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Report No. 11
July 1969

Report on

Grain Sanitation Workshop

July 7-12, 1969

Central Food Technological Research Institute
Mysore, India

FOOD & FEED GRAIN INSTITUTE
KANSAS STATE UNIVERSITY

MANHATTAN, KANSAS 66502

J.D.
Reference Section
Room 1656 NS

Report on
Grain Sanitation Workshop

Presented by USAID/India
in cooperation with

Academy of Pest Control Sciences
and
Central Food Technological Research Institute
Mysore, India
July 7 through 12, 1969

Summary

A grain sanitation workshop was presented at the Central Food Technological Research Institute, Mysore, with 24 participants from Indian industry, government and academic institutions in attendance. In spite of programming difficulties and lack of appropriate laboratory equipment, a meaningful workshop was conducted using lectures and laboratory demonstrations to instruct participants in proper grain sanitation and inspection methods. A seed for growth of the proper attitude and concept of grain sanitation has been planted.

In addition to the workshop, grain storage facilities were observed in urban and rural areas. Government grain storage facilities appear to be well maintained and managed. Grain observed in village markets and storage is not adequately protected from contamination by rodents, insects or birds. Grain and milled products at flour mills are subject to contamination and infestation by rodents, insects and birds from the time grain is received at the mill until the finished cereal product is shipped from the mill.

Rodent control aspects of grain sanitation were an integral part of the workshop, grain storage inspections and discussions with USAID personnel.

Acknowledgment

I wish to express my appreciation to Mr. Kenton L. Harris and USAID/New Delhi for the opportunity to take part in presenting the Grain Sanitation Workshop at Mysore. It was a rewarding and educational experience for me, and I hope the ideas and concepts of grain sanitation put forth by Mr. Harris and I were as rewarding and educational to the workshop participants.

I would also like to acknowledge the many courtesies and assistance provided by the Academy of Pest Control Sciences and the Central Food Technological Research Institute, Mysore, and their personnel. To list the names of all of the people involved would require many pages. Special mention should be given, however, to Dr. H. A. B. Parpia, Director of CFTRI and President of APCS, Mr. S. K. Majumder, Chairman, Infestation Control and Pesticides, CFTRI and Secretary of APCS for their personal efforts and the efforts of their staffs in providing the facilities for the workshop and personnel for part of the workshop instruction.

Special appreciation is also expressed to Dr. N. S. Agrawal, Directorate of Storage and Inspection, Ministry of Food and Agriculture, Government of India for his active participation and enthusiasm in the workshop.

The support of the Indian Pest Control Association indicated by the presence of its president and several members at the workshop is also greatly appreciated.

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Report on
GRAIN SANITATION WORKSHOP

Presented by USAID/India
in Cooperation with

Academy of Pest Control Science
and
Central Food Technological Research Institute
Mysore, India
July 7 - 12, 1969

Prepared by

John R. Pedersen

for the
AGENCY FOR INTERNATIONAL DEVELOPMENT

AID/csd-1588
Technical Assistance in
Food Grain Drying, Storage Handling and Transportation

at the
FOOD AND FEED GRAIN INSTITUTE
KANSAS STATE UNIVERSITY
MANHATTAN, KANSAS 66502

Dr. William J. Hoover, Director
Dr. Harry B. Pfost, Agricultural Engineer
John R. Pedersen, Entomologist

INTRODUCTION

The following report is submitted as requested in PIO/T No. 386-367.3-3-90110, Project No. 386-11-190-367.3, Agricultural Inputs Development (Plant Protection), USAID/India.

Objectives. The major objective of the request for a consultant to supply technical assistance through the War on Hunger contract with Kansas State University, AID/csd-1588 was "to introduce the subject of Grain Sanitation to India as a means of furthering technical interest and competence in grain protection".

Paragraph 21. Scope of Technical Services of the PIO/T outlined the requirements of the consultant, in general as follows:

1) To lead a seminar on grain sanitation in cooperation with the Academy of Pest Control Sciences (APCS) and the Central Food Technological Research Institute (CFTRI), Mysore.

2) To recommend an agenda for the seminar workshop.

3) Provide laboratory and inspection worksheets for participants.

4) Present lectures and demonstrations on inspection and control techniques, laboratory analytical techniques, rodent and insect control, etc.

5) Visit representative Indian urban and rural grain handling and storage locations to observe grain losses due to rodents.

6) Meet with the USAID Biologist-Rodent Control prior to the workshop.

7) Discuss rat control with USAID officials.

