological control of the pest is discussed.

67 Lakshmanan, P.L; Subba Rao, P.V. and Subramaniam, T.R. 1972. A note on the control of the coconut red palm weevil *Rhynchophorus ferrugineus* with certain new chemicals. *Madras agric. J.* 59 : 638-639.

Comparative efficacy of fenthion 0.2 percent, methyl demeton 0.2 percent, carbaryl 1 percent and phostoxin (aluminium phosphide) at 1 or 2 tablets/palm for the control of *Rhynchophorus ferrugineus* on coconut palms were studied. All except methyl demeton killed the pest at all stages, whereas methyl demeton killed the palms.

68 Leefmans, S. 1920. De Palmsnuitkever(*Rhynchophorus ferrugineus*, Oliv.) [The palm weevil, *R. ferrugineus*] Meded. Inst. Plantenziekten, Buitenzorg, 43, 90pp.

These are the first original investigations published in the Dutch East Indies on coconut palm weevil *R. ferrugineus*, Oliv. A black variety of the weevil, *R. ferrugineus* var. schach Oliv. has been described. Crossing between the two has shown that the former is heterozygous and the latter homozygous. The curious result of this crossing is the appearance of grubs with rudimentary legs and chitinous processes on the mesothorax and metathorax.

The measures adopted against Oryctes are generally useful against Rhynchophorus also. The life history of the red weevil has been described in detail. Other beetles, besides *O. rhinoceros* probably act as intermediaries for infection by *R. ferrugineus*. Preventive and chemical control measures against the pest have been described.

69 Lefroy, H.M. 1906. *The more important insects injurious to Indian agriculture.* Govt Press, Calcutta.

The author described *Rhynchophorus ferrugineus* as a local sporadic major pest of coconut and other palms throughout India.

70 Madan Mohan Lal 1917. Report of the assistant professor of entomology. *Rept. Dept. Agric. Punjab* Year ended 30th June 17, Lahore.

Date palms were attacked by *Rhynchophorus ferrugineus*, Oliv., during September October. Various remedial measures were tried; of these the erection of mud enclosures filled with water round the infested trunks proved the most successful.

71 Mathen, K. and Kurian, C. 1959. Comparative efficacy of different insecticides on *Rhynchophorus ferrugineus* F. pp.391-401. **In**: *Proc. Ist Conf. Cocon. Res. Workers,* Trivandrum.

The paper dealt with the response of the weevil and its grubs to 0.1, 0.25 and 0.5 percent concentrations of aldrin, dieldrin, endrin, basudin, folidol and pedix-based emulsion in the laboratory. Endin gave the best results with 92 percent mortality of grubs at 0.5 percent and 100 percent mortality of adults at 1 percent concentrations, seven days after treatment.

72 Mathen, K. and Kurian, C. 1966. Prophylactic control of- *Rhynchophorus ferrugineus* F. the coconut weevil. *Indian J. agric. Sci.* 36 : 285-286.

BHC or chlordane 5% dust, mixed with sand and placed in the leaf axils of young palms thrice a year in the pre and post-monsoon months, reduced red weevil infestation.

73 Mathen, K. and Kurian, C. 1967. Insecticidal trials against *Rhynchophorus ferrugineus* F. the coconut weevil (Curculionidae : Coleoptera). *Indian J. agric. Sci.* 37: 521-523.

Insecticidal trials with carbaryl, isobenzan and dimethoate against grubs of red weevil of coconut were conducted and all of them gave 93 per cent cure of infested palms.

74 Mathen, K. and Kurian, C. 1970. Sevin controls red palm weevil at low cost. *Cocon. Bull.* 1 (5) : 7-8.

Sevin was recommended as a relatively cheap and nonphytotoxic insecticide for controlling red palm weevil *Rhynchophorus ferrugineus* in coconut palms by trunk injection of 20-30g 50 percent w.p. in water per palm.

75 Menon, K.P.V. and Pandalai, K.M 1960. *The coconut palm- a monograph.* Indian Central Coconut Committee, Ernakulam. pp. 261-265.

The work done on life history, habitat, nature of attack, other host plants etc. in respect of *Rhynchophorus ferrugineus* has been discussed.

