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Dr. MK Tripathy
Department of Natural Resource Management, College of Forestry OUAT, Bhubaneswar. Odisha, India

G Parida
Department of Natural Resource Management, College of Forestry OUAT, Bhubaneswar. Odisha, India

MC Behera
Department of Natural Resource Management, College of Forestry OUAT, Bhubaneswar. Odisha, India

Corresponding Author:
Dr. MK Tripathy
Department of Natural Resource Management, College of Forestry OUAT, Bhubaneswar. Odisha, India

Diversity of insect pests and their natural enemies infesting sal (*Shorea robusta* Garten f.) in Odisha

Dr. MK Tripathy, G Parida and MC Behera

Abstract
A field experiment was carried out at five different sites of Odishaie. at Silvicultural Research Station, Bhubaneswar, Barbara Reserve Forest, Khurdha district, Udala Reserve Forest, Athamlik, Angul district, Keonjhar forest Division, Keonjhar district, Bali, Cuttack district during the month of July 2018 to June 2019, to study the diversity of insect pests associated with Sal (*Shorea robusta* Garten f.) In Odisha and occurrence of their natural enemies. A total of 33 numbers of Phytophagus insects found in five different sites of Odisha were recorded and categorized into 5 classes based on their nature of damage. The important foliage feeders were Myllocerus beetle, Hawk moth, Sal defoliators, Chaffer beetle, Green drab, June beetle, Tent caterpillar, semiloopers etc. and sap feeders were Sal psyllid, Leaf hopper, Stink bug, tiny weevil, Cow bug, Gandhi bug etc. However, stem borers were found more damaging and causing more economic losses such as *Hoplocerambyx spinicornis*, Sissoo stem borer, Mango stem borer, Metallic wood borers etc. Three bark feeder species were recorded such as *Odonotermis obesus*, *Microtermis obesi*, *Indarbela quadrinotata*. Only root feeder sp. found during the study was white grub. A total of 39 sp. of natural enemies were recorded during study period including 7 bird spp. and 2 reptile spp. and one amphibian sp six species of spiders and 23 spp. of insects which needs proper conservation for avoiding future economic losses.

Keywords: Sal, Insect pests, natural enemies defoliators, xylophagus

1. Introduction
Sal (*Shorea robusta*), the most valuable timber species and distributed from Central to North India up to foothill of the Himalayas. It is also found in other countries like Nepal, Bangladesh, Pakistan etc. It occupies about 1, 05,790 sq. km or broadly 14.2 to 16% of the total forest cover of the country as per Tewari, 1995 [17] In Odisha, Sal forests of 38.300 sq. km is available which are tropical moist deciduous and dry deciduous types. Durability accomplished by water resistance, resistance to termite attack etc. has increased the diversity of its use from the exterior to internal .It is reported to be attacked by 346 species of insects by Mathur and Singh, 1961 [6] which attacks to roots, seeds, seedlings, full-grown timbers, storage, foliage *etc*. These herbivorous insects feed on different parts i.e. leaves, woods, barks, inflorescences, roots *etc*. of Sal trees and thus causing massive damage to tree health as well as timber quality. Being a slow growing tree, its growth is checked due to attack by several insect pests. The wood and bark boring insects, mainly belonging to the orders Dictyoptera, Isoptera, Coleoptera, Lepidoptera, and Hymenoptera, which bore into the wood in search of food or for shelter. Defoliators, skeletonizer and sapsuckers belong to the orders Coleoptera, Hemiptera, Thysanoptera, Lepidoptera are important in causing damage. As a result, the surface area for photosynthesis and transpiration is greatly reduced and the growth rate of trees, as well as timber quality, is hampered to great extent. The present day climatic and weather changes not only affect the status of insect pests but also affect their population dynamics, distribution, seasonal abundance, intensity and feeding behavior. The intensity of change in climatic ecosystem noted by meteorological science has shown a direct and indirect effect on the prey and host relationship, their immune responses and rate of development. Both abiotic (temperature, humidity, light) and biotic (host, vegetative biodiversity, crowding and diets) stresses significantly influence the insects and their population dynamics. In response to these factors, the insect may prolong their metamorphic stages, survival and rate of multiplication. Sal, although acts as a valuable timber still not preferred for afforestation rather managed as shelter wood system with natural regeneration but the pest problem is likely to be aggravated in near future per increase in regenerated area. Several earlier workers like Fleture 1914 [17], Beeson1941 [2] and Browne 1958 [1] *etc*. has described various insects pests infesting Sal trees