In response to this request the services of John R. Pedersen were offered through Kansas State University's WOH contract AID/csd-1588 as a biologist-entomologist experienced in food plant sanitation, grain storage inspection and sanitation, laboratory testing of cereal grains for rodent and insect contamination and experience in presenting food sanitation workshops. An outline of Mr. Pedersen's background and experience was sent to Mr. Kenton L. Harris, Biologist-Rodent Control, USAID/New Delhi, in a letter dated June 6, 1969.

GRAIN SANITATION WORKSHOP

Agenda. A tentative agenda for the grain sanitation workshop was sent to Mr. Kenton L. Harris, Biologist-Rodent Control, USAID/New Delhi on June 6, 1969 (Attachment I). Shortly after preparing the agenda, a letter was received from Mr. S. K. Majumder, Secretary of APCS, outlining an agenda (Attachment II) for the same workshop. In a letter dated May 26, 1969, from Mr. Harris to Mr. Majumder, Mr. Harris had

specifically requested that the program "remain tentative until the last minute even though this may mean a cyclostyled program". An immovable time table was not wanted. Mr. Majumder, in his letter to me of June 7, 1969, acknowledged a flexible program in stating "when you visit Mysore during the period of the Workshop, the tentative program could be modified as per your requirements. The flexibility still exists in the details of the Workshop".

On my arrival in New Delhi, the agenda submitted by me and the agenda outlined by Mr. Majumder were compared and a revised agenda (Attachment III) prepared by Mr. Harris and I to accommodate Mr. Majumder's personnel.

When we met with Mr. Majumder at Mysore on July 6, to finalize the agenda, Mr. Majumder presented us with a printed program for the Workshop which did not vary significantly from that sent to me by Mr. Majumder on June 7. Our disapproval of the manner in which the preceding arrangements had been made were conveyed verbally to Mr. Majumder in this meeting to finalize the agenda.

Although we were presented with a formal printed program which did not conform to the content or sequence of material which we considered appropriate for a Workshop of this type, we proceeded with the Workshop and were able to (unofficially) reschedule portions of the program to more nearly conform to what we considered appropriate for this type Workshop. In this way, I believe, we were able to accomplish the objective of the Workshop -- to introduce the concept of Grain Sanitation to India.

Laboratory and Inspection Worksheets. A laboratory manual entitled "Outlines of Grain Sanitation Inspection and Analysis" (Attachment IV) was cyclostyled at USAID/New Delhi from stencils prepared at Kansas State University for this Workshop. One hundred of these manuals were delivered to CFTRI, Mysore, and were distributed to participants of the Workshop. Although a maximum of 30 participants were programmed for the Workshop, Mr. Harris had been informed by individuals outside of CFTRI that an additional 50 persons probably would be present.

In addition to the laboratory manual prepared by USAID, APCS/CFTRI had a plastic folder for each of the participants. It contained abstracts of some talks presented at the Workshop and laboratory outlines from some of the sessions conducted by CFTRI personnel. A publication entitled "Grain Sanitation", edited by S. K. Majumder and J. S. Venogupal and printed with USAID funds was distrubuted to participants. Comments on this publication are contained in Kenton Harris' report on the Workshop.

Lectures and Demonstrations. In his letter of June 7, Mr. Majumder had "tentatively programmed" me for a lecture on "Principles of Grain Storage" and indicated "further responsibility of taking the overall charge of the Sanitation and Inspection-A Session on July 9, 1969." Mr. Majumder's letter also indicated I would be assisted by his colleagues at the Institute as indicated in his program. In addition, in Mr.

Majumder's words, "another session you have to look after is the 'Sanitation Measures' on July 11, 1969, in which you will also be assisted by myself and my other colleagues".

Specific subjects and sessions had also been assigned by Mr. Majumder for Mr. Harris' participation in the program.

At this point Mr. Majumder had presented us with both an inflexible program and assignments on subject material to be covered by us. We continued with the program by both Mr. Harris and I emphasizing our concept of sanitation in lectures and laboratory sessions.

The following lectures, illustrated with colored slides, were presented by the consultant during the workshop:

Principles of Grain Storage and Grain Sanitation
11:30 - 12:30 a.m. July 7, 1969

Stored Product Insect Identification
8:30 - 9:30 a.m. July 9, 1969

Insect Fragment Identification
2:15 - 3:15 p.m. July 9, 1969

Mill and Factory Sanitation Techniques
3:45 - 4:45 p.m. July 11, 1969

The following laboratory sessions were conducted by the consultant with the assistance of Mr. Harris during the Workshop:

Biology and Life History of Insects
9:00 - 11:30 a.m. July 8, 1969
(This session was originally scheduled to be coordinated by Mr. Majumder and presented by one of his people. It was necessary, however, to assume responsibility for this session after it had started in order to provide meaningful value to the participants.)

