

STORAGE PESTS AND THEIR MANAGEMENT



Dr. Nihal R

Introduction

- According to FAO, the world wide annual loss due to stored grain insect pest is 10%.
- In India, insects cause loss of 2 - 12% during storage.
- 60 - 70% grains are stored at farmer's level [IARI PhD 2000].
- Insects cause injury to the stored products for their food and shelter requirements - resulting into quantitative and qualitative losses. Indian conditions suit for their multiplication throughout the year.
- Small size, flattened shape of many beetles, strong fliers etc., are some of the reasons which make insects as storage pests.
- Majority of stored insect pests belong to Orders Coleoptera and Lepidoptera, 60 and 8-9% respectively.
- Smallest insect attacking stored grain products is *Cryptolestes minutus* and the largest insect attacking is *Caryedon serratus* [ICAR NET 2019].
- Value depreciation of a product owing to the present of insects or other foreign matter is called **Dockage**



Storage Pest Classification

Based on the site of attack

Internal feeders

Spend most of their life feeding within the kernel of grain

External feeders

Spend their life feeding on the surface of grains or on the finished products of grains

Based on the stage of seed

Primary pest

Attack the healthy grain and cause damage E.g.: Pulse beetle

Secondary pest

Attack the already damaged grains by other insects

Storage Losses

- **Grain deterioration in storage is caused mainly through**
 - (a) bio-deterioration,**
 - (b) insects & non-insect pests and**
 - (c) moulds and fungi.**

1. Bio-deterioration

- **Bio-deterioration is due to the activity of enzymes present in the seed.**
- **The extent of deterioration depends upon the level of enzyme activity, which in turn is determined by moisture and temperature.**
- **Moisture content of grain plays a crucial role in post-harvest processing and is associated with most of the induced characteristics.**
- **'Hot spots' may occur at a site of increased respiration (caused by sprouting, infestation or microbial activity), and condensation may occur on cold grain or containers.**
- **Factors other than insect infestation also contribute, such as moisture, temperature, and oxygen fluctuations.**

2. Insect pests

- **Insects play a major role in the deterioration of food grains causing both quantitative and qualitative losses.**
- **Losses caused by insects are of different kinds: quantitative losses, qualitative losses, losses of seed viability and damage to storage containers.**

1. Quantitative:

- **Insects during storage mainly cause quantitative/weight losses by directly feeding on grain kernels. Insects cause 2-12%.**
- **These losses vary depending upon type of storage containers, storage period, grades and forms of grains, local climatic conditions and several other factors.**

2. Insect pests

2. Qualitative

- Storage pests feed on grain kernels and destroy the germ causing loss in calorific value & biochemical degradation.
- In stored rice, total number of amino acids is found to be reduced by insect infestation in raw and par-boiled rice.
- Loss of palatability and bad odor due to insect excreta.
- Uric acid thus produced by the insects, serves as a sensitive index of infestation of foodstuffs as well as the degree of insect population.
- **Seed viability loss: Germination of seeds tends to decrease with the increase of insect infestation.**
- **Damage to the structures is created by making holes in the storage containers.**
- **Eg.: *Rhyzopertha dominica* has the capability to destroy wooden storage containers.**

3. Fungi and Moulds

- Fungi and moulds attack at suitable moisture conditions and deteriorate the quality of the grains by producing the toxins.
- *Bacillus subtilis*, *B. mycoides*, *B. coli*, *Pseudomonas trifoli*, *P. florescens* etc. through its metabolism raise the temperature of the grain.

Table: The toxins produced by various fungi in moist grains

Fungus	Toxin
<i>Aspergillus flavus</i>	Aflatoxin
<i>A. cohraceus</i>	Ochratoxin
<i>Fusarium sp.</i>	F-2 toxin
<i>Penicillium rubrum</i>	Rubrotoxin

Source of Infestation

1. Field infestation: Some of the insects that attack the grains in the field even before harvest and continue damaging the grains in storage under favorable conditions.

- *Sitotroga cerealella*, *Rhizopertha dominica*, *Sitophilus oryzae* and bruchids infest standing crop at ripening stage.
- Generally, these insects fly from nearby farms, farm store houses oviposit on the maturing grains.
- **Infestation starts from the field itself and carried to the godowns [ARS NET/ PRE 2014].**

- *Sitophilus oryzae*
- *Sitotroga cerealella*
- *Callosobruchus sp.*
- *Cylas formicarius*
- *Caryedon serratus*
- *Corcyra cephalonica*

Source of Infestation

2. Infestation from already used gunny bags
3. Infestation from the machineries
4. Infestation by migration
5. Infestation through conveyance Railway wagons, lorries or trucks which are used to carry grain.
6. **Khapra beetle** *Trogoderma granarium* spread to different parts of country during Emergency period from Punjab.
7. Infestation from threshing yards.
8. Infestation through wind current from nearby fields.
9. Infestation from already stored infested materials
10. Infestation from cracks and crevices of godown.
11. Infestation from birds nests, ant nests and rodent burrows.

Kinds of infestation

Sl. No.		Definition
1	Horizontal infestation	Infestation of a storage insect on mature crop which comes to the storage via post harvest operations.
2	Vertical infestation	In a bulk storage, spreading of infestation from top to bottom and vice versa through gradual migration.
3	Latent infestation	Infestation by insects which are already present in storage structures
4	Cross infestation	Infestation by omnivorous/ polyphagous insects from one source to another. Infestation that comes from other bag in storage is cross infestation.

Factors affecting the Storability

1. Physical quality of grains:

- **Grains containing dirt, dust, insect frass, broken grain pieces and other foreign materials deteriorate quickly.**
- **To avoid this problem, grain could be passed through suitable sieve, winnowing and using proper threshing operation. Excess moisture and mould, insects and rodents are known to be responsible for damage and loss to stored products.**

Factors affecting the Storability

2. Ecological conditions: The abiotic factors affecting are temperature, humidity, oxygen etc. [ARS PRE/NET 2016].

a. Moisture: The moisture content of grain which itself is dependent on relative humidity of the place.

- Optimum moisture % for insect attack in stored grains is 12-14%.
- High moisture conditions (>10%) are essential for most of the species except khapra beetle and lesser grain borer [JRF 2001].
- At high moisture levels, carbohydrate fermentation occurs with the production of alcohol and acetic acid resulting in sour taste.
- At the time of harvest, the grain should be dried until the moisture content is less than 9% which is ideal for storage [SRF 2010].
- For the long-term safe storage of seeds the moisture content of the seeds should be 7 to 8% [ARS NET/ PRE 2016]

Factors affecting the Storability

- Under high moisture content, sugars are lost and lactic acid accumulates and results in sick grain.
- **Damp grain heating:** Above 65 - 75% grain moisture results in growth of microorganisms resulting in increase in temperature up to 63°C.
- **Dry grain heating:** At low moisture content but congenial for fast insect development, the temperature rises to 42°C.

Sl. No.	Insect species	Moisture content (%)	
		Minimum	Optimum
1	<i>Trogoderma granarium</i>	0 - 1.9	11.5
2	<i>Sitophilus oryzae</i>	9.5 – 11.0	14.0 – 14.7
3	<i>Rhizopertha dominica</i>	9.0 – 10.0	11.0 – 14.0
4	<i>Tribolium castaneum</i>	10.0	11.5 – 16.0
5	<i>Coreyra cephalonica</i>	9.0	15.0 – 200.0
6	<i>Ephestia cautella</i>	10.0	16.0

Factors affecting the Storability

b. Temperature:

Temperature	Value
optimum temperature	28-32°C
minimum temperature for growth	15.5 -18.3°C
High lethal temperature	50 to 60°C
Lower lethal temperature	-1 and 3°C

c. Rainfall: This is related to moisture content of grains.

In Paddy 10-15% loss occur due to high moisture content of the grains during rainy season.

In addition mould attack is also high.

Factors affecting the Storability

d. Oxygen/carbon dioxide: Oxygen is needed in the respiration of insects, mites, bacteria, fungi & grains.

- The respiration brings in changes in inter-granular air (depletion of O_2 and accumulation of CO_2), gain in moisture content and rise in temperature.
- Different stored product insects and its stages manifest varying degree of tolerance to depletion of O_2 and accumulation of CO_2 .
- Several other insects are affected at 10-15% level of depletion of O_2 .

Factors affecting the Storability

Sl. No.	Insect species	Stage	% Oxygen depleted
1	<i>Tribolium castaneum</i>	Full- grown larva	14.3
		Adult	13.76
2	<i>Trogoderma granarium</i>	Eggs	4.25
		First-instar larva	15.67
		Full-grown larvae	19.92
		Adult	17.61
3	<i>Rhizopertha dominica</i>	Adult	14.30
		Full grown larvae	9.60
4	<i>Sitophilus oryzae</i>	All stages	16.00

Factors affecting the Storability

3. Period of storage:

- **Longer the period of storage more will be the number of species attacking the stored grains.**
- **For instance, in paddy when left without any control measures, paddy moth infests within 3 months, paddy moth and lesser grain borer infest within 6 months and rice weevil and red flour beetle in addition to the above pest within one year**

4. Storage structures used:

- **Local storage structures like bamboo bin, underground bin etc. are not moist proof and facilitate insect multiplication.**
- **Further it is very difficult to take up the disinfestations**

Factors affecting the Storability

5. Processing: Some of the post harvest processing technologies also influence the insect attack.

- Parboiled rice is more susceptible to insect attack when compared to raw rice.
- Hulled rice is prone to more damage by rice weevil and lesser grain borer.
- Milling increases the attack by *Corcyra cephalonica*

6. Grain characters:

a. Morpho-chemical properties: Texture of the husk, thickness of husk, grain type or grade, relative hardness of the grain/kernel, amylase and protein content etc. can influence the attack by insects.

b. Thermal properties: Grain is a poor conductor of heat. Because of this vapor may arise slowly and condense.

c. Hygroscopic properties: Capacity of the grain to absorb or loose moisture according to exiting humidity in inter-granular space.

INTERNAL FEEDERS

Sl.No.	Common Name	Scientific Name	Family	Order	Damaging stage
1	Rice weevil	<i>Sitophilus oryzae</i>	Curculionidae	Coleoptera	Adult and Grub
2	Lesser grain borer	<i>Rhizopertha dominica</i>	Bostrichidae	Coleoptera	Adult and Grub
3	Cigarette beetle	<i>Lasioderma serricorne</i>	Anobiidae	Coleoptera	Grub
4	Pulse beetle	<i>Callosobruchus chinensis</i>	Bruchidae	Coleoptera	Grub
5	Tamarind beetle	<i>Caryedon gonagra</i>	Bruchidae	Coleoptera	Grub
6	Cigar beetles	<i>Demobrotis sp</i>			Grub
7	Drug store beetle	<i>Stegobium paniceum</i>	Anobiidae	Coleoptera	Grub

INTERNAL FEEDERS

Sl.No.	Common Name	Scientific Name	Family	Order	Damaging stage
8	Dried fruit moth	<i>Vitula serratilineella</i>	Pyralidae	Lepidoptera	Larva
9	Sweet potato weevil	<i>Cylas formicarius</i>	Apionidae	Coleoptera	Adult and Grub
10	Potato tuber moth	<i>Phthorimaea operculella</i>	Gelechidae	Lepidoptera	Larva
11	Red legged ham beetle	<i>Necrobia rutipes</i>	Cleridae	Coleoptera	Adult and Grub
12	Cadelle beetle	<i>Tenebroides mauritanicus</i>	Ostomidae	Coleoptera	Adult and Grub
13	Angoumois grain moth	<i>Sitotroga cerealella</i>	Gelechidae	Lepidoptera	Larva
14	Arecanut beetle	<i>Araecerus fasciculatus</i>	Anthribidae	Coleoptera	Adult and Grub

EXTERNAL FEEDERS

Sl.No.	Common Name	Scientific Name	Family	Order	Damaging stage
1	Red flour beetle	<i>Tribolium castaneum</i>	Tenebrionidae	Coleoptera	Adult and Grub
2	Rice moth	<i>Corcyra cephalonica</i>	Galleridäe	Lepidoptera	Larva
3	Kapra beetle	<i>Trogoderma granarium</i>	Dermeestidae	Coleoptera	Grub
4	Indian meal moth	<i>Plodia interpunctella</i>	Pyralidae	Lepidoptera	Larva
5	Almond moth	<i>Ephestia cautella</i>	Pyralidae	Lepidoptera	Larva
6	Long headed flour beetle	<i>Latheticus oryzae</i>	Tenebrionidae	Coleoptera	Adult and Grub

EXTERNAL FEEDERS

Sl.No.	Common Name	Scientific Name	Family	Order	Damaging stage
7	Yellow meal worm	<i>Tenebrio molitor</i>	Tenebrionidae	Coleoptera	Grub
8	Dried fruit beetle	<i>Carpophilus hemipterus</i>	Nitidulidae	Coleoptera	Adult and Grub
9	Saw toothed beetle	<i>Oryzaephilus surinamensis</i>	Silvanidae	Coleoptera	Adult and Grub
10	Flat grain beetle	<i>Cryptolestus minutus</i>	Cucujidae	Coleoptera	Grub
11	Black fungus beetle	<i>Alphitobius laevigatus</i>	Tenebrionidae	Coleoptera	
12	Red legged ham beetle	<i>Necrobia rufipes</i>			

