# BIONOMICS OF AAK WEEVIL, *PARAMECOPS FARINOSA* (WIEDEMANN) (COLEOPTERA: CURCULIONIDAE), A PEST OF *CALOTROPIS PROCERA* (AIT.) R. BR. IN JAMMU DIVISION OF J & K STATE (INDIA)

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ABSTRACT: The bionomics of Aak weevil *Paramecops farinosa* (Wiedemann) has been studied on *Calotropis procera* (Ait.) R. Br. in Jammu, Reasi and Rajouri Districts of Jammu region of J & K State. This is the first report from India as well as the world. *P. farinosa* has been observed as a major pest of *C. procera*, an important medicinal plant which is grown only in restricted patches in Jammu region of J & K State. Adults feed externally on the tender leaves and flowers whereas larvae feed internally with in the developing seed pods causing heavy damage. Mating usually occurs during night or early morning hours. Copulation lasts for 30 to 45 minutes and females oviposit in the pericarp of seed pods and lay 6 to 12 eggs per clutch. Eggs are oval with both ends rounded, creamish to dull yellow. Larvae are apodous, soft, and cylindrical with dark brown head and pass through five larval instars. Egg, larval and pupal periods is 6.20±0.66, 22.50±1.55 and18.00±1.47 respectively. The total period from egg to adult takes about 46.70±3.75 days. Adults emerge from the infested seed pods from June to November without any interruption and remain actively feeding on host plants till the beginning of next fruiting stage. The pests breed throughout the year and do not undergo winter rest. At least two generations are observed from June to November.

KEY WORDS: Bionomics, *Paramecops farinosa, Calotropis procera*, Medicinal plant, Jammu, Reasi, Rajouri, India.

*Paramecops farinosa* (Wiedemann) has been observed as a major pest of *Calotropis procera*, an important medicinal plant in Jammu, Reasi and Rajouri Districts of Jammu region of J & K State. *C. procera* commonly known as Giant-milkweed, Swallow-wort, Apple-of-Sodom, or Rooster tree is an Asclepias genus that is distributed in tropical and subtropical areas such as India, Nepal, Pakistan, Africa, Australia, Egypt, Iran, and Arabic islands. In India, it is found wild, distributed throughout from Punjab and Rajasthan to Assam and Kanayakumari in comparatively drier and warmer areas upto an altitude of 1,050 m. *C. procera* has so important ecological roles because of its settlements in sandy soils, preventation of soil erosion, natural reproduction and its uses in the weavering, rubbering and medical industries (Golestaneh et al., 2009).

In India, *C. procera* is well known for its medicinal properties and holds a place of pride largely because of its other uses and economic values. This shrub has been widely used in the Sudanese, Unani, Arabic and Indian traditional medicinal system for the treatment of various diseases namely leprosy, ulcers, piles and diseases of the spleen, liver and abdomen. Different parts of this plant have been reported to exhibit analgesic, antitumor, anti-inflammatory, antihelminthic, antioxidant, hepatoprotective, antidiarrhoeal, anticonvulsant, antimicrobial, oestrogenic, antinociceptive, and antimalarial activity (Sharma et al., 2011). The flowers of the plant exhibit hepatoprotective activity, anti-inflammatory, antipyretic, analgesic, antimicrobial effects and larvicidal activity.

The latex of the plant is reported to possess analgesic and wound healing activity, as well as anti-inflammatory and antimicrobial activity while the roots are reported to have anti-fertility and anti-ulcer effects (Meena et al., 2011). The crude aqueous extract from the leaves of *C. procera* showed potent anti HIV-1 activity (Mohanraj et al., 2010).

Besides Paramecops farinosa, this medicinal plant is attacked by number of pests viz. *Spilostethus pandurus*, *Poekilocerus pictus*, *Anosia chrysippus*, *Aphis nerii*, *Corynodes peregrines*, *Phytoschapus* sp. and *Dacus longistylus*. Both adult and larvae feed on various parts of the host plant causing serious damage. But the present study is restricted to *Paramecops farinosa* only and provides details of its bionomics.

