

Small Millets

Insect Pests

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All India Coordinating

Research project on Small Millets

Bengaluru



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Cover page (Front) : Shoot fly adults, maggot, deadheart plant
Cover page (Back) : Grasshopper, *Crotogonus* sp.

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Foreword

Millets are the important food and fodder crops predominantly in semi-arid regions and are gaining importance in a world that is increasingly becoming populous, malnourished, facing large climatic uncertainties. These crops are adapted to range of temperatures, moisture regimes and input conditions supplying food and feed to millions of dry land farmers, particularly in the developing world. Sorghum and millets are affected by a large number of insect pests. On sorghum itself nearly 150 insect species have been reported as pest. The major constraint in production of small millets is the occurrence of insect pests that adds new dimension. Low cost management of insect pests of small millets is of great concern. Preventing the pest infestation in initial stages can prevent major losses, with least investment. Precise identification of the problem is a key factor in these small millets.

As part of the service to the farmers, students, scientists, teachers and extension workers, Project Coordinating Unit of AICRP on Small Millets has taken up task of publishing pictorial manual on insect pests of small millets. This publication contains the specific insect information and colour photographs of nature of damage symptoms which in turn help to identify and solve the problem. I appreciate the efforts taken by Dr. Prabhu Ganiger and Dr. B Boraiah and congratulate them in bringing out this bulletin in an excellent form.



Project Coordinator (Small Millets)

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A. FINGER MILLET PESTS

I. Stem borers

1. Pink stem borer, *Sesamia inferens* (Noctuidae : Lepidoptera)

Distribution: It is widely distributed in all finger millet growing countries. It is more regularly recorded from parts of Orissa, Karnataka, Tamil Nadu and Andhra Pradesh.

Host plant : Ragi, sugarcane, sorghum, rice, wheat, maize, bajra, guinea grass, barley, kodo millet and barnyard millet

Life history

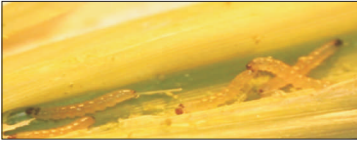
The moth is stout, straw coloured with forewings having three small black dots and an intermediate brown stripe. The hind wings and thorax are white. The female lays about 30-100 yellowish eggs inside the leaf sheath in one to three rows. The eggs are round, creamy white, changing to brown before hatching. After hatching the young larvae disperse to neighbouring plants. The incubation period is seven days. The egg stage lasts for 4-9 days in summer and 9-2.5 days in winter. The full grown larva measures 20 to 26 mm and is pale yellow with purple colour tinge and reddish-brown head. In mature plants, the larvae bore the stems and make tunnels while feeding on the internal tissues. There are 5-7 larval instars and larval period lasts for 25 to 54 days. The full grown larva is pink in color with a dark brown head. Pupation takes place inside the larval tunnel or outside under the leaf sheath. The pupal period lasts for 5-12 days in summer and 12-36 days in winter. Normally the adult emerges in 8 to 12 days. The life cycle is completed in 45-75 days and there are 4-6 generations per year.

Nature of Damage

Larval feeding first leads to leaf scarification and then to make small pin holes in the opening of leaves. The 3rd instar larvae migrate to the base of the plant and The larva bores into the stem and kills the central shoot causing starts drying i.e typical stem borer 'dead heart'. There may be upto five larvae inside a stem and often a number of plants may be damaged by a single caterpillar. In mature plants, the larvae bore the stems and make tunnels while feeding on the internal tissues. It is major pest of finger millet.

Management

- Ploughing of the stubbles of the previous crops is more important to prevent the carryover of the inoculum from the previous crop.
- When the seedlings grow to standard size, earthing up the crop minimized its infestation.
- Dimethoate or quinalphos found to be effective against borers.
- The biological agents seem to be effective against the pest were *Trichogramma minutum* and *Telenomus* species.



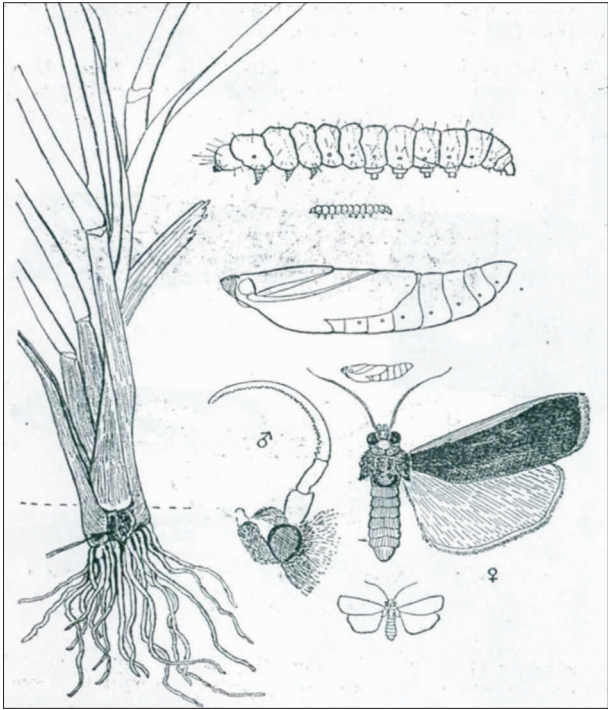
2. Ragi White Stem Borer, *Saluria inficita* Walker (Pyralidae : Lepidoptera)

Distribution: This pest is found in all ragi growing states of India. Predominantly noticed in Karnataka, Tamil Nadu, Andhra Pradesh and Orissa. It has been rarely noted on Tenai and has been recorded on paddy in Mysore. It is not, however, a serious major pest.