Pest causing dense webbing of commodities

- *Podia interpunctella*
- *Corcyra cephalonica* [ARS NET/ PRE 2012, 2015]
- *Ephestia cautella*.
- **Thanatosis:** Most of stored grain pests act as feigning like camouflage

Internal feeders



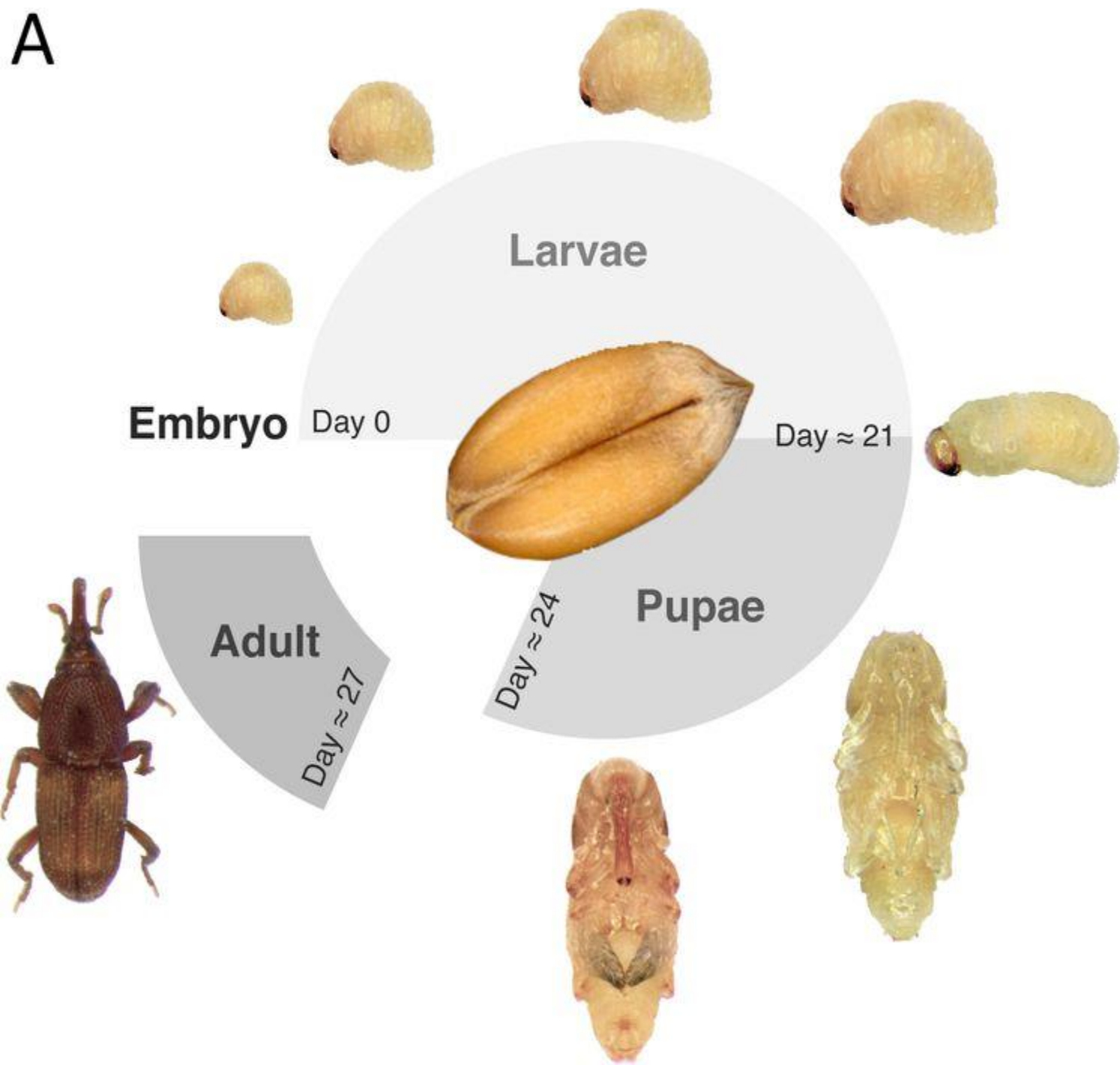
1. Rice weevil

S.N: *Sitophilus oryzae*
(Curculionidae: Coleoptera)

- **The female makes a small hole on the grain, deposits an egg and covers it with a gelatinous fluid [IARI PhD 2013, JRF 2016].**
- **In a period of 4-5 months a female may lay from 60 to 400 eggs.**
- **The life cycle ranges from 26 to 28 days.**
- **Grubs are apodous [ARS PRE/NET 20151.**
- **Rice weevil hibernates in adult stage.**
- **Site of pupation is inside the grain.**
- **Amylase activity in gut is very high [IARI PhD 2002].**





A**B**

Nature of Damage

- Larvae and adult bore into the grains and cause damage making them unfit for consumption.
- The apodous grub feeds inside the grain, pupates there itself and emerges through an irregular hole made on the grain.
- The entire grain is usually destroyed by the time the adult emerges.
- The insect infests the grain both in storage and in field.
- Feeds on starchy contents hallowing the grain out leaving only the pericarp intact.
- **Circular bore hole is noticed.**
- **They destroy more what they eat. Germ feeder [ARS PRE/NET 2015].**
- Rice weevil damage is more in monsoon season.
- Hot spots are observed.

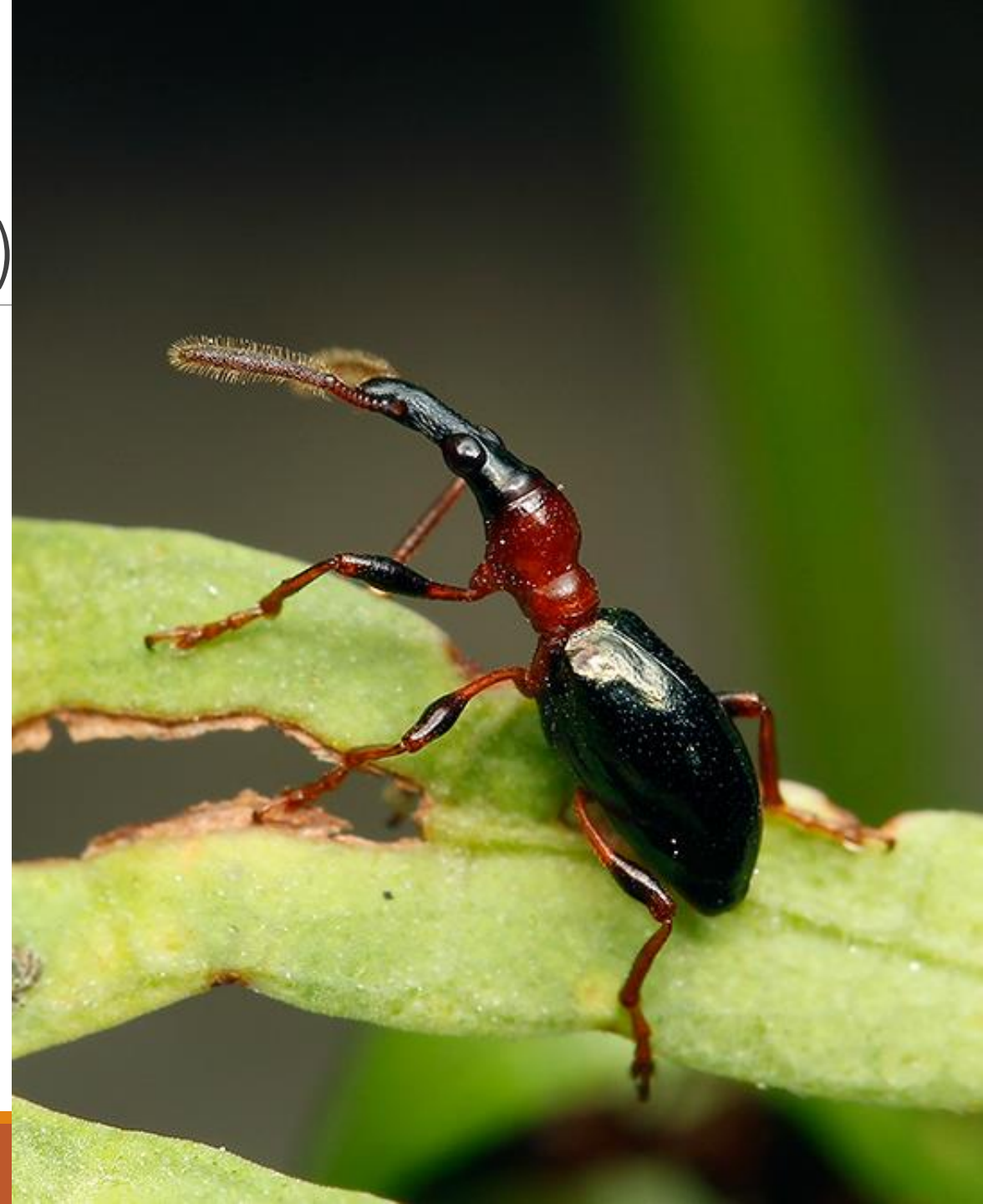


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2. Sweet potato weevil

S.N: *Cylas formicarius*
(Apionidae: Coleoptera)

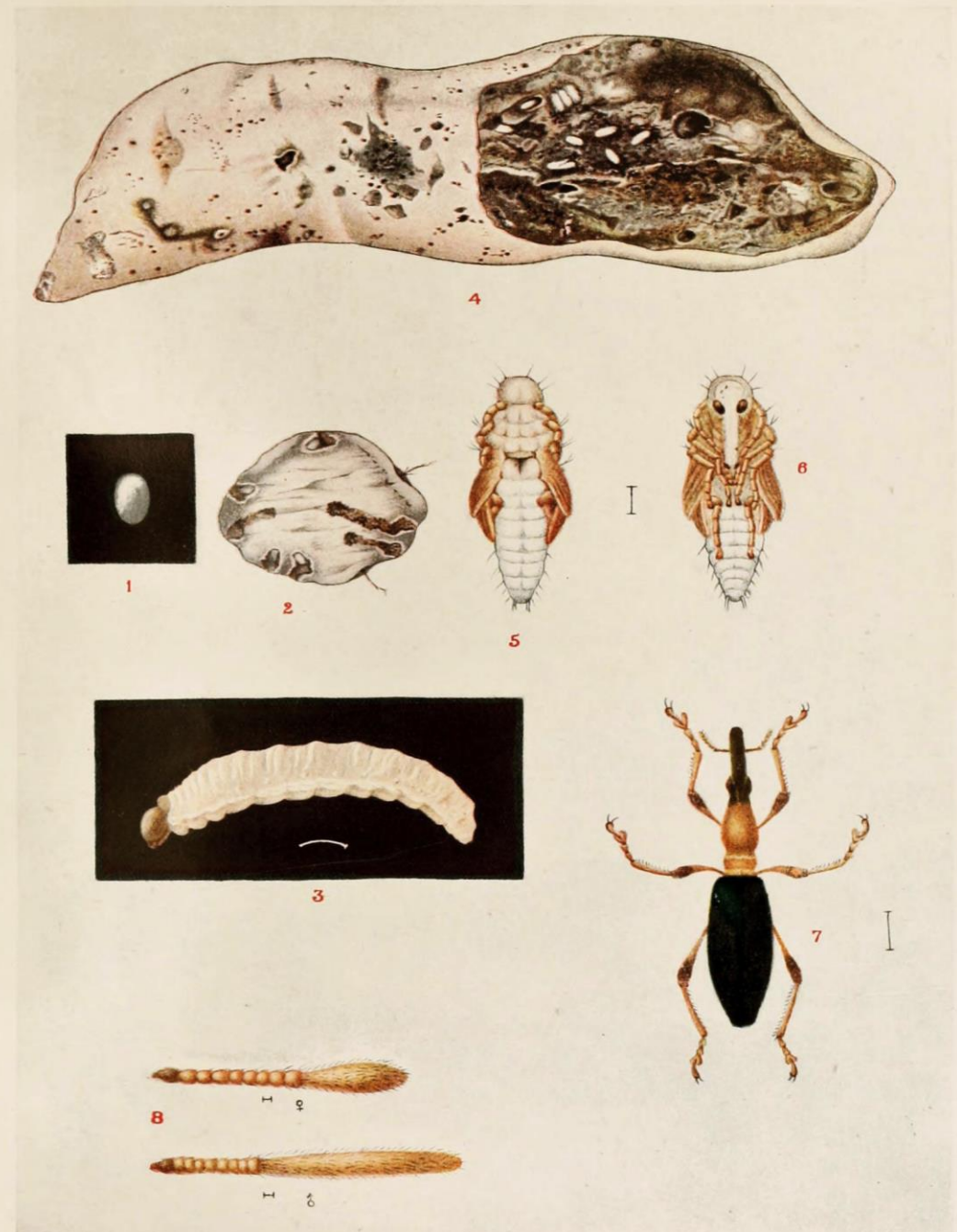
- **S.O.O. singly in cavities in stems or tubers covered and 200 eggs are laid by a female.**
- **The white grubs eat into the tissue leaving only the hole of entry.**
- **S.O.P. in the burrow.**
- **The weevil enters the soil through cracks.**
- **The adult is also capable of causing damage to the tubers.**







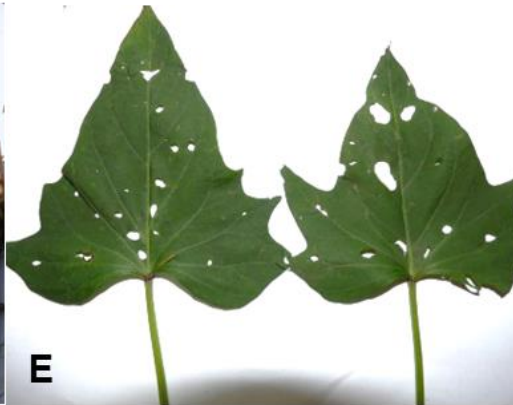
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SWEET POTATO WEEVIL.

