BIOLOGY OF THE SAL DEFOLIATOR *ASCOTIS IMPARATA* WALK. (LEPIDOPTERA: GEOMETRIDAE)

K.P. SINGH AND R.S. BHANDARI

Forest Entomology Division,
Forest Research Institute, Dehra Dun (India).

Introduction

Sal (*Shorea robusta* Gaertn. f.) suffers insect damage at every stage right from seed to finished products. It is attacked by as many as 241 insect species, out of which 145 feed on green standing sal, which may be grouped as seed insects (16), nursery pests (5), defoliators (105), stem and root borers (15) and sap suckers (4) as reported by Mathur and Singh (1960). Among defoliating insect species, the major defoliator is *Ascotis imparata* Walker (Lepidoptera: Geometridae). *A. imparata* causes considerable damage which leads to significant ecological and economic impacts to sal. The effect of insect defoliation on growth and mortality of trees has been studied by various workers (Champion, 1934; Staley, 1965; Nicholas, 1968; Nair *et al*., 1985). Due to repeated defoliation, dieback of tender shoots and deformities result, affecting the growth and increment. Defoliation has a direct effect on photosynthesis and thus on the growth of plant. Sometimes defoliation can cause rapid and significant crown die back (Staley, 1965; Nicholas, 1968). The effect of defoliation is more evident in case of slow growing tree species such as sal.

A. imparata is widely distributed in all parts of the country including northern, central and southern India. It is a cosmopolitan insect species distributed throughout China, Congo, Europe, India, Israel, Japan, Myanmar, Pakistan, South Africa and other tropical and sub-tropical regions (Chatterjee, 1935; Beeson, 1941; Browne, 1968; Zhang, 1994). The insect has wide distribution range in Uttar Pradesh and Uttarakhand. Kulkarni *et al*. (1995) reported its damage from Jabalpur (Madhya Pradesh) and Karnataka in India. The outbreak of *A. imparata* causing serious defoliation in sal, bakain (*Melia azedarach*) and raini (*Mallotus philippinensis)* has been reported by Beeson (1941), Singh and Thapa (1988) and Khan (1995). The insect species also infests *Dalbergia sissoo* in Pakistan (Chaudhary and Khan, 1966). Although brief and scattered information on the biology and life history of *A. imparata* was available but systematic and thorough study on the biology of the pest is lacking (Beeson, 1941; Browne, 1968; Singh and Thapa, 1988). Detailed information on the pest biology, seasonal history, life-cycle and peak period of activity in order to evolve suitable control measure of the pest are given here.

Material and Methods

During the course of study, various

localities were surveyed and immature and adult stages of the defoliator *A. imparata* were collected from forest nurseries and natural stands in and around Dehra Dun. The areas visited include various forest ranges including Choharpur, Langha, Timli, Kalsi and Thano under Dehra Dun Forest Division (Uttarakhand) during April 1999 to September, 2002.

The immature stages were collected from attacked sal trees by hand picking and sweeping in the morning hours. The collected larvae were brought to the laboratory in plastic tubes (10 cm x 4 cm) with the open end covered over with a piece of muslin cloth tied with rubber band. The larvae were released inside glass chimney cages, provided with fresh leaves regularly. Pupal stages of *A. imparata* were also collected by digging out the soil around sal tree bases. Ten samples of 30 cm x 30 cm were taken randomly in the drip line area.

The larvae were reared in mass as well as individually in glass chimney cages and also using wooden cages fitted with wire mesh and glass (60 cm x 60 cm x 90 cm) (Figs. 1 and 2), respectively. The fresh leaves were provided as food on alternate days after replacing the old leaves. In order to study the copulation, oviposition, fecundity and longevity of the adults separate experiments were conducted. In each experiment, ten pairs of moths of *A.imparata* were kept in glass chimney cages. Besides this, the sugar solution soaked in cotton was kept in each cage for feeding the moths.

