PRACTICAL MANUAL

Post-Harvest Entomology

APE 511 2(1+1)

For

M.Sc. (Ag.) Entomology

2023

Department of Entomology

Rani Lakshmi Bai Central Agricultural University,
Jhansi, UP, India- 284003

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INDEX

PRACTICAL NO.1

Insect pest problem under storage

Objectives:

1. To study on types of losses under stored grain done by stored pests.
2. To study on classification of stored insect pest.

❖ **Types of Storage Loss**

Losses occurring during storage are affected by conditions prevailing in the pre-storage stages (harvesting, threshing and drying). Similarly, post storage losses may be affected by conditions during storage.

Define the term "**loss**" and much confusion has arisen since "loss" has frequently been used synonymously with "damage". Loss is a measurable decrease of the foodstuff which may be quantitative or qualitative. It should not be confused with damage which generally refers to the superficial evidence of deterioration, e.g., broken grains (which may later result in loss). Loss precludes utilization, damage inhibits utilization.

❖ **Types of loss**

1. **Quantitative loss:** A physical loss of substance as shown by a reduction in weight or volume. It is the form of loss that can most readily be measured and valued.
2. **Qualitative loss:** It is more difficult to assess and is perhaps best identified through comparison with well defined standards. Nutritional loss and loss of seed are both aspects of quality losses.

✓ **Weight loss:** Reduction in weight is obvious but it does not necessarily indicate loss. It may be due to reduced moisture content and this is recognized by a shrinkage factor. Weight loss results from the feeding of insects, rodents and birds or from spillage, due to improper handling or by the Activity of pests. Moisture changes may lead to an increase in weight and in some cases production of water by and insect infestation may partly offset the weight loss. In many instances weight loss may go undetected as the trader sells by volume. In commercial storage weight is the important factor sometimes leading to malpractices such as adulteration with water, stones, and earth to make up the deficiency. Usually, some allowance is made for slight changes in moisture and also standard weight packages may be used.

✓ **Loss in quality:** Generally, quality is assessed and products graded on the basis of appearance, shape, size, etc., but smell and flavor are sometimes included. Foreign matter content and contaminants are factors in loss of quality. Foreign matter may be in the form of insect fragments, grass, rodent hairs and excrete; weed seeds, parts of plants, earth, stones, glass, etc. Contaminants that cannot be readily removed, include soluble excretions of pests, oils, pesticides, pathogenic organisms spread by rodents, and toxins arising from fungal infections. Chemical changes may also be important, e.g. in oilseeds. Infestation in groundnuts may cause an increase in the free fatty acid level leading to rancidity in the oil, similarly in maize meal.

- ✓ **Nutritional loss:** This, is the product of both the quantitative and qualitative losses. Weight loss during storage (not due to a loss of moisture) is a measure of food loss but the latter may be proportionately larger owing to selective feeding by the pests. Rodents and moth larvae may preferentially attack the germ of the grain thus removing a large percentage of the protein and vitamin content, whereas weevils feeding mainly on the endosperm will reduce the carbohydrate content. Many pests may eat the bran of cereals reducing vitamins such as thiamin. Other storage factors such as moisture and fungal infection also lead to changes in vitamin content. In beans in particular, loss of protein is very important where there is infestation, as up to 25% of the dry matter may be crude protein.
- ✓ **Loss of seed viability:** This relates to loss in seed germination. Seed grain is usually more carefully stored owing to its greater potential value. Loss may be caused by changes of light, temperature, moisture, excessive respiration, infestation and, in some cases, the methods used to control infestation. Insects that selectively attack the germ will cause a greater loss in germination than others.
- ✓ **Commercial losses:** Commercial losses may be a consequence of any of the foregoing factors or be the preventive or remedial actions required, as well as equipment costs. These losses are generally incurred through a lack of knowledge, experience or managerial ability.
    a) **Monetary loss:** Weight loss is an economic loss as is any downgrading of produce due to poor quality. Any control measure that has to be employed to render or keep the commodity saleable can be counted as an economic loss and is perhaps the most easily accountable loss. Losses in packaging and the costs of repacking due to rodent and handling damage, repairs and stoppages in machinery, damage to the fabric of the store are all economic losses that can be the result of infestation.
    b) **Loss of goodwill:** This is not directly accountable but nonetheless it is very important, especially with regard to rising quality standards. A control measure that may seem uneconomic at first but leads to better custom or at least retains custom, is better than no control that leads to losing custom. This is particularly so in exports where a reputation for high quality produce is valuable to a country's economy.
    c) **Loss due to legal action:** This may include damages awarded due to impairment of health of humans and animals, expenses incurred by third persons due to infestation traceable to a particular shipment, and various actions due to contamination.

❖ **Classification of stored insect pests**

1. **Primary insect pests: I**nsect pests cause damage to the previously undamaged kernel or new grain. Stored grain pests are classified as major and minor pests based on the damage they cause. These insects can be classified as external feeders and internal feeders based on their feeding behavior.

a) **External feeder:** These pests feed on external or surface parts of the grains such as the outside part of germ and endosperm. These pests either feed on whole seeds or damage the germinal portion of seeds and also feed on those seeds which are already damaged or attacked by other pests or are mechanically broken. These pests are generally visible among the seeds such as rice weevil, pulse beetle, granary weevil, Angoumois moth, etc.

b) **Internal feeders:** As the name indicates these pests are usually found inside the seeds. These pests mostly lay eggs inside or on the surface of grains, then spend a part or entire larval and pupal life within the grains and emerge as an adult. These pests cause significant loss of germination that is not detected externally, e.g., rice weevil, pulse beetle, granary weevil, Angoumois moth, etc.

2. **Secondary feeders:** As the name indicates these pests are secondary because these pests attack on already infested crops these generally feed on cut and broken seeds, molds, dead insects, animal wastes, e.g., common mites, cheese mites, etc. Damage caused by these pests results in loss of germination, contamination like ball formation, and webbing besides deterioration of grains. Damage caused by these pests results in fungal activity, moisture migration across the stored grains.

Primary storage insect pests			
Common name	**Pest**	**Family**	**Order**
Internal Feeders			
Rice weevil	*Sitophilus oryzae, S. zeamais, S. granarius*	Curculionidae	Coleoptera
Lesser grain borer	*Rhyzopertha dominica*	Bostrychidae	Coleoptera
Angoumois grain moth	*Sitotroga cerealella*	Gelechiidae	Lepidoptera
Pulse beetle	*Callosobruchus chinensis, C. maculatus*	Bruchidae	Coleoptera
Cigarette beetle	*Lasioderma sericorne*	Anobiidae	Coleoptera
Drug store beetle	*Stegobium paniceum*	Anobiidae	Coleoptera
Tamarind Beetle	*Pachymeres gonagra*	Bruchidae	Coleoptera
Sweet Potato weevil	*Cylas formicarius*	Apionidae	Coleoptera
Potato tuber moth	*Phthorimoea operculella*	Gelechiidae	Lepidoptera
Arecanut beetle	*Araecerus fasciculatus*	Anthribidae	Coleoptera
External Feeders			
Red flour beetle	*Tribolium castaneum, Tribolium confusum*	Tenebrionidae	Coleoptera
Indian meal moth	*Plodia interpunctella*	Phycitidae	Lepidoptera
Fig moth or almond moth	*Ephestia cautella*	Phycitidae	Lepidoptera
Rice moth	*Corcyra cephalonica*	Galleriidae	Lepidoptera
Khapra beetle	*Trogoderma granarium*	Dermestidae	Coleoptera
Secondary storage insects pest			
Saw toothed grain beetle	*Oryzaephillis surinamensis*	Silvanidae:	Coleoptera
Long headed flour beetle	*Latheticus oryzae*	Tenebrionidae	Coleopter
Flat grain beetle	*Cryptolestus minutas,*	Cucujidae	Coleoptera
Grain lice	*Liposcelis divinitorius*	Liposcelidae	Psocoptera
Grain mite	*Acarus siro*		Acari

Activity: To collection and identify the stored grain pests.

PRACTICAL NO.2

Collection, identification and familiarization with the stored grains insect pests- Coleoptera

Objectives:

1. To study on collection and identification of stored insect pests of coleoptera.
2. To study on nature of damage of stored coleoptera insect-pests.

Collection of insect-pests from storage

Collected coleopteran insects pest samples from the storage/godown and carry in to Laboratory. Use some technics for insect collection under storage condition:

1. **Insect collecting net:** Sweeping from aerial under the storage after see flying adults beetles and weevils.
2. **Hand-picking method:** Insects are hand-picked and placed in containers from storage bags, wall etc.
3. **Insect collection traps: Light** and pheromone trap are more suitable for insects attractant under storage.
4. **Aspirators and suction devices:** The aspirator, sometimes known as a "pooter" in England, is a simple and effective tool for gathering small weevils and grubs.