Nature of Damage

- **The grubs and adults bore into the tender vines, stems and tubers making them unfit for use.**
- **The tunnel systems are usually infected with fungi and bacteria causing extensive rotting of the tubers.**
- **Adults attack the leaves, vines and tubers.**
- **It is a pest both in the field and storage.**

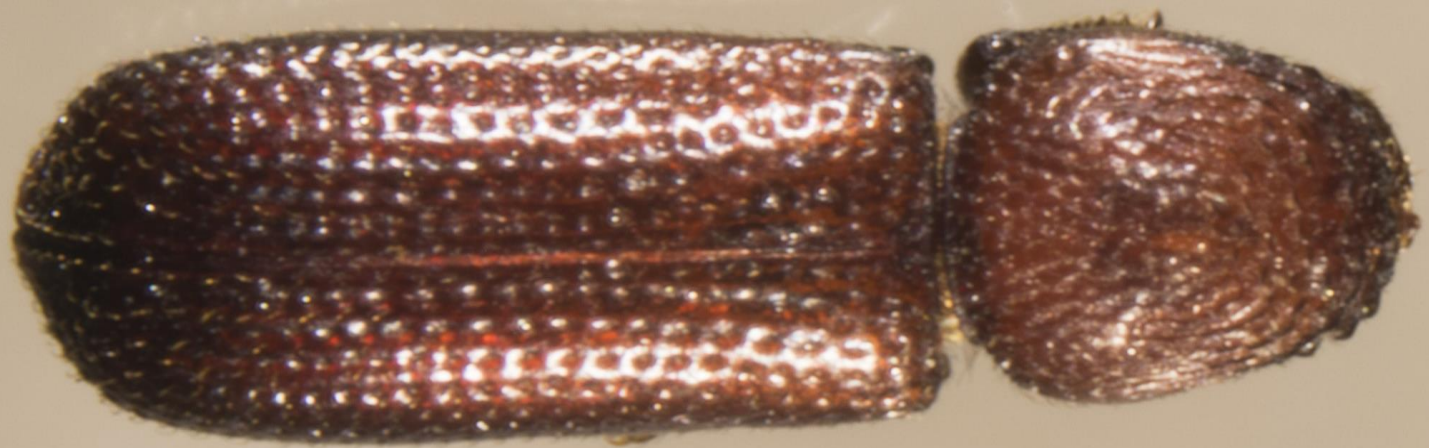


3. Lesser grain borer

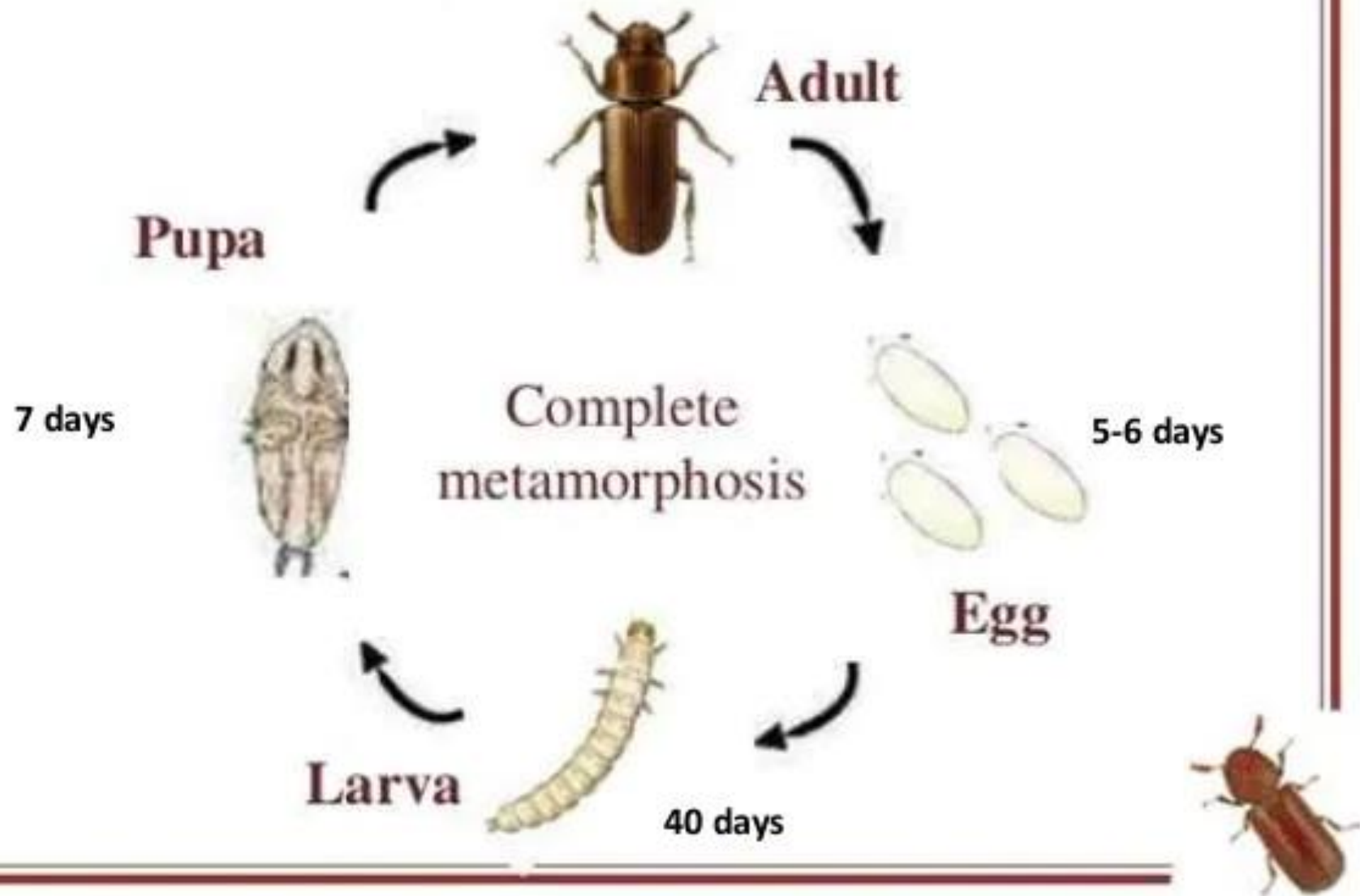
S.N: *Rhyzopertha dominica*
(Bostrychidae: Coleoptera)

- **S.O.O. in crevices or on rough surfaces of a seed.**
- **S.O.P. within the eaten grain.**
- **It is particularly a pest of un-husked paddy becoming serious occasionally.**
- **Adults feeds inside the grain and reduce them to mere shell with many irregular holes.**
- **It is important as a pest of whole cereals.**
- **In undamaged grains adults most frequently attack the germ.**
- **They are primary pests and can attack rice grains (paddy rice) more readily than *Sitophilus*.**





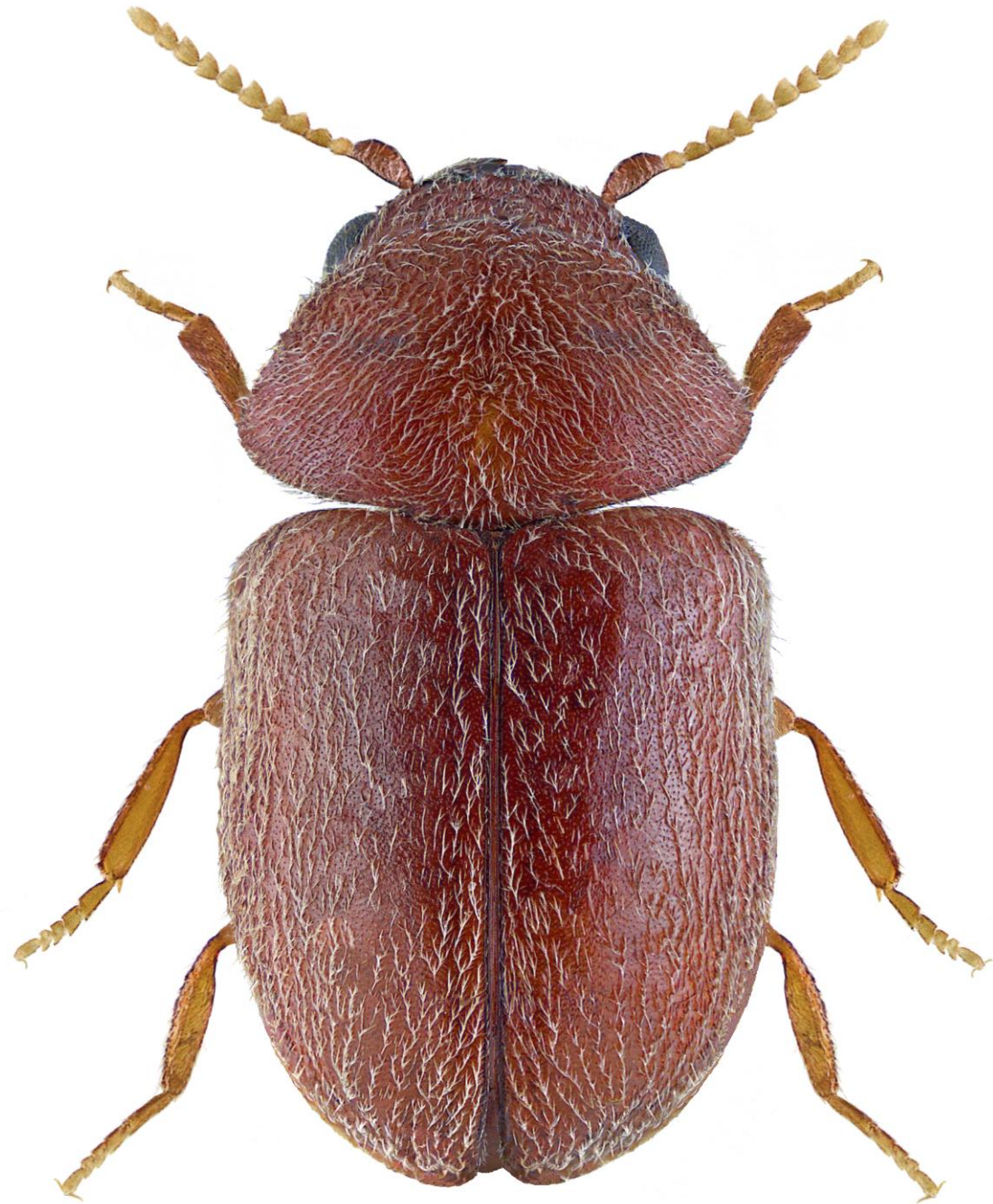
Life Cycle





4. Cigarette or tobacco beetle S.N: *Lasioderma serricorne* (Anobiidae: Coleoptera)

- **S.O.O. on the surface of stored material.**
- **The fourth larval instar stops feeding and builds a cell on some firm foundation for pupation.**
- **The adults cause most of their damage by making holes when they bite their way out of their cocoons.**
- **Grub can attack undamaged cereal grains and pulse seeds, and often show preference for the germ of the seed for feeding.**
- **In packaged cigarettes holes are made in the packets by larvae and adults. Beetle unaffected by nicotine.**
- **Pin head holes in stored products.**







5. Drug store beetle

S.N: *Stegobium paniceum*
(Anobiidae: Coleoptera)

- **Grubs damage dried herbs and spices by making small cylindrical galleries through the commodities.**
- **Adults feed very little if at all.**
- **It tunnels into stored products and make them unfit for consumption**





5 mm



5488322

6. Pulse beetle

S.N: *Callosobruchus chinensis*
(Bruchidae: Coleoptera)

- It is a pest both in the field and in storage.
- The grubs feed on the seeds in pods.



