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BIOLOGY, BIONOMICS AND CONTROL OF *PROUTISTA MOESTA* WESTWOOD (HEMIPTERA : DERBIDAE) : A VECTOR OF YELLOW LEAF DISEASE OF ARECA PALMS*

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The plant hopper, *Proutista moesta* Westwood (Homoptera : Derbidae) is a vector of Yellow Leaf Disease(YLD) of areca palms and a putative vector of spear rot disease of coconut. *P. moesta* breeds on decaying materials. Life-history was completed within a period of 30 to 70 days. Maximum longevity obtained was 62 days. A single female laid on an average 44 ± 4 eggs. The average sex ratio was 1:0.59. Plant hoppers concentrate on the fully mature yellow coloured outer leaves of areca palms. Survey revealed that no YLD garden was independent of *P. moesta.* Highest population was recorded during June and the lowest during November. Seasonal abundance of *P. moesta* was governed by both biotic and abiotic factors. Spraying with monocrotophos was found to be effective for the management of the vector. Under field conditions, a Hymenopteran parasitoid, *Paraphylax sp.* was found suppressing the plant hopper population especially during the months of December to February.

INTRODUCTION

Proutista moesta Westwood belongs to the Order Hemiptera; Suborder Homoptera; Series Auchenorrhyncha, Superfamily Fulgoroidea and Family Derbidae. *P. moesta* is polyphagous in its feeding habit. Nair and Menon (1963) recorded it as a minor pest on the leaves of areca palms. As per the norms cited by Oman (1949) arecanut serves only as a "food plant" for the plant hopper. *P. moesta* feeds on the leaves of oil palms, piercing them to suck the sap (Wood, 1968). Rajan and Mathan (1985) reported *P.moesta* from coconut palms. *P. moesta* was proved as a vector of Yellow Leaf Disease (YLD) of areca palm through positive transmission studies from diseased to healthy areca seedlings (Ponnamma, 1994). Vectoral role in the transmission of root (wilt) disease of coconut palm was also established (Anon, 1996). Since the plant hopper is the prime means of spreading the pathogenic agents - Phytoplasmas (earlier known as Mycoplasma - like - organisms), knowledge about its biology, bionomics and control is essential

MATERIALS AND METHODS

Biology of *P. moesta*

For the laboratory rearing, materials such as decaying wood, dried leaves, coconut husk and rotting oil palm male and female inflorescences were filled individually in glass bottles(20 × 7.5 cm) and mouth of the bottle was covered

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with plastic net. Bits of mature areca leaves were provided inside the bottles for the adults to feed on. Field-collected plant hoppers were released (5 pair each in each bottle) into the bottles. The breeding materials were moistened as and when required. Adults emerged from each of the breeding materials were collected separately. For mass rearing, cement pots having a height of 75 cm and radius of 30 cm were used. Half of the pot was filled with steam sterilized soil. In the middle, an arecanut seedling was planted. Then the pot was filled with rotting male and female inflorescences of oil palm. Steel frames (150 cm) having a radius of 30 cm were provided over the frame and tied tightly to the pot. Ten such cages were set and field collected plant hoppers, 50 pairs each were released in each cage. The pots were kept in the open field and protected from ants and predators. The breeding materials were moistened as per requirement.

Life history

Field collected plant hoppers were used for life history studies. Rotting inflorescences of oil palm were used as rearing medium. Specimen tubes (8 × 2.5 cm) and petridishes (diameter 15 cm) were used as cages. Petridishes half filled with rearing medium were provided for egg laying. On hatching, the first instar nymphs were kept individually in specimen tubes provided with a small quantity of rearing medium. Mouth of the tube was covered with plastic net. Studies were conducted in the laboratory under a temperature range of 29 to 30°C and RH range of 65 to 70 per cent. The newly emerged adults were transferred for further studies such as longevity, fecundity, feeding behaviour, etc.

Bionomics of *P. moesta*

Pattern of distribution on areca palms

Four-year-old 100 apparently healthy arecanut seedlings having five to seven leaves were selected to collect data on the pattern of distribution of *P. moesta* on areca palms. The leaves were numbered serially commencing from the outermost leaf for every observation. The population was assessed between 9 am and 12 noon by direct counting. Data were collected from all the leaves of 100 seedlings at monthly intervals for a period of one year (January to December).