76 Muthuraman, M. 1984. Trunk injection of undiluted insecticides; method to control coconut red palm weevil, *Rhynchophorus ferrugineus* Fab. *Indian Cocon. J.* 15(2) :12-14.

This study makes evident that root or stem injection of monocrotophos 10 ml/tree is effective in the control of both *Nephantis serinopa and Rhynchophorus ferrugineus*. Administering of 5 ml monocrotophos + 5 ml dichlorvos also proved to be successful in control of *R. ferrugineus*. Placement of aluminium phosphide tablets (6 g) in the hole made by the pest was equally effective.

77 Nambiar, S.S. and Joy, P.J. 1988. Pest management in coconut. pp.103-113. **In**: *Six Decades of Coconut Research*. eds Aravindakshan, M., Nair, R.R.and Wahid, P.A. Kerala Agricultural University, Trichur.

The coconut palm is infested by a number of insects and non insect pests inflicting heavy crop losses. The most devastating among them are the rhinoceros beetle, the red palm weevil, the black headed caterpillar and root grubs.

78 Nirula, K. K. 1956. Investigations on the pests of the coconut palm. Part IV. *Rhynchophorus ferrugineus* F. *Indian Cocon. J.* 9(4) : 229-237 & 10 (1) : 28-44.

Distribution, description, life history, natural enemies and economic importance of the red palm weevil are furnished.

79 Nirula, K.K.; Antony, J. and Menon, K.P.V. 1953. The red palm weevil and its control pp.147-148. **In**: *Proc. 40th Sessn. Indian Sci. Cong.*

The life history of the palm weevil has been studied. Total duration of life cycle from oviposition to emergence was from 59 to 120 days, with a mean average of 62 days. To control the pest in large scale pyrocone was found more effective.

80 Paul, W.R.C. 1929. The control of red weevil (*Rhynchophorus ferrugineus* F.) in coconut palms. *Trop. agric.* 73(3):131-135.

Rhynchophorus ferrugineus, F. (red weevil) is the most important pest of coconut in Ceylon. The stems of young trees 4-10 years old are usually attacked. The crowns of the trees of all ages may be attacked when they have been damaged by *Oryctes rhinoceros* L. or due to other causes. Wounds or cracks on the stems of young palms also attract the ovipositing weevils. The larvae on hatching tunnel through the soft tissues of the stem, where life cycle is completed. The weevils have been observed to attack other species of palm, including *Caryota urens*. To prevent infestation, wounding the trees and stripping the leaves should be avoided.

81 Perez, A.L; Hallett,R.H.; Gries, R.; Gries, G.; Oehlschlager, A.C.; and Borden, J.H. 1996. Pheromone chirality of Asian palm weevils, *Rhynchophorus ferrugineus* (Oliv.) and R. *vulneratus* (Panz.) (Coleoptera : Curculionidae). *Journal of Chemical Ecology* 22(2) : 357-368.

The production of 4-methyl-5-nonanol and 4-methyl-5-nonanone by the sympatric curculionids *Rhynchophorus ferrugineus* and R.*vulneratus* suggested that *enantiospecificity* of either compound could impart species specificity of pheromone communication. Weevil-produced, racemic 4-methyl-5-nonanol and 4-methyl-5 nonanone and their stereoselectively synthesized optical isomers were subjected to GC-EAD and GC-MS on a chiral Cyclodex-B columno Only the S,S stereo isomer of 4-methyl-5-nonanol was EAD active and was produced by both *Rhynchophorus ferrugineus* and *R. vulneratus* Production and EAD activity of (S)-4methyl-5-nonanone exceeded that of its antipode in both curculionids. In field experiments in coconut plantations in Java, (4S, 5S)-4-methyl-5-nonanol and stereo isomer mixture were equally attractive. The 4R,5r stereoisomer was inactive. The corresponding ketone enantiomers neither enhanced nor reduced attraction to (4S,5S)-4methyl-5-

nonanol. Lack of apparent differences between *Rhynchophorus ferrugineus* and R. *vulneratus* pheromones suggested that synonomy of both curculionids should be considered unless other pre- or postzygotic reproductive isolating mechanisms were disclosed in future studies.

82 Peter, C. 1989. A note on the mites associated with the Red Palm Weevil, *Rhynchophorus ferrugineus* Oliv. In Tamil Nadu. *Journal of Insect Science* 2 (2) : 160-161.

