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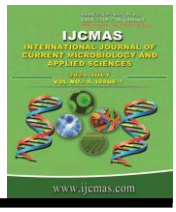

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Diversity of Insect and Non Insect Pest Infesting Karanja, *Pongamia pinnata* (L.) Pierre at Bhubaneswar, Odisha, India and their Natural Enemies

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A B S T R A C T

In an study on diversity of insect and non-insect pests infesting karanja, *Pongamia pinnata* (l.) pierre and their natural enemies at, a total of 28 species of insects including an acarine and 12 species of natural enemies were recorded during 2018-2019. The phytophagus insects were categorized under 5 groups viz. Foliage feeders or defoliators , Stem borers ,Bark borers ,sap feeders and seed feeders Peak infestation due to eriophyid mite was recorded during second fortnight of May 2018 (50.35%).and maximum number of galls per branch due to agromyzid fly infestation was observed in 1st fortnight of August (6.45 galls per branch) and maximum mean number of maggots recovered per gall was 8.50 in 1st fortnight of August2018. The mean percentage plant infestation due to leaf miner attack was varied from minimum of 15% infestation during 1st fortnight of December 2018 to a maximum of 89.00% as recorded during first fortnight of October, 2018.

Introduction

Pongamia pinnata (L.) Pierre is most commonly grown in humid and sub tropic environment, most commonly in coastal areas with its roots in freshwater or salt water but best growth is found in deep well drained sandy loam soil with assured moisture content and can also grow on sandy soils but do not grow well on dry sands (Orwa *et al.*, 2009). It is also used in herbal medicine which is known as botanical medicine or as phytotherapy or phytomedicine which means a plant or plant part is used to make medicine to assist in the healing process during illness and disease. The roots of *Pongamia pinnata* (L.) Pierre is good for cleaning foul ulcers, cleaning teeth, strengthening gums and gonorrhea. Among various constraints causing losses in large trees, insects are the major one, which deteriorates the quality and the quantity of trees, shrubs, herbs as well as their produce There are about 30 species of insect pests recorded to cause damage to *Pongamia pinnata* (L.) Pierre rose usually as avenue and strip plantations on marginal lands. They include leaf miner defoliator, shoot borer, sap suckers, flower feeder etc.

(Orwa *et al.*, 2009; Sundararaj *et al.*, 2005) reported a checklist of insects infesting *Pongamia pinnata* (L.) Pierre in India. This includes about 64 species of insects representing 21 families under six orders and one species of mite belonging to the Family Eriophyid of the Order Acarina. Keeping in view of the immediate need for understanding the arthropods diversity and population dynamics of important pests associated with *Pongamia pinnata* (L.) Pierre and their relationship with weather parameters, investigation was undertaken during the 2018-2019 in Bhubaneswar, Odisha with the objectives to study the diversity of different arthropods associated with *Pongamia pinnata* (L.) Pierre at Bhubaneswar location and To study the population dynamics of major foliage feeding insect *viz.* Leaf miner and some important leaf feeders associated with *Pongamia pinnata* (L.) Pierre.

Materials and Methods

The details of materials and methodology used in these experiments are discussed here under.

Location of the experimental site and season

The present investigation" was carried out during May 2018 to April 2019 at different locations viz., Silviculuture Research Station, Ghatikia, Bhubaneswar, and Seedling nursery of College of Forestry located in OUAT campus, Bhubaneswar, situated at an elevation of 25.9 m above MSL at 20^0 15'N latitude and $85^0$52' E longitude. It is situated in the East & South East Coastal Plain zone of Odisha, which falls under tropical wet-dry or tropical Savanna forest type. The general climate is warm and humid. Highest rainfall of 140 mm was recorded during August I fortnight whereas the total rainfall recoded from October second fortnight to April first fortnight was 3. 88mm. Afternoon relative humidity was more than 70% for the period from June second fortnights to September second fortnight.

Identification of insect pests and their natural enemies

Flying and slow moving insects were collected by means of a swift net and preserved appropriately. Immature stages of Lepidopterans and coleopterons insects were reared in the laboratory up to adult stage in natural food medium in plastic cups of 4-inch diameter and 4-inch depth after following all the sanitation practices. Identification was established either by personnel experience or from entomology museum or by consulting professors of entomology Department or from Internet sources. (Patil *et al.*, 2016, Tripathy *et al.*, 2018)Insect predators and parasites were identified either by directly collected from field or by rearing of field collected countable number of eggs or keeping the blotched leaves along with water soaked cotton wrapped in leaf base Photographs were taken by Stereoscopic binocular microscope modelCDGT510CCD) in the post graduate laboratory fitted with computer and provided with specific software. More critical detail of minute powder post beetles setae types of collected insect's cloaca apertures and their measurements was obtained with scanning electron microscope located in Central laboratory, OUAT, Bhubaneswar.

Population dynamics of major foliage feeding insect's viz. leaf miner and some important leaf feeders

Abundance of defoliating pests of Karanj was recorded at two different locations *viz.*, Silviculuture Research Station, Bhubaneswar, College of Forestry, OUAT campus, Bhubaneswar. At each location, plants of each category as detailed below with uniform

growth pattern and age were selected (I) Seedlings- 0-1-year-old (ii) Saplings- 1-3-year-old (iii)Plants- more than 3 years old. For seedlings and plants of 1-3 years old, all the leaves are selected from 30 plants and sampled. For more than 3 years old plant, five terminal twigs were randomly selected from the lower and middle canopy of each plant and 10 plants were taken, from which leaves from each twig were sampled for observing number of healthy and damaged leaves.

Population densities of different categories of pests are expressed as per Rout (2017) and standard error in each case has been determined by putting the standard formula. Thus percent infestation due to defoliation was worked out by using standard formula,

$$\% \text{ defoliation} = \frac{\text{Number of infested leaves}}{\text{Number of leaves examined}} \times 100$$

Results and Discussion

From Table- 01 and 02 it is evident that 28 species of insects and non-insect pests and 12 species of predators were recorded from *Pongamia pinnata* (L.) Pierre at Bhubaneswar during the period of study (2018-2019). Taxonomically, 5 species of Coleoptera, 9 species of Lepidoptera, 8 species of Hemiptera, 1 species of Acarina, 4 species of Orthoptera and 1 species each from Diptera and Isoptera were recorded. A total of 12 species of natural enemies have been recorded out of which 5 species are spiders, 3 species from Hymenoptera and 1 species each from Odonata, Neuropteran, Mantodea and Hemiptera. While categorising the insects as per the nature of damage out of total species recorded at Bhubaneswar situation, 53.84% constitute the foliage feeders, 32.14% constitutes the sap feeders, 7. 69% are pod borers, 7. 69% are bark feeders and 3.84% are stem borers only. A brief description of the insect pests attacking the plants along with nature of damage as well as their natural enemies is given below.

Foliage feeders

Pongamia leaf miner- (*Lithocolletis virgulata* Meyrick)

The mining was done by the tiny caterpillar which results in formation of white circular blotches on the leaves. In severe damage all the leaves are attacked. Female lay eggs on dorsal side of fresh leaves which hatch in about a week time and starts feeding on chlorophyll of the leaves. Initially they mine in irregular fashion. This give the shape of blotch to the mined portion, the larva feeds about a fortnight and pupate within the blotch the adult of which is a small moth about 2mm long silvery grey, emerges by making a small emergence hole in the upper side to start a new life.