Host plant: It was specific pest on ragi in South India and rarely infests navane (*Sateria italica*) and Rice (*Oryza sativa*).

Nature of damage and ecology : This moth is specific pest of ragi in South India, especially in the Coimbatore tract. The caterpillar is creamy-white with yellow head, and bored into stem like ragi pink borer. It lodges at the lower parts of the plant, close to the soil surface. Oozing of the excreta from the bored hole is very conspicuous in the infested plants. Such plants show the presence of symptoms of drying. The caterpillar pupates in the stem itself. The adult moth emerges as a dark- brown, medium sized moth with pale-white bands along the margin of each forewing and white hind wings. Unlike ragi pink borer, it is not a serious pest.

Nevertheless, its control measures were the same as for pink borer. The moths have some attraction to light as such, light traps may be put up in the nurseries where the infestation starts, to trap the moths and prevent egg-laying. Hence, setting up of light traps in the field of the inoculums, to catch them before they lay eggs.



II. Leaf feeders

1. Grasshoppers

Host plant: finger millet, jowar, foxtail millet bajra, little millet, ground nut, pulses, chilli and cotton.

The hoppers destroy seedlings and feed on leaves, and when the infestations are heavy, resowing may be necessary. The important species are *Colemania sphenarioides*, *Hieroglyphus nigroreplectus*, *H. daganensis*, *Oedaleus senegalensis*, *Schistocerca gregaria*, *Locusta migratoria*, and *Crotogonus* spp.

Life history: *Colemania sphenarioides* Bol. (Acrididae: Orthoptera) The Deccan Grasshopper. This pest is quite serious on Jowar, Ragi and Foxtail millet in Karnataka particularly in the districts of Chitradurga, Devanagere, Bellary and Dharwad. This appears as a periodic pest on these crops. When it appears continues to cause damage for a period of 3-4 years and declines. It appeared in epidemic form during the years 1909 -1912; 1924-25; 1932-34, 1941-48; 1965-66. This is a wingless grasshopper occurring as a serious pest in South India. The adult is green and red and measure about 3.8 cm in length. Eggs are laid in batches, 5-75 cm deep in soil during October and November. They hatch in the following June and July with the advent of rains. The nymph grows by feeding on the leaves of millets and other low-growing plants and becomes full-fed by September. The eggs are destroyed by the larva of *Systoechus* sp., a bombylid fly and by *Zonabris* sp. Both the hoppers and the adults feed on the leaves and also on the flowers and ripening ears causing heavy losses.

Nature of Damage: As soon as the rains (monsoon) are received during June-July eggs hatch into nymphs, initially feed on grasses on the bunds for nearly 2 weeks and later they migrate to ragi or foxtail millet crop. The insect feeds on the foliage and may also devour the florets and ripening earheads. Under a severe infestation, the crop may be completely destroyed, and need to be resown. The nymph grows by feeding on the leaves of millets and other low-growing plants and becomes full-fed by September. They continue feeding for nearly 2-3 months and their life cycle continue.

Other species of grasshoppers include *Crotogonus* sp. (Acrididae, Orthoptera) and mulberry grass hoppers *Orthacris* sp. The earlier one looks like stone, or mimics soil colour. It mainly appears on crop when there is no greenery around or when the field is brought under cultivation by clearing forest land.

Management:

1. Cleaning of bunds having weeds and grasses
2. Use of dusts formulations for management of grass hoppers



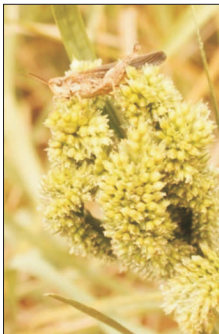
Oxya sp.



Colemania sphenarioides



Acrida exalta



Chrotogonus trachypterus

2. Red-headed hairy caterpillar, *Amsacta albistriga* (Arctidae : Lepidoptera)

Distribution: The red-headed hairy caterpillar (RHC), *Amsacta albistriga* is a voracious polyphagous pest attacking many rainfed crops in low-rainfall areas of Karnataka, Andhra Pradesh and Tamil Nadu in India.

Life-history

The pest completes two generation in a year. First generation moths emerge 1-2 days after good rains during May-July months in Southern Karnataka. Moths deposit eggs on crop plants, weeds, stones, clods, dry sticks, wooden poles, etc. Each female can lay 262 to 1103 eggs in groups. Eggs hatch in 3-5 days. Early instar larvae (I – III) are gregarious and scrape green matter. Older larvae (IV – VII instars) disperse and even migrate from one field to another. After 32-45 days, fully grown larvae pupate in soil at 15-30 cm depth. Second generation moths emerge during September. Second generation diapausing pupae remain soil till next May-July months.