A severe attack by *Rhynchophorus ferrugineus* killed several coconut palms at Padappai in Tamil Nadu, India. A survey for natural enemies associated with this pest revealed the presence of 3 species of mites, of which Hypoaspis sp. was the most abundant.

83 Pillai,G.B. 1985. Coconut pests of national importance. pp.166-173. **In**: *Integrated Pest and Disease Management.* ed. Jayaraj, S. TNAU. Coimbatore.

Among the different species of insects and mites recorded on the coconut palm, the major ones of national importance are the rhinoceros beetle, the black headed caterpillar and the red palm weevil. The bio-ecology, damage potential and the present status of the management of these pests are highlighted in this paper.

84 Pillai, G.B. 1987. Integrated pest management in plantation crops. *J. Coffee Res.* 17(1) : 150-153.

Integrated management of the insect pests of coconut, cashew, pepper and cocoa was reviewed in this paper.

85 Pillai, G.B. 1993. Biological control of insect pests of-plantation crops. pp. 235-252. **In**: *Organics in Soil Health and Crop Production.* (Ed.) Thampan, P.K. Peekay Treecrops Development Foundation,Cochin.

A polyphagous predator *Chelisoches moris* F. has been observed feeding on the eggs and early instar grubs of red weevil in Kerala.

86 Pillai, G.B.; Kurian, C.; Abraham, V.A. and Abdullakoya,K.M. 1985. Final report of research project: Investigations on red palm weevil, *Rhynchophorus ferrugineus* Fabr. pp.191-194. **In**: C.P.C.R.I. *Annual report for 1983*, CPCRI, Kasaragod, India.

A pest management schedule for red palm weevil including biological, mechanical, chemical and other methods like attractants and sterile male release method has been formulated.

87 Pillai, M.D. 1984. Bibliography on red palm weevil (*Rhynchophorus ferrugineus* Fabr.) - a pest of coconut (*Cocos nucifera* Linn.). *Indian Cocon. J.*14(10): 1-4

This bibliography has 47 entries contributed by 31 authors. Entries have been arranged in alphabetical order of the name of the authors and serially numbered. An author index is also appended.

88 Rahalkar, G.W.; Harwalkar, M.R. and Rananvare, H.D. 1972. Development of red palm weevil, *Rhynchophorus ferrugineus* Oliv. on sugarcane. *Indian J. Ent.* 34(3) : 213-215.

In an attempt to develop a method for the mass rearing of red palm weevil *Rhynchophorus ferrugineus* under laboratory conditions, comparative development of this insect on sugarcane and coconut was investigated. It was observed that sugarcane stem can serve as a good laboratory substitute for coconut in rearing this weevil.

89 Rahalkar, G.W.; Harwalkar, M.R. and Ranavare, H.D. 1975.*Proc. Symp. on Sterility Principle for Insect Control IAEA*, Vienna. p281

Authors have demonstrated that by X-irradiation of male weevils with a dose of 1.5 Krad, 1-2 days after their emergence from the cocoons, sexual sterility to the extent of 90 per cent could be induced without any adverse effects on their survival and mating competitiveness.

90 Rahalkar, G.W; Harwalkar, M.R.; Rananavare, H.D.; Shantaram, K. and Goplayengar, A.R. 1973. Laboratory studies on radiation sterilization of the red palm weevil (*Rhynchophorus ferrugineus* Oliv.) males. *J. Plantn Crops* I(Suppl.) : 141-146.

The effectiveness of radiation for the sterilization of *Rhynchophorous ferrugineus* Oliv., a pest of coconut and other palms, was investigated. X-irradiation of 1-2 day old males with a dose of 1.5 kr induced about 90percent sterility without affecting survival. Higher dosages, however, significantly reduced male survival, though near complete sterility was obtained. Some of the sperms present at the time of irradiation were less radiosensitive and contributed towards egg viability during the initial period of oviposition. This egg viability was considerably reduced when the males were not provided with females for 20 days. Similar results were obtained by flushing out the less susceptible sperm from the irradiated males through their successive matings with six females. Alternate matings with normal and irradiated(1.5kr) males revealed predominant utilization of sperm incorporated during recent matings. For appreciable suppression of progeny production, 10 irradiated males were required to compete with a normal one.

