Insect Pests of Small Millets in India

Small millets that are important other than ragi are (comprises of five different crops) viz., foxtail millet (*Setaria italica),* kodo millet (*Paspalum scrobiculatum),* proso millet (*Panicum miliaceum),* little millet (*Panicum sumatrense),* barnyard millet (*Echinochloa frumentaceae).* They are cultivated in less productive soils with minimum management practices.

Economic Loss : A number of shootfly species attack small millets (Jotwani *et al*., 1969; Singh and Dias, 1972 ; Nageshchandra and Musthak Ali, 1983a). *Atherigona destructor* M. alone could bring an 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).

Common name	Scientific name	Damaging stage	Plant part attacked	Status
A. Kodo millet (*Paspalum scrobiculatum*. L.)				
Shoot fly	*Atherigona simplex.* Thom.	Maggot	Growing point	High
Gall midge	*Orseolia sp.*	”	Spikelet	Moderate
Stem or Pink borer	*Sesamia inferens,* Wlk.	Caterpillar	Stem	”
Leaf roller	*Marasmia trapezals,* Wlk.	”	Leaf	Low
Jassid	*Hecalus sp.*	Nymph & Adult	”	”
Gundhi bug	*Leptocorisa acuta*	”	Ear	”
Army worm	*Mythimna separata,* Wlk.	Caterpillar	Leaf	”
Grasshopper	*Acrida exalta,* Wlk.	Nymph & Adult	”	”

Common name	Scientific name	Damaging stage	Plant part attacked	Status
B. Foxtail Millet – *Setaria italica* Beauv.				
Shoot fly	*Atherigona atripalpis* M.	Maggot	Growing point	Moderate
Flea beetle	*Chaetocnema basalis,* Baly. *Madurasia* sp.	Adult	Leaf	Mod-High
Army worm	*Mythimna separata.* Wlk.	Caterpillar	”	”
Leaf roller	*Marasmia trapezalis.* Wlk.	”	”	”
Stem borer	*Chilo partellus,* Swim.	”	Stem	Low

Surface grasshopper	*Chrotogonus* sp.	Nymph & Adult	Leaf	”
Ant	*Sima* sp. *nr longiceps.* Floral	Adult	Ear	”
Leaf miner	-	Maggot	Leaf	Moderate

Common name	Scientific name	Damaging stage	Plant part attacked	Status
C. Little Millet – *Panicum sumatrense*				
Shoot fly	*Atherigona pulla* Wied.	Maggot	Growing point	High
Gall midge	*Orseolia* sp.	”	Spikelet	Moderate
Flea beetle	*Chaetocnema* sp.	Adult	Leaf	Low
Stink bug	*Nezara viridula*	Nymph & Adult	Ear	Low
Black pentatomid bug	*Dolycoris indicus* Stal.	”	”	”
Jassid	*Kolla mimica* Dist.	”	Leaf	”
Grass hopper	*Acrida exalta*	”	Leaf	”

Common name	Scientific name	Damaging stage	Plant part attacked	Status
D. Proso Millet – *Panicum miliaceum* L.				
Shoot fly	*Atherigona simplex* Thom.	Maggot	Growing point	-
Termites	*Odontotermes* sp. *Microtermes* sp.	Workers	Seed to seedling	Moderate
Field cricket	*Brachytrypes* sp.	Nymph & Adult	Leaf & shoot	Low

Common name	Scientific name	Damaging stage	Plant part attacked	Status
E. Barnyard Millet – *Echinochloa frumentacea* (Roxb.) Link				
Shoot fly	*Atherigona falcata* Thom.	Maggot	Growing point	High
White grub	*Anomala dimidiata* Burm. *Holotrichia seticollis* Mos.	Grub Grub	Root Root	Low Low

Pink borer	*Sesamia inferens* Wlk.	Caterpillar	Stem	Moderate
Aphid	*Hysteroneura setariae*	Nymph & Adult	Leaf & Shoot	Low
Leaf caterpillar	*Euproctis sp.*	Caterpillar	Leaf	Low
Gross hopper	*Acerida exalta* Wlk	Nymph & Adult	Leaf	Low

Common insect pests occurring on small millets

1. Shoot fly (*Atherigona* spp.)

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 meristamatic 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 it's 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 (Anon, 1995; Kadiregowda *et al*., 1995) similar trend was reported with respect to sorghum shoot fly (Kulkarni *et al*., 1978; Davis and Seshu Reddy, 1977).

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

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Kodo millet

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

Foxtail millet

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

Little millet

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.

Proso millet

Variety

RAUm 1,2,3, MS 1307, 1316,1437,1595,4872, PM 29-1,BR 6, CO 1

Barnyard millet

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

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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

Occasional insects with a potential for becoming future pests are *gall midge, pink borer, termites, leaf roller, Leaf hoppers, root aphids*

***Gall midge (Orseolia* sp.) :**

It is found on little and kodo millets. The spikelet infestation ranged from 3 to 50 per cent in little millet. The spikelets were found to be hypertrophied due to irritation caused by feeding of the maggots on the ovary. The pest is also of common occurrence in kodo growing areas of Madhya Pradesh.