Nature of damage

The early instars of RHC scrape green matter on leaves without damaging the upper epidermal layer giving papery appearance to the leaves. Grown up caterpillars feed voraciously on the leaves leaving behind the petiole, midribs and the main stem. In endemic areas, larvae swarm from one field to another and devastate the crops. Often the extensive damage in the early stage of the crops may compel the farmers to go for resowing. The resown crops will be less productive due to delay in sowing and inadequate moisture.

Management

- Deep ploughing to expose pupae – after harvesting of crop or after early rains in summer.
- Attracting and killing moths by setting up bon fires or using gas lights between 7 to 10 pm after receiving good rains during May-July months.
- Sowing of trap crops such as cowpea, sesamum and green gram as intercrops and along border to reduce pest load on main crop (Ragi).
- Hand collection and destruction of egg masses and grown up larvae.
- Spraying of AaNPV (6.5×10^{11} – 3.75×10^{12} POB's/ha).
- Application of insecticide dusts such as fenvalerate 0.4 D or methyl parathion 2 D (25 kg/ha) and spraying of fenvalerate (0.02 %) or monocrotophos (0.05 %) or quinalphos (0.04 %) against early larval instars.
- **Use of poison bait against grown up larvae**
Mix rice bran (1 kg) and jaggery (100 g) thoroughly. Add a small quantity of water (enough to moisten the mixture) and allow the mixture to ferment for 24 hours. Then add the insecticide quinalphos or monocrotophos 36 SL (15 ml/kg bait) to the fermented mixture and spread the bait in field during evening hours at the rate of 10 kgs/acre.



Parasitoids on RHHC



Egg parasitoid-*Telenomus* sp.



Exorista sp.



Braconid, *Apanteles* sp.



Adult braconid

3. Grey Weevils and Leaf Beetles

Mylocerus maculosus, *M. viridanus*, *M. subfasciatus* & *M. discolor* (Curculionidae: Coleoptera)

Host plant: Finger millet, bajra and sorghum, maize, pulses, groundnut, cotton, guava

Distribution and Nature of damage: Grey weevils, *Mylocerus* spp occasionally become serious on millets and have a wide distribution all over India. Among these, *M. undecimpustulatus maculosus* is a general feeder with an extensive range of host plants. When the adult numbers reach outbreak proportions, the entire crop may be skeletonized. The grubs feed on the roots and remain in the soil. The damaged plants dry up or remain stunted or leaf margins are notched resulting in wilting of plants in patches. Plants come off easily when pulled. Roots are eaten away by grubs. Adult feed on leaves. Adults are small weevils with whitish grey elytra. Leaf beetles (*Lema* spp and *Chaetocnema* spp) also result in severe damage occasionally during seedling stage in India (Nayar, 1975).

Mylocerus undecimpustulatus maculosus **Desb.:** Maximum damage is done during July and August to young plants. A female weevil lays 98-350 eggs in soil and they hatch in 3-12 days. Larvae and pupae are in soil. There are four larval instars of 23-40 days. Pupal period lasts 3-9 days. Complete life-cycle lasts for 29-58 days. There are three overlapping generations between July and October. Winter is passed as a larva. After harvest of ragi or *bajra* the weevil breeds on brinjal, redgram, bhendi and wild cotton.

M. viridanus: Adult weevil with greenish white elytra.

M. maculosus: Adult weevil with greenish white elytra having dark lines.

M. discolor: Adult weevil is brown with white spot on elytra. Grub is small, white apodous and found feeding on roots. Weevils appear during summer and lay ovoid, light yellow eggs in the soil. Female lays on an average 360 eggs over a period of 24 days. Eggs hatch in 3-5 days. Grub period 1-2 months, pupate in soil inside earthen cells and pupal period is 7-10 days. Life cycle is completed in 6-8 weeks. There are 3-4 generations in a year. Adults live fairly long for 4-5 months in the winter.

M. subfasciatus: The adult weevil light grayish to white with four black spots on the wing covers. The eggs are light yellow and laid deep in the soil. The grubs are fleshy, yellow-colored. Pupation occurs in earthen cells in the soil. Egg, larval, and pupal periods last for 3 - 11, 3-42, and 5- 7 days respectively.

Adults can be managed by dusting with methyl parathion or fenvalerate dust.