Common banded awl *(Hasora chromus* Cramer)

The larvae of *Hasora chromus* Cramer was observed as a major defoliator of *P. pinnata* (L.) Pierre mostly during the rainy season. Larvae folds the leaves and feeds within it, particularly on young and tender leaves. The head was large, black with four white stripes on the dorsal side towards the prothorax up to last abdominal segment of the body. Adult butterflies are brownish in colour with prominent eyes and short antennae.

Bagworm- *(Pteroma plagiophleps* Hampson)

Bagworm infestation was recorded during the *Rabi* season. They are mostly attached to the stem and old leaves and pupa are mostly hanging from the leaves. Sexual dimorphism is well pronounced in adult of both the sexes. Males have well developed wings, legs and mouthparts whereas adult female is devoid of well-developed wings, legs and mouthparts.

Hairy caterpillar- (*Euproctis* sp.) Causes defoliation of host plants. Early instar larvae of hairy caterpillar, *Euproctis* sp. was observed feeding on the green part of the leaves and skeletonized them but later instar larvae feed completely. The soft apical shoots of plants are also damaged at times.

Indian sunbeam- (*Curetis thetis* Drury) Caterpillar they feeds on the leaves and feeding symptoms result in the formation of holes on the leaves. These are mostly seen in the *Kharif* season.

Common cerulean- (*Jamide sceleno* Cramer) the forewings have the terminal margin narrowly edged with black that broadens very slightly towards the apex of wings. Larvae are found feeding on the leaves of *Pongamia pinnnata* (L.) Pierre.

Karanj defoliator (*Maruca ambionalis* Felder) was recorded as the another important defoliator of *Pongamia pinnata* (L.) Pierre during the post rainy period at Bhubaneswar. The larvae caused webbing in young leaves and remained inside the webs and fed on the leaf tissue.

Leaf feeding beetle (*Diabrotica* sp.) Small to medium sized beetles, slender, active in habitat and mostly found during summer months. Both adults and grubs of the leaf beetle were observed feeding on the leaves by making holes. The elytra did not cover the abdomen fully.

Leaf gall mite- (*Aceria pongamiae*Keifer) Belongs to Eriophyidae of Acarina. Eriophyid mite induces finger like or pouched galls on both surfaces of the infested leaf. Most of infestation of *Aceria pongamia* Keifer was observed during the post rainy season during the month of May – October2018.Body cylindrical, whitish or creamy coloured, feather claw 7 rayed, shield design narrowly truncated in front, median line not clear; a median line close to one another, complete meet at rear shield. Abdomen with 70 rings uniformly microtuberculate.

Stem gall fly- Maggots are seen feeding in the soft tender twigs resulting in swellings and galls on the stem. Maggots are whitish apodous having size of 3-4 mm in length whereas adult fly is black in colour and have size of about 3-4 mm

Grasshopper –Found feeding on theyoung seedlings a total of 3 species was recorded.

Tree hopper -Both nymphs and adults of tree hopper were found sucking sap from tender leaves and shoots of *P. pinnata* (L.) Pierre.

Unidentified weevil- Both grub and adult are seen feeding on *P. pinnata* (L.) Pierre leaves leading to small circular holes on the tender leaves. Grubs are black in colour with 3-4 mm in size and having well developed snout.

Stem borer- (*Leiopus nebulosus* Linnaeus) Both grub and adult are seen feeding on *Pongamia* stems by boring holes on the stem. Adult are 3-4 cm long and 1-1.5cm wide with long serrated have long antenna. Adult are greyish in colour with black coloured patches on the elytra (Fig.-)

Bark borer – (*Indarbela quadrinotata* Walker) Bark borer was observed infesting the main stem of the *P. pinnata* (L.) Pierre. Infested stem could be identified by the holes and webbing of frass material along with excreta of the larvae feeding inside.

Sap feeders

Mealybugs (*Ferissia virgate* Cockerell)- Mealy bugs caused damage by sucking the sap of the leaves and young shoots of *P. pinnata* (L.) Pierre. Feeding continuously retarded growth as a result yellowing, withering and falling of leaves were noticed.

Bug (*Homoeocerus biguttata* Westwood)
Both nymphs and adults sucked the sap of young leaves. Body of the bugs was green in colour with brown coloured wing. Adult bug measured about 12.0 to 15.0 mm in length and 3.0-4.0 mm in width.

Stink bug (*Nezara viridula Linnaeus)* Both nymph and adults green bug, *Nezara virudula* were observed as sucking pest on young shoots and leaves of *Pongamia*. Major appearance was observed during post rainy and winter months.

Red cotton bugs (*Dysdercus cingulatus* Fabricius) Both nymphs and adults of red cotton bugs, found sucking sap from tender leaves, petioles and shoots in early stages and then infest flower buds of *P. pinnata* (L.) Pierre.

Pod borer

Pulse beetle (*Callosobruchus sp*.) Grubs are seen inside the pods, cream coloured, scarabaei form, fleshy and feeds inside the seeds

Pod borer (*Ephestia sp.)*-The larvae entered inside the pods at an early stage of larval instar such that their entry hole got healed up later due to which it was difficult to distinguish an infested fruit from an uninfected one by visual observation. Infestation of pod borer was observed to be serious on *Pongamia* pods where seeds were fallen on dampy places.

Natural enemies associated with pests of *Pongamia pinnata* (L.) Pierre

Red ant -Red ant, were observed associated with infesting leaves of *P. pinnata*(L.) Pierre by making nests by joining on an average 4-5 leaves. The ants lived within the nests and came out at the slightest disturbance of the trees.
Black ant – Generally black ants congregating near honeydews.
Green lace wing -*Chrysoperla* sp. was observed as a predator on soft bodied insects such as mealy bugss and plant hoppers
Mantids: Mantid was observed predating on flying insects which included various species such as plant hoppers beetles, moths and butterflies
Spiders: Various species of spiders were recorded on *Pongamia sp.* during the present studies. It was recorded to be a polyphagous predator of various species of insects.
Predatory stink bug- Stink bug predates on the larval stages of various insects attacking *Pongamia pinnata* (L.) Pierre.

Data in Table.3 revealed the mean percentage defoliation/ plant. Peak defoliation was recorded after the onset of monsoon from second fortnight of July, 2018 to second fortnight of October, 2018. No leaf infestation due to the mite *Aceria pongamia* Keifer was recorded during the months of December to February second fortnight The initiation of infestation could be coupled with summer when leaf sprouting occurs during early days of March. Peak infestation was recorded during second fortnight of May 2018 (50.35%). Mean number of gall per pinna also follow similar trends with lowest number of galls per pinna was 5.00% as recorded during 1st fortnight of December to 29 galls per pinna in 1st fortnight of May, 2018.Mean percentage branch infestation in each plant due to agromyzid varied from nil (2nd fortnight of May, 2018 to 1st fortnight of January, 2019) to a maximum of 43.00% (1st fortnight of August,2018) Maximum number of galls per branch was observed in 1st fortnight of August (6.45 galls per branch) and maximum mean number of maggots recovered per gall was 8.50 in 1st fortnight of August.