Identification key

1. Lateral margin of pronotum with six teeth . . . . . 57 Lateral margin of pronotum different . .....
2. (1) Elytra depressed and margins explanate, each elytron with seven, including sutural, longitudinal ridges (carinae) (Fig. 9A); antennae with scape large and globose, pedicel inserted laterally (Fig. 9B), three apical segments forming a club.
   Eye not emarginate; tarsi appearing 4-4-4 segmented, pseudotetramerous (5-5-5 but small basal segment hidden), claws with bisetose empodium; length 2.63.2 mm. ..... Lophocateres pusillus (Klug) [LOPHOCATERIDAE] - Elytra different '(if all interstriae raised and tarsi pseudotetramerous then 4th segment small, claws without bisetose empodium and antennae different) 3
3. (2) Head produced in front of eyes forming a short but distinct (Fig. 9D) to long (Figs 9E, 4D) rostrum which may be curved ventrally (facies not as in Figs 16H or 17A, D). Scape of antenna may be extremely elongate, often retractable into grooves (strobes) on rostrum' tarsi pseudotetramerous (5-5-5 segmented, 4th small, 3rd simple or bilobed)..... 4 - Head not obviously produced in front of eyes to form a rostrum; scape variable..... 5

4. (3) Antennae geniculate (elbowed), scape moderately (Fig. 4D) to extremely elongate (Fig. 9D) usually longer than next three segments combined; elytra variable; trochanters short (Fig. 9H) ..... CURCULIONIDAE (part)
   - Antennae not geniculate, scape shorter than next three segments combined (Fig. 9E); elytra dome shaped (Fig. 9F); trochanters long (Fig. 9G) ..... APIONIDAE
5. (3) Dorsal cuticle of elytra glabrous (without pubescence), metallic green-blue with margins copper coloured, pronotum similarly coloured but with sparse short pubescence laterally; 3facies characteristic (Fig. IOA). Antennae short, serrate; head strongly deflexed; eyes large; tarsal segments 1-4 more or less lobed below; length 13-22 mm. (Beetles belonging to this family are frequently metallic or patterned.) .....Buprestis aurulenta L. (BUPRESTIDAE) - Domall cuticle not similarly coloured (if metallic then antennae not serrate); facies different . . . 6
6. Antennae with asymmetrical, 3-segmented, lamellate club (Fig. 10D); legs adapted for digging, fore tibiae with teeth, tarsi 5-5-5 segmented (Fig. IOC). .....Aphodius spp. (SCARABAEIDAE)
   - Anten:nae not as above; legs various 7
7. Eyes deeply indented by genae which form a canthus (Figs 4B, 31B) and conceal antenna1 insertions from above; tarsi 5-5-4 segmented; antennae usually robust, either with. gradually developed or abrupt club of three or more segments or without club; three basal abdominal sternites immovably fused 53
   - Eyes different, if indented then without above characters combined.....8
8. (7) Maxillary palpi prominent (Fig. lOE), nearly as long as antennae; antennae short with dull pubescent club, basal segment of club (6th) cup-shaped (Fig. IOF); tibiae with spines, tarsi simple; body dorsally strongly convex, ventrally more or less flat.
   Cercyon and Sphaeridium spp. (HYDROPHILIDAE)
   - Maxillary palpi not prominent, much shorter than antennae; if antennae with club then cup-shaped segment absent; if body shape similar then either with maxillary palpi securiform (hatchet-shaped) or tarsal claw with basal tooth and cuticle highly polished (Fig. 25A, B) or with l-segmented antenna1 club 9
9. (8) Head with median ocellus (Fig. 11A); either elytra entire and closing along full length of suture (usual) or in Thylodrius contractus Mots., only closing near scutellum (male) or absent (female) [Fig. 1 lB, C].
   - Body usually covered with setae or scales (Fig. 12A-F), ventral side usually with cavities for reception of antennae and legs .....DERMESTIDAE (part)
   - Head without median ocellus; elytra entire or truncate and thus exposing abdominal tergites 10
10. (9) Prothorax with short, narrow apical neck; head completely exposed; elytra entire; facies ant-like (characteristic) (Fig. 12G) ..... ANTHICIDAE
    - Prothorax without an apical neck; head with at least base fitting into prothorax; elytra entire or short; facies different 11
11. (10) Ventral side of prothorax with notopleural sutures (Fig. 5A); dorsal surface of body with a few long projecting sensory bristles at particular points, usually obvious at least on head near eyes (Fig. 13A, B); not more than terminal segment of abdomen exposed by elytra; fore tibiae may have

antennal-cleaning cavity (Fig. 5A); antennae and tarsi filiform, antenna 1 l-segmented; hind coxae large, immovable, completely dividing basal abdominal sternite (Fig. 5A) .....CARABIDAE

- Prothorax without notopleural sutures; if similar sensory bristles present, then more than terminal segment of abdomen exposed by truncate elytra; never with antennal- cleaning cavity on fore tibiae; antennae various; hind coxae moveable, not dividing basal sternite of abdomen (Fig. 5B) 12

12. (11) Elytra short, truncate at apex exposing at least three, usually more tergites; antenna without club or with loose club; 6 or 7 externally visible sternites; abdomen flexible (Fig. 13C, D).....STAPHYLINIDAE
    - Either elytra entire or if truncate and 2-4 apical segments of abdomen exposed, then either facies entirely different or antenna with compact club (Fig. 25E); usually only 5 externally visible sternites; abdomen not flexible 13
13. (12) Head with strong frontoclypeal suture and lateral longitudinal striae which are well separated from eyes (Fig. 14A); elytra yellow-brown with dark brown to black pattern; body elongate, depressed; tarsi 5-5-5 segmented with 3rd segment strongly bilobed, 4th small but obvious (Fig. 14A).
    - Terminal segments of rather filiform antennae dark; anterior angles of pronotum with about three tubercles bearing setae; length 3.5-5.0mm. ..... Cryptamorpha desjardinsi (Guerin-Meneville) [SILVANIDAE]
    - Head without frontoclypeal suture and lateral striae combined (a frontoclypeal suture may be present); if elytra patterned, then facies different; tarsi various.....14
14. (13) Elytra. yellow-brown with a median brown to black mark (shape variable) and usually apices similarly dark; pronotum with lateral margins finely denticulate; eyes large, prominent; antennae with 3-segmented club; tarsi 5-5-5 segmented; length 1 S2.4 mm, (Fig. 14B-D). .....Monanus concinnufus (Walker) [SILVANIDAE]
    - Elytra without similar marks; facies different 15
15. Pronotum with dorsal antenna1 cavities near anterior angles (Fig. 15A). Antennae lo-segmented with large l-segmented club; tarsi 4-4-4 segmented; body oval, strongly convex, shining, length less than 1.5 mm (Fig. 15A). .....Murmidius spp. (CERYLONIDAE)
    - Pronotum without dorsal antenna1 cavities 16
16. (15) Tarsi 5-5-5 segmented with basal segment extremely elongate, nearly, or as long as other segments combined (Fig. 15B); antennae with elongate scape, short funiculus and large, broad Jut l-segmented club (Fig. 15C); pronotum emarginate at sides; body cylindrical; facies characteristic (Fig. 15D, E).
    - Femora dilated, fore tibiae transversely carinate-dentate; elytral apex frequently dentate or tuberculate. CURCULIONIDAE Platypodinae
    - Tarsi different or facies entirely different 17
17. (16) Abdomen with one or two abdominal tergites (pygidium and propygidium) exposed by truncate elytra and antennae obviously geniculate (elbowed), with solid club of 3 segments (Fig. 15F) or apparently l-segmented.

- Antenna retractable into grooves and cavities under head and prothorax; body characteristically compact, oval, cylindrical or somewhat flattened; cuticle hard, shining and glabrous; legs more or less flat and can be retracted against body, tarsi 5-5-5 segmented (Fig. 15F) .....H ISTERIDAE
- Terminal abdominal tergites hidden or exposed, not visible if antennae geniculate 18

18. (17) Antennae often geniculate and scape elongate, funiculus short or very short, club compact usually large (Fig. 16C); from above, head nearly or completely concealed by pronotum (Fig. 16D) being vertical or slightly deflexed beneath prothorax.
    - Tarsi 5-5-5 segmented, 3rd segment simple or bilobed, 4th small (sometimes concealed by 3rd); moderately sized to extremely small, compact, robust cylindrical beetles (length about 5.0-0.8 mm) whole dorsal surface or only elytra with short, erect or sub-erect, lanceolate, scale-like (e.g. Fig. 16D, E, F) or simple setae (may be lost on rubbed specimens). .....[4]CURCULIONIDAE Scolytinae
    - Antennae different; if with large compact club, then head entirely visible from above OY body not cylindrical 19
19. (18) Tarsi pseudotetramerous on all legs, true 4th segment minute, 3rd either bilobed (Figs 161, 17C) or appearing so, having a small deep dorsal depression (as in Fig. 17F); antennae with loose club (Fig. 165) or without obviously differentiated club (e.g. Fig. 17A, D, E, G); facies as in Figs 16G, 17, 18A or similar to last but elytra short 20
    - Tarsi different or if similarly pseudotetramerous on all legs and with 3rd segment bilobed, then antennae with compact club OY not as in Fig. 165; facies different 24
20. (19) Hind femur broadly expanded, serrate on distal margin (Fig. 17B); pygidium exposed; cuticle not metallic.
    - Eye large, separated across front by less than one diameter .....BRUCHIDAE (part)
    - Hind femur not broadly expanded; if expanded, then facies different 21
21. (20) Antennae with segments 3-8 characteristically thin, club segments broader (Fig. 165); tarsi with 3rd segment deeply bilobed, embraced by prominent setae on angles of 2nd (Fig. 161).
    - Fore coxae globular; eyes not emarginate; length 2.5-4.2 mm. .....Araecerus fasciculatus (Degeer) [ANTHRIBIDAE]
    - Antennae different; angles of 2nd tarsal segment not with setae embracing bilobed 3rd segment (Fig. 17C, F..... 22
22. (21) Body short, compact; pygidium (terminal tergite of abdomen) large, entirely exposed; head long behind eyes, deflexed beneath prothorax (in normal position), not deeplyset in prothorax; basal segment of hind tarsus longer than other segments combined (Fig. 17C, D).. . . . . BRUCHIDAE (part) - - Body various; pygidium not exposed or if so relatively small; head may be deeply set in prothorax; basal segment of hind tarsus shorter than other segments combined 23