Damage symptom



M. discolor



M. viridanus



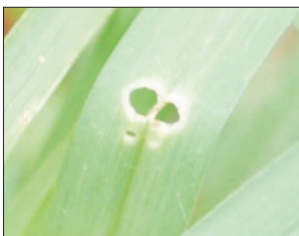
M. subfasciatus



Myllocerus dorsatus



Myllocerus dentifer



Monolepta signata



4. Leaf roller, *Cnaphalocrocis trapezalis* (Guenée) (=*Marasmia trapezalis* (Guenée) (Pyralidae : Lepidoptera)

This is a sporadic pest of sorghum in India but also feeds upon finger millet. The adult moths are slender, brown with waxy brown markings on the forewings. Adult moths possess greyish wings with three dark transverse stripes and a dark wide sub terminal band. The eggs are laid on the upper surface of leaves and the larvae feed on the inside surface of a folded leaf. Head and thoracic shield are reddish brown in colour. The larva is slender, pale yellowish green in colour, and about 20 mm in length, it has small oval spiny patches scattered over the body, from which stout bristly hairs arise. The larvae are fully grown in 11-20 days. Pupation occurs within a leaf fold, and is completed in 6-8 days. As a result of larval feeding, the leaves start drying up from the tips. Broad leaved and succulent varieties are highly susceptible.

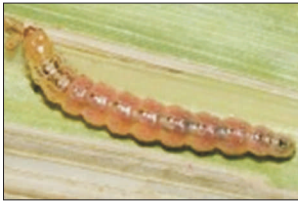
Management

1. Removal of grasses from bunds should be done as the insect breeds on them.
2. Hand picking the rolled leaves.
3. Sprays of monocrotophos, cartap hydrochloride, chlorpyrifos and quinolphos can be recommended.

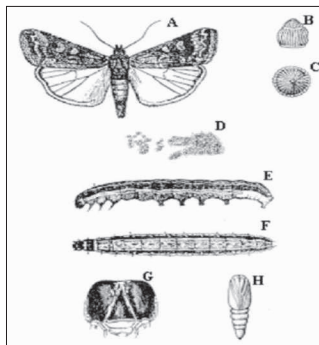
5. Ragi Cutworm, *Spodoptera exigua* Hb. (Noctuidae : Lepidoptera)

Host range: onion, brinjal, cotton, cowpea, chillies, daincha Cabbage, Lucerne, Jowar, Maize, Tobacco, Sugarcane.

This insect is one of the cutworm moths having a very wide distribution all over peninsular India and attack several cultivated crops. It some times causes appreciable damage in ragi nurseries. It is often a serious pest. Sorghum and bajra also are infested by the caterpillars. The adult is a dark-brown medium-sized moth with white hind wings. Eggs are laid in clusters on the young nursery plants. The caterpillars are nocturnal in habit, make feeding holes in the leaf lines. It is brownish green with wavy lines on the dorsal surface and yellow stripes laterally. They graze the entire plant in the early crop growth stage. Day time they hide under stones and clods. The caterpillar grows to a length of about 3.8 cm. The larval period is 10-16 days. It pupates in earthen cocoons in soil for 7-11 days. Any contact insecticide can control the caterpillar. The control measures should be adopted when the larvae are young.



C. trapezalis



Ragi Cutworm, A. Adult. B-C, Eggs (enlarged)
D, Egg mass, E-F, Larvae, G. Larval head. H, Pupa

III. Sucking Pests

1. Shoot aphid: *Hysteroneura setariae* (Thomas) (Aphididae: Homoptera)

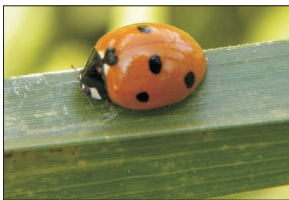
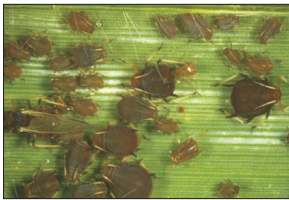
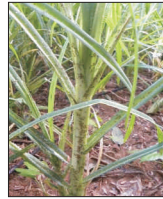
Leaf aphids are also called rusty plum aphid, as the name suggests is a brown, small aphid with dark cornicles and pale cauda with two pairs of hairs. Legs and antennae are brown with intermittent grey abdomen with characteristic single oblique vein on the hind wing. It was reported for the first time in India on rice, sorghum, Italian millet and other crops in Madras.

Distribution in India: *H. setariae* is native of America living on plum trees during autumn as its primary host and cereals and grasses during summer as secondary host. In India ragi leaf aphid was first recorded in southern states during 1967 *viz.*, Madras, Tambaram, Tindivanam, Coimbatore, Madurai, Bangalore, Ananthapur and Coonoor.

Host range: Ragi leaf aphid is known to attack all graminaceous plants and other grasses.

Nature of damage: Adult and nymphs of aphids suck the sap of the plant from the base of the spicklets, and spread to the entire plant. Resulting in reduced vigour of the plant and stunted growth, generally infestation starts from the border row and spreads. The infestation is alarming when appears on crop of less than a month old. The occurrence is during the months of August and September. When the crop is caught in dry spell, infestation continues throughout the crop growth stage. In severely infested plants even the earheads are fully covered by aphids.