MINDEN
PICTURES









7. The tamarind beetle

S.N: *Pachymeres gonagra*
(Bruchidae: Coleoptera)

- **S.O.O on the outside of the pod, to which they are stuck.**
- **S.O.P within the pod or else emerge by boring a large hole and pupate outside in a thin papery cocoon.**
- **Grub bore into fruits and seeds, feed the inner contents and the emerging adult beetle makes a large hole in the pod. Pods are attacked both in the field and in post-harvest storage.**
- **The only stored grain pest of groundnut which attacks both kernel and pods**



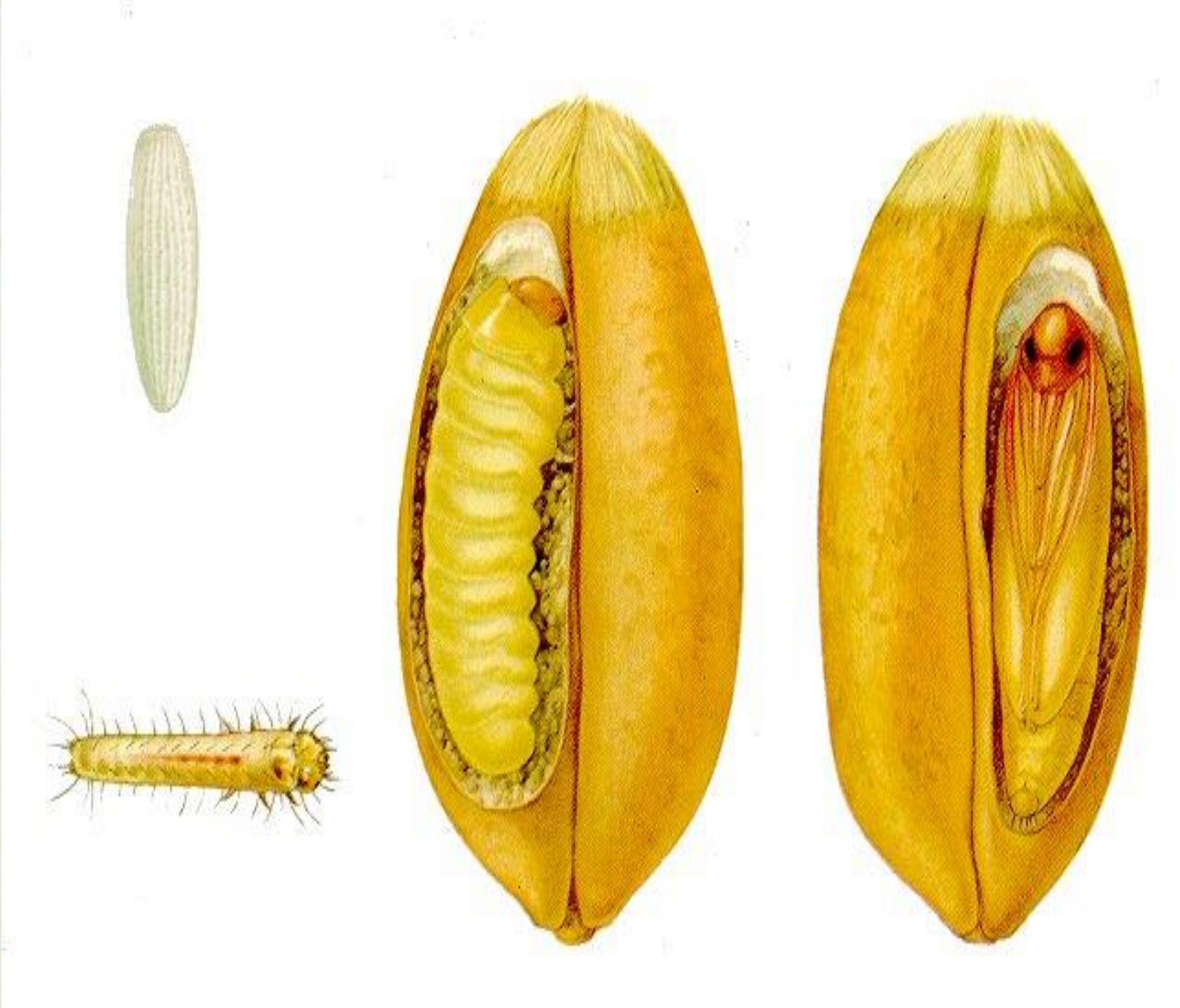
8. Angouinos grain moth

S.N: *Sitotroga cerealella*
(Gelechiidae: Lepidoptera)

- **S.O.O. on the grain.**
- **S.O.P. inside the grain.**
- The caterpillars feed on the internal contents of grains. The upper layer is severely attacked and grains are covered with scales.
- Infested grains with mature larvae or pupae can be recognized by presence of a very small window in the grain.
- On emergence the adult pushes its way through this small circular window and the trap door is left hinged to the grain, which is characteristic of this pest.









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9. Potato tuber moth

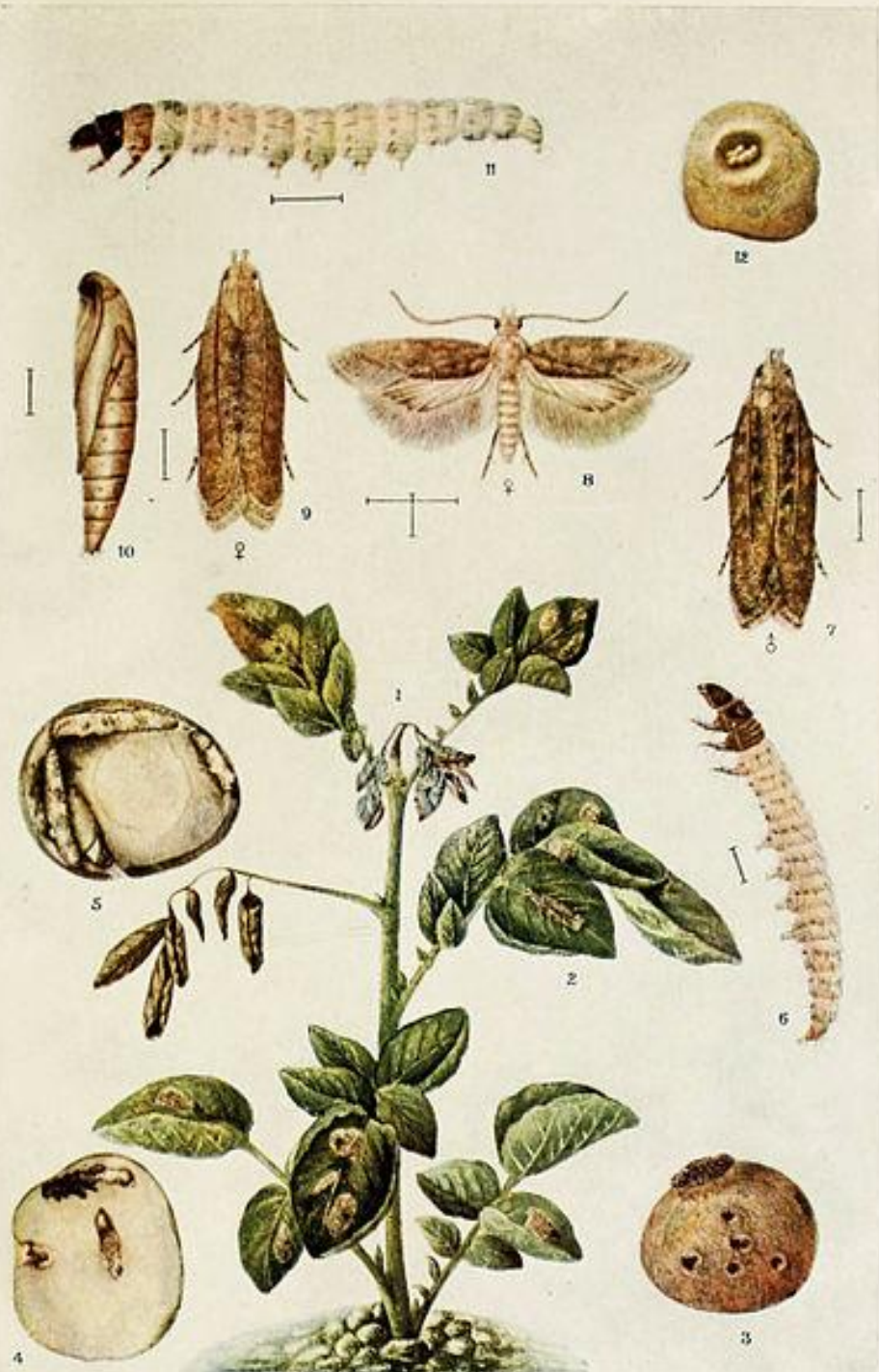
S.N: *Phthorimaea operculella*
(Gelechiidae: Lepidoptera)

- **S.O.O singly in tubers near the eye or on a sprout.**
- **Pupation takes place in a cocoon in the tuber.**
- **Pest of field and storage.**
- **Tubers are bored by the larger caterpillars, and they often become infected with fungi or bacteria.**



Gelechiidae
Phthorimaea operculella

2 mm



10. Coffee Bean Weevil

S.N: *Araeocerus fasciculatus*

(Anthribidae: Coleoptera)

- **S.O.O** singly on the ripening, or fully ripe, seeds, and the white, legless larvae burrow into the seeds.
- **S.O.P** within the seed.



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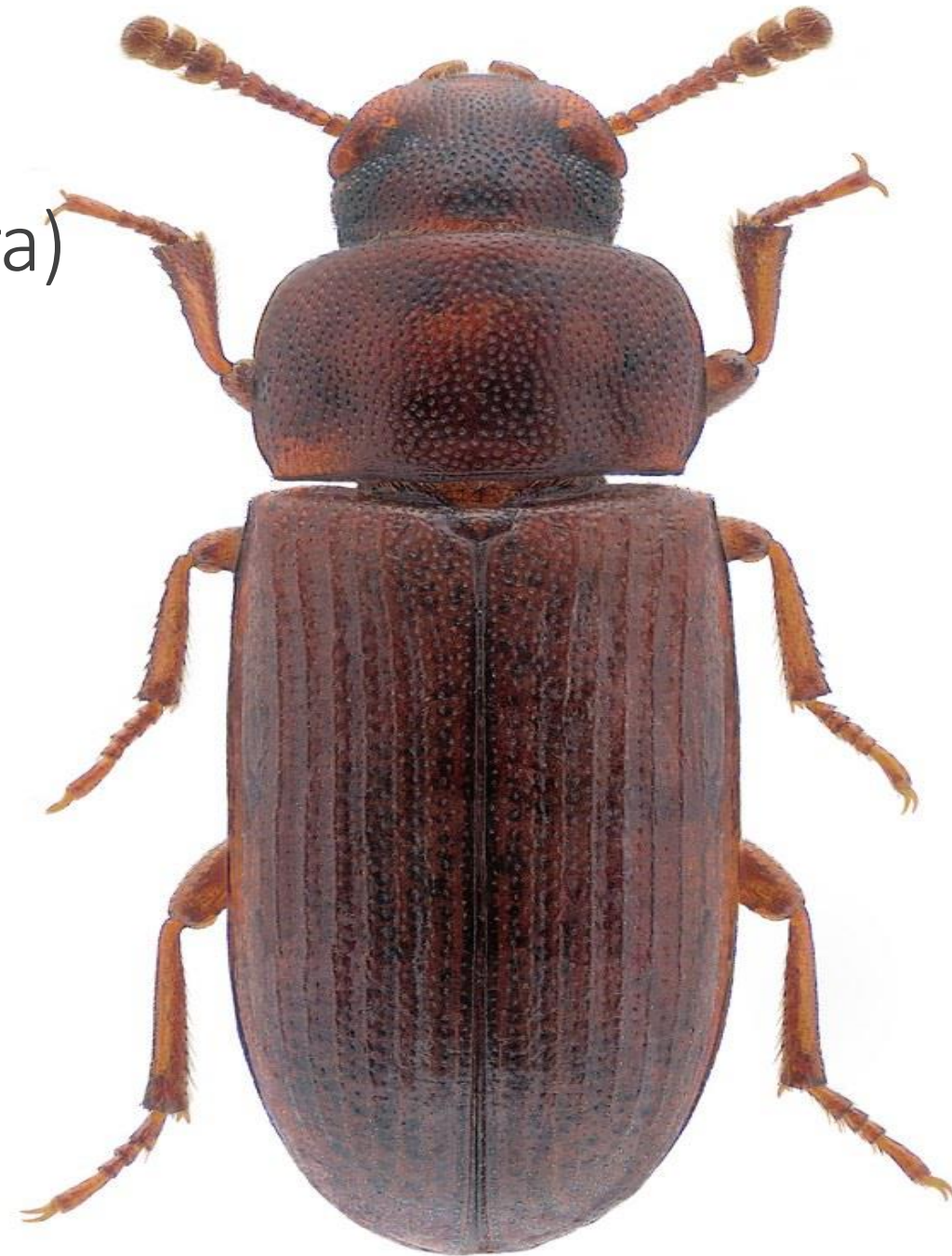
External feeders



1. Red flour beetle

S.N: *Tribolium castaneum*
(Tenebrionidae: Coleoptera)

- **Cannibalism and predation play an important role in the nutrition of *T. castaneum*.**
- **Over winters in adult stage.**
- **Grubs are negatively phototactic.**
- **They lay sticky eggs in the food.**
- **The eggs and pupae are often cannibalized by the adults, the males showing a preference for pupae and females for eggs.**
- **The adults and larvae are known to prey upon all stages of *Plodia interpunctella*, *Ephesia cautella* and *Corcyra cephalonica*.**