***Pink borer (Sesamia inferens)*:**
Its occurrence on barnyard millet sometimes reached up to 30-35 per cent. Early planted crop suffered more damage. The pest is active from July to October.

***Termites* (*Odontotermes* sp. and *microtermes* sp.) :**
Proso millet suffers from the early stage when seeds are sown and even the portions above the ground are not spared. The attack is more pronounced in light sandy soils.

***Leaf roller* (*Marasmia trapezalis*) :**
The caterpillar rolls the edges of the foxtail millet leaves and pastes them to form a tube and eats away the green matter from inside. Continuous wet weather seems to be favorable for the multiplication of the pest.
A common feature of these occasional pests is that the incidence and population levels were fairly high in certain years. However, their economic significance is not fully understood. Therefore, more study is required on this aspect.

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)

Insect pests of Kodo Millet

Insect pests

The occurrence of insect pests in kodo millet is very low. Among the insect pests of kodo millet, shoot fly causes considerable losses. Remaining insect pests are of minor importance in this crop. Kodo millet is only the cereal crop which remains absolutely free from store grain pests during storage. The list of insect pests damaging the plant of kodo millet is mentioned earlier, along with their damaging stage and status of occurrence.

Shoot fly (*Atherigona* spp.)

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:

Jotwani *et al*. (1969) enlisted shoot fly species infecting the kodo millet and other minor cereals at Delhi. Pradhan (1971) reported *Atherigona bituberculata* as kodo shoot fly. Guruswamy and Natarajan (1974) reported the occurrence of shootfly as a pest of *Paspalum* from south India. Nayar et al. (1979) enlisted 3 species of shoot fly namely *Atherigona simplex, A. oryzae* and *A. pulla*. The attack of shootfly on *Paspalum* in Madhya Pradesh was reported by Katiyar *et al*. (1981). Singh (1984) recorded *Atherigona miliaceae* as paspalum 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.

Methods of control

1. **Cultural management :**

- Early sowing with onset of monsoon or in second fortnight of June resulted in low infestation of shoot fly as compared to late sowing. The early sowing also resulted in higher yield.
- High plant density may increase the effectiveness of natural enemies in reducing the pest population. While, higher plant density increases the number of shootflies, eggs laid and plant attacked. Thus, the

density of plant has a significant influence on oviposition by shoot fly (Davis and Reddy, 1982). A seed rate of 10 kg/ha has found optimum for higher grain yield with low incidence of shoot fly.

- Elimination of weeds reduces the shoot fly infestation in kodo millet. One hand weeding, 20-25 days after sowing checks the attack of this pest and resulted in economically higher yield (Singh *et al*. 1993).
- Intercropping of kodo millet with pulses and oilseeds has found beneficial in reducing the infestation, development and movement of shoot fly.

2. **Varietal resistance:** Development of resistant variety is the best and cheapest way for controlling the any insect pest. The varieties developed and recommended for cultivation in recent past possess good resistance against shootfly. These are JK 41, JK 62, GPUK 3, RPS 136-1 and KMV 20 (Singh *et al.*, 1990 and 1993). Among them GPUK 3 possessed stable resistance for shootfly, while KMV 20 and RPS 136-1 exhibited the resistance against shootfly under good management conditions (Singh *et al.* 1997).
3.

Sources of resistance against shoot fly in kodo millet

Resistant sources	Reference
RPS 123, RPS 75-2, RPS 69-2, RPS 1-1 and Keharpur	Singh (1984)
RPS 117 and RPS 40-1	Singh *et al*. (1984)
GPLM 6, 11, 20, 21, 29, 32, 39, 42, 45, 50, 60, 106, 110, 113, 117, 119, 120, 121, 131, 142, 155, 158, 160, 170, 172, 173, 178, 180 and 185	Murthy and Harinarayana (1989)
RPS 40-1, RPS 40-2, RPS 62-3, RPS 61-1, RPS 69-2, RPS 72-2, RPS 75-1, RPS 102-1, RPS 107-1, RPS 114-1, RPS 120-1, RPS 147-1, Co-2 and Keharpur	
RPS 62-3, RPS 41, RPS 75-2 and RPS 123	Singh *et al*. (1990)
GPUK 3, GPUK 4, KMV 20, RPS 136-1 and JK 41	Singh *et al*. (1990)
RPS 136-1, GPUK 3, PSC 1, KK 1, IGBKK3 and KMV 20	Singh *et al*. (1997)

Chemical control

- Application of carbofuron as soil treatment was effective against shoot fly in kodo millet.
- Spraying of monocrotophos or phosphamidon after 10 days of germination had found effective in controlling shoot fly incidence in kodo millet.