of the country. Proper documentation of insect pests along with knowledge on their ecology and population dynamics is also considered important for formulating proper IPM strategies which may be the greater need in near future to protect such valuable species in different growing areas of different regions. In Odisha no such work has been undertaken by any sector till date to document the species of insects damaging Sal trees in different parts of the year nor their natural enemies. Hence, in the present study, an attempt is being taken to document the species and natural enemies' occurrence in three different principal forest types of Odisha which will pave the way for planning for proper conservation of this species in the future.

2. Materials and methods: The details of materials used and methodology followed in the experiment are discussed here under.

2.1 Site and season: The present investigation was carried out from July, 2018 to July, 2019 at different locations of the state as detailed in Table 1. all the studied locations experienced a very hot summer and mild winter. Winter season experienced the minimum temperature of 13 ^{0}C at Bhubaneswar, 14 ^{0}C at Khurda, 15 ^{0}C at Cuttack, 16 ^{0}C Angul and 15 ^{0}C Keonjhar. Total annual rainfalls of the places were 1995.2 mm, 1541mm, 1539 mm, and 1466.19 mm and 1426.48mm respectively. Mean maximum monthly temperature of the studied locations during the month of April was 37.5 ^{0}C at Bhubaneswar, at 39.4 ^{0}C at Khurda, 40.8 ^{0}C at Cuttack and 39 ^{0}C and 42 ^{0}C at Angul respectively. The minimum R.H was recorded to be ranged from 64.5% to 86.5% at Bhubaneswar, 53.5% to 79.5% at Khurda, 52% to 77.5% at Cuttack, 43% to 85% at Keonjhar and 41% to 81% at Angul during the year under study.

Table 1: Details of survey localities and situation

Sl no	Name of the location	GPS reading	Frequency of sampling	Forest type with dominant sp of trees
1	Silviculture Research Station, Ghatikia , and Forest Park Bhubaneswar	20º15`North latitude and 85º52' Eastlongitude Altitude-25.9 msl,	once in each month	Semi evergreen forest type Soil – Red lateric
2	Berbara Reserve Forest ,Khordha	19º86`Northlatitudeand 85º02' East longitude Altitude-25.9msl,	Twice in each season	Moist deciduous forest type Soil-lateritic and mountainous soil
3	Bali Reserve Forest ,Cuttack	20º53`Northlatitudeand85º80' EastlongitudeAltitude-36.0 msl,	Twice in each season	Forest type- Dry deciduous forest Sandy loam acidic soil dominant species Sal
4	Udala Reserve Forest , Athmallik Augul	l20º43`North latitudeand84º31'Eastlongitude Altitude-195msl	once in each season	Forest type- Tropical dry and moist deciduous forests. Soil-Deep loam, red and lateritic.
5	BJP Range, Keonjhar Division	21º70`North latitude and 85º24'East longitude 480 msl	once in each season	Forest type-Northern tropical moist deciduous and dry deciduous forest type. Soil- Red, red laterite rich in potassium. PH- 5.5-6.

2.2. Preservation and Identification of Insects pests of Sal plant: The following sampling methods were used. (1) Trapping- (a) Pheromone traps for catching flying butterflies. (b) Pit fall trap for collecting small dwelling soil insects (2) Beating and jerking –Pole size plants were beaten by a hand stick and falling insects were collected manually by a white cloth or umbrella as per feasibility .The collected insects were poured in a plastic container and brought to the laboratory for identification and counting. (3)Netting- Slow moving insects were collected by a swift net.

2.3. Killing, Pinning and Mounting

Killing was done immediately after capture. Benzeneandethyl acetate was used for killing insects .Ethyl acetate kills the insects more slowly and does not last long. Insect were also killed by using ethyl alcohol or isopropyl alcohol. After killing the insects were pinned to preserve hard bodies so that they will dry and remain in perfect condition on pins without requiring any further treatment. During drying the outer exoskeleton remains intact and the inner soft tissues were dried up. Insects were pinned directly if they were big, they were pinned in such a way that all important diagnostic characters can be viewed clearly. They were pinned vertically through their body. Mounting was done in small insects and all the 3 types of mounting such as staging, carding, pointing were followed.