Preference for YLD affected/healthy areca palms

Laboratory studies

Laboratory studies using detached areca leaflets (from the outer whorl) were conducted to find out whether the plant hoppers show any preference for YLD affected areca palms. Leaflets from healthy and diseased palms were placed in 250 ml conical flasks containing water. Two flasks each containing leaflets from healthy and diseased palms were kept in four corners of a battery jar (45 × 15 × 10 cm). The mouth of the jar was covered with a muslin cloth. Field collected plant hoppers were starved for two hours. Then they were released into the battery jar. The experiment was replicated five times with 50 insects in each replication. The plant hoppers were released in the morning and the number of plant hoppers harbouring on the leaflets of each flask was recorded after 2,4,6 and 24 h.

Field experiment

In order to confirm the results obtained for the laboratory studies the following field experiment was conducted and data for a period of three years were collected. Population of *P.moesta* was assessed from arecanut seedlings (newly planted, two year old). The population was recorded by direct examination and counting. During the initiation of the experiment all the seedlings were healthy. The seedlings were numbered serially from 1 to 100. Data on insect population were collected at fortnightly intervals. YLD incidence was recorded based on foliar symptoms, as per the formula developed by George *et al.* (1980).

Disease indices of the seedlings during the second and third years of planting were also recorded. The data obtained for a period of three

years were analysed correlating the insect population and disease indices to find out whether they showed any preference to disease affected / healthy areca palms. Linear correlation coefficients were worked out between the disease index and the insect population in the same year and in the previous one or two years. This exercise was done separately for the palms found to be diseased in the third year and second year also. In the latter case, the disease indices were correlated with subsequent years population also.

Seasonal abundance of *P. moesta*

One hundred arecanut seedlings (three year-old) were selected in CPCRI, Palode campus. Population of *P. moesta* was recorded in the early morning by direct counting from each leaf of the individual seedlings at fortnightly intervals. The data for a period of 59 months (118 observations) on plant hopper population for 100 areca seedlings were complied.

Occurrence of *P. moesta* in YLD affected areca gardens

Survey was conducted in all the districts of Kerala State and three districts of Karnataka *viz.*, Chickmagalore, Shimoga and Dakshina Kannada. In Kerala, a minimum of five gardens in each (one garden in each taluk) of the fourteen districts, involving eighty nine diseased gardens having 8026 palms were surveyed. In each plot, 20 per cent of the palms (under the age group of 2 to 15 years) were observed as sample palms. Observation regarding the plant hopper population was assessed by direct counting. Details such as the total number of palms, number of healthy/ diseased palms, age of the palm, YLD incidence of palms, alternate host of the plant hoppers present in the garden *etc.* were collected.

Control of *P. moesta*

Chemical control

Laboratory evaluation of insecticides such as formothion, methylparathion, endosulfan, quinalphos, monocrotophos and dimethoate was carried out at different concentrations (Table 6) against the plant hopper. Arecanut leaflets of 30 cm length were taken and the insecticides in the above doses were sprayed on the tip of the leaflets (10 cm long) using the potter's spraying tower (at 1 kg/cm^2 pressure). Field collected normal looking healthy plant hoppers, five each were released in specimen tubes (8 x 2.5 cm). The sprayed end of the leaflet was inserted into the tube and closed with cotton plugs. The base of the leaflet was dipped in water. Observation on the normalcy and mortality were recorded after 24 hours. The experiment was replicated 10 times for each dose of individual insecticides. Data were compiled and subjected to probit analysis.

Biological control

Field collected plant hoppers were screened for parasites. They were caged on potted areca seedlings in plastic net bags (30 x 15 cm) under laboratory conditions and examined daily for the emergence of parasites, if any. Field collected plant hoppers were dissected out regularly to screen endoparasites. Direct examination of the breeding sites and foliages was carried out to catalogue the predators.

RESULTS AND DISCUSSION

Biology

Laboratory rearing and mass multiplication

Results revealed that maximum number of adults emerged (14.8/pair) from the breeding material, male and female inflorescences of oil palm mixed together and minimum from the coconut husk (0.2/pair) (Table 1). Nymphs suck sap from the decaying materials. Emergence of adult plant hoppers was noticed in the early morning after 28 to 32 days. Newly emerged adult plant hoppers were found resting on the leaves of arecanut seedlings inside the cages for mass rearing. A total of 350 plant hoppers were

obtained from 50 pairs of plant hoppers from a single cage set for mass rearing.