Insect Infestation - Contaminant Analysis (Insect Fragments)
9:30 a.m. - 1:00 p.m. July 9, 1969

Detection of Contaminants in Whole Grain
8:30 - 10:30 a.m. July 11, 1969

The following lectures were presented by Mr. Harris during the Workshop:

Introduction to the Workshop and Symposium
10:30 - 11:15 a.m. July 7, 1969

The Role of Grain Standards in Food Sanitation
2:30 - 3:15 p.m. July 7, 1969

Insect and Rodent Filths (Chairman of Session with introductory remarks)
2:30 - 5:30 p.m. July 8, 1969

Rodent Hair Identification and Importance (illustrated with colored slides)
9:00 - 10:00 a.m. July 10, 1969

The following laboratory session was coordinated by Mr. Harris:

Rodent Infestation - Sanitation and Inspection
10:00 a.m. - 1:00 p.m. July 10, 1969

Both Mr. Harris and I discussed the possibility of field trips to local warehouses and mills with Mr. Majumder. We felt this aspect would be of great value to the participants. Mr. Majumder indicated he would try to make arrangements to visit local storage areas on Saturday afternoon, July 12, 1969, and that he would also arrange for a mill tour on Sunday morning, July 13, 1969 in Bangalore.

The field trips to local storage facilities did not materialize.

On July 13, 1969, the day following the Workshop, fifteen (15) of the Workshop participants, Mr. Harris, and I visited the Krishna Flour Mill in Bangalore and made an instructional inspection of the mill and grain storage area at the mill. This inspection was to have been made as an integral part of the Workshop, however, Mr. Majumder's arrangements for the inspection could not be completed in time. Dr. N. S. Agrawal, Deputy Director of Grain Storage and Inspection, Ministry of Agriculture made the arrangements for our visit to the mill.

Participants. Officially, twenty-four (24) participants were registered for the Grain Sanitation Workshop (Attachment V). Participants were selected on the basis of providing representation to government, industry and academic areas in India. Further selection was made on the basis of individuals who would be able to make a useful application of the information presented. In this respect APCS and CFTRI made a good selection of participants. The participants were all attentive, interested and eager to learn "grain sanitation".

Many of the participants were directly associated with the flour and feed milling industry or with the pest control industry in India. These participants were keenly interested in mill sanitation and control measures applicable to pests in mills. Several requests were received for printed information on this subject.

In addition to the "official" Workshop participants, between 50 and 70 additional persons attended the symposium or lecture sessions of the Workshop. These people were at CFTRI to attend either an FAO International or a National short course on "Infestation Control in Raw and Processed Foods".

Accomplishment of Workshop Objectives. At first reading of the preceding paragraphs, it might appear that very little was accomplished in the Workshop. On the contrary, I feel that much was gained on the part of participants, the staff at CFTRI and ourselves.

Although we were placed in a position that made it necessary to "accept" Mr. Majumder's printed program, we were able to emphasize our concept of grain sanitation through the programmed presentations we made, exercising the perogative given us as chairmen of sessions to make introductory remarks at the sessions, the extension of particular sessions we considered important and reduction in time devoted to others, and "after-hours" unscheduled meetings and discussions with various groups of the participants.

We were indirectly effective in demonstrating techniques of instruction to CFTRI personnel which we feel may be more effective than some presently used at CFTRI.

We were able to establish the concept of grain sanitation with many of the participants, FAO and National short course participants, and CFTRI personnel. Hopefully, they in turn will carry the information to others with whom they come in contact in the future.

We ourselves, were educated in the methods used by APCS and CFTRI in a Workshop of this type, the methods used in short courses presented at CFTRI and in the logic used in analyzing research and field situation.

The full value of what Mr. Harris and I would have considered adequate from a workshop on Grain Sanitation were not fully realized because of several factors:

1. The schedule of lectures and laboratory sessions did not make full use of the participants time. There was repetition in material presented by CFTRI personnel, in part, brought about by scheduling to include the two other short courses being conducted at CFTRI concurrently with this Workshop -- an FAO International short course and a National short course on "Infestation Control in Raw and Processed Foods".