Table.1 Diversity of insect and non-insect pest infesting karanja *Pongamia pinnata* (L.) Pierre at Bhubaneswar, Odisha , India

Sl. no.	Common Name	Scientific Name	Family	Order	Status	Infested plant parts
A) Foliage feeders						
1	*Pongamia* leaf miner	*Lithocolletis virgulata*Meyrick	Gracillaridae	Lepidoptera	Major	Foliage
2	Common banded awl	*Hasora chromus*Cramer	Hesperidae	Lepidoptera	Major	Foliage
3	Bagworm	*Pteroma plagiophleps*Hampson	Psychiidae	Lepidoptera	Major	Foliage
4	Hairy catterpillar	*Euproctissp.*Hubner	Lymantriidae	Lepidoptera	Minor	Foliage
5	Indian sunbeam	*Curetis thetis*Drury	Lycaenidae	Lepidoptera	Minor	Foliage
6.	Common cerulean	*Jamides celeno*Cramer	Lycaenidae	Lepidoptera	Minor	Foliage
7.	Karanj defoliator	*Maruca ambionalis*Felder	Crambidae	Lepidoptera	Major	Foliage
8.	Leaf gall mite	*Aceria pongamiae*Keifer	Eriophyidae	Acarina	Major	Leaf
9.	Stem gall making fly	Unidetified	Agromyzidae	Diptera	Major	Top shoots
10.	Brown Grasshopper	*Diabolocatantops axillaris*Jago	Acrididae	Orthoptera	Minor in seedlings	Foliage of seedligs
11.	Long horned grasshopper	*Ducetia japonica* Thunberg	Tettigoniidae	Orthoptera	Major in seedlings	Foliage of seedlings
12.	Katydid	*Pterophylla camellifolia*Fabricius	Tettigoniidae	Orthoptera	Minor in seedlings	Foliage
13.	Short horned grasshopper Weevil	*Oxya hyla*Serville	Acrididae	Orthoptera	Minor in seedlings	Seedlings
14.	Leaf feeding beetle	*Diabrotica* sp.	Chrysomelidae	Coleoptera	Minor	Leaf
15	* Weevil	unidentified	Curculionidae	Coleoptera	Major	Feed on tender

						leaves making small holes
B) STEM BORER						
16.	Longicorn beetle	*Leiopus nebulosus* Linnaeus	Cerambycidae	Coleoptera	Borers	Stem
C) BARK BORER						
17	Bark borer	*Indarbela quadrinotata* Walker	Arbellidae	Lepidoptera	Minor	Bore the bark
18	Termite	*Odontotermes obesus* Rambur	Termitidae	Isoptera	Major	Feeds on bark and roots of fresh transplants.
D) SAP FEEDER						
19	Mealybug	*Nipaecoccus viridis* Newstead	Pseudococcidae	Hemiptera	Major	Foliage, twigs
20	Two tailed mealy bug	*Ferrisia virgata* Cockerell	Pseudococcidae	Hemiptera	Major	Foliage
21	Bug	*Homoeocerus biguttatus* Westwood	Coreidae	Hemiptera	Major	Foliage
22	Red cotton bug	*Dysdercus cingulatus* Fabricius	Pyrrhocoridae	Hemiptera	Minor	Foliage
23	Metallic shield bug	*Chrysochoris stolli* Wolf	Scutelleridae	Hemiptera	Minor	Foliage
24	Spotted lanternfly	*Lycorma delicatula* White	Fulgoridae	Hemiptera	Minor	Foliage
25	Tree hopper	unidentified	Membracidae	Hemiptera	Minor	Foliage
26	Bug	unidentified	-	Hemiptera	Minor	Foliage
E) SEED FEEDERS						
27	Pulse beetle	*Callosobruchus sp.*	Bruchidae	Coleoptera	Minor and feeds on side seeds	Pod borer
28	Pod borer	*Ephestia sp.*	Pyralidae	Lepidoptera	Minor but seed feeder	Pod borer

Table.2 Succession of natural enemies of major insect pests infesting *Pongamiapinnata* (L.) Pierre at Bhubaneswar (2018-2019)

Sr. no.	Common name	*Scientific name*	Family	Order	Type	Remarks
1.	Emerald-banded skimmer	*Cratilla lineata*	Anisoptera	Odonata	Predator	Naids are predators in swampy areas
2.	Two striped jumping spider	*Telamonia dimidiate* Simon	Salticidae	Araneae	Predator	Feeds on small insects
3.	Heavy bodied jumping spider	*Hyllus semicupreus* Simon	Salticidae	Araneae	Predator	Feeds on small insects
4.	Spider	*Neoscona sp.*	Araneidae	Araneae	Predator	Feeds on small insects
5.	Hasselt's spiny spider	*Gaster acanthahasselti* Koch	Araneidae	Araneae	Predator	Feeds on small insects
6.	Giant golden orb-weaver	*Nephilla* Leach	Araneidae	Araneae	Predator	Feeds on small insects
7.	Red ant	*Solenopsis* Westwood.	Formicidae	Hymenoptera	Visiting	Seen on honeydew
8.	Black ant	*Lasiusniger* Linneaus	Formicidae	Hymenoptera	Visiting	Seen on honeydew
9	Leaf miner parasitoid	unidentified	Eulophidae	Hymenoptera	Parasioid	Found inside mines
10	Green lacewing	*Chrysoperla sp.*	Chrysopidae	Neuroptera	Predator	Found in plants
11	Preying mantid	*Mantis sp.*	Mantidae	Mantodea	Predator	Found in plants
12	Green stink bug	*Nezara viridula* Linnaeus	Pentatomidae	Hemiptera	Predator	Found in plants

(*)- unidentified

Table.3 Infestation of different gall forming insects in *Pongamia pinnata* (L.) Pierre (2018-2019) at Bhubaneswar