(a) Larva



(b) Pupa



(c) Adult



A



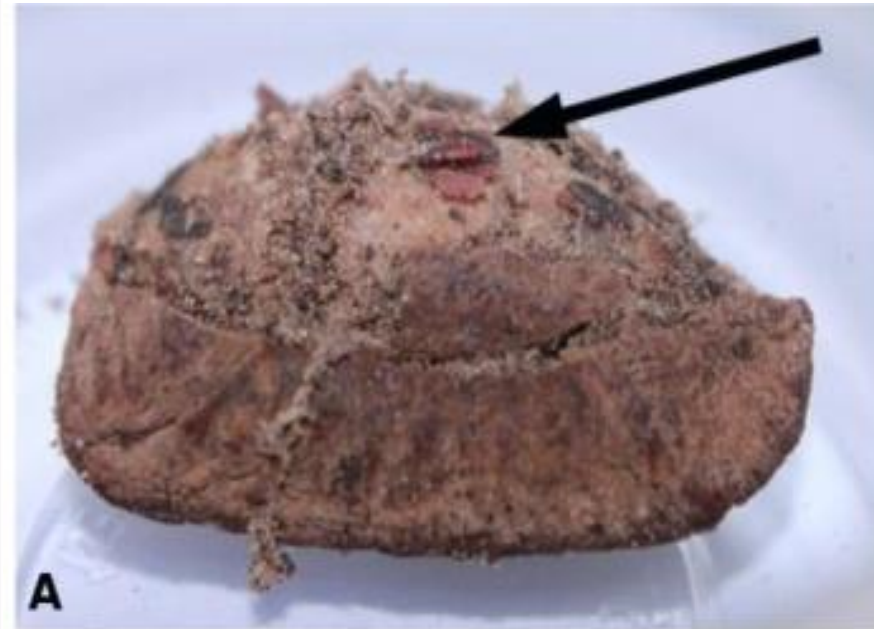
B



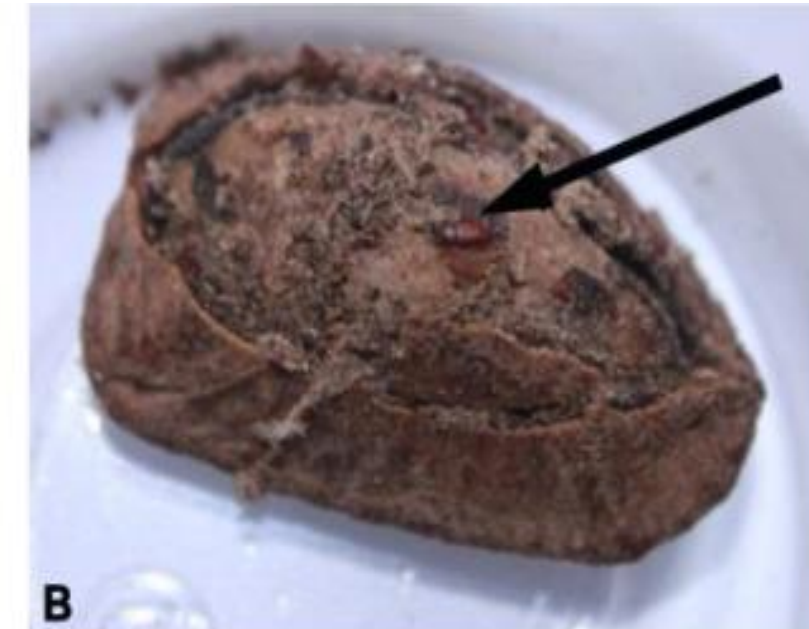
C



D



A



B

Figure 4. *Tribolium castaneum* (Coleoptera: Tenebrionidae) inside

Nature of Damage

- **Beetle releases gaseous of benzo-quinones from a pair of abdominal defense glands in the medium which gives an off flavor to the produce [ICAR ARS NET 2019].**
- **Greatest damage is during the hot and humid monsoon season.**



2. Indian meal moth

S.N: *Plodia interpunctella*

(Pyralidae: Lepidoptera)

- Each female lays some 200-400 eggs which are stuck to the substrate.
- Overwinters in larval stage.
- The direct eating of the produce, especially the germinal part of grains, is the primary damage.
- but the secondary damage is the contamination of foodstuffs with larvae, frass and silk webbing.









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3. Rice moth

S.N: *Corcyra cephalonica*

(Pyralidae: Lepidoptera)

- **S.O.P in silken cocoons.**
- **Before metamorphosing into a pupa, *Corcyra cephalonica* passes through a larval phase consisting of 5 instars [JRF 2000].**
- **The overwintering stage larval stage.**



Nature of Damage

- Infestation is normally limited to upper 45 cm only in bulk grains.
- **Caterpillars web together the grains and feed within.**
- In case of whole grains, kernels are bound into lumps up to 2 kg.
- **It attacks broken grains and flour especially the milled products which are heavily damaged, if neglected.**
- It pollutes food grains with frass, moults and dense webbing.



4. Khapra beetle

S.N: *Trogoderma granarium*

(Dermestidae: Coleoptera)

- **Without food the larvae undergo diapause and survive about nine months.**
- **Pupa usually remains in the cast skin of the last instar larva.**
- **egg stage is more sensitive to decreased oxygen content.**
- **It can be checked by lowering oxygen concentration below 16.8 % or increasing the CO₂ content or storing grain in air tight containers.**
- **It survives at high temperature (36° C) and low humidity [ARS NET/ PRE 2014, JRF 2016].**



Nature of Damage

- Feeding by grubs reduces seeds to frass usually hollowing out the grain.
- Grubs eat near the embryo region of the grains.
- Beetles are confined to the upper 50 cm layer of grains in a heap or to the periphery.
- The grubs are positively thigmotactic and can be collected by placing gunny bags on the heap of grain



5. Tropical Warehouse/Almond / Dried-currant Moth

S.N: *Ephestia cautella*
(Phycitiae: Lepidoptera)

- S.O.O. holes in the bags.
- S.O.P in the crevices or where two bags are in contact with each other.
- **Webbing in the grain and on the surface of bags, with cocoons between adjacent surfaces.**



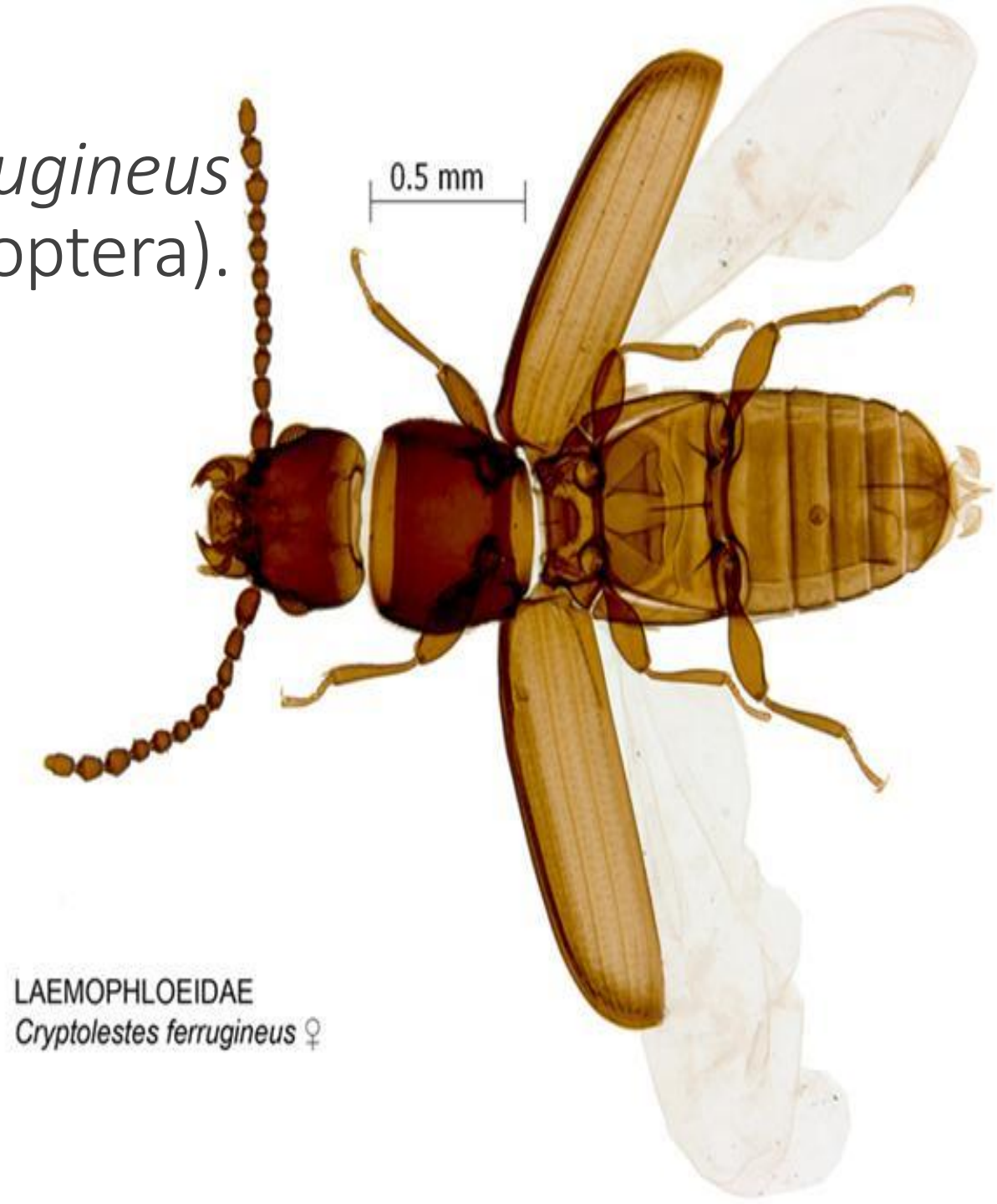


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6. Rusty grain beetle

S.N: *Cryptolestes ferrugineus*
(Cucujidae: Coleoptera).

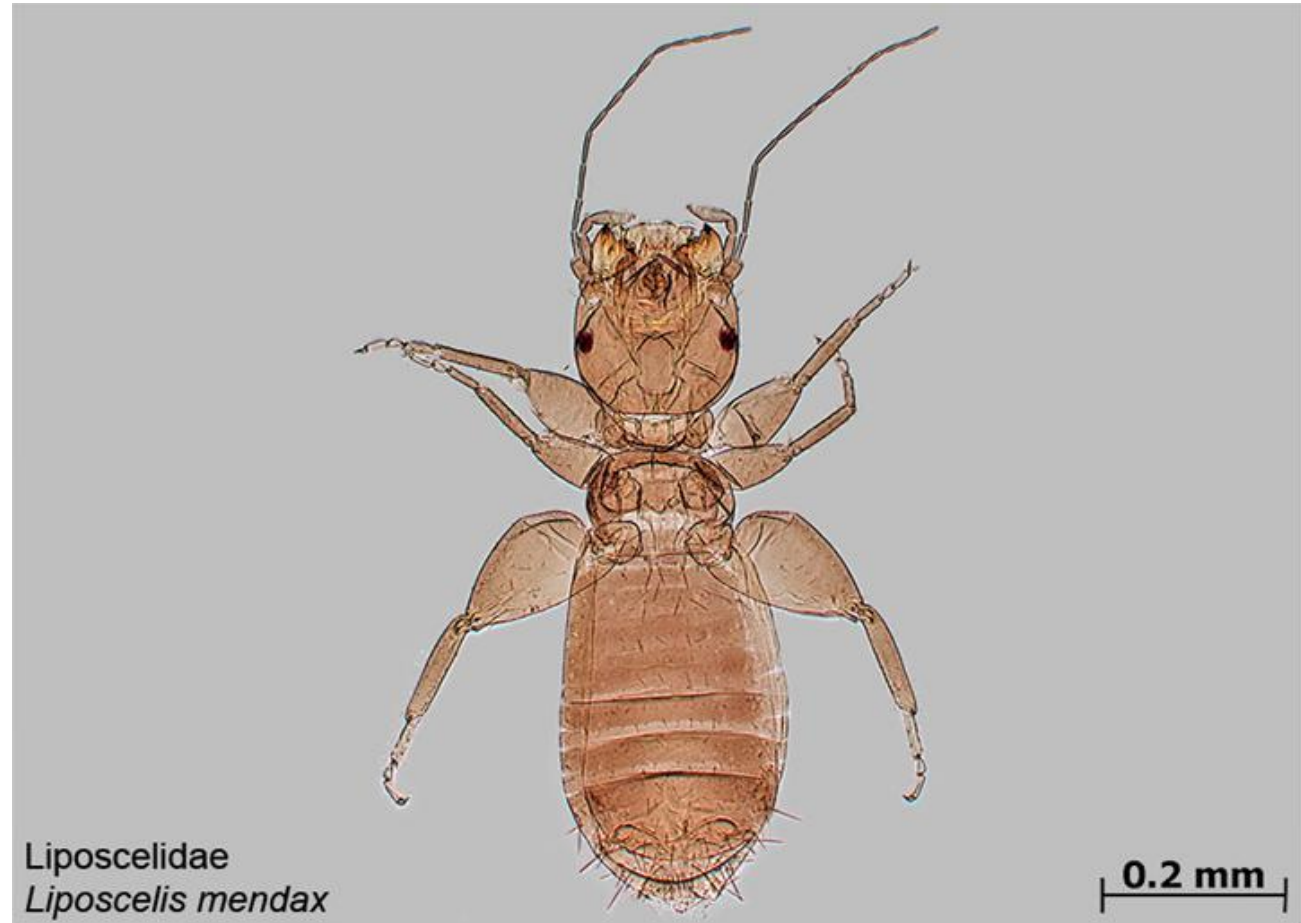
- **This beetle is the most serious pest of stored grain.**
- **It usually feeds on the germ (embryo) part of a whole seed.**
- **Heavy infestations cause grain to spoil and heat.**
- **It moves rapidly in warm grain and can fly when the air temperature is above 23°C.**
- **Eggs are laid in the crevices of kernels**