## MATERIALS AND METHODS

Collections were made from Akhnoor (District Jammu), Dhanwa (District Reasi) and Solki (District Rajouri) of Jammu province, where the Aak plantations, *Calotropis procera* are in abundance. Studies were conducted during the period 2009-2011 when the occurrence of the pest was at peak. Rearings were made through culture on potted cage plants. Mating pairs were collected and kept in captivity in the laboratory in 20×20×20 cm rearing cages with wire gauge (5 meshes per cm) on the sides and on top. They were kept supplied with fresh and healthy twigs bearing flowers, fruits/seed pods and leaves of *Calotropis procera*. Copulatory behaviour was studied and each mating pair was observed for pre-mating, mating, pre-oviposition and oviposition behaviour and duration both in the field and under laboratory conditions. Eggs laid by each female within the fruit were counted and egg period was determined from freshly laid eggs. These eggs were placed in the niches and on moist filter paper in petridishes to prevent their desiccation before studying them for hatching.

In order to determine the individual larval periods cellular rearing was done. Freshly oviposited places on previously uninfected shoots were covered by thin wire mesh cages and examined regularly. From the collected data only the total larval period could be derived. For determining the instars, newly hatched larvae and the subsequent stages were subjected to Dyar's law (Dyar, 1890). For determining the pupal period matured larvae collected from the infested plants were observed at intervals till the emergence of adults. Eggs were preserved in 5 per cent formalin with few drops of glycerine where as larvae, pupae and adults were preserved in 90 per cent ethyl alcohol. For studying number of generations, the time taken to complete adult stage in one generation in captivity was considered. For the morphological studies, the twenty numbers of each biological stage (eggs, larva, pupa, adults) were selected. All the stages were examined and photographed with Sony Cyber-Shot T10, Digital Still Camera, having 5x optical zoom with 7.2 effective megapixels and with inbuilt macro function for extreme close-ups.

## RESULTS AND DISCUSSION

### Distribution:

The results revealed the distribution in Jammu and Kashmir as: Poonch, Rajouri, Reasi, Jammu and Samba Districts of Jammu Province; and from literature throughout southern India all the year round (Fletcher, 1914); Rajasthan Desert (Parihar, 1983); througout District Rajouri in Solki, Sial Sui (Kalakote); Chingus, Narian (Rajouri); Rajal, Lamberi (Nowshera) and Siot,

Thanda Pani (Sunderbani) and Rajasthan, Ujjain, Madhya Pradesh, Bengal, Mexico, USA (Sudan, 2008).

**Host Plants:**

*P. farinosa* is a monophagous pest of Milkweed plants (Asclepiadaceae) and has been found feeding on Calotropis procera, *Calotropis gigantea* and *Asclepias syriaca*. Both adults and larvae cause severe damage to these plants (Sudan, 2008).

**Pest status:**

Both adults and larvae make extensive damage to the host plants throughout the year. Adults leave a characteristic crescent-shaped hole in one half of leaves that have been eaten and the larvae go on boring inwards and feeding on all seeds until it was fully fed and the last instar larvae emptied the fruit from most of its seeds. Maximum of 10 adults and 20 larvae at different stages of development were recorded per twig and per fruit of *C. procera* respectively. The percentage incidence recorded during the month of June is as high as 85.00±1.41 per cent and this reveals its serious pest status.

**Seasonal Incidence:**

The pest is prevalent throughout the year, the peak of the incidence being attained during May-June. Adults are found to be most active from March to November, whereas, larval stages being internal feeders are quite active from April to October as the fruits or seed pods of *Calotropis procera* are available from April in the field. Adults breed throughout the year, though activity slows down during winter months from December to February. Adult do not undergo hibernation or winter rest, although, during winter the adults remained confined in the basal portion of the plant or in the surrounding leaf litter at the base of plant.

**Nature and Extent of Damage:**

The most adapted and specialized insect occurring on *C. procera* is the Aak weevil, *Paramecops farinosa*. It is a small, cryptic, monophagous herbivore that feeds nocturnally on the leaves and flowers of *C. Procera*. Both adults and larvae of *P. farinosa* cause considerable damage to this milkweed plant. The adult weevils prefer to feed on the leaves, buds and flowers thus leaving number of characteristic crescent-shaped holes in leaves whereas, the larvae prefer to feed on the developing seeds thereby completely destroying all seeds inside the pods and thus check the reproduction and growth of this particular medicinal plant. With the increase in infestation and number of individuals at different stages of development, entire plants get defoliated and even the flowers are damaged, thereby resulting in complete drying of entire plant.