Period of observation	Mean (%) defoliation per plant	Infestation due to mite (*Aceriapongamiae*Keifer)					Infestation due to Agromyzid			
		Mean plant infestation %	Mean percentage compound leaf infestation	Mean gall intensity of infested compound leaves	Mean percentage simple leaf infestation	Mean no. of galls per pinna	Mean % plant infestation	Mean % branch infestation	Mean gall intensity per branch	Mean number of maggot recovered per gal
MAY I, 2018	12.10±0.05 (11.00-12.75)	38.20±1.05 (35.00-45.00)	45.45±4.50 (30.00-50.00)	42.25±2.50 (35.00-60.00)	26.00±2.50 (23.00-35.00)	29.00±1.50 (22.00-32.00)	15.00±0.05 (10.00-20.00)	30.00±0.55 (25.00-35.00)	4.35±1.05 (2.00-6.00)	6.00±0.05 (2.00-11.00)
MAY II 2018	9.64±0.75 (8.50-10.00)	50.35±3.08 (50.00-55.00)	46.75±3.50 (30.00-50.00)	45.75±1.50 (40.00-50.00)	27.75±2.50 (23.00-32.00)	28.25±2.50 (22.00-33.00)	18.00.15±0.01 (10.00-25.00)	31.33±0.60 (25.00-35.00)	4.15±2.01 (3.00-8.00)	6.50±0.05 (3.00-8.00)
JUNE I 2018	13.71±0.82 (13.0-14.00)	28.00±2.05 (25.00-35.00)	37.33±2.05 (20.00-38.00)	40.20±1.75 (35.00-50.00)	25.45±2.50 (13.00-32.00)	25.45±3.50 (20.00-35.00)	20.05±0.03 (15.00-25.00)	34.50±0.55 (30.00-40.00)	4.45±2.03 (3.00-7.50)	7.5±0.05 (3.00-12.00)
JUNE II 2018	16.80±0.09 (15.85-17.05)	36.90±2.06 (35.00-45.00)	39.40±4.50 (20.00-35.00)	38.75±2.50 (20.00-45.00)	22.45±2.50 (13.00-25.00)	20.45±1.50 (12.00-25.00)	24.05±0.05 (15.00-30.00)	37.00±0.85 (35.00-45.00)	4.05±1.05 (3.00-8.00)	7.75±0.05 (3.00-12.00)
JULY I 2018	20.75±1.45 (15.0-26.00)	35.80±3.04 (25.00-38.00)	35.45±3.50 (20.00-35.00)	36.45±2.70 (20.00-39.00)	20.65±1.50 (15.00-25.00)	18.50±0.80 (10.00-25.00)	25.50±0.04 (20.00-30.00)	39.40±0.50 (35.00-45.00)	5.50±1.04 (3.00-9.00)	7.80±0.05 (2.00-9.00)
JULY II 2018	30.45±0.90 (26.00-38.00)	30.40±1.02 (20.00-40.00)	32.00±6.50 (20.00-38.00)	34.45±3.50 (25.00-50.00)	16.90±2.50 (5.00-18.00)	14.50±0.70 (2.00-15.00)	28.00±0.01 (20.00-35.00)	40.00±2.55 (30.00-45.00)	6.00±1.01 (3.00-10.00)	8.00±0.05 (3.00-11.00)
AUG. I 2018	36.43±0.40 (30.50-42.50)	25.45±2.05 (20.00-30.00)	27.45±4.50 (20.00-38.00)	27.35±4.50 (15.00-30.00)	13.25±2.50 (6.00-15.00)	12.75±1.50 (8.00-25.00)	30.45±0.02 (20.00-35.00)	43.00±1.20 (35.00-50.00)	6.45±1.02 (3.00-8.00)	8.50±0.05 (4.00-12.00)
AUG. II 2018	38.25±1.30 (35.00-47.80)	22.30±2.03 (20.00-30.00)	25.90±3.50 (20.00-35.00)	25.90±2.50 (20.00-30.00)	12.25±1.50 (8.00-20.00)	11.35±2.50 (8.00-25.00)	3.35±0.05 (1.00-6.00)	8.00±0.75 (3.00-10.00)	0.35±0.05 (0.00-1.50)	2.50±0.05 (2.00-3.00)
SEP. I 2018	40.65±2.20	21.00±1.02	22.65±4.50	22.90±2.90	11.85±2.50	8.65±1.50	2.30±0.01	2.25±0.55	0.30±0.01	2.10±0.05

	(32.00-53.00)	(20.00-30.00)	(20.00-36.00)	(15.00-35.00)	(8.00-20.00)	(6.00-20.00)	(1.00-3.00)	(2.00-5.00)	(0.00-1.50)	(2.00-3.00)
SEP. II 2018	42.63±1.65 (25.00-55.000	20.10±4.05 (20.00-25.00)	20.75±2.50 (15.00-30.00)	19.25±3.50 (10.00-25.00)	10.45±2.50 (9.00-25.00)	8.25±3.50 (5.00-15.00)	0.00±0.00	00.00	0.00±0.00	00.00
OCT.I 2018	47.15±2.50 (36.00-58.00)	18.50±1.01 (20.00-25.00)	17.45±4.50 (15.00-20.00)	18.75±2.50 (10.00-25.00)	9.35±2.50 (7.00-25.00)	8.00±2.50 (4.00-15.00)	0.00±0.00	00.00	0.00±0.00	00.00
OCT. II 2018	53.16±2.30 (48.50-60.70)	17.75±3.05 (20.00-20.00)	17.00±3.50 (10.00-20.00)	12.35±2.70 (10.00-15.00)	9.25±2.50 (5.25-17.00)	7.45±1.00 (2.00-12.00)	0.00±0.00	00.00	0.00±0.00	00.00
NOV. I 2018	49.16±3.32 (42.00-54.00)	16.90±1.06 (10.00-25.00)	16.45±4.10 (10.00-18.00)	8.35±3.50 (6.00-12.00)	8.56±2.50 (5.00-15.00)	6.75±2.50 (2.00-12.00)	0.00±0.00	00.00	0.00±0.00	00.00
NOV. II 2018	44.53±01.50 (44.00-45.00)	14.05±2.03 (11.00-23.00)	13.45±4.50 (10.00-20.00)	6.90±2.50 (3.00-10.00)	7.25±2.50 (6.00-15.00)	5.75±1.50 (2.00-9.00)	0.00±0.00	00.00	0.00±0.00	00.00
DEC. I 2018	26.25±1.45 (25.50-26.25)	7.00±0.00 (5.00-10.00)	12.75±1.75 (10.00-20.00)	5.65±4.50 (5.00-8.00)	5.25±2.50 (5.00-9.00)	5.00±0.50 (2.00-10.00)	0.00±0.00	00.00	0.00±0.00	00.00
DEC. II 2018	12.25±1.08 (10.00-22.00)	00.00±0.00	0.00±0.00	0.00±0.00	00.0	00.00±0.00	0.00±0.00	00.00	0.00±0.00	00.00
JAN. I 2019	10.60±1.26 (8.50-15.00)	0.00±0.00	0.00±0.00	0.00±0.00	00.00	00.00±0.00	0.00±0.00	00.00	0.00±0.00	00.00
JAN.II 2019	12.07±0.45 (9.00-17.00)	0.00±0.00	0.00±0.00	0.00±0.00	00.00	00.00±0.00	10.00±1.00 (5.00-15.00)	17.45±1.90 (15.00-20.00)	2.25±0.05 (1.50-4.00)	5.00±1.00 (3.00-6.00)
FEB. I 2019	12.90±0.50 (7.00-15.50)	0.00±0.00	0.00±0.00	0.00±0.00	00.00	00.00±0.00	13.50±1.50 (10.00-18.00)	20.38±2.67 (17.00-22.00_)	2.75±0.06 (1.75-4.00)	5.20±0.05 (3.00-7.00)
FEB. II 2019	10.00±0.50 (9.00-10.50)	0.00±0.00	0.00±0.00	0.00±0.00	00.00	00.00±0.00	15.00±2.00 (12.00-18.00)	22.65±1.00 15.00-25.00)	3.90±0.05 (2.00-5.00)	5.25±1.00 (3.00-4.00)
MARCH I 2019	10.14±0.30 (9.00-13.00)	0.00±0.00 (00.00-00.00)	0.00±0.00	0.00±0.00	00.00	00.00±0.00	18.00±2.50 (12.00-25.00)	25.90±3.75 20.00-28.00)	4.20±0.02 (2.00-5.00)	5.75±0.05 (2.00-9.00)
MARCH II	10.34±1.40	12.70±2.08	11.45±2.50	12.15±2.50	12.25±2.50	18.25±2.50	20.00±2.00	28.45±2.80	4.25±0.03	5.80±1.00