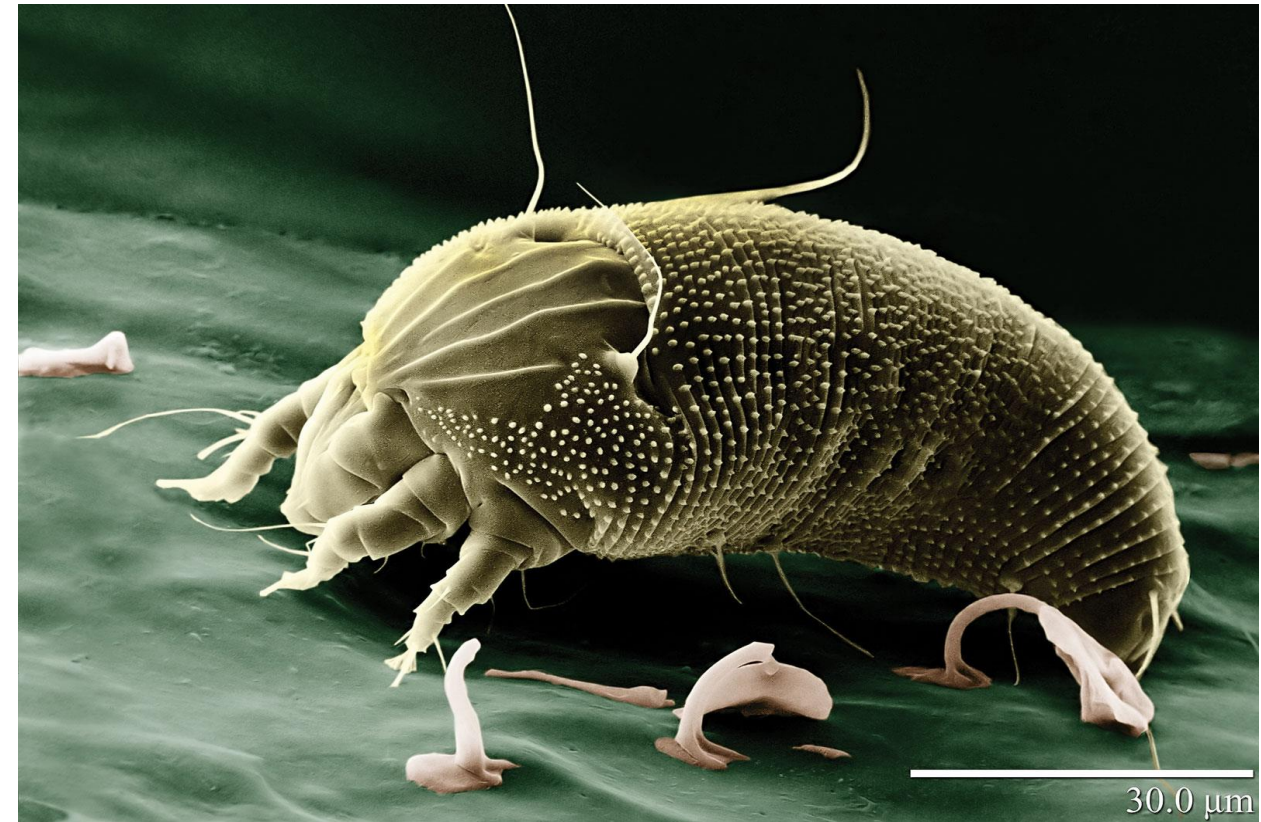
7. Psocids (book lice/ grain lice): S.N: *Liposcelis transvallensis* (Liposcelidae: Psocoptera)

- **These insects are slightly larger than grain mites.**
- **They can feed on damaged kernels and are found in tough or damp grain.**
- **They are usually found with other insects or mites.**
- **More common in coastal areas and rainy season.**



8. Mites

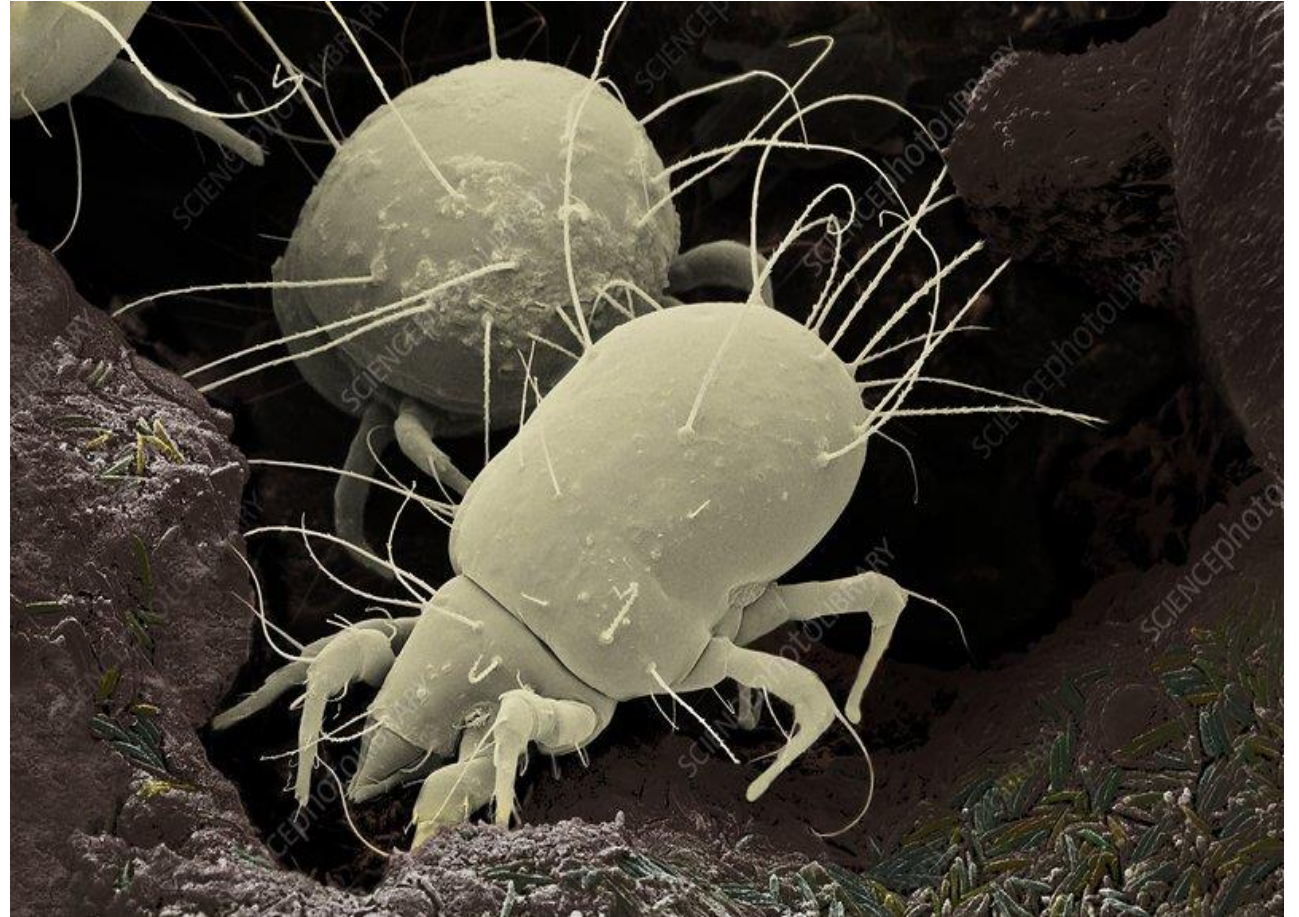
- **Mites are the smallest of the stored-product pests.**
- **They are common in seeds stored at 14- 17% moisture content.**
- **Mites are cold-hardy, mostly feed on broken grain, weed seeds, dockage and moulds.**
- **Some mites are cannibals.**
- **They breed in tough and damp pockets of cereals.**
- **Some give a strong, minty odour to infested grains and oilseeds.**



Storage Mites

Sl. No.	Common Name	Scientific Name
1	Grain mite	<i>Acarus siro</i>
2	Cheese mite	<i>Tyrophagus casei</i>
3	Mold mite	<i>Tyrophagus putrescentiae</i>
4	Dried fruit mite	<i>Carpoglyphus lactis</i>
5	Itch mite	<i>Glycyphagus domesticus</i>

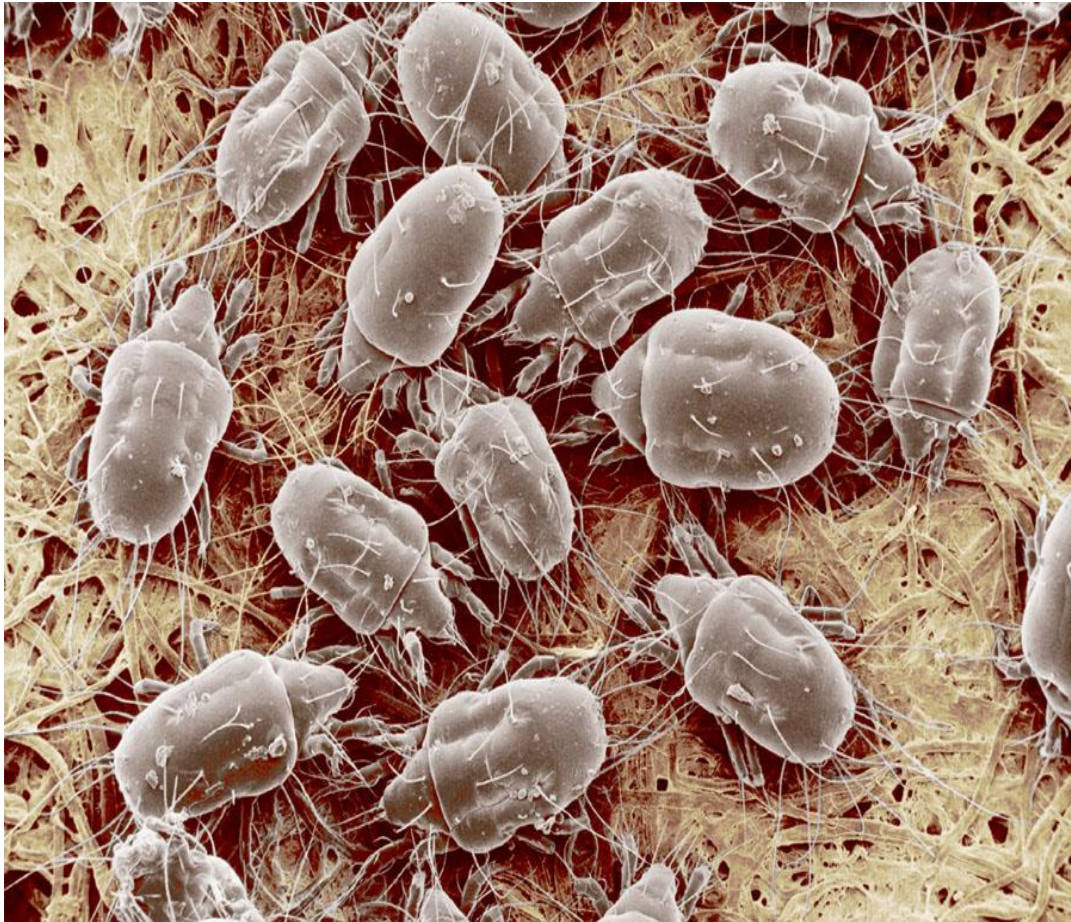
Flour mite: *Acarus siro*



Cheese mite: *Tyrophagus casei*



Mold mite: *Tyrophagus putrescentiae*



9. Saw toothed grain beetle

S.N: *Oryzaephilus surinamensis*
(Cucujidae: Coleoptera)

- **11 segmented antennae.**
- **The slender dark brown much flattened beetle has a 6 saw like sharp teeth, 3 on each side of the prothorax [SRF 2010].**



Nature of Damage

- *Oryzaephilus* beetles are general feeders, and usually secondary on stored products, following the more destructive primary pests such as grain weevils and pyralid moths.
- Their actual diet consists of fragments of animal and plant debris.
- *O. surinamensis* is more frequently found on cereal products, and *O. mercator* on oil-seed products.
- It feeds on grains and dried fruits; by carving of grain surface or burrowing holes in them.
- Generally, it does not cause serious damage.



Primary and secondary storage pests

- **Primary Storage Pest:**

Rice weevil, Khapra beetle, Lesser grain borer/Hooded grain borer/paddy borer beetle, Angoumois grain moth or Grain moth, Pulse beetle, Tamarind/Peanut bruchid, Cigarette beetle, Drug store beetle, Sweet Potato weevil, Potato tuber moth.

- **Secondary Storage Pest:**

Rust red flour beetle, Long headed flour beetle, Saw toothed grain beetle, Rice moth, Fig or Almond or Warehouse moth, Indian meal moth.