91 Rahalkar, G.W; Harwalkar, M.R.; Ranavare, H.D.; Kurian, C. ; Abraham, V.A. and Abdulla Koya, K.M. 1977. Preliminary field studies on the control of red palm weevil, *Rhynchophorus*

ferrugineus using radio sterilized males.*J. Nuclear agric.* biol. 6(3) : 65-68.

Feasibility of using sterile male release method for the control of red palm weevil, *Rhynchophorus ferrugineus* Oliv., was investigated. A total of over 5000 radiosterilized males were released in an 800 acre coconut plantation near Kayangulam in Kerala. Data on the fertility pattern of native females is presented and the factors affecting the efficacy of sterile male release for control of this insect are discussed.

92 Rahalkar, G.W.; Mistry, K.B.; Harwalkar, M.R.; Bharathan, K.G. and Gopalayengar, A.R. 1971. Labeling adults of red palm weevil (*Rhynchophorus ferrugineus*) with cerium for detection by neutron activation. *Ecology* 52(1) : 186-188.

Reported the work carried out in labeling adults of red palm weevil with Cerium for detection by Neutron activation analysis.

93 Rahalkar, G.W;Shantaram,K. Harwalkar, M.R. and Ranavare, H.D. 1982. Mating competitiveness and effective life of the radiation sterilized male red palm weevil *Rhynchophorus ferrugineus* Oliv. pp.395-400. **In**: *Sterile insect technique and radiation insect control.* Vienna,IAEA.

The feasibility of using the sterile insect technique for controlling the red palm weevil, *R. ferrugineus* has been evaluated. In this insect an X or gamma-ray dose of 1.4 krad induces about 90 percent sterility in males, which survive for 90-100 days compared with 100-110 days of control insects. Since the sterile males would survive for such a long period after their release in the field it was of interest to evaluate their mating competitiveness as they advance in age in order to determine their effective life. Data from sex ratio experiments indicated that mating competitiveness is reduced by about 50 percent by the time the sterile male is half way through its life expectancy. Reduction in the overall competitiveness could not be attributed only to the reduction in their mating ability but also to depletion in sperm production during aging. Results are discussed in the light of the precedence in sperm utilization in this insect.

94 Rahalkar, G.W.; Tamhankar, A.J. and Santaram, K. 1978. An artificial diet for rearing red palm weevil,*Rhynchophorus ferrugineus* Oliv. *J. Plantn Crops* 6 : 61-64.

An artificial diet for mass rearing red palm weevil (*Rhynchophorus ferrugineus* Oliv), has been developed. The diet consists of sugarcane, coconut cake, yeast, sucrose, essential minerals and vitamins, agar, water, and food preservatives. Twelve generations of the weevil were reared on the diet without any variation from the normal in the proportion of newly hatched adults, adult weight, fertility, and survival rates.

95 Rajmanickam, K.; Kennedy, J.S and Christopher, A. 1995. Certain components of integrated management for red palm weevil, *Rhynchophorus ferrugineus* F. (Curculionidae: Coleoptera) on coconut. Mededelingen-Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen, *Universiteit Gent* 60 (3a): 803-805.

Experiments conducted with different natural phagostimulants showed that sugarcane molasses and toddy (alcohol extracted from coconut) attract the curculionids in a large numbers. These substances can therefore be included as a component in integrated pest management as bait to monitor the dynamics of the population. Further experiments with systemic insecticides showed that monocrotophos applied in the early stages of attack was efficient in controlling the pest *Rhynchophorus ferrugineus*.

96 Rajan, P.and Nair, C.P.R. 1997. Red palm weevil - The tissue borer of coconut palm. *Indian Cocon. J.* 27 (12) : 2-4.

Host plants, life cycle, symptoms of infections, management of the red palm weevil(*Rhynchophorus ferrugineus*) were discussed.

97 Ramachandran, C.P. 1991. Effects of gamma radiation on various stages of red palm weevil, *Rhynchophorus ferrugineus* F. *J. Nuclear Agric Biol.* 20(3) : 218-221.