Table 1. Evaluation of different breeding materials for the laboratory rearing of *P. moesta*

Breeding materials	Number of adults emerged per pair of plant hoppers
Decaying Dried leaves	0.8
Decaying wood	9.4
Coconut husk	0.2
Oil palm male inflorescence	0.2
Oil palm male and female inflorescences mixed together	14.8

Life history

Life history was completed within a period of 30 ± 0.70 days (range 28 to 32 days). The average incubation period was seven days. There were 5 nymphal instars and each instar was completed within four to five days.

Adult plant hoppers were bluish-black in colour. Head is small compared to thorax and abdomen and is inclined to longitudinal axis of the body. Head is provided with well developed compound eyes, with two ocelli in front of it. Antennae are three segmented, scape is thick and flat, pedicel is small and fat and flagellum is slender and long. Mouth parts are of piercing and sucking type. Rostrum is well developed and three segmented, the distal and proximal segments are dark brown and middle is yellowish white in colour. Pro, meso and metathorax are well developed with legs and wings. Legs are provided with stiff hairs. The wing span is about 7 mm. Wings are uniform textured, the forewing being slightly harder in consistency than the hind wings. While at rest, the wings are held parallel to the body and during feeding the wings are held vertical to the body having a 'v' shaped appearance. Abdomen is with alternating black and orange red bands. It is broad and flat in females and pointed in males.

Eggs are laid singly in the breeding materials. Fresh eggs are pearl white in colour as development proceeds, change to yellowish white. Operculum is brownish in colour. Shape is somewhat elongate and oval.

Newly hatched nymphs are pure white in colour. Body is transparent and internal organs can be seen through the skin. Head is well developed with three segmented antennae and dark red eyes. Three segmented rostrum reaches upto the half of the body. Thorasic and abdominal segments are clearly marked. Legs are more transparent than the body. A reddish line starts from the prothorasic segment and continues downwards as dots in the meso and meta thorasic segments. In between the abdominal segments red lines are clearly visible. Body colour changes to light rose, when about to moult. Nymphs used to hop on slight disturbance.

Second instar nymphs are rose in colour immediately after moulting, later turns to dull brown. First segment of the antennae (scape) becomes thick and stout, the distal segments are filiform. Well developed tracheal system which gives off branches to all segments of thorax and abdomen can be seen through the transparent cuticle. Third instar nymphs are dark brown in colour. Rudiments of two pairs of wings are clearly visible for the first time. Fourth instar nymphs are bluish black in colour. Head, thorax and abdomen are clearly marked with well developed appendages. Head is small compared to thorax and abdomen. Wing rudiments are more visible. Fifth instar nymphs resemble the adult externally, except in size and the absence of fully developed wings. Nymphs are bluish black in colour, abdomen with alternating orange red and black bands. Wing rudiments stretches upto the two-third of the abdomen. Fifth instar moults to adult. Nymphs have a tendency to remain hidden in the breeding material.

Longevity

Longevity of laboratory-reared planthoppers was assessed under field conditions

(n=243). Maximum longevity obtained was 62 days (n=2) for females and 55 days for males (n=5) on areca palms. The average longevity obtained was 49.35 ± 1.7 days (range 29-62 days). Among the alternate hosts tried, maximum longevity obtained was on sugarcane, 39 days.

Fecundity

Under captivity, females are found laying eggs in specimen tubes, soil and in decaying materials. Eggs are laid one by one and at a stretch a single female laid on an average 13 eggs within two minutes. On an average a single female laid 44 ± 4 eggs (range 32 to 68 eggs) (average of 16 laboratory reared plant hoppers).

Sex ratio

Males are smaller than females. Sex ratio (male : female) of laboratory reared plant hoppers was 1:0.6 (n=2300) and that of field collected plant hoppers was 1:0.59 (n-3600). Fortnightly observations at two locations (CPCRI campus) from January to December revealed almost the same ratio except during April, May, July and September. The number of females was more from the second half of April (1:1.02) to second half of May (1:0.8). During July and September also the same trend was noticed (1:0.8).

Feeding behaviour

Plant hoppers are vascular tissue feeders. When *P. moesta* is in full swing of feeding, the wings are kept vertical to the body. The legs are also kept straight until feeding is over. They are found feeding on a single point upto half an hour. When the feeding is in full swing, they cannot be removed on a slight disturbance. Remaining on the under surface of the leaf, they suck sap both from tender as well as mature leaves of areca palms showing a preference for yellow coloured mature leaves. They feed on areca palms, irrespective of the age, health and variety of palms. Plant hoppers are polyphagous in feeding habit. They were found associated with Napier grass, paddy and banana. The population of plant hoppers was observed to be high in coconut and arecanut gardens where Napier grass was raised as an intercrop. Under field conditions maximum population was noticed on oil palm and arecanut followed by coconut and sugarcane.