Similar observations were made by Parihar (1983) who recorded that the grubs bored into the soft tissues of pods and then fed on the developing fibers and young seeds and the adults after their emergence also fed on the leaves.

**Life Cycle:**

**Mating behaviour (Fig. 1):**

Field observations revealed that mating usually took place during night or early morning hours and sometimes they mate during a mid-day hours under cool and calm weather conditions but the frequency of mating was quite low in these

situations. a number of mating pairs were observed in the field and it was seen that a mating pair always tried to hide in leaf axils or branches of the host plants.

**Courtship and Copulation Behaviour:**

After about half an hour of courtship, the male weevil succeeds in riding over the female and holds it firmly with the help of its legs. During the process of copulation, the antennae remained directed upwards and forward and male also strokes the female with the help of its snout. It has been observed that the freshly emerged adults are not sexually mature and the pre-copulation and pre-oviposition periods are observed to be 1 to 2 days and 5 to 10 days respectively. Copulation lasted for 30 to 45 minutes but sometimes it continues for several hours.

**Site Selection and Oviposition Behaviour (Fig. 2):**

A *Paramecops* female has a very interesting ovipositional behaviour. Gravid female positioned herself on the upper side of the fruit (a follicarium), and uses her mandibles to cut a hole of approximately 1 mm diameter into the outer layer of the three layered fruit wall (pericarp). A copious amount of latex exudes during the process from the perforated laticifers present in the fruit wall. The female then turns by 180° and aligns her ovipositor structures with the hole. Eggs are laid into the fibrous middle layer of the fruit wall. The female turns again by 180° and spreads the plant latex on and around the hole, using her mandibles to seal it, presumably to prevent desiccation as well as predation of eggs by potential enemies, e.g. ants that inhabit the host plant in great numbers. Latex from the damaged pericarp forms a hard plug over the entrance to the hole, sealing the egg inside and protecting it as it develops. The female then engages herself in removing the partially coagulated latex from her mandibles and legs. Having freed herself from the latex, the female moved away from the fruit, but not before depositing her excrement near the sealed hole, presumably to deter oviposition by conspecific females. The entire process of oviposition typically lasted 20-30 minutes. Eggs are usually laid in a small group or a clutch and the number of eggs in a clutch varies from 6 to 12. The average number of eggs per clutch was approximately 10±2 (Amritphale & Sharma, 2006).

**Egg and Incubation Period (Fig. 3):**

Freshly laid eggs are oval with both ends rounded, surface smooth, shiny, soft and creamish or light yellow which frequently changes to dull yellow as development proceeds. The egg measures 1.25±0.12 mm ranging from 1.00 to 1.40 mm long and 0.80±0.11 mm broad ranging from 0.50 to 0.90 mm. Incubation period varies from minimum of 5.00 and maximum of 7.00 days with an average of 6.20±0.656 days.

**Hatching (Fig. 4):**

The eggs hatch into a small, apodous, creemish white grub in the space between a double-walled pericarp layers of fruits of *Calotropis procera*, sometimes wandering about before making a hole through the inner layer of the pericarp to enter the fruit or seed pod containing the seeds.

**Larval instars (Figs. 5-10):**

Since the larva is an internal feeder, Dyar's law has been applied to determine the number of larval instar, and it was observed that the grub passes through five instars. Not much difference has been observed between the five different instars

in general characters and hence the detailed description of the first instar larva and the final instar larva are taken into account.

Freshly hatched larva is elongate, smooth, soft, apodous, transparent white to creamish white, narrow posteriorly and slightly curved with C-shaped body. Head prominent, smooth, pale brown, shiny with yellowish tinge, comparatively larger in size and with biting and chewing type of mouth parts. Mandibles prominent, dark brown, pointed, triangular and bidentate. Body segments not clearly discernible. Abdomen wrinkled, tapering posteriorly and curved ventrally forming C-shaped structure. Head capsule of the first instar larva measured 0.20 to 0.35 mm averaging 0.25±0.043 mm in length and 0.30 to 0.45 mm averaging 0.40±0.046 mm in width. Body length ranged between 1.50 to 2.50 mm with a mean of 2.00±0.291 mm and width ranged between 0.30 to 0.60 mm with a mean of 0.52±0.085 mm. The width of the head capsule in the successive instars increase in the geometrical progression.