Early detection of storage pest infestation

- **Importance of insect pest detection**
 - a. **Stop the grain quality and quantity degradation**
 - b. **Pest identification**
 - c. **Determination of pest populations**
 - d. **Design the pest management strategy.**
 - e. **Check the effectiveness of different control measures.**
- **Inspect regularly to detect the infestation or spoilage.**
- **For this draw samples, every two weeks, from the bulks and look for insects and heating in Berlese funnel or sieving.**
- **Use of magnifying glass.**
- **Draw from various depths in case of bulk storage.**

Detection of hidden infestation

- **Stored grain insect pests like rice weevil (*Sitophilus oryzae*), maize weevil (*Sitophilus zeamays*), lesser grain borer (*Rhyzopertha dominica*), Angoumois grain moth (*Sitotrogra cerealella*) and bruchids (*Callosobruchus spp*) are the few important species which have latent form of infestation.**
- **Hidden or latent infestation of grain cannot be determined by the usual grain sifting in the sieves.**
Hidden infestation starts from field [ARS PRE/NET 2016]

Different methods for detection of hidden infestation

1. Staining method

- **Principle:** various dye solutions are used for staining egg plugs in grain samples.
- **Rapid method**
 - a. **Acid fuchsin:** The stain is prepared by mixing 0.5 gm Acid fuchsin in one liter of 5% aqueous glacial acetic acid.

Uniform samples of grains are prepared by soaking in warm water for 5 minutes and are immersed in the stain for 2 to 5 minutes.

The excess stain is removed by washing in tap water.

The egg plugs of weevils are stained bright cherry red and feeding punctures including mechanical injuries are stained in light pink. [ARS PRE/ NET 2015]



Figure 1. Egg plugs identification: (a) non colored grains, (b) grains colored with an acid fuschinic solution, (c) gelatinous egg plug (cherry red).

Different methods for detection of hidden infestation

b. Gentian violet.

- Grain samples like wheat are immersed for 2 minutes in a solution containing 10 drops of 1% aqueous stock solution of gentian violet in 50 ml of 95% ethanol.
- The egg plugs are stained to purple colour.

c. Berberine sulphate:

- Grain samples are immersed in 20 ppm solution of the dye for one minute, rinsed and examined under ultra violet light (wave length of 366 Å).
- The egg plug stains show intense greenish yellow colour.

Different methods for detection of hidden infestation

2. Density or floatation method:

- Use of different specific gravity solutions viz. **sodium silicate** in water (sp. gravity 1.16 to 1.19) and **methyl chloroform** (sp. Gravity 1.30).
- The grain is immersed in the fluids and a three

3. Gelatinization method:

- When the grain is boiled for 10 minutes in a 10% solution of sodium hydroxide the kernels become translucent, thereby, reveal the presence of internal infestation

Different methods for detection of hidden infestation

4. Cracking floatation method

- **Cleaned grain is coarsely ground to release the internal insects and is either soaked in a water alcohol mixture or in boiling water and then mixed with gasoline or mineral oil.**
- **The insects are floated off with the oil layer in a flask and collected on a filter paper and counted.**

5. Spectrophotometer analysis:

- **Dehydroxy phenol present in insect cuticle is indirectly estimated.**
- **These phenols produce certain colour when mixed with dichloroquinne chlorimide and this colour is measured with the help of Spectrophotometer**

Different methods for detection of hidden infestation

6. Ninhydrin colour reaction:

- **Insect haemolymph reacts with ninhydrin impregnated filter paper (0.7% solution in Acetone) and produce a colour.**
- **Ninhydrin test was described .by Oden & Von Hofsten [ARS PRE/ NET 2015]**
- **Eg. Ashman Simon Hidden Infestation detector**
- **Highly sensitive method**

Different methods for detection of hidden infestation

7. X-ray radiographic method:

- **X-rays helps to detect the internal infestation.**
- **All life stages can be observed.**
- **Widely popular & quick method [ARS NET/ PRE 2012].**
- **Requires dark room.**

Pest Detection devices/ gadgets

1. Probe trap

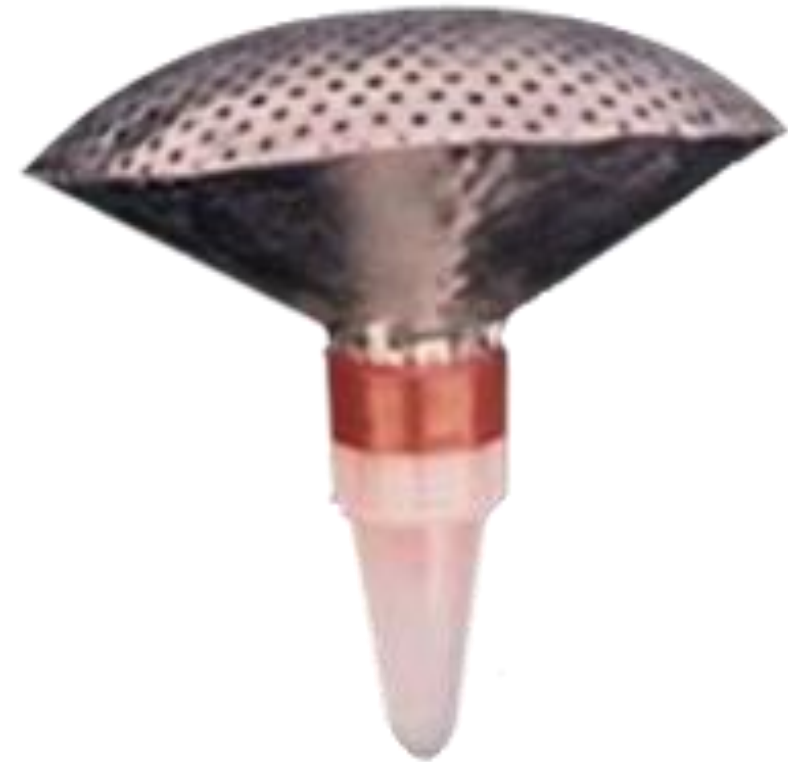
- Insect in search of air move towards it
- It has 3 components namely perforated tube, pitfall mechanism and a collection tube.
- The trap can be inserted into the stored grains and the wandering beetles enter the perforation for air and get permanently trapped into the collection tool.
- Used for monitoring and pest detection
- *Rhizopertha dominica*, *Sitophilus oryzae* and *Tribolium castaneum*



Pest Detection devices/ gadgets

2. Pitfall trap:

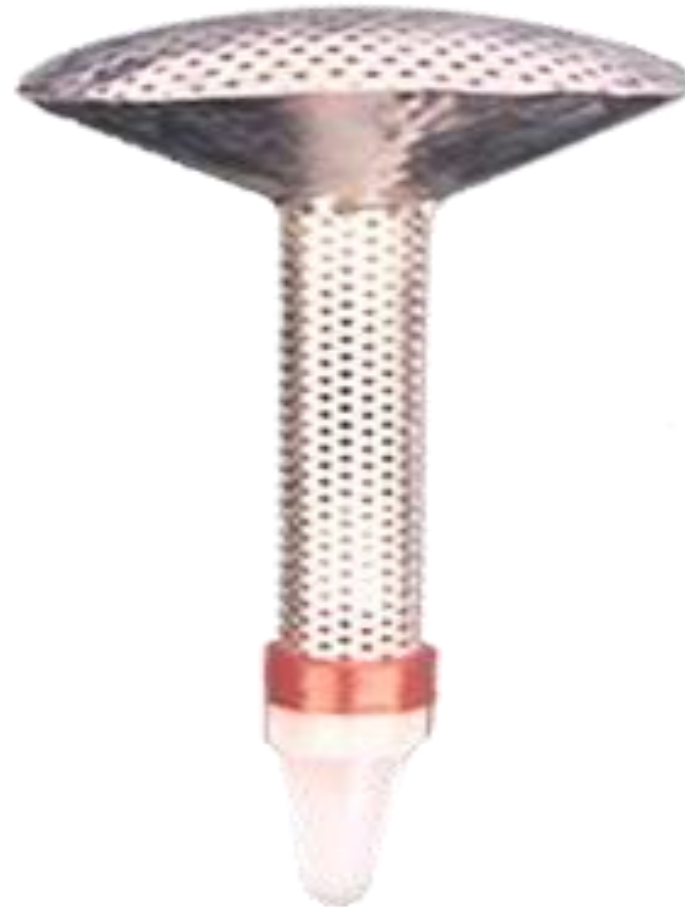
- Insects come out over the surface of bags for wandering and mating.
- Then, the insects fall through perforation and tapering cone is smeared with sticky material.
- It is a cone shaped trap with a perforated lid.
- The bottom tapering cone acts as a collection device.
- Used for Monitoring and mass trapping tool.



Pest Detection devices/ gadgets

3. Pitfall and probe trap:

- Combination of probe and pitfall.
- No need to use sticky material.



Pest Detection devices/ gadgets

4. Indicator device:

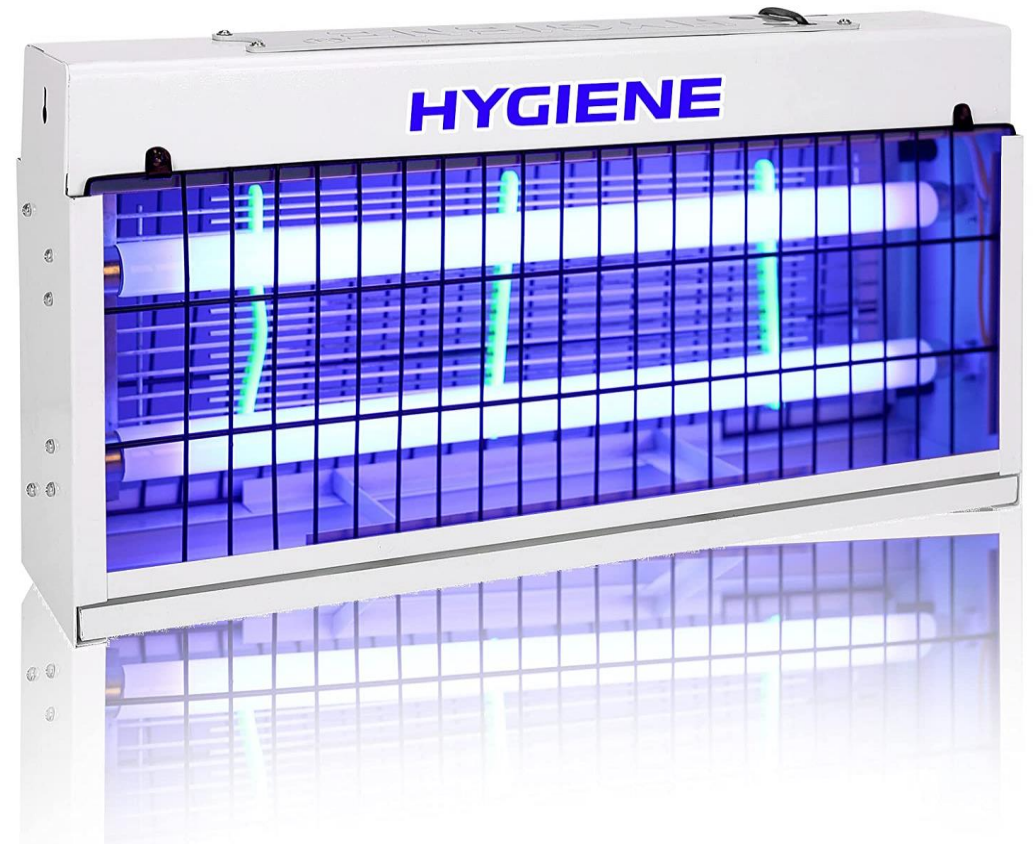
- Insect in search of air and wandering behavior gets trapped
- It consists of a cone shaped perforated cup (3mm perforation) with a lid at the top.
- The cup is fixed at the bottom with container and circular dish, which are to be smeared with sticky material like Vaseline.
- **Pulse beetle**



Pest Detection devices/ gadgets

5. UV light trap:

- Insects are attracted to 350 nm wavelength (UV).
- UV light traps can be used in mass trapping and for population monitoring of beetles
- Beetles attacking paddy



Scientific Storage of Grains

- **In India 70% food grains is retained and stored by farmers for consumption, seed, feed and payment of wages & rest with public & private agencies.**
- **At village level grains are stored for a period between 3 months to 2 years, depending upon the requirement.**
- **Post harvest losses occur both in quantity and quality.**
- **With the advent of improved agricultural technology, the farmer can afford to store the grain for longer period such as Vacuum process storage (VPS) where the food grains don't get infected or catch fungus as the air is sucked out while storing in the PVC containers.**
- **They can be stored up to 3-4 years.**

Need for Storage

- **To store the surplus produce in safe and secure facility so as to sell the same when the market price is remunerative.**
- **To store the produce when the transport facility or climatic conditions are not favorable.**
- **To maintain buffer reserves by government to meet the unforeseen situations.**

Prerequisites for safe storage

- **The produce must be thoroughly cleaned and graded.**
- **Dried to the safe storage moisture level of 10-12% for food grains and 7-9% for oilseeds (on wet basis) for a safe storage period of 6-12 months.**
- **Storage structures should to be properly repaired cleaned and disinfested.**
- **Structures should bear the load of grain stored and do not permit contact/exchange with outside humid air.**
- **The structures should be constructed in the coolest part of the house/farm.**

Some indigenous practices

Sl. No.	Practice	Remarks
1	maize cobs suspended from the roof of the house	This practice avoids the grains from absorbing moisture and prevents pest infestation.
2	Pulse seeds treated with mud slurry and dry them	Keep off the insects from damage and maintains the seed value.
3	burning candles or camphor in storage facility	Reduce oxygen inside the storage structures and thus insect activity is reduced.