Adult males of *Rhynchophorus ferrugineus* were treated in the laboratory with gamma radiation (0.5,1.0, 1.5 and 2.0 Krad). Pupae were treated with 0.5 or 1.5 Krad and larvae with 1.0 Krad radiation. Irradiated males were given the opportunity to mate with untreated females. The production of viable eggs decreased with increasing radiation dose. There was no apparent effect on the F2 generation.

98 Ramachandran, C.P. and Nair, B.S. 1994. An insecticide injector for palm weevil control. *Invention Intelligence* 29(11): 563-564,571.

A tree injecter has been designed with a built-in pump and needle to suit red palm weevil control operations in coconut palms.

99 Rananavare, H.D.; Santaram, K.; Harwalkar, M.R. and Rahal Kar, G.W. 1975. Method for the laboratory rearing of red palm weevil, *Rhynchophorus ferrugineus* Oliv. *J. Plantn Crops* 3(2) : 65-67.

A method for laboratory rearing of red palm weevil (*Rhynchophorus*

ferrugineus Oliv.) has been developed. Freshly shredded sugarcane stem tissue, packed perforated boxes, served as site for oviposition and source of food for adults. Eggs were easily harvested by dispersing the oviposition medium in 30 percent glycerol in which eggs float and the medium sinks to the bottom. Newly hatched larvae were cultivated individually on a medium consisting of sugarcane shreds and nutrient agar (1 percent by weight). Larvae from second instar were individually reared on sugarcane stem pieces.

100 Sadakathulla, S. 1991. Management of red palm weevil, *Rhynchophorus ferrugineus* F. in coconut plantations. *Planter* 67(786) : 415-419.

Information is provided on the red palm weevil the most destructive pest of coconut palm and a number of other palms. The subjects discussed include (1) insect biology, (2) alternative hosts, (3) the extent of damage (4) the problems and prospects associated with the management of red palm weevil. The coconut plantations should be kept clean, dead and felled trunks or stumps of palms which allow the pest to breed should be promptly removed. Inflicting mechanical injuries on palms should be avoided. Several methods of cultural and chemical pest control are reviewed.

101 Sadakathulla, S. 1994. Screening coconut genotypes to red palm weevil, *Rhynchophorus ferrugineus* F. *Ann. Plant. Res. to Insects Newsletter* 17:30.

102 Sadakathulla, S. and Ramachandran. 1993. Field screeninig of coconut cultivars to red palm weevil at Tamil Nadu. *Ann. Plant. Res. to Insects News letter* 19:43.

103 Sathiamma, B., Abraham, V.A. and Kurian, C. 1982. Integrated pest management of the major pests of coconut. *Indian Cocon. J.* 12(6/9) : 27-29.

Oryctes rhinoceros, *Nephantis serinopa*, *Rhynchophorus ferrugineus* and *Leucopholis coneophora* are the major pests of coconut among 830 insects and mites species reported to be associated with coconut palm. Mechanical and biological control methods are being used other than the use of pesticides to keep these pests under check. Integrated pest management incorporating all these known methods is the most successful and economical control measure.

104 Shamseldean, Muhammad. Mustafa and Abd-Elgawad, Mahfouz. Mohamed. 1994. Laboratory evaluation of six Egyptian isolates of Heterorhabited nematodes for control of the red palm weevil. *Egypt. J. Appl. Sci.* 9(3): 670-679.

The recent discovery of *Rhynchophorus ferrugineus* Oliv. (Coleoptera: Curculionidae) as a destructive pest of palm trees in Egypt and the growing dissatisfaction with chemical insecticides to control such a pest inspired the search for effective and indigenous biocontrol agents. Six geographical novel isolates of the entomopathogenic nematodes Heterorhabditis spp. poinar (Rhabditida: Heterorhabitidae) were tried against palm weevils collected from infected palm trees in El- Salhia, El-sharkia province. After 72 hours of exposure to the nematodes, a 100% mortality of the insect pupae and adults was achieved as compared to the control. The insect stages varied in their mortality percentages according to the applied nematode isolate after the same time of exposure. An overall average of 80.7 percent, 70.8 percent, 16.7 percent and 33.3 percent mortality occurred for 1-cm long larvae, 3- to 4-cm long larvae, pupae and adults of the insect, respectively. Increasing the efficacy of the nematode isolates and their potential field application to control the palm weevil were discussed.