23. (22) Antsennae inserted on prominences on front of head (Fig. 18B); legs longer; elongate, frequently large beetles Sfacies as or similar to Fig. 18A, elytra may be reduced exposing several abdominal tergites .....CERAMBYCIDAE
    - Antennae not inserted on prominences on front of head; legs shorter, facies different (may have femora obviously enlarged) Fig. 17E-G ..... CHRYSOMELIDAE
24. (19) Length 7.0-10.4 mm; pronotum with prominent lateral carina; head and elytra black or metallic (in teneral specimens elytra may just have metallic sheen), pronotum and ventral side of body yellow to reddish yellow.
    - Head, thorax and elytra with bristly setae; antennae serrate; elytra with sutural, lateral and three dorsal ridges, the humeral ridge being ill-defined (Fig. 19A, B). .....Melyris oblonga F. (MELYRIDAE)
    - Facies different; if pronotum with lateral carina, then smaller species 25
25. (24) Margins of prothorax and elytra (at least) with projecting bristly setae (Fig. 18C, F, G); dorsal cuticle may be entirely or partly metallic, elytra sometimes with median yellow band (Fig. 18G), sometimes bicoloured. Tarsi frequently with one or more bilobed segments, i.e. segments extended beneath by membranous lobes (Fig. 18D); fore coxae projecting, conical .....CLERIDAE
    - Body without projecting bristly setae or if present on pronotal margin, then facies not as in Fig. 18C-G; if metallic, then body compact and ovate 26
26. Large reddish to brownish-yellow species, apex of elytra black (length 7.3-13.2 mm); 6facies characteristic (Fig. 19C); elytra with three low, rather ill-defined, dorsal ridges 3rd obsolete basally, plus a lateral ridge.
    - Tarsi 5-5-4 segmented, penultimate segment bilobed; antennae long, filiform; elytra finely pubescent. .....Nacerdes melanura (L.) [OEDEMERIDAE]
    - Body form and colour different; elytra without similar ridges 27
27. (26) Prothorax strongly hooded over head, anterior aperture facing downwards (Figs 20.4-E, 21A, D, E); either three distal segments of antennae much larger or longer than other segments, forming a loose club (their combined length may be equal to or greater than other segments combined) or antennae serrate (Figs 20 and 21) 28
    - If prothorax similarly hooded over head, then antennae different 29
28. (27) Body cylindrical, cuticle very hard (strongly sclerotized); surface of pronotum rugose; elytra with more or less obvious, flat apical declivity (often with apical spines) [Fig. 20A-D]; antennae with three distal segments large; hind coxa without longitudinal cavity for reception of femur. .....BOSTRICHIDAE Dinoderinae and Bostrichinae
    - Body subcylindrical, cuticle not very hard; pronotum not rugose; elytra without obvious fla.t declivity apically; antennae with three distal segments moderately or extremely elongate, or antennae entirely serrate (Fig. 21B, F, G); hind coxa with longitudinal cavity for reception of femur (Fig. 21E) .....ANOBIIDAE
29. (27) Antennae filiform, inserted close together on front of head (on frons), separated by less than length of scape; facies characteristic (Fig. 22A-D). Fore coxae conical; head deflexed, may be concealed from above by hooded prothorax; elytra and prothorax rather globose or whole body

appearing so; prothorax small compared with elytra; legs relatively long giving more or less spider-like appearance (hence common name: spider-beetles).....PTINIDAE

- Antennae various, if filiform not inserted close together on frons; facies different..30

30. (29) Antennae with abrupt 2-segmented club; eyes relatively large, prominent and widely separated; prothorax with median depression or fovea (more or less pronounced) [Fig. 23A]; tarsi 5-5-5 segmented; body generally rather elongate and parallel sided. Cuticle may bear scales.....BOSTRICHIDAE Lyctinae
    - If antennae with 2-segmented club, then facies and/or tarsal segmentation different 31
31. (30) Hind coxa with longitudinal cavity for reception of femur (Fig. 23B); length 5.5-12.5 mm; antenna short with large, compact, 3-segmented club (Fig. 23C). Lateral margins of prothorax and elytra almost continuous; dorsal and ventral cuticle densely pubescent. .....Dermestes spp. (DERMESTIDAE)
    - Hind coxae without femoral cavities; if with compact 3-segmented antenna1 club, then smaller species 32
32. (31) Antennae 11-segmented with two distal segments close fitting, forming characteristic spheroidal club (segment 10 large, 11 small with a sub-apical groove giving two segmented appearance) [Fig. 24B]; body more or less elongate; elytra truncate at apex exposing last one or two tergites of abdomen (Fig. 24A,C); 1st visible abdominal sternite considerably longer than following, at least as long as next two combined .....RHIZOPHAGIDAE
    - Antennae without similar spheroidal club; without other characters combined 33
33. (32) Pronotum with paired, complete lateral carinae (Fig. 23D) and two medial carinae represented at apex or at both apex and base (lateral margins explanate in Microprius).
    - Antenna1 club 2-segmented; elytra with longitudinal carinae; body more or less elongate. .....Bitoma and Microprius spp. (COLYDIIDAE)
    - Pronotum without or with not more than one lateral 34
34. (33) Pronotum with complete arcuate sub-lateral carina; body ovate, tapering posteriorly, with long pubescence (Fig. 24D). Antennae with loose 3-segmented club; tarsi 4-4-4 segmented although 3rd segment small; length 1.5-l .8 mm.

    .....Mycetaea subterranea (F.) [ENDOMYCHIDAE]
    - Either pronotum without a complete sub-lateral carina or if carina present, then not arcuate, body form different and without long pubescence 35
35. (34) Body hemispherical to elongate-ovate; last segment of maxillary palp securiform (hatchet-shaped) [Fig. 24F]; tarsi pseudotrimerous (4-segmented but appearing 3-segmented, third segment small almost hidden in lobate second segment) (Fig. 24E). Dorsally often brightly coloured red and black, or yellow and black, sometimesdull red or yellow brown; antennae with 3-segmented club (e.g. Fig. 24G) .....COCCINELLIDAE
    - Either body different or if similar, then tarsi different and last segment of maxillary palp not securiform 36
36. (35) Cuticle of dorsal surface highly polished, glabrous; body form characteristically ovoid, very convex (Fig. 25A).

- Length 3 mm or less; tarsi 5-5-5 segmented, 4th segment very small, 2nd and 3rd emarginate and more or less expanded apically; claws with basal tooth (Fig. 25B); antennae with 3-segmented club; apical segment of maxillary palp not securiform .....PHALACRIDAE
- Cuticle of dorsal surface not highly polished or body form different 37

37. (36) Antennae with abrupt compact club composed of 3 flattened strongly transverse segments, funiculus comparatively thin (Fig. 25E); elytra entire or truncate and exposing up to four abdominal tergites (e.g. Fig. 25C, D, F); tarsi 5-5-5 segmented, at least one segment lobed. Trochantins obvious (on fore and middle coxae)..... NITIDULIDAE
    - Antennae different (if with 3-segmented club, form of club different); elytra never exposing abdominal tergites 38
38. Tarsi with conspicuous bisetose empodium between claws (Fig. 26C), 5-5-5 segmented but pseudotetramerous (basal segment extremely small, hidden), segments slender, simple. Body depressed, shining, prothorax somewhat cordiform (heart-shaped), or more parallel sided, quite distinct from elytra having intervening "waist", anterior angles produced forward; antennae with a loose, somewhat asymmetrical, 3-segmented club (see Fig. 26A, B).
    ..... 'Tenebroides spp. (TROGOSSITIDAE)
    - Tarsi without a bisetose empodium between claws, if pseudotetramerous either basal segment not small or antennae different 39
39. (38) Pronotum with complete, longitudinal, sub-lateral carinae (Fig. 26D); extremely small to small (not longer than 3 mm) body, strongly (usual) to slightly depressed; side of elytra sub-parallel; antennae without obvious club, sometimes as long as body; tarsi 5-5-5 or 5-5-4 segmented; facies characteristic (Fig. 26D) CUCUJIDAE Laemophloeinae
    - Prono turn without similar carinae; if very small flat species, then antenna with obvious club and tarsi different (3-3-3 segmented or less)..... 40
40. (39) Tarsi 3-3-3 segmented or less; small or very small species, usually less than 3 mm 41
    - Tarsi different, 3-4-4, 4-4-4, 5-5-4 or 5-5-5 segmented; very small to large species.....43
41. (40) Antennae with l-segmented club (Fig. 26H) [faint sub-apical line may be present on the club]; 8body more or less spherical (often tending to approach the form typical of Coccinellidae); tarsi always 3-3-3 segmented; lateral margins of pronotum and dorsal margin of elytral epipleuron with glandular openings (Fig. 26F, G); only mesa1 region of coxae exposed, all coxae appearing very small (Fig. 26E); tropical, absent from Australia. Elytra with confused puncturation.
    .....Aphanocephalus and ParafuNiu spp. (DISCOLOMIDAE)
    Antennae with 2 or 3 segmented club; body more or less elongate, depressed; tarsi may be 3-3-3, 2-3-3 or 2-2-3 segmented; lateral margin of pronotum and elytra without glandular openings; coxae not largely hidden; fore coxal cavities may be open; cosmopolitan.....42
42. (41) Dorsal surface smooth, glabrous; clypeus in same plane as from; fore coxal cavities open behind. Elytra with a single (sutural) stria (Fig. 27A). .....Holoparamecus spp. (MEROPHYSIDAE)
    - Dorsal surface more or less rugose or strongly punctured or closely pubescent; upper surface of head more or less uneven, clypeus not in same plane as frons (Fig. 27B-E); fore coxal cavities closed behind .....LATHRIDIIDAE