Rural storage structures



1. Underground storage

- It is an age-old method of rural storage.
- Pits are dug up to to 5 m to hold 50 tons of grains and lined with mud plaster/ concrete to make moisture and rodent proof.
- Even paddy straw is placed along the borders of the pits.
- It is cheaper over above ground storage structures.
- Wheat, paddy, sorghum, fingermillet, etc., can be stored underground for a period of 2 years.
- Not suitable for high rainfall and high water-table areas, High rodent damage



2. Bitumen/coal tar drum/Bhopal bin/ Udaipur bin:

- **To have an alternative metal bin of almost similar technical performance and of low cost, the bitumen/coal tar drum bin have been modified as storage bins.**
- **The bitumen left in the drum is removed by burning.**
- **Lids made of metal sheet and latches and hooks are fitted.**
- **These bins are of 520 mm diameter and 900 mm height.**
- **They can store 1.5q of wheat and 1.2 q of Bengal gram.**



3. Hapur bin/ kothis

- **These are circular bins of 2. 5. 7.5 and 10q capacities and have potential of meeting requirements of even large farmers.**



4. Stone bin/ Chittore stone bin

- **suitable for storage of food grains for short duration and can be adopted by small farmers in place of mud bins.**



5. Bamboo bin

- **These bins are made of double wall bamboo with polyethylene lining in between and have varying capacities.**
- **These bins are suitable for short-duration storage and can be adopted by small and marginal farmers.**



Other rural storage bins

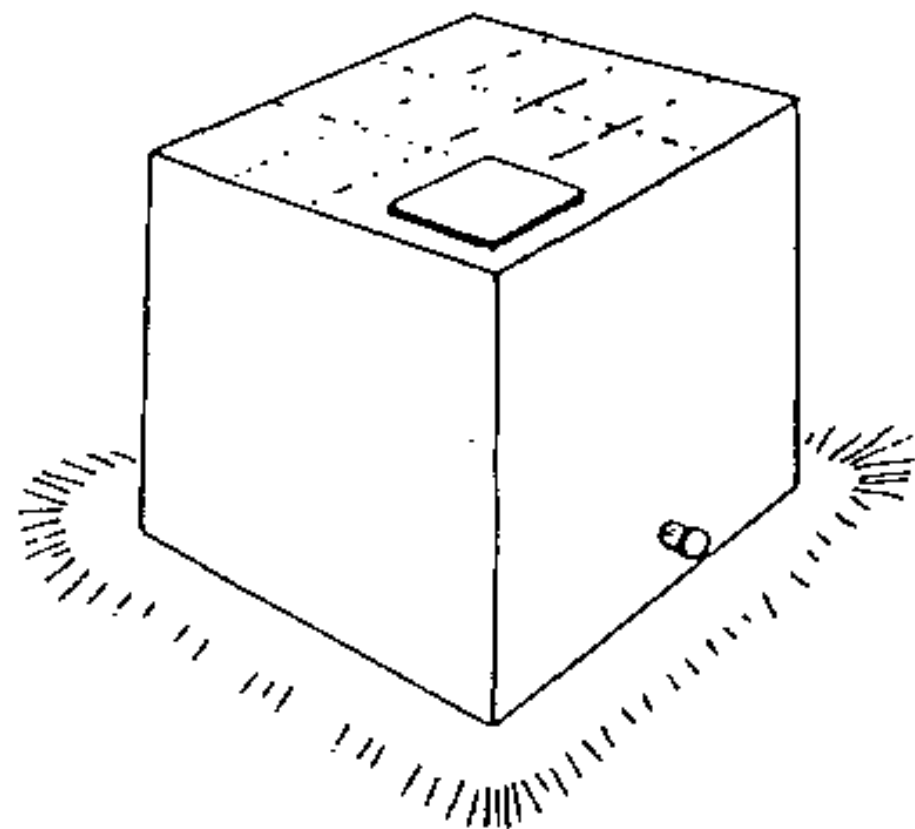
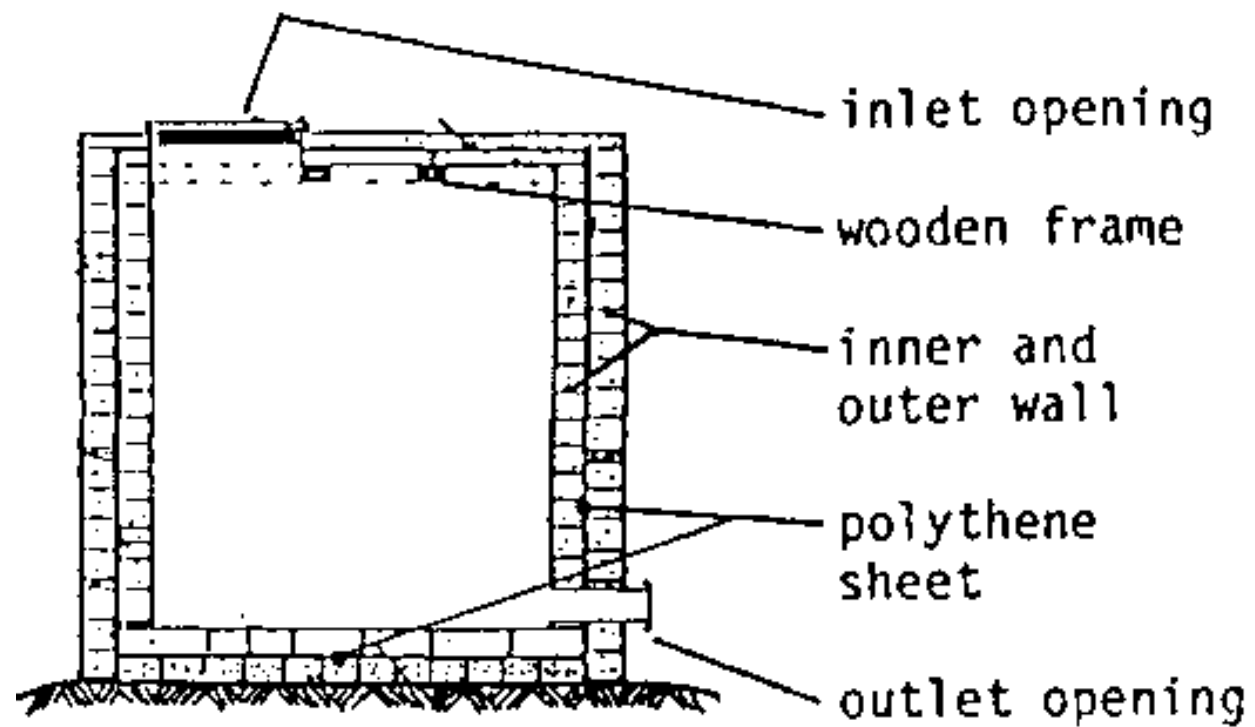
- **Baked clay bin**
- **PKV bin**
- **Pusa cubicle**
- **Pusa kothar**
- **Metal bins**

Pusa bin

- **It is a modification of the ordinary mud storage structure commonly used in villages.**
- **To provide moisture-proof and airtight conditions, polyethylene film of 700 gauge thickness [ARS PRE/NET 2016] has been embedded at the top, bottom and on all the sides of the mud bin.**
- **The embedding process provides mechanical support and safety to polyethylene film.**
- **The construction of outer walls with burnt bricks up to 45 cm height makes the structure rat proof as well.**
- **The Pusa bin is constructed with unburnt bricks on burnt bricks or concrete floor to avoid rat burrowing.**
- **The bin can be constructed for storing different quantities of grain ranging from 0.4 to 3.2 tonnes.**
- **A round hole of 15 cm diameter is left at the bottom of the front wall to fix a pouch made up of metal sheet or polyethylene pipe, for withdrawing the grain.**

Pusa bin

- **All the sides of inner walls are plastered and 50 cm x 50 cm clear hole at the left hand corner of the front side is left for grain filling.**
- **On top wooden pole is spread at 45 cm distance for the support of the roof.**
- **The mud slabs (made with mud, paddy husk mixed with and bamboo split) are used as top cover.**
- **The top is also covered with 5 cm layer of mud.**
- **The structure is plastered and is allowed to dry thoroughly before filling of grain.**
- **Thoroughly dried grain should be filled to full capacity.**
- **The grain and seed both remain safe in the bin for more than 1 year when this precaution is followed.**



Source: Bodholt and Diop (1987)

Silos



CAP storage

- For want of required storage space in godowns food grains are also stored in the open and this method of storage is known as CAP storage. **[Cap stands for cover and plinth]**
- Open spaces in warehouses and elsewhere are used for storing the produce.
- Crates are placed on floor, mats are spread on the crates and finally bags are placed over the crates.
- The stacks are built in the form of domes.
- As protection against rain and sun the stacks are covered with thick (600 to 1000 gauge) black polythene sheets and the cover is tied to the stack with the help of plastic ropes.

CAP structure



Stored grain pest management

- **Preventive methods**
- **Curative methods**

Preventive methods

- **Threshing floor/ yard should be clean, free from insect infestation and away from the vicinity of villages/granaries.**
- **Clean the harvesting and threshing machines before their use.**
- **Trucks, trolleys or bullock carts which are used for transportation of food grains should be made free from insect infestation.**
- **Before stacking the grains; the godowns, store rooms or receptacle should be cleaned and made free from insects.**
- **All dirt, rubbish, sweepings and webbings should be removed from the stores and disposed/destroyed.**
- **All the cracks, crevices, holes existing in the floors, walls, ceiling should be plastered with mud or cement permanently.**

Preventive methods

- **All the rat burrows should be closed with a mixture of broken glass pieces and mud and then plastered with mud/cement.**
- **Whitewash the store rooms before storage of food grains.**
- **Food grains should be kept in stores which are rat and moisture proof.**
- **Proper stacking of bags also helps in grain protection.**
- **Disinfestation is done by fumigation. The material to be stored should be cleaned and dried well in the sun.**
- **Excess moisture in the grain causes heating and development of mould which give rise to disagreeable odour, discoloration and even caking, if neglected.**
- **The bags or bins can be made damp proof by providing dunnage of bamboo poles or bamboo matting or wooden crates.**

Preventive methods

- **The bags should be staked in such a way as to allow proper ventilation and sufficient moving space for periodical inspection.**
- **Malathion at 15 ml of 50% EC /4.5 litres of water may be sprayed as a thin film on bags and about 3 litres of the spray solution may be necessary for 100 sq. m. If drenched the humidity of grain may increase and infestation may take place. The incoming new arrivals should not be stored along with old or infested stocks in the godown.**
- **Egg-laying by bruchids on pulses is prevented by Oil treatment.**
- **Entry of an insect which is not found in the particular area can be prevented by the imposition of Destructive Insect Pests Act 1914.**
- **If the produce is meant for seed purpose, mix 1 kg of activated kaolin or Malathion 5% dust for every 100 kg of seed and store/pack in gunny or polythene lined bags.**

Preventive methods

- **Apply one of the following pesticides at the specified dosage over the bags. Malathion 50 EC @ 10 ml per liter of water and 3 liters of spray solution per 100 sq. m. DDVP 76% SC @ 7 ml per liter of water and 3 liters of spray solution per 100 sq. m.**
- **Gunny bag impregnation:** Empty bags are soaked in 0.1% Malathion emulsion for 10 minutes and dried before use for grain storage.

Curative methods

- **The stocks of grains should be periodically examined and if insects are noticed to appear the stock should be removed, sundried and cleaned.**
- **Heavily infested material should be fumigated with phosphine or hydrogen phosphide, EDCT, EDB etc.**
- **Phosphine is generated from 3 g tablet containing aluminum phosphide (56%) and ammonium carbamate/ carbonate (44%) used at 3 tablets/tonne or Aluminium phosphide 15% tablet of 12 g used at 1 tablet/tonne for the control of stored grain pests, the exposure period being 5-7 days.**
- **The tablets are placed in between the bags and entire stock covered with rubberized cloth cover and mud applied along the edges to make it air tight.**
- **EDCT is used at 24- 32 kg/100 cu. m.**

Curative methods

- **Methyl bromide is used at 2.5 to 3 kg/100 cu. m. exposure period being 48 hours. It should be used with great care.**
- **Ethylene dibromide was developed in the form of tablets under the name 'minifume' by the CSTRI, Mysore and used at one tablet per quintal of grains or pulses (it should not be used in oil seeds or flour products) stored in seed bins. [IARI PhD 2013]**
- **Seed material may be mixed with insecticides like carbaryl or malathion at 1:200 by weight and the treatment may keep the stock insect free for one year.**
- **EBD 1:8 CCl₄. Dose 10 ml/ quintal. Used to fumigate vegetables and fruits. Have ovicidal action.**
- **Most commonly used insecticide for storage is Malathion and Dichlorvos.**
- **Synthetic pyrethroids mainly used against stored grain pest is Deltamethrin.**
- **Empty bins and storage structures are treated the with Diatomaceous earth**

Curative methods

- **Chlorpyrifos methyl (Reldan) is effective against stored product insects except *Rhyzopertha dominica*.**
- **Chlorpyrifos methyl (Reldan), Cyfluthrin (Tempo), dichlorvos, fenitrothion, carbaryl, and pirimiphos methyl (Actellic) are used as Grain protectants.**
- **Seed treatment with malathion 5% @ 250 g/ quintal of seed is the recommendation.**
- **To protect the pulses from the pulse beetles cover them with 7cm layer of sand/ saw dust/ dung ash.**

THANK YOU.