The oviposition and percentage of hatching were also recorded. After hatching of eggs the newly hatched larvae were transferred individually inside the small glass tubes (10 cm x 2 cm) with open end corked, having a hole covered over with muslin cloth for the study of moulting etc. The fresh and tender leaves were supplied daily as food. The observations on the larvae and their development, duration of each larval stage, the number of instar, size and colour and feeding habit of each instar were recorded. The studies on pupa and its duration (pupal period) were also recorded in the laboratory.

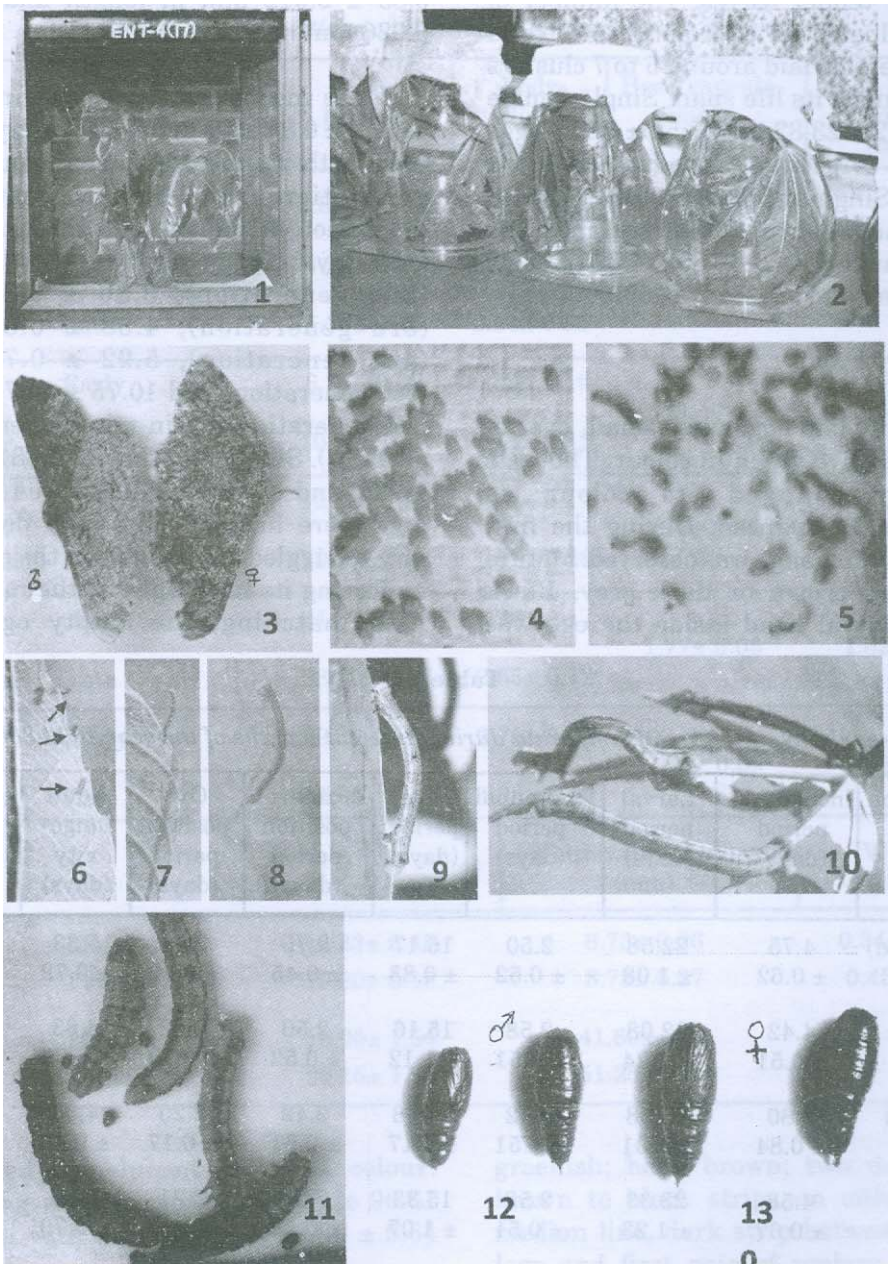
Morphological observations were made on immature and adult stages like egg, larva, pupa and adults of *A. imparata* using stereo-zoom research microscope. Ocular micrometer and stage micrometer were used for measuring various body parts. The weight of male and female pupa was recorded with electronic balance. Ten randomly selected immature and adult stages were taken for recording measurements.