43. (42) Facies. characteristic, Fig. 28A-D; head more or less concealed; eyes inconspicuous, may be extremely small, always encircled by dorsal cuticle of head, apparently without or with relatively few facets.
    - Brown, shining, pubescence sparse and very short in species less than 1.5 mm long, may be longer in larger species; antenna with a compact club of free fused segments, apical club segment may be small and junction of basal and middle segments ill-defined giving l-segmented appearance; pronotum somewhat globular, elytra may also be globose; length not exceeding 3 mm; tarsi 5-5-5 segmented .....DERMESTIDAE Thorictinae
    - Facies different; head not concealed; eyes absent or obvious, not similarly encircled 44
44. (43) Antennae with large l-segmented club; body ovate, convex; elytra striate (Fig. 28E, H); tarsi 4-4-4 segmented, 1st segment (basal) lobed, 4th elongate (Fig. 28G). Margins of pronotum and elytra may be explanate. .....Euxestoxenus spp. (CERYLONIDAE)
    - Antennae different; facies different 45
45. (44) Eyes absent; base of elytra slightly broader than base of pronotum, humeri with moderately prominent apical angles (Fig. 29A). L,ength 1.62.2 mm; body moderately elongate, sub-cylindrical, glabrous and shining; head large, antennae with 3-segmented club (Fig. 29B); elytra not striate; tarsi 4-4-4 segmented, none of segments lobed. .....Aglenus brunneus (Gyllenhal) [OTHNIIDAE]
    - Eyes Ipresent; form of base of elytra and pronotum different 46
46. (45) Pronotum with lateral callosities (Fig. 29C, D, E) 47
    - Pronotum without lateral callosities 49
47. (46) Lateral margin of pronotum with a tooth medially or towards lateral callosity (tooth may be hidden by marginal setae); body elongate-ovate, clothed with fine setae (Fig. 29C).
    - Antenna with 3-segmented club; total body length not greater than 4.5 mm; tarsal segmentation 5-5-5 (9) usually 5-5-4 (6) none of segments lobed; pronotum with a basal furrow joining two small foveae. .....Cryptophagus spp. (CRYPTOPHAGIDAE)
    - Lateral margin of pronotum without a tooth, only callosity present 48
48. (47) Body elongate, clothed with greyish lanceolate setae (Fig. 29D, F). Tarsi 5-5-5 segmented (9 and 6); length 2.7-3.3 mm. .....Leucohimatium arundinaceum (Forskal) [LANGURIIDAE]
    - Body elongate-ovate, without lanceolate setae 57
49. (46) Antennae moniliform (beaded), three apical segments only slightly larger than rest (Fig. 30C); ventrally, maxillary palpi concealed by forwardly projecting process of hea capsule (Fig. 30B); front of head with median shallow depression (see Fig. 30A), head characteristic.
    - Basal segment of tarsus much shorter than 2nd segment; body subcylindrical (Fig. 30A); length 3.7-4.0 mm.
    - Laemotmetus rhizophagoides (Walker) [PASSANDRIDAE] Antennae not moniliform or head different 50
50. (49) Pronotum with short basal carina on each side (Fig. 30D). Cuticle glabrous, shining, dark brown to red-black; antennae with 3-segmented loose club; fore coxal cavities open behind; tarsi 5-5-5 segmented, 4th segment small; length 4.0-4.5 mm.
    .....Pharaxonotha kirschi Reitter (LANGURIIDAE)

- Pronotum without short basal carinae, facies different 51

51. (50) Antennae inserted close together on frons (separated by not more than length of 1st segment) [Fig. 3OE]. Small (about 2 mm) somewhat ovate and convex species; antennae with 3-segmented club; fore coxal cavities open behind; side of pronotum simple.
.....Atomaria spp. (CRYPTOPHAGIDAE)
- Antennae not inserted on frons, widely separated 52

52. (51) Lateral margin of pronotum serrate (bearing 9-10 small teeth of equal length), basal margin with furrow and foveae as in Cryptophagus (couplet 47) [Fig. 30F].
- Elytra with prominent, complete sutural stria; fore coxal cavities open behind; tarsal segmentation 5-5-5 (Q, 5-5-4 f(J); elytra unicolorous.
.....Henoticus spp. (CRYPTOPHAGIDAE)
- Either margin of pronotum not serrate or if so, then basal margin without furrow and foveae
.....53

53. (52) Tarsi 5-5-4 segmented ($8); not lobed beneath, head with genae more or less produced (7) and concealing antenna1 insertions; eyes either emarginate, being deeply indented by genal canthus (Fig. 31B) [most genera] or complete and genae tangential to dorsal margin of eye (e.g. Palorus and related genera) [Fig. 31A]; cuticle hard; head maybear horns or prominences; fore coxal cavities closed behind (e.g. Figs, 31A-E, 32A-F) .....TENEBRIONIDAE (part)
- Tars:i different, 3-4-4, 4-4-4 or 5-5-5 segmented, may have certain segments lobed; eyes not emarginate; fore coxal cavities open or closed behind 54

54. (53) Antennae II-segmented with apparently 2-segmented club (9th segment is small but should perhaps be regarded as part of club), 3rd antenna1 segment at least as long as next three combined (Fig. 33C); dorsal surface of body with short recumbent scale-like setae, on elytra arising from tubercles within striae; facies characteristic (Fig. 33B-E).
- Tarsi 4-4-4 segmented; pronotum with anterior angles produced, lateral margins finely serrate; fore coxal cavities open behind.....Colobicus spp. (COLYDIIDAE)
- Antennae without similar elongate 3rd segment and 2-segmented club combined; dorsal surface of body without scale-like setae 55

55. (54) Fore coxal cavities open behind (Fig. 34B); tarsal segmentation 4-4-4 (O), 3-4-4 (8). not strongly lobed.
- Head with distinct frontoclypeal suture; antennae with 3 or 4-segmented club; dorsal surface of body pubescent; pronotum at base as wide as elytra; elytra may be unicolorous or bear reddish-yellow areas on darker background; length I.&4 mm (e.g. Fig. 34A-E).
.....MYCETOPHAGIDAE
- Fore coxal cavities closed behind; tarsi either 5-5-5 segmented with 4th segment small, 3rd may be lobed or spoon-shaped or 4-4-4 segmented.....56

56. (55) Tarsi 4-4-4 segmented. Antennae with loose 4 to Ssegmented club (7th segment small but differentiated); hind angles of pronotum obtuse, pronotum widest near apical third, narrower than elytra; length about 2 mm (Fig. 33A). .....Myrmechixenus spp. (TENEBRIONIDAE)
- Tarsi 5-5-5 segmented, 4th segment 57

57. (56) Anterior angles of pronotum acute (frequently forming a tooth)

- (48) (Fig. 35B), or slightly produced laterally, or rounded to produce a slight callosity (e.g. (1) Fig. 35A, D, F); lateral margin of pronotum simple, or finely serrate, or bearing six large teeth (e.g. Figs 35A, B, D, F and 4C).
- Body elongate-ovate to extremely elongate, moderately to strongly depressed; 3rd tarsal segment lobed or simple. .....SILVANIDAE (part)
- Anterior angles of pronotum obtuse, not produced laterally, sides of pronotum moderately arcuate from base to apex, lateral margins not serrate; body somewhat ovate, moderately depressed (Fig. 33F).
- Tarsi 5-5-5 segmented, hind tarsus with 3rd segment lobed beneath (Fig. 33G); eyes large; antenna with loose 3-segmented club (Fig. 33H). .....Cryptophilus spp. (LANGURIIDAE)

Activity: To identify the given specimens and prepared the insect key.

PRACTICAL NO.3

Collection, identification and familiarization with the stored grains insect pests-Lepidoptera

Objectives:

1. To study on collection and identification of stored insect pests of Lepidoptera.
2. To study on nature of damage of stored Lepidoptera insect-pests.

1. Angoumois grain moth: *Sitotroga cerealella* (Olivier) (Lepidoptera:Gelechiidae)

Identification: A full grown larvae is about 5 mm long, with a white body and yellow brown head. The adult is buff, grey yellow, brown or straw-colored moth, measuring about 10-12 mm in wing expanses. The characteristic feature of this insect is the presence of the narrow-pointed wings fringed with long hair, most prominent along the posterior margin.

Nature of damage: The damage is at its maximum during the monsoon. Only the larvae cause damage by feeding on the grain kernels before harvest and also in store. The larva bores into grain and feeds on its contents. Exit holes of 1 mm diameter with or without a trap door, are seen on the affected cereal grains. As it grows, it extends the hole which partly gets filled with pellets of excreta. It imparts unhealthy appearance and smell. In a heap of grain, the upper layers are most severely affected.

2. Potato tuber moth : *Phthorimaea operculella* (Zell.) (Lepidopera: Gelechiidae)

Identification: The adults are very small narrow winged, night active moths, greyish brown in colour and mottled with darker brown. The forewings are light black in colour with fringed apical margin. A characteristic feature of the moth is that its hind wings are densely fringed. Female moths are larger (8.2 mm) than male moths (7.63 mm). Moreover, newly emerged females has a dark black patch of scales in the middle of forewings. The abdominal tip is conical in females and broad in males.

Nature of damage: The infestation starts in the field on leaves and acts as an initial source of infestation. Potato tuber moth is a serious pest of stored potato tubers and does considerable damage to potato plants and developing tubers in field. The damaging stage of the pest is larva, which feeds on potato foliage and attack tubers in the field before and shortly after harvesting. The foliage feeding larvae make transparent galleries in infested leaves. The tuber mining larvae bore mostly near the eyes of tubers filling the tunnels with excrement. Fungus grows in burrow and discolours it so that course of work may be easily followed. Later, the skin of potato partially dries and sinks so the scars become very prominent; this is called sub-epidermal injury.

3. Fig or Almond moth: *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae)

Identification: The adult is a greyish coloured moth and measures about 12 mm across the spread wings with transverse stripes on grey coloured wings. In the resting position the fore part is elevated giving a distinct slop to the wings, which are wrapped about the body. The adult is slightly smaller than Corcyra but longer than Sitotroga. The larva is white in colour with pinkish tinge and possesses setae arising from pigmented spots on the cuticle.

Nature of damage: The damage is caused by the caterpillars, which infest the germ portion of sound kernels. One caterpillar in its life time destroys the germs of about 48 kernels of wheat. The larvae spin silken threads profusely wherever they crawl. Food particles, grains, flour etc., all are webbed together in a connected

mass. Sometimes, the machinery of flour mills is clogged as a result of cake formation of flour by larval threads. Imported varieties of wheat are more susceptible than the indigenous ones to their attack. The greatest damage is caused during the rainy season.

Activity: To collection, identify and prepared the life cycle of rice moth.

PRACTICAL NO.4

Fungus problem under storage

Objectives:

3. To study on storage fungus and it caused losses.
4. To study major factors governing growth of fungi in stored products.