Even though the scheduling and repetition did cause some difficulty, it did provide the opportunity to stress the concepts of food sanitation to an international group of nearly 100 persons from a variety of Southeast Asian countries including Burma, Thailand, Philippines, India and others. Where we may have lost on the one hand, we gained on the other.

We would have preferred more time in the laboratory on subjects other than those scheduled by CFTRI.

2. Lecture and laboratory space was adequate, however, equipment for proper study of insects and their contaminants was not adequate. There were four dissecting microscopes available for use by the twenty-four Workshop participants. This meant that six participants were required to share a microscope and greatly reduced the amount of material we were

able to cover in a given period of time in the laboratory. According to information available to both Mr. Harris and me, there should have been sufficient microscopes available for each participant to have one for use.

3. Some of the material scheduled by Mr. Majumder did not bear directly on grain sanitation as we conceive the subject. Subjects such as "rice quality," "wheat quality" and "poisonous seeds" were non-sanitation oriented and of little or no value to the Workshop.

RURAL AND URBAN GRAIN STORAGE

Prior to proceeding to Mysore for the Workshop, Mr. Harris arranged for visits to the Food Corporation of India storage site at Nariana, a Maundi market and village storage site at Narela and the Modi Flour Mill, Ltd. in New Delhi. Storage and sanitation conditions were observed at each of the storage sites. In addition, the Krishna Flour Mill in Bangalore was visited. Mr. N. S. Pruthi, District Manager of Food Corporation of India accompanied us to the storage sites at Nariana and Narela.

Food Corporation of India. Grain storage at the FCI site at Nariana was well managed and maintained. Conditions about the perimeter of the storage warehouses (godowns) were nonconducive to rodent, bird and insect infestation. Godown interiors were clean and free of grain spillage. Construction was of concrete (cost about Rs 90/M.T.). All stock was neatly stacked on pallets (dunnage) off the floor. Records are kept on each lot of grain with respect to date of arrival, moisture, infestation and insecticide and fumigant treatment. Grain is sampled biweekly. Both tarpaulin fumigation and space fumigation using aluminum phosphide were being used.

A small corrugated metal warehouse (140 metric ton capacity) was being tested at the storage site. If successful (and it appeared to be good storage) it would provide a relatively inexpensive (Rs 40/M.T.) storage structure.

Narela Village Storage. Grain comes to the market either in jute bags or in bulk. It is roughly cleaned on screens and weighed into jute bags for sale. All of the grain observed in Narela at the market was newly harvested and free of infestation. It was very dry and appeared in good shape.

The storage areas we observed were not adequate for proper grain storage and practices used were not good. In general, the bagged grain was stored in series of small rooms, stacked on the floor and against walls. Grain was stored adjacent to fertilizer, sugar and other commodities. The storage areas were dark and open so that rodents and birds would have no difficulty in entering. Responsible individuals at the village indicated the grain is not stored here over two months. This would, however, provide ample opportunity for the grain to become contaminated.

Flour Mills.* In general, flour mills in India are not designed to exclude rodents, birds or insects.

Grain is not stored at the mills for extended periods of time, generally not over two weeks. There appear to be considerable amounts of spillage in areas where grain is stored and fed-in to the mill. This spillage is a constant attractant to birds which appear to be quite numerous around the mills. Storage and feed-in areas are open to bird entry.

Exteriors of mill equipment and mill areas (walls, floors, etc.) in general appear reasonably clean. Conditions within mill equipment, however, appear just the opposite. There appears to be no attempt at cleaning equipment interiors or insect control measures other than the annual mill fumigation required by the government. In some cases, this may not be accomplished. Insect tracks and moth webbing are present in nearly every piece of equipment. Depending on when the last fumigation was performed, there may also be heavy infestations of insects in accumulations of "dead" stock in equipment and in cracks and crevices of spouts, bins and equipment.

At present, ethylene dibromide is the recommended fumigant for mill fumigation. Because of the close proximity of residences to the mills and the general conditions observed, it would appear that a good program of cleaning together with a "spot fumigation" program could improve the sanitation levels in mills immensely.

The potential for bird contamination could be greatly reduced merely by reducing the amount of spillage in grain handling areas and by screening windows and doors of the mill structure.

RODENT CONTROL

Throughout my visits to storage sites and structures, food processing plants and during the Workshop, the various aspects of rodent control in India were discussed.

It is evident that rodent control in India is a very complex problem from many aspects; political, sociological, religious, economic, etc. It is a problem that will not be solved by physically reducing the numbers of rodents by baiting or trapping methods. The total potential of the environment to support rodent populations must be reduced. This involves changes in basic sanitation habits of the people, altered waste disposal systems and methods, etc. on community wide bases.