Staging- the stage was a narrow rectangular piece of pith or corkwhere insects were kept.

Carding- a rectangular white card or celluloid bit was used as a stage in some cases`.

Pointing -The insect specimen was glued to a card or celluloid cut into a triangle of 10 mm height and 5 mm baseand used during identification.

2.4. Identification: Immature stages of Lepidopterous and Coleopterous insects were reared in the post graduate 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 as followed by Patil *et al*., 2016 [9] Insect predators and parasites were identified either by directly collected from field or by rearing of field collected countable number of eggs. The identity was confirmed from bio-control laboratory of Entomology Department, College of Agriculture. Bird predators were identified by taking constant observation on their feeding habit during the day time, taking their photograph and matching with standard monographs.as like Tripathy *et al.*, 2018 [18]

3. Results and Discussion

In the present study we have recorded a total of 33 species of phytophagus insects from Sal in different forest types of the State (Table-2). Although large number of insect pests are found to be associated, only few of them were able to cause damage, thus attended pest status. About 145 species of insects attacking this plant have been reported by Nair, 2007 [7] from India infesting living plants and about 346 insect species are reported to be associated with living and felled timbers by few earlier workers. Those include mainly defoliators (108), Borers (20), Sap feeders (17), and 4 species of sap suckers as reported by Stebbing, 1914 [16]; Beeson, 1941 [2]; Mathur and Singh, 1960 [6]; Browne, 1968 [1] and

Thakur, 2000 [19]. Sal has highest number of insect fauna among the forest trees. Only 155 species of insects are associated with living trees. Among these, the Sal heartwood borer, *Hoplocerambyx spinicornis* Newman (Coleoptera : Cerambycidae), commonly known as Sal borer, is the most devastating insect pest responsible for catastrophic damage of Sal forests of India as opined by several earlier workers like Bhandari and Singh, 1988 [3], Roychoudhury 2017 [12], Roychoudhury *et al.* 2018 [13]; 2019 [14]. In Odisha it was found that a total of 17 defoliators constituting 52% of all the recorded phytophagus species was infesting Sal plants in natural situation, which was followed by sap feeders, (8 species and 24%) and stem borers (4 species and 12%) and only a single species was enlisted as root feeder constituting 3% of the total reported species (Figure-1). Categorizing the insect pests on taxonomic basis revealed that as highas11 species were belonging to Lepidoptera (29%) followed by 9 species from Coleoptera (29%), 7 species from Hemiptera (23%) along with lowest number of species belonging to Thysanoptera (Fig:2). The immature stages of *Holotrichia* species as found in the present study has been recorded from teak seedlings in forest nurseries by earlier workers like Oka and Vaishampayan1979 [8] and Vaishampayan and Bhandari, 1981 [21]. Stem borers are often considered as important pest of Sal causing considerable losses of the stand. In the present study we have recorded 4 species of Stem borers including the most notorious one i.e., *Haplocerambyx spinicornis*. Incidence of this pest has been reported earlier by workers like Roychoudhury *et al.* 2019 [14] from Kanha Tiger Reserve of Madhya Pradesh and. Prakasam *et al*. 2003 [10] in central India. This pest is widely distributed in Central and North India The defoliating semilooper found in the present study was already reported by Singh and Thapa,, 1988 [15]. from Deheradun of N. India. Another notorious polyphagus stem borer *Acanthophorus serraticornis* was also recorded from one of the study site at Keonjhar which has been primarily reported from Sissoo in India and also the largest reported beetle from the country as viewed by Ghate *et al*. 2003 [5] with *Mangifera indica, Bombax malabaricum, Morus alba*, and *Shorea robusta* serving as its hosts which was initially reported by Beeson 1941 [2].