2019	(10.0-11.00)	(10.00-25.00)	(9.00-18.00)	(5.00-15.00)	(9.00-15.00)	(15.00-25.00)	(15.00-25.00)	24.00-30.00)	(2.00-5.00)	(2.00-10.00)
APRIL I 2019	11.26±0.50 (11.00-12.00)	14.10±1.04 (10.00-20.00)	12.75±2.50 (10.00-15.00)	14.75±4.50 (5.00-25.00)	14.25±2.50 (9.00-20.00)	20.35±1.50 (17.00-25.00)	23.00±1.00 (18.00-28.00)	31.75±2.00 (25.00-32.00)	4.30±0.04 (2.00-5.00)	6.00±0.05 (3.00-12.00)
APRIL II 2019	11.90±1.50 (10.00-13.0)	15.60±3.02 (15.00-20.00)	17.65±2.50 (15.00-20.00)	16.85±3.50 (15.00-25.00)	16.25±2.50 (9.00-20.00)	20.75±2.50 (18.00-25.00)	25.80±1.00 (20.00-28.00)	33.25±2.55 (25.00-33.00)	4.30±0.01 (2.00-5.00)	6.00±0.05 (3.00-12.00)

I – First fortnight, II- Second fortnight*Figure in the parenthesis are range values*Each figure is the mean of 50 sampling units ±S.D.

Table.4 Infestation of leaf miner in *Pongamiapinnata*(L.) Pierre at Bhubaneswar (2018-2019)

Period of observation	leaf miner mean % plant infestation	Mean % compound leaf infestation	Mean blotch intensity per compound leaves	Mean % of blotches harbouring miner larvae	Mean larval population density per leaf
MAY I, 2018	10.70±1.45 (8.00-12.00)	4.75±1.03 (3.00-7.00)	3.70±1.04 (2.00-6.00)	22.54±5.50 (15.00-25.00)	1.50±0.50 (1.00-2.00)
MAY II 2018	13.85±1.45 10.00-15.00)	6.25±1.03 (3.00-9.00)	4.25±1.03 (3.00-7.00)	27.54±5.50 (20.00-30.00)	1.50±0.50 (1.00-2.00)
JUNE I 2018	15.75±1.45 (10.00-18.00)	7.50±1.03 (4.00-10.00)	5.00±3.02 (3.00-10.00)	37.54±5.50 (35.00-45.00)	1.50±0.50 (1.00-2.00)
JUNE II 2018	20.45±1.45 (15.00-25.00)	10.00±1.03 (8.50-12.00)	5.70±2.01 (3.00-10.00)	57.54±5.50 (50.00-65.00)	1.50±0.50 (1.00-2.00)
JULY I 2018	65.00±5.50 (60.00-70.00)	20.00±1.03 (15.00-23.00)	6.60±1.05 (3.00-8.00)	90.00±5.50 (80.00-100.00)	1.50±0.50 (1.00-2.00)
JULY II 2018	70.00±5.50 (65.00-75.00)	25.66±3.45 (15.00-30.00)	8.30±1.07 (4.00-9.00)	85.00±5.50 (70.00-90.00)	1.50±0.50 (1.00-2.00)
AUG. I 2018	80.00±5.50 (70.00-90.00)	30.66±3.45 (25.00-35.00)	13.25±2.04 (10.00-16.00)	80.00±5.50 (70.00-85.00)	1.50±0.50 (1.00-3.00)
AUG. II 2018	82.00±5.50 (70.00-85.00)	50.66±3.45 (45.00-55.00)	15.80±1.01 (12.00-18.00)	70.00±5.50 (65.00-75.00)	1.50±0.50 (1.00-2.00)
SEP. I 2018	84.00±5.50 (80.00-90.00)	56.66±3.45 (50.00-60.00)	18.65±0.03 (15.00-20..00)	50.00±5.50 40.00-55.00	1.50±0.50 (1.00-3.00)
SEP. II 2018	85.00±5.50 (80.00-90.00)	60.66±3.45 (60.00-70.00)	19.00±0.05 (16.00-22.00)	52.00±5.50 (45.00-55.00)	1.50±0.50 (1.00-3.00)
OCT.I 2018	89.00±5.50 (80.00-95.00)	66.66±3.45 (60.00-70.00)	22.60±1.07 (18.00-24.00)	28.00±5.50 (25.00-30.00)	1.50±0.50 (1.00-3.00)
OCT. II 2018	70.00±5.50 (60.00-80.00)	60.00±2.45 (55.00-65.00)	22.05±2.03 (18.00-25.00)	21.00±5.50 (15.00-25.00)	1.50±0.50 (1.00-2.00)
NOV. I 2018	40.00±5.50 (30.00-45.00)	40.00±3.45 (35.00-45.00)	20.35±3.05 (19.00-26.00)	18.33±5.50 (15.00-25.00)	1.50±0.50 (1.00-3.00)
NOV. II 2018	25.00±5.50 (20.00-30.00)	25.00±1.45 (20.00-35.00)	13.35±0107 (10.00-15.00)	13.33±5.50 (10.00-20.00)	1.50±0.50 (1.00-2.00)
DEC. I 2018	15.00±5.50 (10.00-20.00)	12.25±3.45 (10.00-15.00)	1.50±2.04 (1.00-3.00)	5.00±5.50 (4.00-11.00)	1.50±0.50 (1.00-2.00)
DEC. II 2018	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
JAN. I 2019	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
JAN.II 2019	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
FEB. I 2019	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
FEB. II 2019	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
MARCH I 2019	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
MARCH II 2019	5.00±1.45 (2.008.00)	3.25±3.45 (2.00-5.00)	3.40±2.05 (2.00-6.00)	12.75±5.50 (9.00-15.00)	1.50±0.50 (1.00-2.00)
APRIL I 2019	8.25±1.45 (5.00-12.00)	5.25±1.45 (3.00-8.00)	3.40±1.03 (2.00-6.00)	15.65±5.50 (9.00-18.00)	1.50±0.50 (1.00-2.00)
APRIL II 2019	10.75±1.45 (8.00-13.00)	7.50±2.45 (4.00-12.00)	3.50±2.01 (2.00-6.00)	17.54±5.50 (15.00-20.00)	1.50±0.50 (1.00-2.00)

*Figure in the parenthesis are range values *Each figure is the mean of 50 sampling units ±S.D