Results and Discussion

Mating and oviposition : Mating was not observed immediately after emergence but started after 5 to 6 hours after emergence. During the process of mating, male moth mounted on the female and copulated (Fig. 3). The male fluttered its wings whereas in female, the wings remained in normal resting position. Pairing lasted for 127 to 164 mins with an average of 147.50 11.91 mins. Copulation took place only once, after which the male became sluggish and later on died. The mating took place during night hours, but some time it took place during the day time also.

Female moth after copulation laid eggs after 2.42 0.51 to 3.25 0.87 days (pre-oviposition period). Eggs were laid in the form of clusters and often laid singly

Figs 1-13



Ascotis imparata Walk.

1. Rearing of larvae in wooden cage; 2. Rearing of larvae in chimney cages; 3. Mating moths; 4. Freshly laid eggs; 5. Hatching of eggs; 6. I-instar larvae; 7. II-instar larva; 8. III-instar larva; 9. Late IV-instar larva; 10. Late V-instar larvae; 11. Pre-pupae; 12. Male pupae; 13. Female pupae

on the leaf surface, preferably on the lower surface of tender leaves. The number of eggs per cluster varied from 20 to 300 and a gravid female laid around 5 to 7 clusters of eggs during its life span. Single female laid 429.92 23.82 to 658.58 38.39 eggs during its oviposition period which lasted 2-3 days. Singh and Thapa (1988), Tiwari (1994) and Mishra (2000) reported the oviposition period as 52.83 4.02 to 66.92 3.45 hours and fecundity of 500-600 eggs.

Eggs (Fig. 4 & 5)

Freshly laid eggs were small, oval in shape and olive green in colour. The eggs gradually changed its colour as development advanced. During the first three days no change was observed. Mature egg turned brown or dark grey. Black coloured larval head inside the egg was visible from outside. The egg measured 0.83 0.012 mm in length and 0.52 0.026 mm in width (Table 1).

The incubation period was recorded as 3.80 0.84 days in the laboratory during the month of June-July. In each successive generation from first to sixth, the incubation period was recorded as 4.75 0.62 days (1st generation), 4.42 0.51 (2nd generation), 3.80 0.84 days (3rd generation), 4.58 0.67 days (4th generation), 5.92 0.79 days (5th generation) and 10.75 0.87 days in 6th generation i.e. in winter generation (Table 2). Singh and Thapa (1988), Tiwari (1994) and Khan (1995) observed that the eggs were hatched in 3 to 5 days. The larva wriggled out itself from the egg shell by forcing its head against the micropile. After hatching, the empty egg shell

Table 1

Seasonal biology of Ascotis imparata during different months of the year 2000-2001

Generations	Incubation period (days)	Larval period (days)	Pre-pupal period (days)	Pupal period (days)	Pre-oviposition period (days)	Oviposition period (days)	Adult longevity (days)	Total life period (days)
March (mid)	4.75 0.62	22.58 1.08	2.50 0.52	16.17 0.83	2.75 0.45	2.34 0.22	5.33 0.79	56.32 1.35
May	4.42 0.51	22.08 1.24	2.58 0.51	15.16 1.12	2.50 0.52	2.22 0.19	4.83 0.72	53.79 1.31
June (last)	3.80 0.84	21.58 1.31	2.42 0.51	14.08 1.17	2.42 0.51	2.20 0.17	4.86 0.86	51.36 1.32
August	4.58 0.67	23.33 1.23	2.58 0.51	15.33 1.07	2.50 0.52	2.21 0.16	5.50 0.79	56.03 1.22
Sept. (last)	5.92 0.79	25.92 1.31	4.42 0.67	18.50 1.17	2.50 0.52	2.57 0.29	5.75 0.62	65.58 1.70
Nov. (last)	10.75 0.87	32.92 1.56	8.17 0.72	64.42 3.45	3.25 0.87	2.79 0.14	6.42 0.51	128.72 1.63