Two species of bark feeder's viz., termites and bark borer (*Indarbela quadrinotata*) are reported from teasel plants. Termites although not causing mortality in large plants but can make them vulnerable to biotic stressesbut in young species they are highly polyphagous. The pest *Indarbela* has been reported to infest 70 plants species across the forests and avenue plantations of the country by Verma & Khurana, 1978 [20]. Among the 33 species of insect pest reported of Sal of this studied areas majority were found during rainy season whereas few defoliators like semiloopers and pyralids were also appeared during pre-rainy and late summer season coinciding with appearance of new flushes along with floral shoots in the plants. Few sap sucking insects like mealy bug, psyllids, one species of stink bug, thrips were also found during winter season (Table -2). In the present study, total 8 species of sap feeding insects are reported. It is a fact that forest plants being larger in size are less affected by the action of sap feeders, but in seedlings the loss is same like the action due to defoliators. There may be a direct loss of foliage's arising from a wound reaction to infection of saliva by the feeding insects. Growth may be stunted with reduced base diameter, very often promotes forking in later phases which may makes it unfit for timber. As the psyllid *Trioza minor* appeared for a short period in the early spring season at all the studied area and the damage caused to the new leaves are felt less damaging by causing small pit galls. Sal being an indigenous tree harbors a number of trees and under story bushes as well as herbs in the growing ecosystem, which favors the growth and multiplication large number of natural enemies including predators, parasites and pathogens. This has been presented in Table 3. Forest being a natural permanent ecosystem also supports large number of insects along with their natural enemies and so also Sal forests. At present the increased pest problems experienced in plantations is due to disruption of natural enemy's action. The attainment of pest status by some species those are accidentally introduced in a region is due to absence of their natural enemies. In the present study we have recorded as high as 39 natural enemies of different types including two parasitic insects in different studied Sal forests of the state. The percentage composition of each group of natural enemies are aves, 15%, amphibian 3%, acarines 18% Insects 56% and reptiles 8%. Among insects hymenoptera is the dominant order followed by coleopteran recording 8 and 6 species respectively.

Reports on augmented biological control in Sal forest is quite migre from India. As reported by Beeson 1941 [2] up to 10-15% vacant Sal borer pupae chamber was found to be occupied by *Apanteles serbidus* but for Teak vast literature is available from the state by Rout 2017 [11]. It is due to the fact that Sal plants are mostly found in natural forests and required more manpower for working in tropical forest situation.

Table 2: Diversity of different phytophagus insects of Sal at different study sites during the experimental period (2018-19)

Sl.no	Common name	Scientific name	Family	Order	Pest category	Status	Season of peak activity
1	Jewel bug	*Chrysocoris stolii*wolff	Scutellaridae	Hemiptera	Sap sucker	Minor	Rainy season
2	Gundhi bug	*Leptocorisa oratorius* Fab	Alydidae	Hemiptera	Sap sucker	Minor	Rainy season
3	Cow bug	*Oxyrachis sp.*	Membracidae	Hemiptera	Sap sucker	Minor	Rainy season
4	Sal psylid	*Trioza minor* Crawford,	Psyllidae	Hemiptera	Sap sucker	Major	Rainy season
5	Mealy bug	*Pseudococcus sp.*	Psuedococcidae	Hemiptera	Sap sucker	Minor	Winter season
6	Tiny weevil	*Apion sp.*	Apionidae	Coleoptera	Sap sucker	Minor	Winter season
7	Stink bug	*Asopus malabaricus*Fab	Pentatomidae	Hemiptera	Sap sucker	minor	Winter season
8	Leaf hopper	*Nephotettixsp.*	Cicadelidae	Hemiptera	Sap sucker	minor	Summer season
9	Semi looper	*Ascotis selenaria*Walker	Geometridae	Lepidoptera	Defoliator	Major	Rainy and summer season
10	Thrips	Unidentified	Aeolothripidae	Thysonptera	Defoliator	Minor	Winter season
11	Hawk moth	*Acherontia styx*Westwood,	Sphingidae	Lepidoptera	Defoliator	Minor	Rainy season
12	Tussock moth	*Lymantria semicincta*Walker	Lymantridae	Lepidoptera	Defoliator	Major	End of summer