105 Shantappa, P.B.; Viswanath, B.A. and Sulladmath, V.V. 1979. Red palm weevil *Rhynchophorus ferrugineus* from the inland plantation of Karnataka. *Curr. Res.* 8(2) : 32.

Rhynchophorus ferrugineus a pest of coconut in coastal areas of Karnataka and Kerala, is reported from coconut plantations in inland areas of Karnataka. Chemical control measures are described.

106 Sivaraman, K. ; Moni, R.S.; Sasikumar and Ramachandran, C.P. 1989. Red palm weevil detector. *Invention Intelligence* 24(1): 32-35.

Early detection of red palm weevil infestation on coconut is imperative in undertaking timely control measures in order to save the palm. Therefore an electronic instrument for the early detection of the pest has been developed. The instrument designed for the purpose could detect the feeding sound of the grubs eleminating all unwanted signals.

107 Subba Rao, P.V.; Subramaniam, T.R. and Abraham, E.V. 1973. Control of the red palm weevil on coconut. *J. Plantn Crops* 1(1&2) : 26-27.

Three trials were carried out in Coimbatore District during 1971-72 for the control of the red palm weevil, attacking coconut trees. The results of the first trial indicated that fenthion 0.2% and carbaryl 1 percent suspension, and phostoxin at 1 tablet and 2 tablets per tree were effective against the larval, pupal, and adult stages of the pest. Further trials confirmed that Phostoxin could be used at half to one tablet per tree for the control of the pest.

108 Venkatasubbaiyer, C.S. 1940. Two interesting and unrecorded enemies of the palm weevil *Rhynchophorus ferrugineus* F. *Indian J. Ent.* 2 : 98.

Adults of *Rhynchophorus ferrugineus* F. are parasitised by larvae of *Sarcophaga fuscicauda,* Boettcher. When full-grown, the larvae leave their hosts and pupate, the adults emerging within a week.

109 Vestal, E.F. 1956. Control of coconut beetles and weevils in Thailand. *FAO Plant Prot. Bull.* 5(3) : 37-44.

Much damage is caused to coconut palms in Siam by *Oryctes rhinoceros* (L), *Rhynchophorus ferrugineus* and *R. schach*, the adults of all of which are briefly described.

110 Viado, G.B.S. and Bigornia, A.E. 1949. A biological study of the Asiatic palm weevil *Rhynchophorus ferrugineus* Oliv. (Curculionidae, Coleoptera). *Philipp. Agric.* 33 : 1-27.

The biology of the pest has been studied in detail.

111 Vidyasagar, P.S.P.V. and Bhat, S.K. 1991. Pest management in coconut gardens. J. *Plantn Crops* 19(2) : 163- 182.

The coconut palm is attacked by nearly 57 species of insects and 12 species of rodents and other vertebrates in India. Among them the rhinoceros beetle, *Oryctes rhinoceros* L., the leaf eating caterpillar, *Opisina arenosella* Meyr., the red palm weevil, *Rhynchophorus ferrugineus* F., the white grub *Leucopholis coneophore* and black rat are considered to be the major pests. The nature of damage and severity of infestation are discussed.

112 Wickremasuriya, C.A. 1958. An important injection technique for coconut palm of special reference to the control of red weevil *Rhynchophorus ferrugineus* F. *Ceylon Cocon.* Q. 9: 40-54.

An improved system for injecting liquid in to coconut palm has been perfected. This gear facilitates injection of the liquid in to the trunk at a desired pressure and prevents access of air into the conducting system. Further, it is possible to inject through a number of borings on a single tree from a central reservoir. This technique has been named 'parallel type' and has been proved to be very effective in controlling red weevil infestation.

AUTHOR INDEX

BIG POTENTIAL FOR COIR DUST IN AUSTRALIA

Coir dust is being sold mostly in new South Wales, some in Queensland and Victoria for around 30 cen per kilogram. There are however strict Australian rules for quality control. The dust has to be cleaned a must also be low in salt content. Meanwhile a major importer intends to supply processing and bail equipment designed by them to Indonesia to ensure supplies meet their standards. The dust must be ba and has to be mixed with water to break down the density.

- *The Coconut*