Before getting to the consumer's digestive system, the grains go through a number of stages. Each of them experiences pre- and post-harvest challenges that have an impact on the final grain quality. Microbial invasion is one of the variables that impacts the grain's quality. The following degradation occurs when bacteria, mainly fungus, invade the grains: The grain experiences the following negative effects:

- ✓ Loss of nutritional quality,
- ✓ Severely impaired germination ability,
- ✓ Increase in free fatty acid content,
- ✓ Decrease in non-reducing sugar content,
- ✓ Development of an off-odor,
- ✓ Decline in processing quality,
- ✓ Loss of weight, flavour, and colour,
- ✓ Occurrence of hot spot generation leading to charring of grain, and
- ✓ Production of mycotoxins.

The three most significant mycotoxin-producing fungus connected to food and feed are Aspergillus, Penicillium, and Fusarium. In severe cases, mycotoxins can result in animal death due to carcinogenesis, lung disease, gastro-intestinal inflammation, decreased feed efficiency, aberrant protein synthesis, and diarrhoea and vomiting.

❖ **Factors governing growth of fungi in stored products**

Eight factors govern the growth of fungi in foods:

i. Water activity
ii. Hydrogen ion concentration
iii. Temperature
iv. Gas tensions, specifically of oxygen and carbon dioxide
v. Consistency that is, liquid or solid state
vi. Nutrient status
vii. Specific solute effects
viii. Preservatives.
ix. Other factors like damaged grain during harvest, handling, threshing or drying, penetration of water (leakage).

Major fungal diseases in Onion, and Garlic Symptoms (on onion):

1. **Black mold**: Its develops as black discoloration (usually at the neck), shallow lesions on outer scales, streaks of black mycelium and conidia beneath the outer dry scales, and black discoloration in bruised areas. Bulbs usually do not rot, unless secondary bacterial infection occurs.
2. **Gray mold (neck rot)**: Its develops as a semi-watery decay, usually in the neck, that progresses down through the bulb. Fleshy scales soften and become water-soaked and translucent, with white to gray mycelium between scales. Gray to black sclerotia and gray mold may form on outer and inner scales.
3. **Blue mold:** first appears as pale yellow blemishes, watery soft spots, and occasionally purple-red stain on scales. A green to blue mold may develop on the surface of lesions, there may be a light tan or gray color on the fleshy scales, and bulbs may become tough (punky) with a musty odor.
4. **Fusarium basal rot starts** in the field and can progress in storage from a dry basal plate rot to a dry rot of the fleshy scales.

Activity: To identify the fungus damage caused in groundnut.

PRACTICAL NO. 5

Biology of stored grain insect pests of Coleoptera

Objectives:

1. To study on morphological characters and biology of Khapra beetle, *Trogoderma granarium* (Coleoptera: Dermestidae)
2. To study on morphological characters biology of pulse beetle, *Callosobruchus chinensis* (Coleoptera: Bruchidae)

- **Khapra beetle, *Trogoderma granarium* (Coleoptera: Dermestidae)**
- **Identification characters**
  - ✓ **Adults** are blong-oval beetles with dimensions of 1.6 to 3.0 mm in length and 0.9 to 1.7 mm in width make up the adults.
  - ✓ Males range in colour from brown to black, and their elytra have hazy reddish brown patterns.
  - ✓ The size and coloration of females are slightly different from those of males.
  - ✓ With short, 11-segmented antennae, the head is deflexed and tiny.
  - ✓ The pronotum's side has a groove that the antennae's club, which has three to five segments, fits into.
  - ✓ The adults have hair all over them.
  - ✓ **Eggs**: The eggs are milky white, turning pale yellowish with age, cylindrical, 0.7 by 0.25 mm, with one end rounded, the other pointed and bearing spine-like projections.
  - ✓ **Larvae**: The larvae at hatching are approximately 1.6 to 1.8 mm long, more than half of this length consisting of a tail made up of hairs on the last abdominal segment.
  - ✓ Larvae are uniformly yellowish white, except head and body hairs are brown.
  - ✓ As the larvae increase in size, their body color changes to a golden or reddish brown, more body hairs develop, and the tail becomes proportionally shorter.
  - ✓ Mature larvae are approximately 6 mm long and 1.5 mm wide.
  - ✓ Larvae bear characteristic body hairs:
    (1) Simple hairs in which the shaft bears many small, stiff, upwardly directed processes, and
    (2) Barbed hairs with a constricted shaft in which the apex is a barbed head as long as the preceding 4-segmented-like constrictions.
- **Biology**
  - ✓ Adult khapra beetles have wings, but apparently do not fly and feed very little.
  - ✓ Mated females live from four to seven days, unmated females from 20 to 30 days, and males from seven to 12 days.
  - ✓ Mating occurs about five days after emergence, and egg laying begins almost immediately at 40°C.

- ✓ Egg laying may begin at one to three days at cooler temperatures, but no eggs are produced at 20°C.
- ✓ Eggs hatch in three to 14 days after the female lays an average of 50 to 90 eggs that are loosely scattered in the host material.
- ✓ Complete development from egg to adult can take 26 to 220 days, depending upon temperature.
- ✓ Optimum temperature for development is 35°C. If the temperature falls below 25°C for a period of time or if larvae are very crowded, they may enter diapause.
- ✓ They can survive temperatures below -8°C. In diapause, the larvae can molt but are inactive and may remain in this condition for many years.
- ✓ Development can occur at a relative humidity as low as 2%.
- ✓ High relative humidity may be the limiting factor in the survival of introduced khapra beetles.
- ✓ Larvae feed on a wide variety of stored products and dried foods.
- ✓ They prefer whole grain and cereal products such as wheat, barley, and rice, but larvae have been recorded on the following: oats, rye, corn, dried blood, dried milk, fishmeal, ground nuts, flour, bran, malt, flax seed, alfalfa seed, tomato seed, pinto beans, blackeyed cowpeas, sorghum seed, grain straw, alfalfa hay, noodles, cottonseed meal, dried fruits, lima beans, coconuts, garbanzos, lentils, powdered yeast, and many others.

❖ **Pulse beetle, *Callosobruchus chinensis* (Coleoptera: Bruchidae)**

❖ **Identification characters**

- ✓ **Egg:** Eggs were cigar shaped and shiny bright yellow. They were attached singly to developing pea pods, often with several eggs on each pod.
- ✓ **Larval:** The larvae passed through at least 4 instars in which all were creamy coloured 'C' shaped, scarabeiform larva.
- ✓ **Pupal:** Pupa inside the seed was obtect type and also creamy coloured.
- ✓ The larval and pupal period was varied from 13-20 days with average of 16.4±2.07 days.
- ✓ The total developmental period was calculated from the day of oviposition to adult emergence. It was varied from 22-28 days with an average of 25.2+2.59 days.
- ✓ **Adult** : Adult beetles were chunky, 5 mm long, brownish beetles flecked with black, grey and white patches.
- ✓ The tip of the abdomen extended beyond the hard wing covers.
- ✓ The portion of the abdomen that was visible, white in colour and marked with two black oval spots.
- ✓ The male was different from female ones by having pectinate type of antenna whereas females having serrate antenna and male lived longer than female.

❖ Biology

- ✓ **Pre-oviposition period:** The time period between first mating and deposition of first egg was observed to spread over 4 to 9 hours.
- ✓ **Oviposition period and fecundity:** The oviposition period lasted for 5 to 10 days with a mean of 7.10 ± 1.66 days. The highest number of eggs was observed to be laid on the second day of oviposition period; thereafter the number of eggs laid declined gradually till

the end of oviposition period. The total number of eggs laid per female of C. chinensis on host seeds varied from 75 to 100 eggs.

- ✓ **Incubation period**: The incubation period of the eggs of C. chinensis on ranged from 4 to 6.
- ✓ **Grub**: During its development period, the grubs of C. chinensis moulted three times thus giving rise to four instars. The four instars were identified based on the size of grub and castings of head capsule. The first instar grub was small, opaque and creamish yellow in appearance. It was 0.46 to 0.55 mm long and had a breadth of 0.28 to 0.33 mm. The duration of first instar ranged from 3 to 5 days.
- ✓ The second instar grub size, it had a length of 0.70 to 0.82 mm and a breadth of 0.53 to 0.59 mm. It was also recognized by the presence of casting of head capsule of the first instar. The second instar larval duration ranged from 3 to 6 days.
- ✓ The third instar grub: The larval length varied from 1.02 to 1.35 mm with an average of 1.15 mm and it was 0.67 to 0.95 mm broad. The final stage of grub was 2.00 to 3.80 mm long with an average length of 2.62 mm and was 1.22 to 2.16 mm broad. The grub fed deeper into the seed extending upto the seed coat where it left a thin layer of testa appearing like a circular window.
- ✓ **Pre-pupal and pupal periods**: An inactive stage that comes in between the grub and pupal stages. Unlike the larval stages, the body divisions of pre-pupa were distinct and the abdominal portion is markedly broader than the thorax region. The length of prepupa was observed to be 3.76 to 3.90 mm and the breadth was observed to be 1.86 to 2.06 mm. The pre-pupal duration was 2 to 3 days. The pre-pupa moulted to give rise to an exarate pupa which was cream coloured. The length ranged from 2.92 to 3.75 mm and the breadth ranged from 1.76 to 2.90 mm. The appendages were free but held close to the body. As it reached the end of pupal period, the colour was observed to change to brown. The pupal development ranged from 6 to 8 days. Total development period, i.e., the number of days from egg to adult emergence of C. chinensis occupied 26 to 40 days.
- ✓ **The adults** emerged through the characteristic circular window which was cut by the last instar grub before pupation. The adult males were 3.22 to 3.90 mm long and the breadth ranged from 1.60 to 1.96 mm. Adult females were 3.52-4.60 mm long and were 1.60 to 2.09 mm broad. The male antennae were pectinate with 4-10 segments conspicuously expanded anterolaterally whereas the female antennae were serrate. The antennae of both sexes were with 4-l1 segments and dark brown in colour. Pygidium of female was covered with white coloured setae. After emergence, the males which were comparatively more active, chased the females for mating. The females expressed resistance to the mating attempts by pushing the males away with hind legs. After several attempts the males succeeded in grasping the females and established copulation. Repeated matings were observed in case of both the sexes.