13	Myllocerus beetle	*Myllocers usevasus*Marshall,	Curculionidae	Coleoptera	Defoliator	Major	Rainy season
14	Bag worm	*Pteroma plegeophleps*	Psychidae	Lepidoptera	Defoliator	Minor	Winter season
15	Tent caterpillar	*Trabala vishnu*Lafebvre	Lasiocampidae	Lepidoptera	Defoliator	Major	Winter season
16	Myllocerus beetle	*Myllocerusdiscolor*Marshall	Curculionidae	Coleoptera	Defoliator	Occasional major	Rainy season
17	June beetle	*Adoretus bicolor*Brenske	Scarabidae	Coleoptera	Defoliator	Occasional major	Rainy season
18	Hairy caterpillar	*Selepa celtis* Moore	Nolidae	Lepidoptera	Defoliator	Major	Summer season
19	Grass hopper	*Oxyia velox* Fab	Acrididae	Orthoptera	Defoliator	Major	Rainy season
20	Green drab	*Ophius atirhaca*Cramer	Erebidae	Lepidoptera	Defoliator	major	Rainy season
21	Short horned grass hopper	*Arphia conspersa*Walker	Acrididae	Orthoptera	Defoliator	Major in seedlings	Rainy season
22	Sal defoliator	Unidentified	Pyralidae	Lepidoptera	Defoliator	Major in all stages	Spring and summer
23	Chafer beetle	*Holotrichia serrate* Fab	Scarabidae	Coleoptera	Defoliator	Major	Rainy season
24	Slug caterpillar	*Althanivea* Walker	Limacodidae	Lepidoptera	Defoliator	Minor	Summer season
25	Slug moth	Unidentified	Limacodidae	Lepidoptera	Defoliator	Minor	Summer season
26	Brown Grasshopper	*Diabolocatantops portentosus*Walker	Acrididae	Orthoptera	Defoliator	Minor	Summer season
27	Termite	*Odontotermisobesus*Rambur	Termitidae	Isoptera	Bark feeder	Major	Winter season
28	Termite	*Microtermis obesi*Holm Grain	Termitidae	Isoptera	Bark feeder	Major	Winter season
29	Bark feeder	*Indarbela quadrinotata*Walker	Metarbelidae	Lepidoptera	Bark feeder	Major	Rainy season
30	Sal heartwood borer	*Haplocerambyx spinicornis* Newman	Cerambycidae	Coleoptera	Stem borer	Occasional but major	Rainy season
31	Metallic wood borer	*Psilopteracupreosplendes* Saunders	Buprestidae	Coleoptera	Stem borer	Occasional and minor	Rainy season
32	Mango stem borer	*Batocerarufomculata*Degeer	Cerambycidae	Coleoptera	Stem borer	Major	Rainy season
33	Sisoo stem borer	*Acanthophorus serraticornis*Olivier	Cerambycidae	Coleoptera	Stem borer	Major	Rainy season

Table 3: Natural enemies of major insect pests of Sal recorded in different study sites during the observation period (2018-19)

Sl no	Common name	Scientific name	Family	Order	Category	Area of availability
1	*Hasselt's spiny spider*	*Gastercantha hasselti* Koch	Araneidae	Arenae	Predator	Bhubaneswar, Keonjhor, Athamallik
2	*Oriental spiny orb weaber*	*Gastercantha geminate* Fab	Araneidae	Arenae	Predator	Bhubaneswar, Bhubaneswar, Keonjhor, Athamallik
3	Golden orb spider	*Nephilia spp.*	Araneidae	Arenae	Predator	Bhubaneswar
4	*Jumping spider*	*Telmonia dimidiate* Simon	Salticidae	Arenae	Predators	Bhubaneswar
5	Acrobat ant	*Crematogaster sp*	Formicidae	Hymenoptera	Predator	Keonjhar
6	Ground beetle	Unidentified	Carabidae	Coleoptera	Predator	Bhubaneswar
7	Pepcid spider wasp	Unidentified	Pompilidae	Hymenoptera	Predator	Keonjhar
8	Mud dubber wasp	Unidentified	Sphecidae	Hymenoptera	Predator	keonjhar
9	Assassign bug	Unidentified	Reduviidae	Hemiptera	Predator	Keonjhar
10	Stag beetle	Unidentified	Lucandiae	Coleoptera	Predator	Barbera, Khurda
11	Six spotted ground beetle	*Anthias exguttata* fab	Carabidae	Coleoptera	Predator	Barbera, Khurda
12	Diving beetle	Unidentified	Dytiscidae	Coleoptera	Predator	Barbera,Khurda
13	Water strider	Unidentified	Gerridae	Hemiptera	Predator	Barbera, Khurda
14	Bark mantis	*Gyromantis sp.*	Mantoidea	Dictyoptera	Predator	Barbera, Khurda
15	Daddy long leg spider	Unidentified	Pholcidae	Arenae	Preadtor	Barbera, Khurda
16	Golden silk orb weaver	*Nephila sp.*	Araneidae	Arenae	Predator	Bhubaneswar and Barbera
17	Red grass hawk	*Neurothormis fluctuans*Fab	Libellulidae	Odonata	Predator	Barbera
18	*Dragon fly*	*Libellula pulchella*Drury	Libellulidae	Odonata	Predator	Barbera
19	Paper wasp	Unidentified	Vespidae	Hymenoptera	Predator	Barbera
20	Pepcid spider wasp	Unidentified	Pompilidae	Hymenoptera	Predator	Barbera
21	Sand Wasp	Unidentified	Crabronidae	Hymenoptera	Parasites	Barbera, Khurda
22	Long legged fly	*Condylostylus spp.*	Dolichopodidae	Diptera	Predator	Barbera, Khurda
23	Earwig	Unidentified		Dermaptera	Predator	Barbera, Khurda