Table 2

Biometric observations on different stages of Ascotis imparata

Stages		Body Length (mm)	Body Width (mm)	Head capsule length (mm)	Head capsule width (mm)
Egg		0.83 0.012	0.52 0.026	-	-
Larva	Early	1.99 0.05	0.24 0.007	0.34 0.007	0.35 0.007
I- Instar	Late	5.30 0.48	0.84 0.09		
Larva	Early	6.31 0.42	0.89 0.16	0.63 0.02	0.66 0.03
II- Instar	Late	10.50 0.53	1.12 0.32		
Larva	Early	12.73 0.88	1.19 0.11	1.07 0.02	1.10 0.03
III- Instar	Late	19.20 0.63	1.87 0.26		
Larva	Early	21.87 1.13	1.98 0.17	1.77 0.06	1.82 0.05
IV- Instar	Late	28.00 0.67	2.65 0.12		
Larva	Early	29.73 0.79	2.76 0.09	2.70 0.09	2.92 0.07
V- Instar	Late	55.60 1.40	4.35 0.10		

			Width/wing expanse (mm)	Weight (gm)
Pupa	Male	16.83 0.48	6.73 0.26	0.34 0.063
	Female	19.30 0.48	8.73 0.37	0.45 0.09
Adults	Male	19.00 1.54	41.60 3.44	-
	Female	20.15 1.73	51.25 3.86	-

appeared translucent white in colour. Hatching was recorded as 70.91 to 96.61 per cent with an average of 85.99 9.64 per cent.

Larva

First instar larva (Fig. 6) : Body base is greenish; head brown; two dorsal dark brown to black strips on either side of median line, dark strip between thoracic legs and first pair of prolegs ventrally. Thoracic legs were with some black patches. The duration of first stadium was 2.50 0.52 days. The length and width of newly hatched larva was measured 1.99

0.05 mm and 0.24 0.007 mm, respectively. The late instar larva measured 5.30 0.48 mm long and 0.84 0.09 mm wide. The head capsule measured 0.34 0.007 mm long and 0.35 0.007 mm wide (Table 1).

Second instar larvae (Fig. 7) : Body is generally light green and mottled with white spots of irregular shapes and sizes. Ventrally abdomen darker between the third thoracic legs and first prolegs. Head is pale and mottled with white markings. The duration of second stadium was is 2.50 0.52 days.The body length and width of early instars larvae measured 6.31 0.42 mm and 0.89 0.16 mm, respectively. While late instar larva measured 10.50 0.53 mm in length and 1.12 0.32 mm in width. Head capsule measured 0.63 0.02 mm long and 0.66 0.03 mm wide (Table1).

Third instar larva (Fig. 8) : Body colour is greenish brown to dark brown. Head is pale and mottled with white granulations and lines. The duration of third instar was 3.50 0.50 days.The body length and width of early third instar was 12.73 0.88 mm and 1.19 0.11mm, respectively while late instar larvae measured 19.20 0.63 mm long and 1.87 0.26 mm wide. Head capsule length and width measured 1.07 0.02 mm and 1.10 0.03 mm, respectively (Table 1).