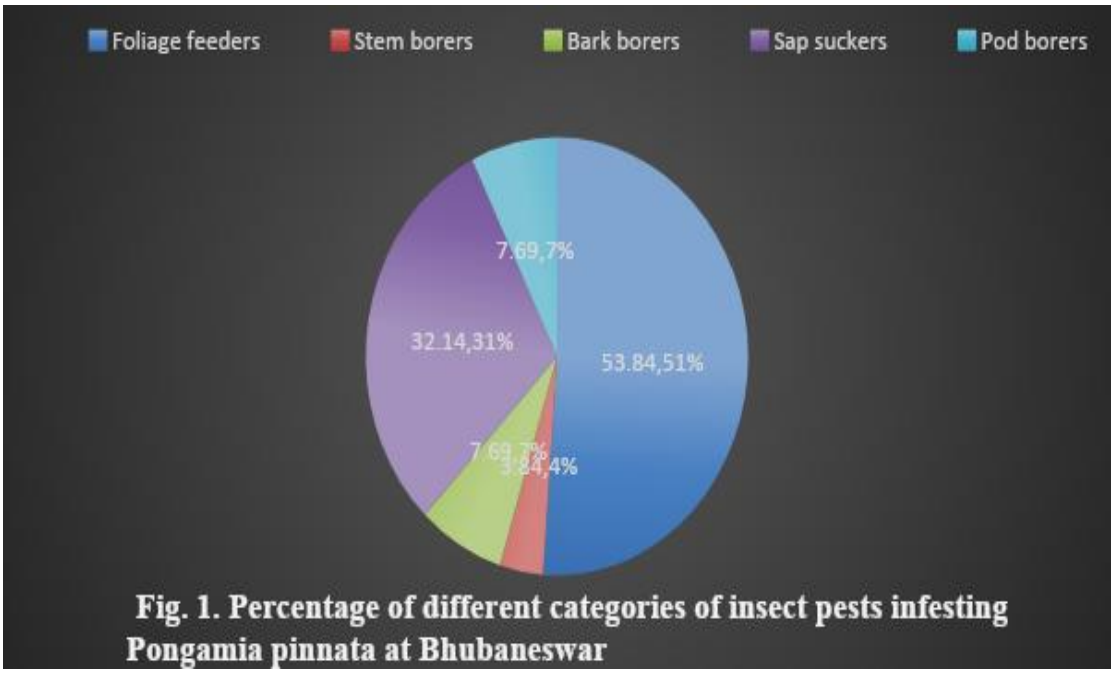


Fig. 1. Percentage of different categories of insect pests infesting Pongamia pinnata at Bhubaneswar

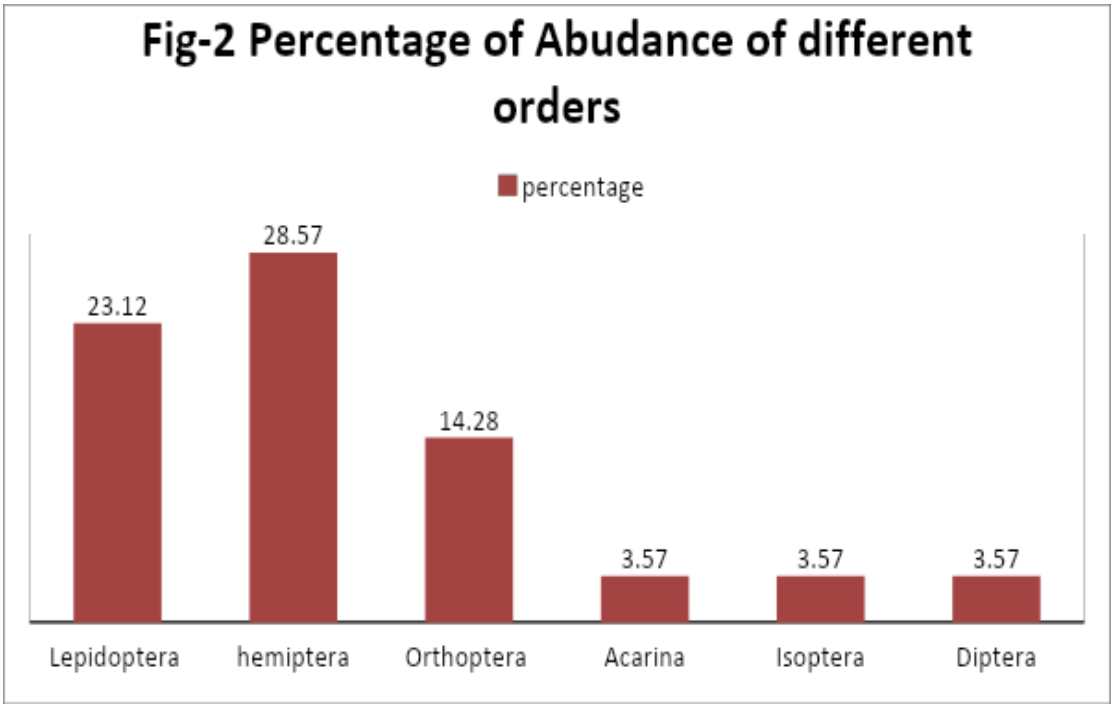
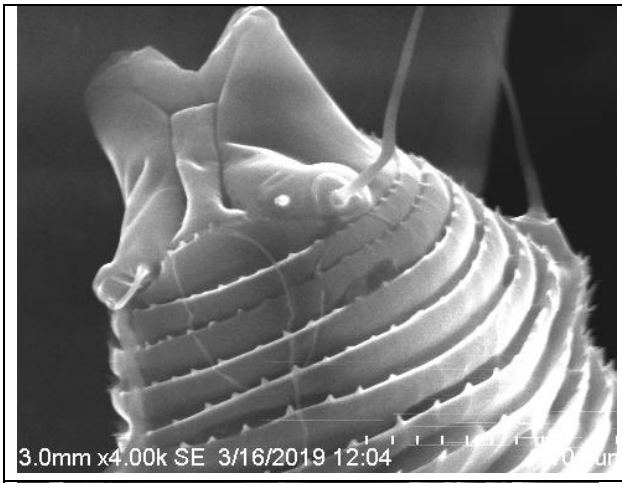
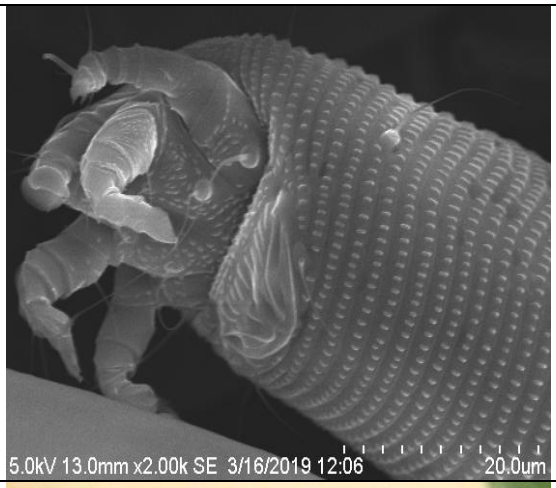
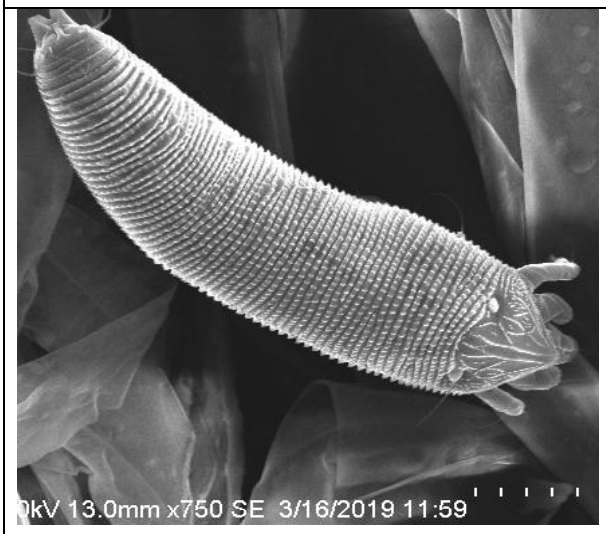