24	*Indian common club tail*	*Ictinogomphus rapax* Rambur	Gomphidae	Odonata	Parasite	Athmallik
25	Weaver ant	*Oeophylla smaragdina*Smith	Formicidae	Hymenoptera	Predator	Athmallik
26	Tree borer parasite	*Xanthocryptus sp.*	Xanthomonidae	Hymenoptera	Predator	Athmallik
27	Stink bug	*Cantheconidia sp.*	Pentatomidae	Hemiptera	predator	Athmallik
28	Stink Bug	*Delepada sp.*	Pentatomidae	Hemiptera	predator	Bali, Cuttack
29	Black napped golden oriole	*Orolus chinensis*	Oriolidae	Passeriformies	predator	Barberaforest ,Khordha
30	Black hooded golden oriole	*Oriolus xanthornus*	Oriolidae	Passeriformies	predator	Barberaforest ,Khordha
31	Common myna	*Acridotheres tristis*	Sturnidae	Passeriformies	predator	Barberaforest, Khordha
32	Blue jay	*Cyanocittacristata*	Corvidae	Passeriformies	predator	Barberaforest, Khordha
33	Jungle barbler	*Argyastriata*	Leiothrichidae	Passeriformies	predator	Barberaforest, Khordha
34	Black kite	*Milvus migrans*	Accipitridae	Accipitriformes	Predator	Barberaforest ,Khordha
35	Oriental magpie robin	*Copschus saularis*	Muscicapidae	Passeriformies	Predator	Barberaforest,K hordha
36	Garden lizard	*Clotes versicolor*	Agamidae	Squamata	Predator	Athamalik
37	*Chameleon*	*Chamaelo calyptratus*	Chamaeleonidae	Squamata	Predator	Athamalik
38	*Chameleon*	*Chamaeleo zeylanicus*	Chamaeleonidae	Squamata	Predator	Athamalik
39	*Frog*	*Fejervaria orissaenis*	Dicroglossidae	Anura	Predator	Athamalik

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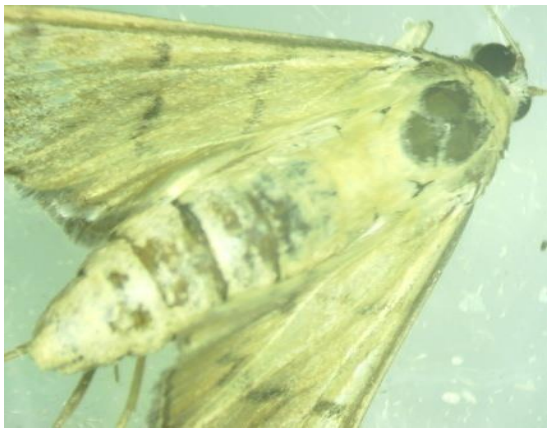