Fourth instar larva (Fig. 9) : Larval colour was found similar to that of third instar. The duration of fourth instar was 4.42 0.51 days.The early fourth instar larva measured 21.87 1.13mm long and 1.98 0.17mm wide. While late instar measured 28.00 0.67mm in length and 2.65 0.12mm in width. Head capsule measured 1.77 0.06 mm long and 1.82 0.05 mm wide (Table 1).

Final instar larva (Fig. 10) : In fifth instar (final stage), the body base colour changed to pale, light brown, brown to greenish and had black lines and patches. Head pale yellow to whitish with irregular lines intermingled by fine brown lines across the vertex. Larva had three black lines, one median and two laterals. The duration of fifth stadium was 8.50 0.52 days.The early instar larva measured 29.73 0.79 mm long and 2.76 0.09 mm wide. While late instar larva measured 55.60 1.40 mm long and 4.35 0.10 mm wide. Head capsule measured 2.70 0.09 mm long and 2.92 0.07 mm wide (Table 1). The existance of five larval instars was confirmed by applying Dyar's law (Dyar, 1890). The ratio of increase in each instar is obtained by dividing each observed width of the head with that of the preceding instar. The average of such ratios came to 1.69. After attaining full grown size, the mature larva ceased feeding few hours before undergoing pupation. After three to four days the larva was transformed into pre - pupal stage (Fig. 11) and finally into the pupal stage.

Larval duration : The duration of larvae varied from generation to generation. The observations were recorded in all first to sixth generation. It was observed that the larval development from 1st to 5th instar took 22.58 1.08 days in first generation, 22.08 1.24 days in second generation, 21.58 1.31 days during third generation, 23.33 1.23 days in fourth generation, 25.92 1.31 days in fifth generation and 32.92 1.56 days during sixth generation (Table 2). Singh and Thapa (1988) reported 28-42 days of larval period in *A. imparata.* Beeson (1941) observed 30-35 days larval period in *A. infexaria* Walk. Venugopal (1958) reported that larval period in case

of *Hyposidra successoria*, another defoliator of sal as 18-20 days.

Pupa (Fig. 12 & 13)

The pupa is obtect, stout, shining and hairless, reddish- brown in colour. The size of male pupa was measured 16.83 0.48 mm in length and 6.73 0.26 mm in width and weighed 0.34 0.063 g. Whereas, the female pupa measured 19.30 0.48 mm in length and 8.73 0.73 mm in width and weighed 0.45 0.09 g (Table 1).

In all the generations (1st to 6th) the prepupal period was lasted 2.50 0.52 days, 2.58 0.51 , 2.42 0.51 , 2.58 0.51, 4.42 0.67 and 8.17 0.72 days respectively (Table 2). The pupal duration was found 16.17 0.83, 15.16 1.12, 14.08 1.17, 15.33 1.07, 18.50 1.17 and 64.42 3.45 days during first to sixth generation, respectively (Table 2). Chatterjee (1935) reported 10-16 days of pupal period in *A. imparata*. Beeson (1941) also observed that pupal period in case of *A. imparata* was 12 to 14 days. Kulkarni *et al* (1995, 1996) reported that the pupal development period was 10-11 days in case of *A. imparata*, where as the pupal duration in *Hyposidra successoria* Walk. and *Hyposidra talaca* Walk. was found 8-9 days in July-September, 15 days in November and prolonged up to 56 days (over winter).

Adult Longevity and Sex ratio

A. imparata moth exibits sexual dimorphism. Males are smaller than female. Antenna of male is minutely serrated and fasiculate (bipectinate) with 59 segments while in female it is filiform with 60 segments. Body length is 19.00 1.54 mm in male and 20.15 1.73 mm in female. The wing expanse was measured 41.60 3.44 mm and 51.25 3.86 mm in male and female, respectively (Table1). Females lived longer (5.42 0.90 days) than males (4.33 0.79 days). The sex ratio in males and females was 1.00: 1.11, not showing any significant difference.