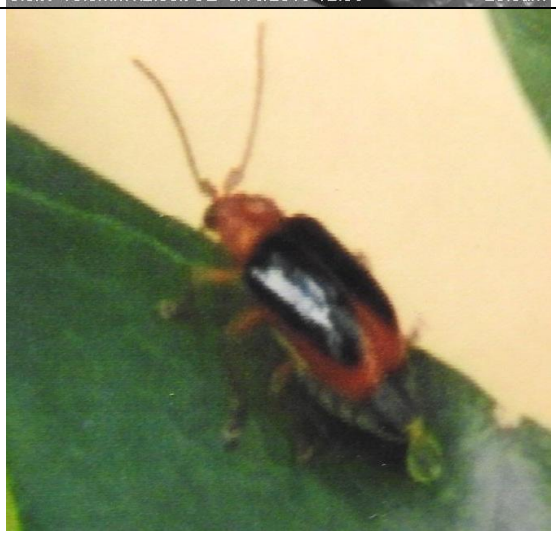
Fig.3 Insect and non insect pest of *Pongamia pinnata*

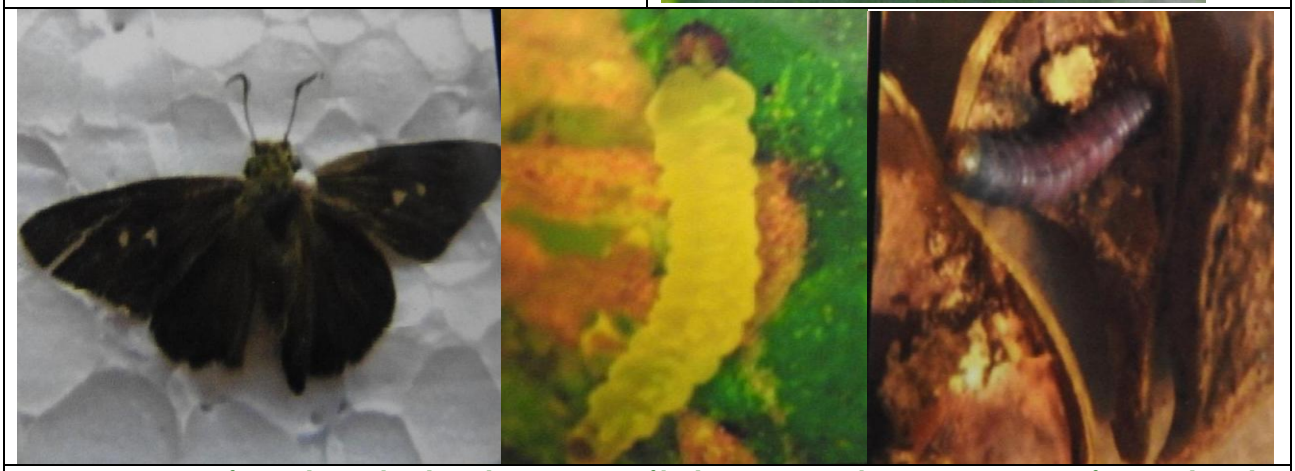
1. Adultof *M.ambuanalis* 2. Larva of *M. ambuanalis*3.Maggot of stem gall fly 4.Stem galls due to gall fly 5.Partially opened galls with maggots 6.Leaf blotch after minor emergence7. Grass hopper 8.Stem borer 8.Leaf galls due to eriophyid mite