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Fig 1A: Phytophagus insects infesting Sal plants in different study sites(1 to 30) 1 *Chrysocoris stolli* 2 *Leptocorisa oratorious* 3 *Holotrichia serrate* 4 Sal psyllid 5 metalic wood boring beetle Myllocerus beetle6 *Apion* sp 7brown grass hopper 8 Hawk Moth9Mangostem borer 10 grass hopper 11. *Arphia* 13 Pentatomid14Pentatomid *15Inderbela quadrinotata* 16leaf hopper 17 June beetle adult*18Acanthophoris serraticornis* 19pentatomid 20*Acaraga sp* 21 slug cater pillar22Salheartwood borer 23Bagworm 24.mealy bugs25 greendrab larva 26 green drab pupa 27Green drab adult 28Pyralid larva defoliator 29 Semilooper 30 Defoliating caterpillar

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Fig 1B: Natural enemies of pests of Sal 1 *Ictinogomphus rapax* 2 Cicindelidae 3 Golden orb spider 4 *Nephila sp.* 5. *Gasteracantha hasselti* 6*Telamonia dimidata* 7 *Xanthocryptus sp.* 8 Praying mantis 9 Assassign bugs10 red ant11 Ground beetle12 Daddy long leg spider 13mud dabber wasp 14 sand wasp 15 dytiscid16 pompilid wasp17 18carabid beetle 19 chamelion 20 Garden lizard 21 Chamelion 22 Frog 23Chamelion 24 Orieole

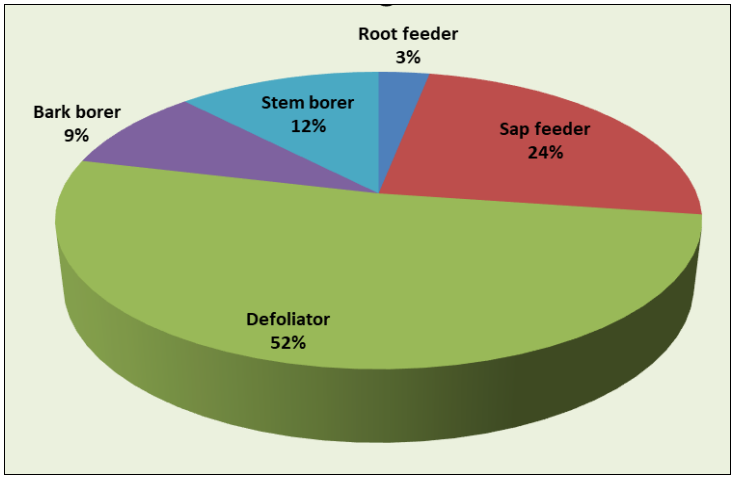

Fig 2: Distribution of Insects as per nature of damage in Sal

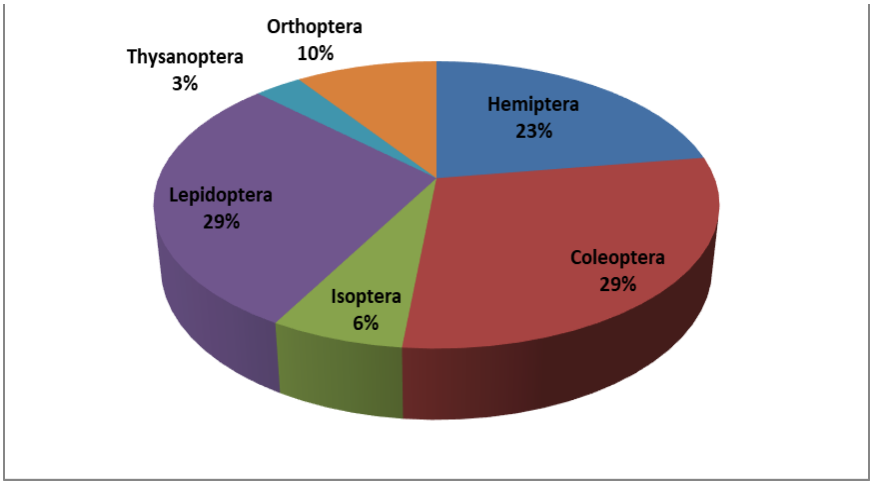

Fig 3: Distribution of Insects according to families infesting Sal plants of the studied area (2018-19)