Life history—The duration (days) of nymphal period of females derived from apterous parent, varied from 6 to 7.5 days (average 6.47) while the preovipositional, reproductive, post ovipositional period and total longevity 0.26 ; 1.74 and 33.56 days, respectively. The fecundity varied from 59.13. The nymphal period of females “derived from alate parent” was 9.23, while pre-ovipositional, reproductive, post - ovipositional and total longevity varied from 0.82 ; 27.7, 4.86 and 42.62, respectively. The fecundity of female with an average of 52.46. The preovipositional, reproductive, post-oviposition period and total longevity of alate adult 1.0, 25.86, 0.64 and 27.57, respectively. The fecundity with an average of 32.8.



Coccinella septempunctata

Coccinella transversalis

2. Ragi root aphid, *Tetraneura nigriabdominalis* (Sasaki) (Pemphigidae : Homoptera)

Distribution: In India it occurs as endemic pest in traditional ragi growing districts of Karnataka. It was reported to appear in large area of Hassan district during the year 1970, which also led to a debate in the state assembly.

Alternate hosts: Eighteen host plants under families poaceae, cyperaceae; commelinaceae and rubiaceae.

Nature of damage and biology: The root aphids are minute pale white lice found damaging the roots of ragi plants, though very rarely serious. It reproduces viviparously. The external evidence of the presence of this pest is gradually fading away of the badly infested plants and the presence of ants visiting the roots, such plants when pulled out will show colonies of the aphids attached to the roots. Moderately old plants are preferred for infestation by the aphid. It is found in colonies on the root system, up to 100 adults and 150 nymphs being seen on one plant. When they feed persistently on the plants the entire collar region of the root turns black, cortical tissues dry up and secondary roots show burnt appearance. The plants show symptoms of wilting, excess tillering, stunted growth and early maturity and occasionally caused drying of the roots. Plants turn yellow and setting of seeds is reduced. The aphid is dispersed by alatae or through association with ants like *Camponotus compressus*. Sometimes it causes indirect damage by transmitting plant viruses. The average life cycle is spread over a period of 30 days with five instars adults live for about 15 days. Although this species is known to lay eggs occasionally, in the laboratory conditions. Generally it perpetuates by giving birth to young ones. The young produced by a Viviparous female undergo four five nymphal instars occupying a total of 7-9 days. The longevity of the adult in general ranges from 5 to 11 days and produces 10-35 offsprings. These aphids assume serious pest status on ragi by sucking the juice from the roots so persistently that the whole crop withered unless constantly irrigated and even then the yield was considerably reduced.

Management: Insecticides are not recommended for control of both root and shoot aphids as the predators of family Coccinellidae and Syrphidae are very active in the field. At heavy incidence use systemic insecticides.



3. Spider mite : *Oligonychus indicus* (Tetranychidae: Arachnida)

Host range: Sorghum, maize, rice, millets, members of Poaceae.

Female and immature stages feed on the foliage. They thrive under web on the under surface of the leaves. Adults of sorghum spider mite are deep red or maroon and the nymphs are also slightly reddish.

Nature of damage: Although found early in the growing season rapid population increases occurs only after the panicle emergence. They suck the plant sap first on the under surface of the functional leaves and the infested areas initially are pale yellow, but later turn to reddish (in purple pigmented cultivars) or brownish tan (in tan pigmented plants) on the upper leaf surface. This extends to the entire leaf area which spreads upwards through the plant affecting plant growth and seed development. The underside of the heavily infested leaves have dense deposits of webbing and in severe infestations they may invade and web even the sorghum/finger millet panicle. It often causes damage to finger millet/sorghum in prolonged drought situations.

IV. Earhead caterpillars

1. *Cryptoblabes angustipennella* Hamps (Pyraustidae : Lepidoptera)

This is a serious pest of finger millet in South India. The moth, measuring 15 mm across outstretched wings, lays eggs on the newly opened flowers or other parts of the inflorescence of ragi. A female lays up to 14 eggs in 3 days. The larva first feeds on the lemma of the flowers scraping the chlorophyll and later on the milky grains. Larval period lasts 19-22 days which includes five instars. The full-grown larva pupates within a silken cocoon for a period of 7-20 days. The complete life-cycle has duration of 31-43 days. The caterpillar causes damage by constructing webs on ragi earheads and feeding on the flowers and the grains.

2. *Helicoverpa armigera* (Noctuidae : Lepidoptera)

This is a polyphagous pest. It attacks the ear during dough stage and starts feeding on developing grains and cause damage. They are severe on local varieties of finger millet which have closed fingers giving them a perfect niche for its development and hiding from the natural enemies. While the recent high yielding varieties have semi compact and open type of earheads which are not much preferred by these caterpillar pests to invade.



Spider mite *Oligonychus indicus*



Cryptoblabes sp.



Helicoverpa armigera

B. INTEGRATED PEST MANAGEMENT IN FINGER MILLET

I. Cultural Control

1. **Sanitation:** Field sanitation, and uprooting and burning of stubbles help to reduce the carryover of stem borers.
2. **Tillage:** Field tillage before planting and after the crop harvest helps to expose the hibernating/aestivating/hiding larvae and pupae of many insect species. Deep ploughing is particularly helpful in reducing the populations of grasshoppers and hairy caterpillars.
3. **Intercropping:** Finger millet with Mustard and Niger in the ratio of 4:1:5 and 4: 2: 4 respectively, favours buildup of natural enemies and sustains their population.
4. **Weed Control:** Proper and timely weeding of the crop reduces the damage by *Mythimna separata* (Sharma and Davies, 1982) and *Spodoptera* spp (Ndoye et al. 1986). A clean crop is often less hospitable to insects as the weeds can provide hiding and oviposition sites for some insects.