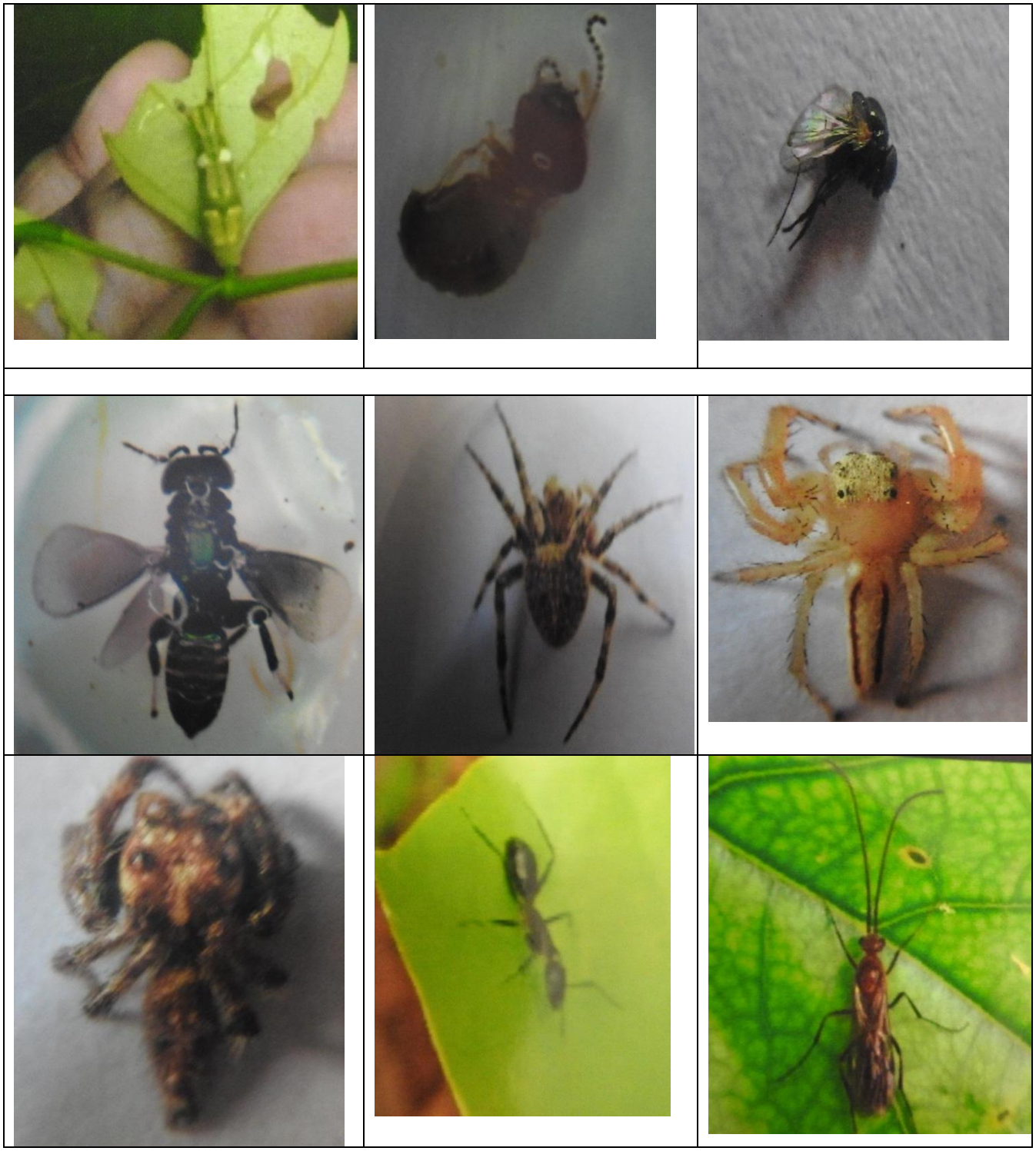






10.Posterior parts of mite alog with enlarged EMS image of bodyrings11.Mouth parts12. Structre oof mite enlarged EMS views13.*Diabrotica sp* 14 Adult of *Hasora chromus*15.Larvae of leaf minor16.Larva of *Ephestia cautela17.Curetis thetis* 18 Termite *Coptotermus sp*!9 Adult of gall making fly
Natural enemies-1.Eulophid parasitoid of leaf minor 2.Spotted ord weaver spider 3 two striped jumper spider

Fig.4 Natural enemies of insect pests of *Pongamia pinnata*



4.Heavy bodied jumper spider,Hyllus semicuprus Simon, 5. Black ant Lesius niger
6. Parasitoid unidentified

Infestation of leaf miner *Lithocolitis virgulata* Meyrick

The mean percentage plant infestation due to leaf miner attack was varied from minimum of 15% infestation during (1st fortnight of December 2018) to a maximum of 89.00% as recorded during first fortnight of October, 2018.(Table-4) Then no incidence was observed in fresh leaves up to first fortnight of March, 2019. Mean percentage of blotches harboring miner larvae varied from 5.00% (1st fortnight of December) to 80.00% during 2nd fortnight of September and 1stfortnight of October. A total of 28 species of insects including 1 species of Acarina are recorded to infest this plant which are categorized under 5 groups viz. i) Foliage feeders or defoliator ii) Stem borer iii) Bark borer iv)Sap feeder v) Seed feeder. The essentialities of present classification are that of Speight (2004).Out of the total species recorded 32.14% belongs to the order Lepidoptera, followed by 28.57% from Hemiptera, 14.28% each from Orthoptera and Coleoptera and 3.57% each from Acarian, Isoptera and Diptera. A total of 12 species of natural enemies including 5 species of spiders were also recorded.. Leaf miner (*Lithocolitis virgulata* Meyrick) has been reported as the major pest of this plant in Delhi, Hyderabad and Jabalpur by Sushil Kumar (1992). However, Orwa *et al.,* (2009) from Kenya reported the blotch miner in this plant as the major pest. The status of both the names is not clearly mentioned everywhere. Another related species of miner *Acrocercops syngramma* was reportedly attacking other plant of Cashew in several places of South India (Nair and Abrahim, 1982; Pillai,1979) but Fletcher (1919) had reported 70 species under Gracillaridae were be the leaf miners out of which 40 species were belonging to genus *Acrocercops* only. Workers like Lal *et al.,* (1996) from Eastern U.P. and Singh (1990) also opined bark eating caterpillar, *Inderbela quadrinotata* to be the number one pest of this plant at their places. Sundararaj *et al.,* (2005) reported a total of about 30 species of insects from Bangalore whereas Sahu *et al.,* (2016) from Raipur and Seth (2017) from Jabalpur observed 24 and 10 species of insect pest infesting this plant respectively as. major pest. The status of both the names is not clearly mentioned everywhere. Reports of occurrence of leaf miner in other countries like Myanmar, Srilanka, Nepal, Pakistan is also available. Anonymous (2010). From Kenya and AfricaOrwa *et al.,* (2009) reported 30 species of insect pests causing damage to *Pongamia pinnata (L.)Pierre*. *Hasorachromus* Cramer was also reported as the major pest of this plant during monsoon season by Harinath *et al.,* (2012). Occurrence of leaf gall mite in this plant in causing gall incidence is also reported from other places like Kerala, Nasareem and Ramani (2014) and Bangalore, Rani *et al.,* (2018). Sahu *et al.,* (2015) from Raipur, Chavan and Saxena from South Gujarat (2012) and Sundararaj *et al.,* (1984) from Bangalore, Haseeb *et al.,* (2000) from Aligarh were also reported natural enemy complex of pests infesting this plant. However, detailed studies on extent of parasitization of any parasites on any specific pest have not been available from any sources. Perhaps because of large size and difficulty to work in height particularly effective sampling methods attract fewer workers to work in detail. But huge scale plantation in all the possible areas with increase in number of insects and non-insect pests will force to formulate the area specific IPM strategies in which use of bio control agent is the important one. Although classification of insects as per their mode of feeding is available for important timber yielding trees like Sal, Sissoo, teak, acacia etc., it is the first attempt in this country to categorize the documented insects infesting this plant, based upon their mode of feeding. Among the species recorded defoliators were comprising 54% of the total and this is

followed by 31.14%% of sap feeders, other species of insect categories comprised of 14.86% of the total recorded species.. Stem gall fly incidence was recorded throughout the investigation period except from September 2nd fortnight to January 1st fortnight and the infested branches were also either regenerating branches or side tender shoots of pole or medium age trees. More than one maggot were recovered from each gall and highest (8.50 maggots/gall) number of maggots were recovered during August 1st fortnight, 2018.

The multilocular galls generally support one maggot in each chamber and adult flies come out of the gall by making holes. Pupation generally occurs inside the galls. The galls are formed by hypertrophy and hyperplasia of medullary and pith cells. Gall making flies and tehritids also possess the same characteristics (Johnston and Deneke, 2008). Being a general Dipteran more activity of this pest was found during rainy and post rainy season period. Population density fluctuation over a period of time is population dynamics which may be influenced by both the climatic and biotic factors. The men population density of *Hasora chromus* Cramer larva was found highest (19.80/plant) during October 1st fortnight, 2018 and lowest was found during December 1st fortnight, 2018 (1.95 larva/plant). However, during rest period of the year neither the larvae nor the eggs were reported. The availability is higher in post rainy period which was continued up to December 1st fortnight. This is in full agreement with Harinath *et al.,* (2012) from A.P. As observed from the present study the population is mostly confined to plants grown in swampy areas. Other skipper infesting paddy in Odisha made its significant presence in their major host plant paddy during the same period as reported by several workers Tripathy *et al.,* (2016). *Hasora chromus* is a polyphagous pest and other reported host plants are *Swietenia*, *Ricinus*, *Murraya*, *Pithecellobium*, Castor etc. Suryanarayan *et al.,* (2015) so during the period of unavailability it might be switched to any of its host plants or might undergo diapause or hibernation to spent winter which needs to studied in detail. *Maruca ambionalis* Felder is recently reported as a pest infesting this plant, but the appearance is for a short period The population of other related species *Maruca vitrata* is recorded from its major host plant pigeon pea during the pod development and flowering period i.e. October to December in major cultivation areas.

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