* These remarks are based on personal observations and discussions with Mr. K. L. Harris.

Prepared by John R. Pedersen

Attachment I

TENTATIVE AGENDA
GRAIN SANITATION WORKSHOP

Monday

8:00 - 9:00 a.m.	Registration.
9:00 - 9:10	Welcome or Inaugural Address.
9:10 - 9:30	Introduction to Workshop. Scope and aims of the Workshop with a challenge to participants.
9:30 - 10:00	Principles of cereal product sanitation - What is Sanitation?
10:00 - 10:15	BREAK
10:15 - 12:00	Basic principles of grain storage. -- What is grain? description - morphology, -- Factors affecting grain in storage, -- Loss in quantity and quality, -- Importance of moisture.
12:00 - 1:15 p.m.	LUNCH
1:15 - 3:00	The pests - insects (Laboratory - Lecture) Basic entomology - classification - morphology. Primary insect pests of grain and cereal products.
3:00 - 3:15	BREAK
3:15 - 5:00	Secondary insect pests of grain and cereal products - Incidental insect pests.
5:00 - 7:30	DINNER
*7:30 - 9:00	Informal Discussion.

Tuesday

8:00 - 8:45 a.m.	The Pests - Rodents.
8:45 - 9:15	The Pests - Birds.
9:15 - 10:00	The Pests - Microbes.
10:00 - 10:15	BREAK
10:15 - 12:00	Detection of insect, rodent and microbial infestation and/or contamination of grain (sampling, inspection, etc.) in the field.
12:00 - 1:15 p.m.	LUNCH
1:15 - 3:00	Laboratory-Lecture - Detection of insect, rodent and microbial contamination in grain.
3:00 - 3:15	BREAK
3:15 - 5:00	Laboratory-Lecture - Detection of insect, rodent and microbial contamination of cereal products.
5:00 - 7:30	DINNER
*7:30 - 9:00 p.m.	Informal Discussion - "Cracker Barrel" Sessions.

Wednesday	
8:00 - 8:30 a.m.	Pest Control - Its relationship to the integrated sanitation program.
8:30 - 9:15	Pest Control - Inspection and housekeeping.
9:15 - 10:00	Pest Control - Physical and mechanical methods.
10:00 - 10:15	BREAK
10:15 - 11:15	Pest Control - Chemical Methods. Pesticide properties (Insecticides, fumigants, rodenticides).
11:15 - 12:00	Pest Control - Pesticide safety.
12:00 - 1:15 p.m.	LUNCH
1:15 - 1:45	Pest Control - Insecticides - residual spraying and space fogging.
1:45 - 2:15	Pest Control - Insecticides - prophylactic or protectant treatments of commodities and packaging.
2:15 - 3:00	Pest Control - Fumigation of raw materials, in bulk and warehouses.
3:00 - 3:15	BREAK
3:15 - 4:00	Pest Control - Fumigation of equipment and food processing plants.
4:00 - 4:30	Pest Control - Fumigation of finished foods.
4:30 - 5:00	Pesticide Residue Problems.
5:00 - 7:30	DINNER
*7:30 - 9:00 p.m.	Informal Discussion.
Thursday	
8:00 - 10:00 a.m.	Tour of C.F.T.R.I.
10:00 - 10:30	BREAK and return to program.
10:30 - 11:15	Sanitation problems - Storage and warehousing (of raw materials and finished food products).
11:15 - 12:00	Sanitation problems - Processing Plants (flour mills, rice mills, oil plants).
12:00 - 1:15	LUNCH
1:15 - 2:00 p.m.	Sanitation problems - Food processing plants (other than mills).
2:00 - 2:45	Sanitation problems - Dried fruit, nuts and spices.
2:45 - 3:00	BREAK
3:00 - 3:45	Sanitation problems-transportation.
3:45 - 4:30	Sanitation problems-Restaurants, hotels and households.
4:30 - 7:30	DINNER
*7:30 - 9:00 p.m.	Informal Discussion.

Friday

8:00 - 10:00 a.m.	Regulations and Control - Standards, food laws, pesticide regulations, etc.
10:00 - 10:15	BREAK
10:15 - 11:15	Development of an Integrated Sanitation Program.
11:15 - 12:00	Roles of government, management and employee in sanitation program.
12:00 - 1:15	LUNCH
1:15 - 2:00 p.m.	Sanitation - past, present and future in India.
2:00 - 3:00	Discussion and critique of Workshop.
3:00 p.m.	Adjourn.