Bionomics

Pattern of distribution

Data collected on the population of plant hoppers from 9 am to 12 noon by direct counting at monthly intervals for a period of one year (January to December) recorded maximum population from the outermost leaves (241) of areca palms and minimum (nine) in the innermost leaves. The population from the outermost to the innermost leaf was 241, 199, 156, 96, 58, 15 and 9 respectively (total for 100 seedlings for one year).

Preference for YLD affected / healthy areca palms

Laboratory trial

The data revealed that when diseased and healthy leaflets put together in a single cage, maximum number of plant hoppers harboured on leaflets from healthy palms at all intervals. After 2 h, on healthy leaflets 82 plant hoppers were noticed compared to 62 on leaflets from diseased palms. After 4 h, 112 harboured on healthy leaflets whereas 80 harboured on diseased. After 6 h and 24 h it was 125 and 147 on healthy compared to 92 and 75 respectively on diseased leaflets (Tables 2).

Tables 2. Preference for healthy / diseased areca palms-laboratory studies

Intervals (h)	Healthy	Diseased	Unsettled
2	82	62	106
4	112	80	58
6	125	92	33
24	147	75	28

Field trial

The frequency distribution (Table 3) showing the average plant hopper population in the healthy palms as well as those in the different stages of disease did not give any indication as to their preferential feeding habit on YLD affected. healthy areca leaves. It was observed that with increase in disease index there was a marginal decrease in plant hopper population. During the third year, the plant hopper population was about 23 percent less in diseased palm when compared to the average of healthy palms. As in the case of laboratory studies here also the results revealed that the plant hoppers preferred healthy areca seedlings compared to diseased (Table 4).

Table 3. Frequency distribution, showing the average pest population in the healthy as well as those in different stages of disease

Disease index		Pest population	
	n	Second year	Third year
Palms diseased in the second year			
0	75	20.4	33.4
1-10	5	25.8	23.2
11.20	13	23.8	35.6
21-30	5	22.2	36.0
31.40	2	38.0	21.5
>40	0	-	-
Palms diseased in the third year			
0	42	23.4	37.4
1-10	11	21.7	31.3
11-20	16	23.0	32.6
21-30	7	16.4	25.9
31.40	6	16.3	28.5
> 40	5	14.8	15.4

Table 4. Correlation co-efficient between disease index and population of *Proutista moesta*

		Correlation co-efficient between disease index and the plant hopper population in			
Palms found diseased in	No. of palms	Two year earlier	Previous year	Same year	Next year
Second year	25	-0.3822	0.1345	-0.1946	0.0894
Third year	45	0.1919	-0.3480	-0.2829	NA

Seasonal abundance of *P. moesta*

The compiled data on average monthly plant hopper population for five years (Fig. 1) recorded the highest population (382) during June and lowest (108) during November. Comparatively high population was noticed during May (267), July (253) and August (232) and a medium population was noticed during September (151), October (141), December (147) and January (140). Low population was recorded during February (123), March (123) and April (127).

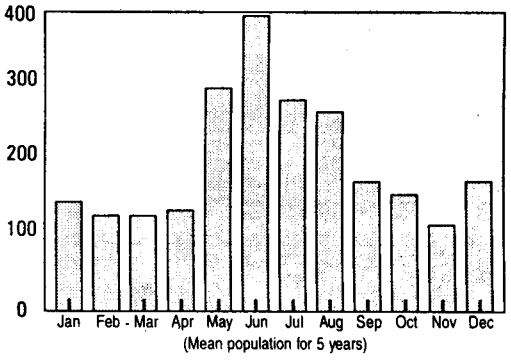

Fig. 1. Seasonal abundance of *P. moesta*

Occurrence of *P. moesta* in YLD affected areca gardens

Eighty nine areca gardens distributed in fourteen districts were surveyed. One thousand six hundred and twenty five sample palms were observed in 76 gardens (Table 5). YLD was noticed in all the fourteen districts and occurrence of plants hoppers was noticed in all the affected gardens. Plant hopper population was high in neglected garden where breeding materials were plenty and also in gardens where alternate hosts such as Napier grass and sugarcane were present. In Karnataka, the survey was conducted in twenty four YLD affected gardens distributed in the three districts, having 35622 areca palms. Occurrence of plant hoppers was noticed in 45 per cent of the gardens surveyed. Maximum population was noticed in Shimoga and Thirthahalli taluks. The occurrence of the plant hopper in all the YLD affected gardens is a supporting evidence for its role as a vector of YLD of areca palms.