II. Mechanical Method

1. **Mechanical Collection and Destruction:** Egg masses of hairy caterpillars and other lepidopteran pests can be hand collected and destroyed. Aphid infestations can also be reduced by uprooting and destruction of the infested plants. Blister beetles can be collected by hand and destroyed (Jotwani and Butani 1978). Head bugs and other external feeders on the ear-head can be dislodged into a bucket containing water to which kerosene has been added (Nair, 1975).

III. Physical Method

1. Setting up of light traps helps in attract and kill the stem borers and other moth pests.

IV. Host plant Resistance Sources

A good number of genotypes are found to be resistant to stem borer and aphids which are presented under separate tables 1 & 2. Plants that are inherently less damaged or less infested by phytophagous insects under comparable environments in the field are termed as resistant (Painter, 1951).

Table 1: Finger millet genotypes either tolerant or less susceptible to *Sesamia inferens* Walk

Genotypes	Reference
IE 932, IE 982 and IE 1037	Lingappa (1979)
PES 9, PES 144, PES 224, KM 1, KM 14, HR 228, JNR 1008 and T 36-B	Kishore and Jotwani (1980)
KM 1, RAU 1, RAU 3, Indaf ;7, Indaf 8, HR 154, HR 374, HR 1523, PES 110, PES 400, WR 9, VL 110	Murthi and Harinarayana (1986)
VL 109, VR 530, PR 202, HR 374	Dhamdhere (1988)

Table 2: Promising finger millet cultures resistant to earhead worms, aphid and shoot fly identified in coordinated multi-location screening

Earhead worms		Aphids		Shootfly
1980-86	1990-96	1980-86	1990-96	1992
Indaf 7	KM 229	PES 176	PES 400	HR 374
Indaf 8	KM 230	RAU 1	VL 149	PES 400
PR 202	PR 202	HR 374	GPU 36	VL 162
PR 177	PPR 2618		KM 225	VL 171
HR 374	HR 374			VL 231
HR 1523	PES 400			VR 584
PES 110	PES 110			VMEC 35
PES 1877	GPM 36			RAU 8
TNAU 1877	TNAU 551			MR 5
TNAU 294	VMEC 35			MR 6
VL 110	VL 149			L 15-1
	VR 530			
	VR 696			
	VR 708			

V. Chemical Control

1. Dusting the crop with Malathion 5% D or Methyl parathion powder for management of red-headed hairy caterpillar, grass hoppers, weevils and also reduce the leaf eating caterpillars.
2. Quinalphos or Methyl parathion 2 ml mixed with one liter of water then sprayed for the management of leaf eating caterpillars.
3. Use of poison bait: Use 10 kg of rice bran or wheat bran mixed with one kg of jaggery and keep it for overnight. During evening hour insecticide 100 ml quinalphos mixed with fermented mixture of rice bran or wheat bran. Then sprinkle throughout the field to manage Spodoptera sp.
4. Use of systemic insecticide i.e dimethoate 1.7ml/lit of water for the management of leaf aphid.

Future line of work

- **Stem borers and ear-head worms on finger millet**
Work on different borer and ear worm species need to be intensified with regard to economic status of each species by determining the incidence and losses caused in different areas. Besides, research for natural sources of resistance must be continued.
- **Aphids on finger millet and gall midges and borers on small millets**
Biology and ecology refinement and standardization of screening techniques and continued search for the sources of resistance deserve attention.
- **Biological Control:** Limited information is available on the natural enemies of pests infesting small millets. Critical studies are, therefore, required of key pests and their natural enemies. Surveys of natural enemies should be undertaken and their relative efficiency assessed.

C. SEEDLING PESTS ON SMALL MILLETS

Shoot fly (*Atherigona* spp.)

A number of shootfly species attack small millets (Nageshchandra and Musthak Ali, 1983a). *Atherigona destructor* M. alone could bring a yield loss of 36 per cent in proso millet (Natarajan *et al.*, 1974) and 39 per cent in case of little millet (Selvaraj *et al.*, 1974). Per cent reduction in yield to the extent of 44.9 in barnyard, 90.9 in proso, 78.5 in little, 35.0 in kodo and 1.8 in foxtail millets was reported by Nageshchandra and Musthak Ali (1983b).