❖ **Activity:**

1. To study on morphological characters and biology of khapra beetle, in wheat.
2. To study on morphological characters and biology of pulse beetle in chickpea.

PRACTICAL NO.6

Biology of stored grain insect pests of Lepidoptera

Objectives:

1. To study on morphological characters and biology of Rice moth, *Corcyra cephalonica*
2. To study on morphological characters and biology of Angoumois grain moth: *Sitotroga cerealella*

Rice moth, *Corcyra cephalonica*

- ✓ **Egg:** Eggs are whitish, oval in shape, 0.5 mm long and having an incubation period of 4-5 days. Moth lay eggs singly or in groups of 3-5 each on the grains, bags and on other objects in the godowns. A single female lay 62-150 eggs during its life- span of 24 days.
- ✓ **Larvae:** Full grown larva is pale whitish in colour. 15 mm long with short scattered hairs and no markings on body. They are full-fed in 21-41 days, after which they make silken cocoons among the infested grains.
- ✓ **Pupae:** Pupal period is about 10 days but may extend to 40-50 days to tide over winter.
- ✓ **Adult:** Adults light greyish-brown in colour, 12 mm long. Wing span of about 15 mm. The adults live for - one week. They complete life-cycle in 33-52 days and the pest completes approximately 6 generations in a year.

Angoumois grain moth: *Sitotroga cerealella*

- ✓ **Egg:** The single female lays up to 150 eggs on the outside of kernels and in cracks usually within a week after mating. Egg period is 4-8 days.
- ✓ **Larvae:** The insect overwinters as a hibernating larva and as the season warms up, it pupates in early spring. A full grown larva is about 5 mm long, with a white body and yellow brown head. Larvae capable of tunnelling sound grains.
- ✓ **Pupae:** Larvae spins a silken cocoon inside the grain and changes into reddish brown pupa. Before pupation, larvae cut a circular opening on husk which is covered by silken cover to come out. Pupal period is 9 -12 days.
- ✓ **Adult**: The adult is a buff, grey yellow, brown or straw coloured moth, measuring about 10-12 mm in wing expanse. Adult live for about 4 – 10 days.

Activity; To collection, identify and prepare life cycle of Angoumois grain moth.

PRACTICAL NO.7

Conventional methods of insect pests detection in stored food grains

Objectives:

1. To study conventional methods of insect pests detection.

In grain storage facilities, a number of standard techniques are employed, with eye inspection, probe sampling, and the insect trap approach being the most common. These techniques are straightforward but time-consuming, labor-intensive, and arbitrary. The following sections provide a quick discussion of a few of the well-liked methods.

- **Detection of insect presence**
    1. **Visual inspection:** Visual inspection can be used to find insect infestations in grains of preserved food. It is a consistent, qualitative, and arbitrary method that is employed as a benchmark for comparing quantitative procedures. By using the naked eye, it is possible to detect the presence of eggs, adult insects, and infested grains without taking grain samples or checking for lingering infestation in the storage bags.
    2. **Probe sampling and traps**: Probes are used to extract grains (0.5–1 kg) from the storage bin. Insects are removed from the grains using sieves. Long-term storage of probes in grain storage bins necessitates manual removal and visual inspection, which adds time and occasionally difficulty to the process.Traps of all kinds are helpful for quickly identifying and keeping track of insect infestations in grains that have been stored. In storage godowns that are 1.5 metres above ground level, UV light traps with 250 nm (4 W germicidal lamp) ultraviolet photons are utilised.
    3. **Pheromones and visual lures**: By utilising the reactions of insects to light, "light" can be utilised for the detection, monitoring, and management of insects in stored food grains in warehouses, godowns, lifts, etc. Utilising three different types of lighting—incandescent, fluorescent, and ultraviolet—it is a "clean" form of technology.
- **Detection of insect density**
    1. **Berlese funnel method:** For 8 hours, grain samples are placed in the funnel beneath the incandescent light. The insects are then captured in a jar with alcohol or water. Funnels come with a screen bottom that is both big enough to let insects pass through and small enough to hold the grains. The insects are removed from the grains using dry heat. Dry heat warms the grains and forces the insects to travel in a funnel-shaped pattern away from the heat.
    2. **Uric acid method**: The major component of insect excrement, uric acid, has been suggested as a way for tracing insect infestation in food grains that have been preserved. This method detects the insect infestation of the entire storage period indirectly.
    3. **Hidden infestation detector:** It is a relatively straightforward and inexpensive tool used to find concealed pest infestations in grains. Three circular plates are stacked on top of one another

to make it. To make lifting easier, the top and middle plates are hinged. Filter paper that has been ninhydrin-treated covers the base plate. This detector was used to examine samples of wheat, sorghum, and green gramme affected by the cowpea weevil (*Callosobruchus maculatus*), *Sitotroga cerealella*, and angoumois grain moth, respectively. Grain samples with a moisture content of around 20% were placed inside the perforations of the middle plate. To crush the grains, the top plate was squeezed. The stained grains were counted after being stained by filter paper, and the percentage of infection was calculated by comparing the results to other techniques.

- **Activity:** To detection of infestation by using Berlese funnel method.

PRACTICAL NO.8

Modern methods of insect pests detection in stored food grains

Objectives:

1. To study on modern methods of insect detection.

The use of contemporary techniques in the storage of food grains may provide a simple, quick way to identify both internal and external infestation, even of low density, through minimal material degradation, so that prompt action may be performed. Some technological methods for detecting insects employ sensors, cameras, microscopes, radiation sources, volatiles, sound, etc. These techniques need significantly less labour than traditional techniques, but the labour must be sufficiently skilled to operate the advanced machinery in accordance with the protocols. Based on the characteristics used to identify insects, these technologies can be divided into four categories: electrical conductivity, olfactory reaction, electromagnetic spectrum, and acoustic signals. The following sections provide details of the attempts performed under these various headings.

- **Conductance based method**

1. **Electrically conductive roller mill:** The principles of electrical conductivity and compressive force are applied in this technique to stop infection in foodgrains that are being kept. One kernel serves as a resistor in a voltage-divider circuit with two resistors and a single kernel for characterization. The voltage produced as the kernels are crushed between the rolls is used to check the conductance of the kernels. The moisture level of the kernel increases when insects are present, making it simpler to distinguish healthy kernels from infested kernels. In low moisture grains, this method is not appropriate for finding insect eggs, young larvae, or dead insects.

- **Olfactory based methods**

1. **Solid phase micro-extraction (SPME):** Techniques for smelling out insect infestation and assessing grain quality are becoming more and more common. Additionally, this technique makes it easier to determine storage age, identify food grain varieties, and spot infestations early on. In order to separate the volatile substances that had vaporised from the samples, SPME employed headspace techniques. The volatiles were then condensed and measured using gas chromatography-mass spectrometry (GCMS). Temperature and extraction time affect the SPME method's sensitivity and effectiveness. Headspace analysis (HS-SPME) in combination with GCMS allows for the collection of more analytes that *T. castaneum* and *C. ferrugineus* have detected.
2. **Electronic nose (E-nose):** The use of various electronic nose (E-nose) sensor types and tools operates according to the electronic aroma detection (EAD) concept. An odour sensor(s) set, a data pre-processor, and a data interpretation system make up the three components of the e-nose. The sensor set reacts by changing the electrical characteristics when it detects volatile chemicals in the headspace of grains of stored food. It includes an inbuilt predefined database to distinguish between

particular volatiles. E-nose has the potential to quickly and automatically find insects in grains that have been kept.

- **Electromagnetic-spectrum based methods**
  1. **Imaging methods**
     1.1 **Machine vision within visible domain:** Machine vision also known as computer vision, is an emerging technology which combines the mechanics, optical instrumentation, electromagnetic sensing, digital and image processing technology. This technique is suitable to detect the whole and live insects in stored food grains. The three main steps in machine vision technology are picture acquisition, image analysis or processing, and recognition and interpretation. Image acquisition is the process of turning a real image into a digital image utilising tools like cameras, scanners, movies, etc. The initial processing of the raw image is known as image pre-processing. Pre-processing is sometimes done to improve the quality of the image by reducing undesirable distortions or "noise" or by emphasizing key points of interest.

     1.2 **X-ray imaging:** An encouraging methodology that uses a non-contact sensor to inspect huge samples while appreciably supplying the information is the X-ray imaging method. A quick, non-destructive, and direct method for finding concealed insects in stored food grains, rating the interior quality of agricultural products, and finding insects in mangoes is soft X-ray imaging.According to Kotwaliwale, Subbiah, Weckler, Brusewitz, and Kranzler (2007), the imaging media used to collect the photos was shielded from the radiation of the environment by a case. For internal inspection, soft X-rays with wavelengths between 0.1 and 10 nm and energies between 0.12 and 12 keV are utilised. The process takes only a few seconds (around 3–5s).

  2. **Non-imaging methods**
     2.1 **Electronic grain probe insect counter (EGPIC):** The Electronic Grain Probe Insect Counter is an automated passive grain probe that collects data on the levels of infestation in stored food grains and displays it remotely. It is made up of a probe, system components, a data recorder, and an interface. Electric power and electronics are kept outside of the storage structure due to the risk of grain dust explosions, and only low voltage, high impedance sensor leads are passed through the grains from the beam generation/detection circuitry to the sensor head. The computer receives input from the sensors and processes it to create time-stamped records of detection.

     2.2 NIR spectroscopy: The concentration of biological substances like water, protein, starch, etc. is measured using near-infrared spectroscopy (NIRS) by measuring the sample's dispersion reflectance, interactance, or transmittance in the 780–2500 nm wavelength range. It is a non-destructive, quick, precise, and affordable technology that works for both internal and external detections in fruits, vegetables, cereals, and pulses**.**

  3. **Acoustic detection:** In order to determine the type and density of insects within a stored grain mass, acoustic technology relies on the concept that the sound produced by insect movement and eating may be observed. Results on identifying both internal and exterior insects in the grain mass at the beginning of an infestation have been positive.