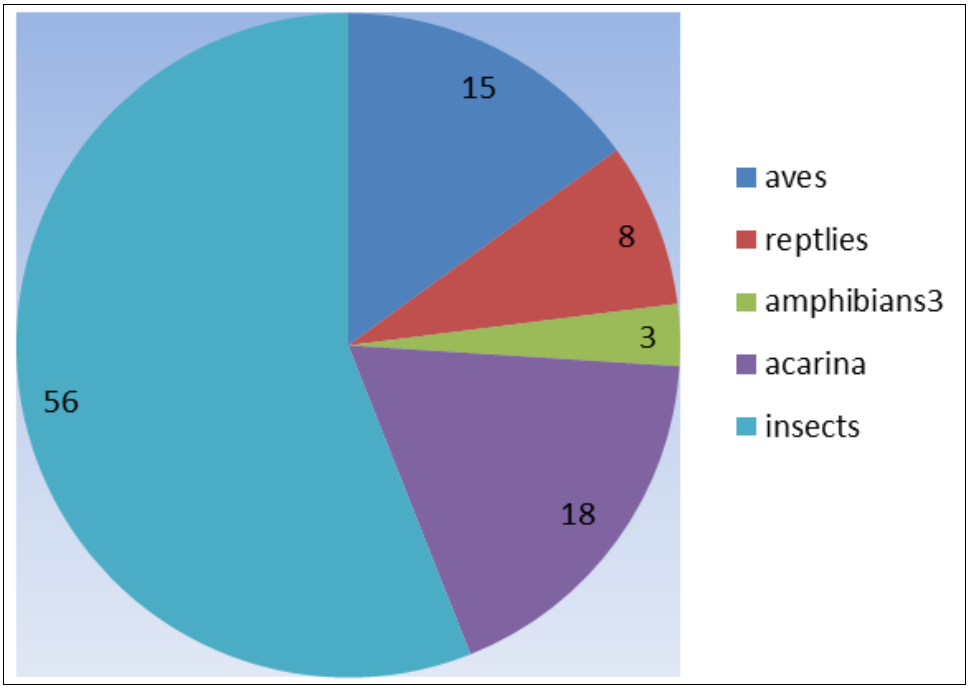

Fig 4: Percentage distribution of different categories of natural enemies

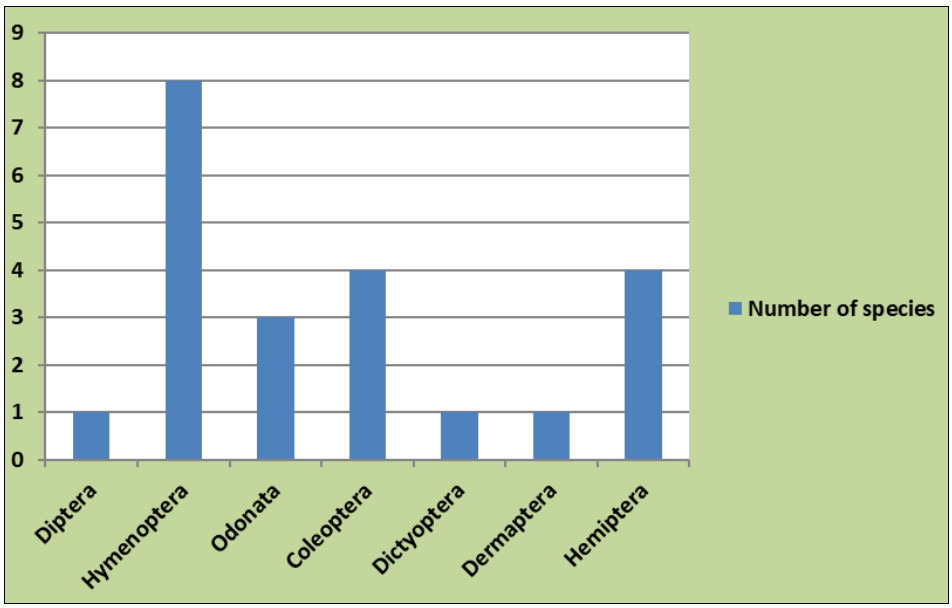

Fig 5: Distribution of Insect natural enemies in different orders (2018-19)

4. Conclusion

A total of 33 species of phytophagus insects pests belonging to five different categories based on feeding behavior were recorded, from different Sal growing forest areas of the State of Odisha. whereas a total of 39 species of natural enemies including seven bird species and three reptiles one amphibian predator and 23 insect species were also recorded. It is needed for taking appropriate conservation measures of natural enemies for conservation of the puresal dominated forests in the future.

5. References

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