1. Little millet Shoot fly (*Atherigona pulla*)

Nature of Damage

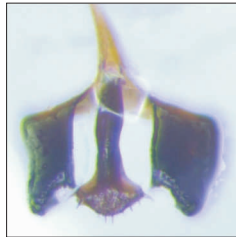
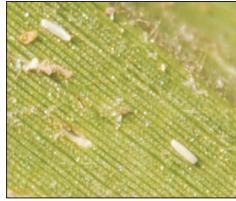
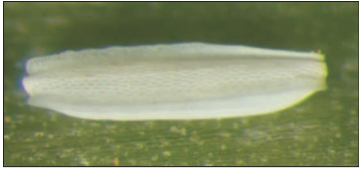
Shoot fly is the major seedling pest of small millets. Infestation usually begins during the seedling stage (1-5 leaf stage). Maggot gradually slides through the leaf lamina and reaches the growing point of the stem and starts damaging the meristematic tissue of the plant by its pincer like mouth parts and remains inside the stem for a period of 6-10 days. The damage of this pest is observed from sowing to six weeks of old crop. As result of its feeding the central shoot starts drying and shows the typical symptoms of dead heart in the early stage and profuse tillering in the later stage, which are also affected. Damaged tillers may produce ear heads, but with no grains (white ears). Maximum incidence occurs during late July or early August. Extreme temperatures and continuous rainfall adversely affect fly activity.

Population Dynamics

The population of small millet shoot fly monitored by fishmeal trap had two peaks during 4th week of August and September. During October the population was low. It further picked up during first fortnight of November and December. Similar trend was reported with respect to sorghum shoot fly.

Identification characters

Vibrissae, usually together with an adjacent seta and a few ground-setulae, clear yellow. Palpi, interfrontalia, humeri and male fore femur yellow. Tergites without or in some females, with a very small pair of dark spots. Male hypopygial prominence and trifoliate process and female sternite 7 and tergite 8. Male: fore tarsus brown, the apical segments paler, with long hairs on anterodorsal and posteroventral surfaces of the basal and succeeding segments; fore tibia yellow, brown at tip; 3rd antennal segment orange-yellow *A. pulla* (Wiedemann)



Trifoliate process



Little millet



Panicle initiation stage

2. Kodo Millet Shoot fly (*Atherigona simplex*)

Economic loss

Patel and Rawat (1982) recorded 49% yield losses in kodo millet due to attack of shoot fly. Nagesh Chandra and Musthak Ali (1983) reported 35% reduction in yield due to attack of shoot fly in kodo millets.

Distribution: *Atherigona simplex* as kodo shoot fly. Presently the 5 species have been thus reported so far attacking kodo millet in India. They are *Atherigona simplex*, *A. miliaceae*, *A. pulla*, *A. bituberculata* and *A. oryzae*.

Nature of Damage

Shoot fly is a seedling pest, which attack the plant seedling/tillering stage from 3-5 weeks after sowing. The shootfly also remain associated with older plants, but damage is very less. The infected plant showed “dead hearts” caused by the tiny maggot, when entered in central shoot. More tillers are produced when main tiller is damaged by shoot fly. Maximum population of shoot fly is observed from last week of July to first fortnight of August.

Life cycle

The total of *Atherigona simplex* from egg to adult completed in 19 days (Singh, 1984). The adults were observed to live from 1-8 days. The adults generally laid the eggs in morning (8-9 am) or in evening just before sunset. The eggs were laid singly but sometimes in 1 or 2 rows having 2-3 eggs in each row. The fecundity varied from 10-15 eggs/female during the life span of 1-4 days. Freshly laid eggs are white colored, sculptured, elongated and remain deposited inside the leaf mostly on stem base. The eggs are cylindrical in shape and tapered at both ends measuring a size of 1.2 mm x 0.35 mm. The incubation period lasts for 1-2 days. The anterior end become darker before hatching and larva comes out in about 2-3 minutes from cell after rupturing the tip.

Newly hatched maggot rest for half an hour near the eggshell, then migrate to upper surface of the leaf blade and moves along the leaf margin towards the leaf sheath. It moves down between leaf sheath and axis of stem and enters into the stem at base by puctering from lateral sides. Finally maggots cut the growing point of shoot and destroyed it centrally by feeding on the tissues. It is thereby causes the characteristic “dead heart”. The larvae undergo two moultings and larval period lasts within 7-9 days. Larva converts into pupa within 6-8 days. The pupation takes place inside the stem at the base. Sometimes it also occurred on lower surface of stem or in soil surrounded by stem. Only 1 pupa is formed inside one seedling and changes its colour from light brown to deep brown. The puparium is barrel shaped with 4.75 mm x 1.00 mm in size. Pupa contains 10 visible segments with pupal period of 8-10 days. The freshly emerged adult is dirty grey with a length of 4.5- 5.0 mm. Males are smaller than females. The females having a dark marking on the posterior end of the abdomen which differentiate from the male.



Kodo Millet



Foxtail Millet



Proso millet



Barnyard millet

3. Sorghum shoot fly, *Atherigona soccata*

Host range: Sorghum, maize, finger millet, pearl millet, rice, wheat, several species of grasses.

Fly is a small 3-4 mm long, dark grey housefly like. A female fly lays whitish cigar shaped eggs singly on lower surface of the leaves. On hatching the maggot enters the seedling and destroys the growing point causing deadheart formation. Mature larva is yellowish and pupation takes place either at the plant base. The fly population tends to increase in July and reaches the peak in August. From September onwards the population gradually declines and remains at a moderate level till March.