Life cycle and Generations

Under normal condition *A .imparata* had six generations annually. Overlapping of generations was also observed. The first generation of *A .imparata* started in mid March from eggs laid by adults emerging from over wintering pupae. The pre-oviposition and oviposition periods were recorded as 2.75 0.45 and 2.34 0.22 days, respectively. The first generation took 56.32 1.35 days for completion of the life cycle (Table2). The second generation started in April-May. The pre-oviposition and oviposition periods were recorded as 2.50 0.52 and 2.22 0.19 days, respectively. The second generation was completed in 53.79 1.31 days. The third generation started in June ending or early July. The recorded pre- oviposition and oviposition period were 2.42 0.51 and 2.20 0.17 days, respectively. The life cycle of this generation was completed in 51.36 1.32 days (Table 2).

Fourth generation started in the month of August with a pre-oviposition and oviposition period 2.50 0.52 and 2.21 0.16 days, respectively. The fourth generation was completed in 56.03 1.22 days. The fifth generation of *A. imparata* started in the end of September. The pre-oviposition and oviposition period were recorded as 2.50 0.52 and, 2.57 0.29 days, respectively. The duration of total life cycle was found to be 65.58 1.70 days in this generation (Table 2).

Sixth generation (hibernating generation) lasts from November to March, thus occupying a period of more than 120 days. The duration of pre-oviposition and oviposition period were 3.25 0.87 and 2.79 0.14 days, respectely. The total life cycle was completed in 128.72 1.63 days in this over winter generation (Table 2). Beeson and Chatterjee (1939) reported that the insect completes its life cycle in 4-5 weeks during April to October and 6-8 weeks in October to November. In *A. imparata* six generations were recorded in a year in South India, while five generations in North India (Beeson, 1941).

SUMMARY

Moth of *A. imparata* was whitish grey or pale fuscous in colour, irrorated with dark grey and brown lines. Mating duration took 147.50 ± 11.93 minutes. Eggs were small, oval and olive green in colour. Incubation period was 3.80 ± 0.84 days. Larvae were voracious feeders and had two pairs of prolegs 1st on A6 and 2nd on A10. It has four moultings representing five instars. The full grown larva was light brown in colour. The larval duration was 21.58 ± 1.31 days. Pupa was obtect stout, shining, hairless and reddish- brown in colour. Pupal period lasts 14.08 ± 1.17 days. Life cycle of *A. imparata* completed in 51.36 ± 1.32 days in June – July. There were six generations in a year.

***Key words* : *Ascotis imparata*, Sal defoliator, Biology, Life cycle.**

शाल निष्पत्रक कीट, (*एस्कोटिस इम्पाराटा*) वाक० (शल्किपक्षाः ज्योमेट्रिडी) की जैविकी

के०पी० सिंह व आर०एस० भण्डारी

सारांश

एस्कोटिस इम्पाराटा का भृंग घूसर या हल्के कपिश रंग का होता है जिस पर गहरी घूसर और भूरी रेखाएं बनी रहती हैं। संभोग काल में 147.50 $\pm$ 11.93 मिनट लगे। अंडे छोटे अंडाकृति और जैनूनी हरे रंग के थे। अंडे सेये जाने में 3.80 $\pm$ 0.84 दिन लगे। जातक भुक्खड़ो की तरह खाने वाले होते हैं तथा ए 6 पहला और ए 10 पर दूसरी इस तरह इनके पूर्वपार के दो जोड़े होते हैं। इनकी चार बार खाल उतरती है जो इसके पांच रूपों की प्रतिनिधि होती है। पूर्ण विकसित जातक हल्के भूरे रंग का होता है। जातक बने रहने की अवधि 21. 58 $\pm$ 1.31 दिनो की होती है। इसका कोशित आच्छादित, मजबूत चमकीला, अरोमिल और ललछौंह भूरे रंग का होता है। कोशित अवस्था 14.08 $\pm$ 1.17 दिन रहती है। *ए० इम्पाराटा* का जीवन चक्र 51.36 $\pm$ 1.32 दिनों में जून जुलाई में जाकर पूरा हेाता है। एक वर्ष में इसकी छह सन्ततियां हो जाती हैं।

References

Beeson, C.F.C. (1941). *The Ecology and Control of the Forest insects of India and Neighbouring Countries.* Vasant Press, Dehra Dun. 1007pp.