Table 5. Occurrence of *Proutista moesta* in YLD affected gardens in Kerala

District	No of gardens observed	No of gardens *P. moesta* infested	Total palms	Sample palms examined	*P. moesta* per 100 palms (no.)
Thiruvananthapuram	6	5	192	40	17.5
Kollam	6	5	268	54	16.6
Alappuzha	7	6	357	72	22.2
Kottayam	7	6	315	64	53.8
Ernakulam	8	8	941	189	18.5
Thrissur	6	6	887	179	14.5
Malappuram	5	5	599	122	36.9
Kozhikode	5	5	287	58	17.2
Kannur	6	6	488	100	43.0
Kasaragod	6	2	952	192	16.1
Wynad	8	6	840	170	17.6
Palakkad	6	5	593	121	10.7
Idukki	8	6	1066	214	21.4
Pathanamthitta	5	5	241	50	18.0
Total	89	76	8026	1625	324.1

Control

Chemical control

The order of relative toxicity based on LD 50 after 24 h was monocrotophos, endosulfan, dimethoate, quinalphos, methylparathion and formothion (Table 6). The above results revealed that the plant hoppers can be effectively controlled using the systemic insecticide, monocrotophos.

Biological control

A parasitoid, *Halictophagus* sp. (Strepsiptera : Halictophagidae) was found attacking the plant hoppers under field conditions. Parasitization was noticed throughout the year. Heavy incidence was noticed during the month of December to February. Hernia-like swellings can be seen on the body wall of plant hoppers projecting between abdominal segments. The hernia-like projections lead into a case inside which the eggs/larva/pupa are found. The larvae pupates inside the case and emerges from the cocoon through a small hole made on the upper surface of the projections. Different stages of the wasps were observed inside the body cavity of the plant hoppers. Parasitized plant hoppers were found inactive and the longevity was reduced. The parasatoid is host specific.

Predators

Earwig, *Chelisoches moris* was found to feed on the nymphs and adults of plant hoppers. But they were not host specific. Under laboratory conditions within 5 min an earwig was found to feed four plant hoppers leaving behind the wings. Some species of spiders were also found to feed on the nymphs and adults of plant hoppers. Since the adult plant hoppers are sluggish in nature, they are easily amenable to the attack of the predators. According to Kiritani *et al.* (1972) spiders are the most important factor responsible for nymphal mortality. Since *P. moesta* breeds on decaying materials (Fletcher, 1914; Wood, 1968) rotting inflorescences and bunches of oil palm, field sanitation is essential for the control. An integrated pest management approach may be adopted for the effective control of the vector.

Table 6. Comparative efficacy of six insecticides against *Proutista moesta*

Insecticide	Dose	Dead	Log(Dox x 10) (%)	Emperical (x)	LD 50 probit (y)	Regression a y=1+bn	
						a	b
Formothion	0.00062	36	1.79	4.64	0.004	3.59	0.52
25 EC	0.00031	26	1.49	4.32			
	0.00015	20	1.18	4.16			
	0.00007	20	0.85	4.16			
	0.00003	12	0.48	3.83			
Methyl	0.00031	60	1.49	5.31	0.0009	4.31	0.65
parathion	0.00015	52	1.18	5.05			
25 EC	0.00007	42	84	4.87			
	0.00003	38	0.48	4.69			
	0.00001	24	0.00	4.29			
Endosulfan	0.00019	76	1.28	5.71	0.00006	5.21	0.46
35 EC	0.00009	74	0.98	5.64			
	0.00004	72	0.60	5.58			
	0.00002	66	0.30	5.41			
	0.00001	49	0.00	4.95			
Quinalphos	0.00015	66	0.18	5.41	0.00003	4.24	0.51
25 EC	0.00075	56	1.88	5.15			
	0.000037	54	1.57	5.10			
	0.000018	44	1.26	4.85			
	0.000009	38	0.95	4.69			
Monocrotophos	0.00004	74	1.60	5.64	0.000004	4.59	0.63
40 EC	0.00002	66	1.30	5.41			
	0.00001	56	1.00	5.15			
	0.000005	50	0.70	5.00			
	0.000002	46	0.30	4.87			
Dimethoate	0.00007	60	2.85	5.25	0.000032	3.99	0.42
	0.000035	50	2.54	5.00			
	0.0000175	48	1.94	4.85			
	0.0000043	34	1.63	4.59			

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