Damage symptoms: It is a seedling pest normally occurring in the 1-6th week after germination. Maggot feeds on the growing tip causing wilting of leaf and later drying of central leaf giving a typical appearance of dead heart. If the infestation occurs a little later, damaged plants produce side tiller which are again infested. In case of Pearl millet pest attacks the crop both in seedlings and boot leaf stage. It causes dead hearts in young pearl millet seedlings and chaffy grains in terminal portion of panicle in the mature crop.

Fore femur entirely yellow. Fore tibia mostly yellow, darkened only at tip. Tergite 5 without dark spots. Hypopygial prominence with two simple diverging arms, rounded or truncate at tips. Trifoliate process entirely sclerotised and dark brown, with the shoulders sloping; the median piece elbowed at middle in lateral view *A. soccata* Rondani.

Sorghum, Finger millet : *Atherigona soccata* Rondani

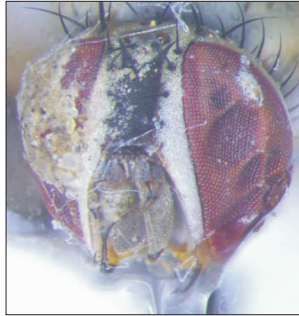
Pearl millet : *A. approximata* Malloch

Proso millet, Kodo millet : *A. simplex* Thompson

Fox tail millet : *A. atripalpis* Malloch

Barnyard millet : *A. falcata* Thompson

Little millet : *A. pulla* Wiedmann



Interfrontalia Black



Sorghum deadheart



Fish meal bait trap



Inner small bottle with holes at top

Fish meal trap
(Moistened dry fish keep it for over night)

3-4 mm holes at bottom of the
bottle

Funnel

Shoot flies collecting bottle in 70
per cent alcohol or
water mixed with insecticide

D. INTEGRATED MANAGEMENT OF SHOOT FLY

The available knowledge on shoot fly of small millets is restricted to only little millet; however the following low cost management practices can be adopted for effective management of shoot fly.

1. **Early sowing of crop** i.e second fortnight of July or with the onset of monsoon.
2. **Adopt higher seed rate** (1.5 times the recommended seed rate) to make up for seedling mortality.

3. Host plant resistance

Promising small millets relatively resistant to shoot fly in India

<i>Kodo millet</i> Variety RPS 40-1, RPS 40-2, RPS 62-3, RPS 61-1, RPS 69-2, RPS 72-2, RPS 75-1, RPS 102-2, RPS 107-1, RPS 114-1, RPS 120-1, IQS 147-1, CO 2, Keharpur
<i>Foxtail millet</i> Variety RAU 1,2,6 ISe 119, 185,358,700,700, 702,703, SiA 5, 36,67, 242, 326, 395, SE 21-1, SIC 1, 2, CO 3
<i>Little millet</i> Variety PRC 2,3,7,8,9,10,11,12, RPM 1-1,8-1,12-1,41-1, RAU 1,2, k1, co 2, Dindori 2-1, GPMR 164, 274,236,243,110 and 213.
<i>Proso millet</i> Variety RAUm 1,2,3, MS 1307, 1316,1437,1595,4872, PM 29-1,BR 6, CO 1
<i>Barnyard millet</i> Variety VL 8,13,21,24,30,31,32, ECC 19,18,20,21, RAU 7,KE 16,K 1, PUNE 2386, Bhageshwar Local-2

4. **Intercropping** of soybean and radish in little millet substantially reduced the shootfly occurrence as compared to sole millet or millet mixed with French bean, ladies finger or pigeonpea. Growing of mung bean (*Vigna radiata*) or urd bean (*Vigna mungo*) and pigeonpea also reduced the succession and build up of insect pests in sorghum and pearl millet.
5. **Need based application of insecticides**
 - Soil application of phorate 8-10 kg/acre in furrow is effective in checking shoot fly infestation in kodo and little millet and gave higher yields.
 - Carbofuron 3G (1.5 kg a.i/ha) as soil application was most effective in reducing shoot fly incidence in proso millet.
 - Spraying of quinolphos (2ml/lit) effectively reduced shoot fly infestation in little millet.

Knowledge Gaps

From my perspective, seven major gaps in our knowledge of shoot flies (Diptera); they may apply similarly to other faunal taxa:

- Biogeography distributional ranges of taxa need to be fully mapped (Population ecology).
- Phenology or seasonal occurrence and local movements of species to be determined.
- Host plant, prey, saprophytic food, etc., of species need to be investigated.
- Life-histories and bioecology of different species should be studied on different host plants.
- Parasitoids, parasites and predators of fly species to be documented and its ecology studied.
- Survey and sampling of remaining undisturbed habitats for species diversity is a major and primary need of the hour. (The specificity of shoot fly and the occurrence of alternate or collateral hosts need critical investigations).
- Attractants, repellants and sex attractants need to be studied (Isolation of sex pheromone).

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