Body of full grown larva stout, creemish white, apodous, elongate, cylindrical and when taken out of the follicle shows typical curvature, becomes C-shaped with posterior end slightly narrower. Head dark brown, fairly well sclerotized, provided with mandibulate mouth parts. Mandibles strong, black, triangular and bidentate. Thorax with three segments, each with a pair of cushion-like pedal lobes on the ventral side, slightly broader than abdominal segments with transverse rows of hairs dorsally one each in every segment on either side. Abdomen large, prominent, nine segmented and narrow posteriorly; first seven segments almost equal in size while eighth and ninth are quite narrow and rounded; a row of long hairs in each segment present dorsally on either side. Sparse hairs present all over the body. Laterally eight pairs of small spiracles with pale brown margin are clearly visible; one pair in the segmental groove of metathoracic segment and seven pairs each in first seven abdominal segments. Head capsule measures 1.00±0.053 mm in length ranging between 0.80 to 1.02 mm and width between 1.50 to 2.00 mm averaging 1.80±0.144 mm. Fifth instar larva measured on an average 15.20±0.808 mm in length ranging between 13.50 to 16.00 mm and 5.25±0.420 mm in width ranging between 4.50 to 6.00 mm.

**Larval Duration:**

The larval period of Indian Aak weevil on *Calotropis procera* in Jammu region lasts for 20.00 to 25.00 days with an average of 22.50±1.547 days.

**Pupation (Figs. 11 & 12):**

After passing through a number of instars the full grown larva pupate inside a "cocoon" made from the silk threads of the seed parachutes by cutting and winding short pieces of fibrous material of the seed silk around its body, thus enclosing itself with in the cocoon, where they transform into pupae after passing through prepupal stage. The cocoon is pale white to creamish, elongate, cylindrical which effectively plugs the exit hole apparently bitten in advance by the mature larva. The average length of the cocoon measures 25.24±4.059 mm ranging from 15.00 to 30.00 mm and width of 10.00 mm to 25.00 mm with an average of 20.05±4.285 mm while the average length of the pupal chamber inside the cocoon varies from 12.00 mm to 20.00 mm with an average of 18.12±2.615 mm and average width of 8.52±0.826 mm ranging from7.00 mm to 10.00 mm.

**Pupa (Figs. 13a,b):**

Pupa is exarate, naked, with all the appendages distictly visible and freely projecting on the ventral surface. General colour is creemish white in the

beginning but gradually turn pale yellow to pale brown. Fine sparse hairs are present all over the body. Head is light brown with sparse hairs, small broader than long and ventrally prolonged in the form of elongate, cylindrical, well developed rostrum which touches coxae of first leg. Eyes are prominent, black, and present at the base of the rostrum. Mouth parts are prominent, located at the tip of rostrum, which reaches upto the middle of the abdomen ventrally; mandibles black, small, pointed and clearly visible. A pair of geniculate antennae present on either side of the rostrum and segmentation not clearly demarcated. Thorax is three segmented, creemish pale brown with two wing pads, and three legs sharply bent and folded on the ventral side. Abdomen prominent, narrow posteriorly, with clearly demarcated segments and bears sparse setae on either side. Pupa measures 12.00±0.968 mm in length varying from 10.00 mm to 13.00 mm and 5.52±0.630 mm in width varying from 4.00 mm to 6.00 mm. The pupal period including pre-emergence resting period of adult lasts for 15.00 to 20.00 days with an average of 18.00±1.468 days.

**Adult Emergence (Fig. 15):**

The pupa ultimately transforms into adult and emerges out from the pupal chamber through the emergence hole made by the mature larva with its mouth parts at anterior end of the cocoon or sometimes at the middle of the cocoon. Emergence hole in cocoon varies between 5.00 to 8.00 mm in length with an average of 6.50±0.795 mm and 4.50 to 6.00 mm in width with an average of 5.00±0.426 mm while emergence hole in the pericarp layer of fruit or follicle varies from 5.00 to 6.00 mm with an average width of 5.50±0.331 mm. Even after transforming into adult, the weevil remains in the cocoon for about 5 to 8 days, with an average of 6.50±0.842 days, attained maturity and then finally emerged out.