PRACTICAL NO.9

Estimation of insect pest losses in stored food grains

Objectives:

1. To assessment of losses due to insect pest under laboratory condition.
2. To estimated germination and weight losses after insect pest infestation.

MATERIAL AND METHOD

To estimate the losses at different population levels of insects pests at different numbers (1st pair, 2nd pairs, 4th pairs, 8th pairs and 16th pairs etc.) of adults (both male and female) were released in separate jars containing 100g host plant seeds. The experiment was replicated three times. The observations given below were recorded at 30th, 60th, and 90th days after release of adults of beetles. Mean grain damage (%) A sample of 100g of grains were taken from the jars of each replicate of every set after 30th days. The damaged grains were separated out from the total number of grains taken for observation in each replication. Care was taken to avoid recount of damage grain. The data taken was used for calculating the mean per cent damaged grains. The same procedure was adopted for recording observations at 30, 60 and 90 days after release of pulse beetle.

- **Grain damage**

The following formula was used for determination of mean damage percent as described.

$$\textbf{Grain damage (\%)} = \frac{Total\ number\ of\ damaged\ grains}{Total\ number\ of\ grains}\ x\ 100$$

- **Mean germination loss (%)**

To investigate the effect of plant leaf extracts oil and edible oils on seed viability, 100 seeds were taken from each treatment and were placed in petridish separately having water soaked blotting paper at its bottom. The petridishes was placed in B.O.D. at 18±2.5 ^{0}C temperature and 75± 5% relative humidity. After incubation, the germinated seeds was counted and worked out the percent seed germination. The mean per cent germination loss was calculated by following formula:

$$\textbf{Per cent germination} = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ selected\ seeds}\ x\ 100$$

- **Mean weight loss** After removing the beetles from each jar the weight of grains were taken separately on an electric balance from each replicate after 60 and 90 days of release. The mean per cent loss in weight was calculated by the following formula:

Mean weight loss $= \frac{I-F}{I} \; x \; 100$

Where, I=initial weight of grains, F=final weight of grains

Activity:

1. To assessment of losses due to pulse beetle in chickpea under laboratory condition.
2. To estimated germination and weight losses after pulse beetle infestation in chickpea.

OR

3. To assessment of losses due to khapra beetle in cereal under laboratory condition.
4. To estimated germination and weight losses after khapra beetle infestation in cereal.

PRACTICAL NO.10

Estimation of fungal losses in stored food grains

Objectives:

1.To assessment of losses due to fungus under laboratory condition.

2. To estimated germination and weight losses after fungus infestation.

Among the *Aspergillus section* Flavi, *A. flavus, A. parasiticus* and *A. nomius* are the most prevalent species which produce aflatoxin and can be detrimental to human health and animal productivity.

Disease severity

Three replication, and 200 kernels were randomly sampled per replication and used for mould infection. Infected and normal kernels were separated visually by the help of hand lens and counted separately using seed counter. The disease severity will calculate using the following formulas

Disease severity (%) = $\frac{Total\ number\ of\ damaged\ grains}{Total\ number\ of\ grains}\ x\ 100$

Per cent germination = $\frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ selected\ seeds}\ x\ 100$

Mould incidence in kernel

Blotter test was used to determine occurrence of mould on kernel. A total of 360 kernels in three replicates were tested from each sample. After disinfection using 5% sodium-hypochlorite 32 solution (NaOCl) kernels will be plate directly on top of three layers of well-soaked sterileblotterpaper. Ten seeds are plate on plastic Petri-dish of 9 cm diameter by surface disinfection. The plated kernels are incubate in growth chamber (LEEC, model PL2, PL3, PL33. Notthgham, UK) at 25±2°C for 7 days under alternate cycles of 12hr light and 12hr darkness. After incubation plated kernel are examine for the growth of seed borne pathogen and the infected and healthy seeds will counted and recorded. Finally incidence was calculated as follow:-

Disease severity (%) = $\frac{Total\ number\ of\ damaged\ grains}{Total\ number\ of\ grains}\ x\ 100$

- **Isolation and identification of Aspergillus:** The direct plating method was used to assay Aspergillus from each sample following the method of Pitt and Hocking (1997). Kernels were surface sterilized for 1 min in 2.5% NaOCl, washed in three changes of sterile distilled water and plated 5 kernels per petri plate directly on the surface of Subaroaud Dextrose Agar (SDA) supplemented with 0.1% streptomycin to suppress the bacterial growth. Three replicates from each sample were plated, incubated in the dark at 25°C for 5 days and then the fungal growth colonies from the kernels were single spored to obtain

pure cultures. The pure cultures were subcultured on the Czapek Dox (CZ; Himedia Laboratories, Mumbai, India) agar for the identification of Aspergillus species by means of colony characteristics. All isolates were cultured on *Aspergillus flavus* Parasiticus Agar (AFPA; Himedia Laboratories, Mumbai, India) for 3 to 5 days at 27°C to confirm section identification by colony reverse colour. The colonies which developed yellow-green, green, deep green, shades of black and brown, white, bluish grey on CZ were identified as *Aspergillus* species. Isolates belonging to Aspergillus section Flavi had a bright orange colour on the reverse of the plate on AFPA media while negative isolates had either cream or black reverse colours.

Activity:

5. To assessment of losses due to fungus in cereals crops under laboratory condition.
6. To estimated germination and weight losses after fungus infestation in cereals.

PRACTICAL NO.11

Determination of moisture content in stored food grains

Objectives:

1.To determine the moisture content of grains.

- **Requirements**

Electric balance, Brown-duel moisture meter, Satake moisture meter, Indosaw universal moisture meter, Oven, Desiccators, Moisture boxes.

- **Procedure**

a) Oven drying method

1) Take the sample box and weigh it with lid over it
2) Put the sample in it (approximately 5-10 grams)
3) Keep the sample in an oven at 105 QCfor 24 hours
4) Take out the sample after 24 hours and weigh it along with the lid over it

Observations Table

Sl. No.	Items	Sample No.	Weight
1.	Initial Weight of Sample	1	
		2	
		3	
2.	Final Weight of Sample	1	
		2	
		3	
3.	Container Weight Without Sample	1	
		2	
		3	

Calculations

Calculate the moisture content in percent with the following formula b) Brown-Dual distillation method

Moisture content (Wet basis) = $\frac{Initial\ weight\ of\ sample - Final\ weight\ of\ sample}{Initial\ weight\ of\ sample}$

Moisture content (Dry basis) = $\frac{Initial\ weigh\ \ of\ sample - Final\ weigh\ \ of\ sample}{Dry\ weigh\ \ of\ sample}$

Procedure

i. Arrange the instrument and settings
ii. Take IOOg of material by weighing on the balance
iii. Take 150 ml mineral oil (high BP) using measuring jar
iv. Take the grain and oil in a flask and keep it in the assembly
v. Supply the current and keep it for 30 minutes
vi. Collect the condensed water in a graduated cylinder
vii. Stop the supply when water collected in the cylinder is negligible
viii. Take the cylinder and measure the reading which will give directly the wet basis moisture content.

Universal moisture meter

a. Arrange the instrument and set up
b. Take the sample and check the volume cup to be used from the meter
c. Fill the sample in the cup up to top
d. Read out the pressure to be applied
e. Provide the compaction by means of rachet handle
f. Press the button provided at the top such that the countdown starts from 10
g. After the end of countdown, moisture content is displayed 0 the screen which give the moisture content on wet basis
h. Repeat for three samples of same material

Result:

Sl. No.	Moisture measurement method	Sample No. (wet basis)	Moisture content
1.	Air oven method	1	
		2	
		3	

2.	Universal moisture meter method	1	
		2	
		3	
3.	Brown-dual fractional distillation method	1	
		2	
		3	

Activity:

1. The temperature and time for moisture removal is maintained properly
2. Clean and dry moisture boxes should be used for experimentation
3. Condensed water should be collected properly and weighed

PRACTICAL NO.12

Familiarization of storage structures

Objectives:

1.To study on different storage structure.

Requirements of storage:

Provide adequate protection from rodents, birds and insects. Provide aeration and fumigation when required. Prevent losses due to moisture and temperature. Permit easy inspection. Facilitate proper cleaning and should be self cleaning in case of silo. Economical on unit storage cost basis. Capable to protect the grains from weather, fire and theft.

Design of grain storage structures:

- ✓ Proper design of the storage is not only to restrain and properly hold the material but also to minimize the damage to the grain due to moisture condensation or excess temperatures.
- ✓ The storage unit must be so designed as to withstand the change in pressures during loading and unloading.
- ✓ The several aspects to be considered in a storage design are types and quantities of grain to be stored, location, size and number of bins, handling equipment and methods, structural requirements, conditioning methods and requirements and plans for future use and expansion.

Conventional or traditional storage structures

1) Underground storage
2) Straw storage
3) Bamboo storage
4) Wooden storage
5) Mud Storage
6) Gunny storage
7) Metal bin storage

Conventional structures

1) Bukhari type storage structure
2) Morai type storage structure
3) Kothar type storage structure

4) Metal or plastic drums

Improved structures

1) Pusa bin
2) Metal silos
3) Cover and plith storage
4) Pucca kothi
5) Hollow brick storage structure
6) Reinforced brick masonry bin
7) Partly underground and partly above ground bin

Hermetic Storage

Hermetically, or sealed, storage systems put grain in an airtight container such as a drum or a plastic bag. This stops air and water getting in to the stored grain from outside. Once the container is hermetically sealed, The moisture content of the grain will be controlled. So it reduces pest damage without using pesticides. Depending on the number of insects, and type and size of the system, oxygen levels will be reduced from 21% to less than 10%within a short period of time. At oxygen levels below 10%, insects are curtailed and the viability of seed ensured. Since it minimizes biological activity inside the storage, container hermetic storage also helps maintain grain quality and seed viability. Popular in tropical regions these systems vary in size from 3 kilograms to 300 tons.

Activity:

1. To study well developed modern storage structure nearest to University.
2. To study local and traditional storage structure nearest to University.

PRACTICAL NO.13

Fumigation techniques under storage structures

Objectives:

1.To study on different fumigation techniques under storage structure.