Beeson, C.F.C. and N.C. Chatterjee (1939). Possibilities of control of Lantana (*Lantana aculeata*) Linn.) by indigenous insect pests. *Ind.ian For. Rec.*, **6** (3) : 59 - 60.

Browne, F.G. (1968). *Pests and Diseases of Forest Plantations Trees*. Clarendon Press, Oxford. 1324 pp.

Champion, H.G. (1934). The effect of defoliation on the increment of teak sapling. *Indian For. Bull. (Silv.),* **89** : 6.

Chatterjee, N.C. (1935). Entomological investigations on the spike disease of sandal (25), Lepidoptera. *Indian For Rec*. (*Ent.*), **1** (10) : 196.

Chaudhary, G.V. and S.M. Khan (1966). Survey of Insect fauna of forest of Pakistan. *Final Technical Report, P.L. 480 Project No. A17-F5-11*. (Pakistan Forest Research Institute, Peshawar).

Dyar, H.G. (1890). The number of moults of lepidopterous larva. *Psyche,* **5** : 420-422.

Khan, H.R. (1995). *Insect Pests of Dalbergia and their Management.* ICFRE, Dehra Dun. 141pp.

Kulkarni, N., K.C. Joshi and S. Somnath (1995). A new report of *Ascotis selenaria imparata* Walk. (Lepidoptera: Geometridae) as a pest of *Pongamia pinnata* (L.) (Pierre). *Indian Forester*, **121** (3): 239-240.

Kulkarni, N., S. Kalia, S. Somnath and K.C. Joshi (1996). First report of *Ascotis selenaria imparata* Walk (Lepidoptera: Geometridae) as a pest of *Moringa pterigosperma* Gertn. *Indian Forester*, **122** (11): 1075-1076.

Mathur, R. N. and B. Singh (1960). A list of insect pests of forest plants in India and adjacent countries, arranged alphabetically according to the plant genera and species, for the use of forest officers. List of insect pests of plant genera 'P' to 'R'. *Indian For. Bull*., **171** (7): 130.

Mishra, R.M. (2000). *Insect Pests of Ailanthus excelsa and their Management*. Bishan Singh Mahender Pal Singh, Dehra Dun. p. 47.

Nair, K.S.S., V.V. Sudheendrakumar, R.V. Verma and K.C. Chacko (1985). Studies on the seasonal incidence of defoliators and the effect of defoliation on volume increment of teak. *KFRI Research Report, No. 30* (KFRI, Peechi, Trichur, India). p. 78.

Nicholas, J.O. (1968). Oak mortality in Pennsylvania, a ten year study. *J. For*., **66**: 681-694.

Singh, P. and R.S. Thapa (1988). Defoliation epidemic of *Ascotis selenaria imparata* Walk. (Lepidoptera: Geometridae) in sal forest of Asarori Range, West Dehra Dun Division. *Indian Forester*, **114** (5): 269-74.

Staley, J.M. (1965). Decline and mortality of red and scarlet Oak. *For. Sci*., **11**: 2-7.

Tiwari, D.N. (1994). *A Monograph on Shorea robusta* (Sal). International Book Distributors, Dehra Dun. 277.pp.

Venugopal, S. (1958). Studies on *Hyposidra successaria* Walk. a geometrid pest on *Sesbania speciosa* in South India. *Indian J. Ent*., **20** (3): 283-289.

Zhang, B.C. (1994). *Index of Economically important Lepidoptera*. Deptt. of Crop Protection, CAB International, Wallingford, U.K. p. 92.