**Adult (Fig. 16):**

Adult robust, usually reddish brown on emergence and turned light grey to greyish black on maturity. Integument glossy, often partially or largely covered with a consistent, moderately pruinose coating, not easily removable. Antennae and occasionally pronotum and tarsi are dark ferruginous. Head globose; interocular space on vertex, half as wide as the base of the rostrum. Rostrum nearly cylindrical, weakly broadened apically. Eyes flat, elongate elliptical, closer together at the bottom and rounded at their lower margin. Antennae strong; scape straight or barely curved forwards, moderately and regularly thickened from basal third to apex; funicle segment one approximately 2 times longer than broad; segment 2 slightly longer than broad; segments 3 to 5 nearly subquadrate; segments 6–7 conical, broadened and transverse; club elliptical, as long as the last five segments of the funicle. Pronotum distinctly granulose, often having deeper and more clearly delimited punctures, as long as it is broad; base strongly bisinuate, broadly curved towards elytra at middle; maximum width at base, sides slightly convergent from base to near apex. Elytra with maximum width at humeri; metathoracic wings very large, macropterous. Fore femora scarcely broadened at middle, inner side with barely developed median teeth, hidden by the setae and the pruinose coating; tibiae short, straight, robust, inner side indistinctly sinuate; segment 3 of tarsi with lobes moderately developed.

Average length of adult from head to abdomen and from snout to abdomen measures 11.00±0.963 mm ranging from 9.00 to 12.00 mm and 13.02±0.862 mm ranging from 11.00 to 14.00 mm respectively; antennal length varies from 2.80 to 3.20 mm with an average of 3.00±0.106 mm; snout varies from 2.50 to 3.20 mm

in length with an average of 3.00±0.230 mm and 0.50 to 0.90 mm in width with an average of 0.80±0.120 mm; average length of head is 1.80±0.139 mm varying from 1.50 to 2.00 mm while head width varies from 1.80 to 2.20 mm averaging 2.00±0.114 mm; length of thorax varies from 5.00 to 7.00 mm with an average of 6.00±0.515 mm and width across pronotum averages 3.00±0.269 mm ranging from 2.50 to 3.50 mm; average abdominal length is observed as 5.00±0.553 mm with a range of 4.00 to 6.00 mm and average width of 3.50±0.317 mm ranging from 3.00 to 4.00 mm; elytral length and width are observed on an average of 7.02±0.281 varying from 6.50 to 7.50 mm and 3.25±0.147 varying from 3.00 to 3.50 mm.

**Total Life Cycle:**

The total life cycle of *Paramecops farinosa* i.e. from egg to adult emergence on *Calotropis procera* in Jammu region observed is of 46.70±3.746 days ranging from 40.00 to 52.00 days.

**Adult Feeding Behaviour (Figs. 17, 18, 19a,b):**

Adult weevils feed on *Calotropis* leaves and flowers and are mostly active at night, hiding during the day in the leaf axils on the lower side of leaves or in the leaf litter at the base of the plant. The adult weevils feed on milkweed leaves in a very distinctive way, first making characteristic feeding marks on leaves, puncturing or cutting the latex canal of the midrib, and then feeding distally to the cut. This is a form of "latex-canal sabotage behaviour", a way of reducing the impact of the plant's defensive reaction by preventing the milky alkaloid-laden exudates from reaching the feeding site and this form of feeding is also practised by many other milkweed herbivores. It leaves a characteristic crescent-shaped hole in one half of leaves that have been eaten.

**Larval Feeding Behaviour (Figs. 20a,b,c,d):**

Immediately after emergence from the egg in the space between double-walled pericarp layers of fruits of *C. procera*, the neonate larva begins to feed on the internal tissue for sometimes and then makes its way in the form of a hole through the inner pericarp layer. The larva moves by wriggling movements and penetrates fully to feed on the developing seeds, completely destroying all seeds within the seed pod. The larva goes on boring inwards and feeding on all seeds until it is full fed and the last instar larvae empties the fruit from most of its seeds and uses the fine filaments attached by them to construct its cocoon and pupate. The pupa develops into an adult. The adult found its way out of the cocoon and the fruit through a small hole to start a new life cycle.