- **Fumigation Methodes**
  - ✓ Raw agricultural products are stored in bins, silos and other structures.
  - ✓ They may also be kept in boxcars or other railcars, trucks or in ship holds for short periods during transportation.
  - ✓ Because fumigants can move through tiny cracks and crevices, fumigation must occur in structures that are relatively airtight.
  - ✓ Some buildings and boxcars are naturally well-sealed.
  - ✓ Others may need fumigation tape, polyethylene sheeting or other materials to make them airtight.
  - ✓ Still other structures, particularly those that are leaky, may need to be tarped.
  - ✓ Fortunately, several fumigation methods are available.
- **The most common methods used to fumigate raw agricultural commodities are:**
  1) **Vault Fumigation:** Vault fumigation uses atmospheric or vacuum chambers to treat infested products. Other structures such as truck trailers, boxcars or other railcars, grain bins, silos and other storage structures can be vaults if they are well-sealed.
  2) **Tarpaulin Fumigation:** Tarpaulin fumigation places commodities under a tarp or covers an entire structure. Fumigant is released beneath the tarp and held until pest control is complete.
  3) **Spot (Local) Fumigation:** Spot fumigation is used to treat small items or areas with light to moderate infestations. Spot fumigation is also used routinely to prevent infestations from developing or recurring.
- **For simplicity, this chapter will discuss three types of vault fumigation:**
  1. **Fumigation in atmospheric chambers:** An atmospheric chamber can be any airtight structure under normal air pressure. It is usually a small building located away from other structures. Some are specially built for fumigation. Others are modified from existing structures.
  2. **Fumigation in vacuum chambers:** Vacuum chambers are large steel structures. Unlike other vaults, treatment occurs in a “vacuum” rather than at atmospheric pressure. In a vacuum, the air pressure is lower. This does two things. First, it denies oxygen to the pest.

Under a vacuum, the oxygen level inside a chamber decreases. Pests become stressed and are easier to kill. Second, the vacuum helps the fumigant penetrate the commodity.

3. **Fumigation in sealed structures:** Fumigation by sealing, also called "tape-and-seal" fumigation, works by turning an entire structure (grain bin, warehouse or boxcar) into a temporary fumigation chamber. To do this, it helps if the structure is airtight. Tape-and-seal fumigation accomplishes this by working only with structures that are in good repair. Workers find and seal all leaky spots with fumigation tape. The goal is to create a "vault" that is as close to airtight as possible.

Activity

1. Describe three methods of fumigation used to treat raw agricultural commodities.
2. List the three types of vault fumigation and explain the advantages and disadvantages of each.
3. Describe how to prepare for a tape and seal fumigation.

PRACTICAL NO.14

Detection of hidden infestation in stored food grains

Objectives:

1. To study on methods of determination of hidden infestation

(a) Emergence hole counts: The number of grains with insect emergence holes in a given sample is counted. In this method, the grain is also taken out to observe the presence of larvae. The examination under the microscope to observe the immature stages of insects not visible through the naked eye is also undertaken.

(b) Incubation: In this method the samples of grain to be tested are incubated under controlled conditions of temperature as well as humidity in glass jars and the number of insects emerged after a period of every 24 hours are counted for a period of 15-20 days depending upon the life cycle of the insects emerging. This method is reliable but time consuming.

(c) Stain method: In this method, solution of various dyes is used for staining egg plugs in a given sample. The stained insect plugs are separated and estimated. The stained kernels must be examined closely to differentiate whether the stained portion is a plug hole or endosperm of the grain. The principle objection of egg plug stains is that there is no indication of stages of development of the insect within the kernels. The following different methods employing various stains have been developed for detecting hidden infestation of insects.

(i) Acid fuchsin: This is rapid method of detecting the presence of weevil infestation within grain which was described by Franken field (1948). He employed an acid fuchsin stain whereby the gelatinous weevil egg plugs in grain were stained a bright cherry red and feeding punctures and mechanical injury stained a light pink. The stain was prepared by mixing 50.0 ml glacial acetic acid in 950 ml distilled water and adding 0.5 g acid fuchsin. Uniform samples of grains prepared by soaking in warm water for 5 minutes were immersed in the stain for 2-5 minutes after which the excess stain was removed by washing in tap water. The egg plugs are about the size of an ordinary pin prick and can readily be seen with the naked eye.

(ii) Gentian violet: Goosens (1949) suggested a gentian violet method for determing the hidden infestation. The wheat is exposed for 2 minutes in a solution containing 10 drops of 1 per cent aqueous stock solution of gentian violet in 50 ml of 95 per cent ethanol. The egg plugs are stained purple.

(iii) Iodine solution: The sample to be tested is immersed in iodine solution which gives a dark brown stain on the egg plug. While examining stained grains care must be taken in separating kernels with broken skin as such. kernels are likely to be stained by this solution.

(iv) Berberine sulphate: A fluorescent stain berberine. sulphate was suggested by Milner et al. (1950) for staining the egg plugs but has not come into general use. By this method, kernels of wheat are emerged in

dilute solution of berberine sulphate (20 ppm) for one minute. When exposed to ultra violet light the egg plugs show an intense yellow fluorescence.

(d) Carbon dioxide determination: Howe and Oxley (1944) proposed a method based on the fact that insect breeding in grain produce carbon dioxide. By measuring the quantity of carbon dioxide produced by the given sample of grain in 24 hours, the extent of internal infestation could be estimated. If the carbon dioxide concentration exceeds one per cent, it is certain that a potentially dangerous infestation is present. A figure of 0.3 per cent may represent insect free grain if the moisture content of the grain is 14 per cent or above. If the moisture content is below 14 per cent, such a reading would indicate a slight infestation. A reading between 0.3-0.5 per cent indicates either a slight insect infestation or a moisture content higher than 15 per cent. A figure between 0.5 and 1.0 per cent indicates that the grain is unfit for prolonged storage. This method requires too long a period and fails to indicate the presence of dead insects.

(f) Sodium hydroxide gelatinization method: This method was suggested by Apt (1950) for quickly detecting the presence of insect infestation in wheat. The treatment consists of boiling the grain for ten minutes in a 10 per cent solution of sodium hydroxide. This method has been adopted on a large scale.

(g) X-ray method: This is most accurate and rapid method of determining internal insect infestation and has the advantage. that all stages of development of the insects can be observed. This method was described by Milner et al. (1950). In this method, X-ray machines are used to take radiographs of 100 g sample of wheat. These radiographs reveal the presence of insect forms within the kernels. X-ray manufacturers have developed X-ray units specifically for this purpose. Equipment is rather expensive but is being used extensively by large milling concerns.

(i) Ninhydrin process: Dennis and Decker (1962) suggested the use of a chemical indicator technique for determining the presence of living insect infestation in grains, based on a colour reaction between the body fluids with ninhydrin impregnated filter paper. In a machine developed for the purpose, grain to be tested is fed into the machine into a fold of filter paper impregnated with a 0.7% ninhydrine acetone solution. The tape containing the kernels is passed through rolls which crush the kernels, allowing the body fluids of 10 insects within the kernels to react with the chemical in the filter paper forming purple spots which can be counted.

Activity: Estimation of hidden infestation by using Ninhydrin method in the laboratory.

PRACTICAL NO.15

Detection of Rats in fields and warehouses

Objective:

1. To study on Presence of Rats in the Field and Warehouses

Detect Presence of Rats in field

Rats are found in the heap of wood, burrows, or even in the ditch. The depth of a burrow may be 0.3-1.4 m. One burrow may contain 2-42 openings. There are three types of burrows:

(a) Round type: The diameter varies from 1.5 to 2.0 inch. Most of these are not inhabited by rats.

(b) Irregular type: Burrows which are irregular in shape and the fresh soil is very often found at the base of these burrows. These holes are slanting inside and leads to the burrows and such burrows are inhabited by rats.

(c) Semi-circular type: This type of burrows has a diameter of about 2-3 inch. These burrows are inhabited by rat generally by females which live matured stage of pregnancy with the freshly born young ones.

Detect Presence of Rats in Warehouses

From following points, the presence of rat can be detected in warehouses:

(a) Spoilage: Gnawed bags with grain scattered on floor.

(b) Dropping: Excreta of rat is known as rat dropping. Dropping indicates the presence of rat.

(c) Gnawing marks: Presence of regular holes in wooden doors and windows indicate the presence of rats.

(d) Run ways: Marks of foot and tail left on dusty floor represent active rat infestation in godown.

(e) Holes and scrap: The presence of holes with scraps and newly dug out loosen soil heaped any where inside or around godown give information of infestation.

(f) Disappearance of baits: When we put bait at the active burrows and if it disappears, it is sure that the rats are present or presence may be inspected.

(g) By noise of rat: The presence may be suspected.

(h) Odour: Rats have little odour unless the population is large or well established. Mice can offen be detected by their musty odour.

Activity; To collection and identify the Rats species in field and warehouses.

PRACTICAL NO.16

Sefety measures against poisoning

Objectives:

1. To study on direction and precautions against poisoning

Directions and Precautions for Fumigation

All fumigants are more or less toxic to human beings and domestic animals; hence, they must be used very carefully. The following consideration should be kept in mind while fumigating.

- Food stuffs are removed from the building to be fumigated.
- Edibles to be fumigated should be with proper safety to human lives, operation should be carried out by trained personnels with protective clothings.
- Enclosure must be airtight as possible. Avoid windy or cold weather.
- Use accurate dosages, proper exposure and ventilation for live plant fumigation.
- Optimum temperature for fumigation of live plants is 14-27°C.
- Optimum temperature for fumigation of stored grains/ receptacles is 21-30°C.
- Commodities containing fat should not be fumigated with EDB/MB.
- Study literature of fumigants before the operation.
- Keep first aid ready and wash hands after fumigation.
- Destroy empty containers.
- Put 'Poison Gas Danger' at the entry of building till proper ventilation.
- Call a physician immediately in accidental poisoning.
- Avoid smoking within 15 metres of fumigated area.

Activity: To enlist the fumigants based on toxicity.