**Management:**

Medicinal plants have great scope to achieve net higher returns and in international agribusiness which has an estimated growth rate of approximately 5-10%. However, they are facing danger of extinction due to the attack of some serious insect pests, diseases, deforestation, extensive exploitation and harvesting from natural sources and lack of proper knowledge on these problems among majority of the people. Report on insect pest's management of medicinal plants is meagre and scattered. In the recent past the emphasis was given to the insect management measures which are scientifically sound, environmentally safe and economically feasible.

A wider range of useful botanicals or bio-extracts serve as natural repellent/pesticides and proved to be more effective in controlling many insect

pests and diseases. In this case, some preparations from botanicals i.e. leaf extracts of four plants viz. *Azadirachta indica* A. Juss (Meliaceae) commonly known as Neem, *Melia azedarach* Linnaeus (Meliaceae) commonly known as Chinaberry tree, *Mentha longifolia* (Linnaeus) (Lamiaceae) commonly known as Hourse mint and *Vitex negundo* Linnaeus (Verbenaceae) commonly known as 5-leaved Chaste tree at different concentrations (10%, 50%, 70% and 100%) were evaluated against important insect pests of *Calotropis procera* besides using kerosene oil and water (control) in Jammu Division of J & K State.

The results with botanical extracts @ 100% concentration revealed that *A. indica* caused 80.92%, 86.92% & 92.71% reduction in adult and 85.63%, 91.57% & 96.99% reduction in larval population of Aak weevil, *P. farinosa* at 3, 5 & 10 DAS respectively. On the other hand, *M. azedarach* @ 100% concentration being superior, caused as high as 92.35% reduction of adult and 95.86 % larval population of *P. farinosa* at 3 DAS which was further increased upto 95.64% & 98.36% and 100% control over adult and larval population at 5 and 10 DAS respectively as compared to control (water treatment). *M. longifolia* leaf extract resulted in 70.80%, 68.98% & 65.63% reduction of adult and 75.97%, 73.85% & 70.80% of larval population followed by *V. negundo* leaf extract which caused 50.64% 48.47% & 46.91% reduction in adult and 52.27%, 50.98% & 48.63% in larval population of *P. farinosa* at 3, 5 & 10 DAS respectively. None of the extracts were found to produce phytotoxicity in any form.

Among all the bio-pesticides tested on the basis of overall effectiveness, *Melia azedarach* (100%) suppressed more than 98.36% and 100% adult and larval population in the tenth day after spray (DAS) respectively and is thus a promising pesticide for the management of this pest.

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## LITERATURE CITED

**Amritphale, D. & Sharma, S.** 2006. Oviposition Mechanism of the Indian Aak Weevil. Curculio-An International Newsletter for Curculionoidea Research, 52: 7-8.

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

**Fletcher, T. B.** 1914. Some south Indian insects and other animals of importance considered especially from an economic point of view. Printed by the Superintendent, Government Press, Madras, 332-333.

**Golestaneh, S. R., Askary, H., Farar, N. & Dousti, A.** 2009. The life cycle of Danaus chrysippus Linnaeus (Lepidoptera: Nymphalidae) on Calotropis procera in Bushehr-Iran. Munis Entomology and Zoology, 4 (2): 451-456.

**Meena, A. K., Yadav, A. & Rao, M. M**. 2011. Ayurvedic uses and Pharmacological activities of *Calotropis procera* Linn. Asian Journal of Traditional Medicines, 6 (2): 45-53.

**Mohanraj, R., Rakshit, J. & Nobre, M.** 2010. Anti HIV-1 and antimicrobial activity of the leaf extracts of *Calotropis procera*. International Journal of Green Pharmacy, 4: 242-246.

**Parihar, D. R.** 1983. Some ecological observations of insect pests of Aak (*Calotropis procera*) and their significance in Rajasthan desert. Indian Journal of Forestry, 4 (3): 191-195.

**Sharma, A. K., Kharb, R. & Kaur, R.** 2011. Pharmacognostical aspects of *Calotropis procera* (Ait.) R. Br. International Journal of Pharma and Bio Sciences, 2 (3): 480-488.

**Sudan, M.** 2008. Survey of Insect pests infesting some medicinal plants in district Rajouri (J&K). M. Phil. Dissertation, University of Jammu, Jammu.


Plate I. Fig. 1: Mating pair, Fig. 2: Ovipositional hole on fruit, Fig. 3: Eggs, Fig. 4: Hatching, Fig. 5: Neonate First instars, Fig. 6: Late First instars, Fig. 7: Second instar, Fig. 8: Third instar.

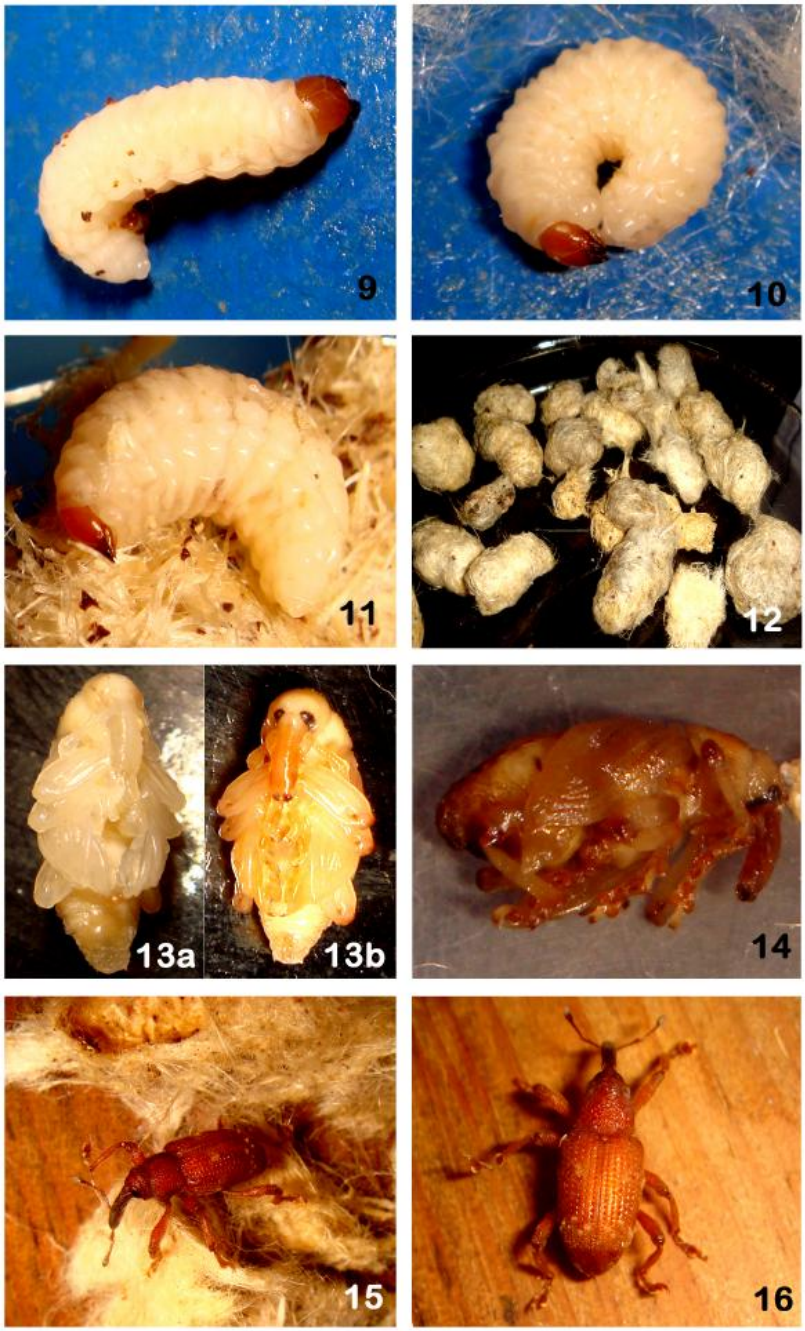


Plate II. Fig. 9: Fourth instar, Fig. 10: Fifth instar, Fig. 11: Final instar ready for pupation, Fig. 12: Cocoons, Fig. 13a: Early Pupa, Fig. 13b: Late Pupa, Fig. 14: Premature Adult, Fig. 15: Adult Emergence, Fig. 16: Newly emerged Adult.


Plate III. Fig. 17: Adult feeding on inflorescence, Fig. 18: Adults feeding on leaves, Fig. 19a & 19b: Damaged twigs of *Calotropis procera,* Fig. 20a-20d: Damaged fruits due to larval infestation.