* Informal sessions are for discussion of mutual problems and material covered during lectures and/or work sessions. They may be moderated by selected individuals, voluntary participation or excluded as required.

Attachment II

Prepared by S. K. Majumder

ACADEMY OF PEST CONTROL SCIENCES, MYSORE 2A

WORKSHOP OF GRAIN SANITATION

Tentative Program

(July 7, 1969 to July 12, 1969)

July 7, 1969

Morning		
9:00 AM	Registration	
10:00 AM	Presidential Address	Parpia, H.A.B.
	Inaugural Address	. . . . .
	Introduction to the Workshop and Symposium	Harris, K.L.
	Preview of the Program	Majumder, S.K.
11:15 AM	Tea Break	
11:30-12:30 PM	Visit to CFTRI Laboratories	
1:00-2:30 PM	Lunch Break	
Afternoon (2:30-5:00 PM)	(Lec.1) SESSION I: Principles of Grain Storage	Pingale, S.V. Pedersen, J.
	(Lec.2) SESSION II: Principles of Food Grain Sanitation	Harris, K.L.
	Grain Standards	Bagchi, K. Desikachar, H.S.R. Bains, G.S.
	Export-Import Regulations	Modowal, C.N.

July 8, 1969

Morning (9:00 AM to 1:00 PM)	Biology and Life History (WS-1) - Majumder, S.K.	
	(Lab.1) Insects - Narasimhan, K.S. Mites - Pillai, P.R.P.	
	(Lab.2) Rodents - Krishnakumari, M.K.	
	(Lab.3) Fungi - Raghunathan, A.N.	
Afternoon (2:30-5:00 PM)	(Lec.3) SESSION III: Insect Filth	Venkat Rao Krishnamurthy, K. Kadkol, K. Pillai, P.R.P.
	(Lec.4) SESSION IV: Rodent Pollution	Parrack, D.W. Krishnakumari, M.K.

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July 9, 1969

Morning	Sanitation and Inspection-A (WS-2) Insect Infestation	Pedersen, J.
9:00-10:00 AM	(Lab.4) Fragment count - Narasimhan, K.S.	
10:00-10:15 AM	Tea Break	
10:15-12:00 Noon	(Lab.5) Uric Acid Estimation - Parvathappa, H.C.	
1:00-2:30 PM	Lunch Break	
Afternoon	(Lec.5) SESSION V: Microflora and mycotoxins in Cereals	Majumder, S.K. Raghunathan, A.N. Agarwal, N.S. Sreenivasamurthy V.

July 10, 1969

Morning	Sanitation and Inspection-B Rodent Infestation - Harris, K.L.	
9:00-10:00 AM	(Lab.7) Rodent excreta - Urs, Yashoda, L.	
10:00-10:15 AM	Tea Break	
10:15-11:15 AM	(Lab.8) Rodent Hair - Mukta Bai, K.	
11:15-12:30 PM	(Lab.9) Microbial Pollution by Rodents	Krishnakumari, M.K. Narasimhan, K.S.
1:00-2:30 PM	Lunch Break	
Afternoon	(Lec.6) SESSION VI: Poisonous seeds, pesticides and unintentional foreign particles	Ebeling, Walter Singh, Amir Visveswariah, K. Venugopal, J.S. Chopra, S.L.

July 11, 1969

Morning	Sanitation and Inspection-C Microbial contamination - Majumder, S.K.	
9:00-10:00 AM	(Lab.10) - Estimation of fungi	Raghunathan, A.N.
10:00-10:15 AM	Tea Break	
10:15-11:15 AM	(Lab.11) Estimation of bacteria	Nagamma, M.V. Narasimhan, K.S.
11:15-12:30 PM	(Lab.12) Detection of Mycotoxins	Sreenivasamurthy, V.
1:00-2:30 PM	Lunch Break	

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Afternoon	Sanitation Measures (WS-3) -	Pedersen, J.
	(Lab.13) Integrated sanitation measures	Majumder, S.K.
	(Lab.14) Insect and Rodent Proofing	Krishna Rao, J.K.
	(Lab.15) Disinfestation techniques	Krishnamurthy, T.S.
	(Lab.16) Mill and Factory Sanitation Techniques	Pedersen, J.

July 12, 1969

9:00-11:30 AM	Discussion and Conclusions
	Films
	Lunch break and visits
4:30-6:30 PM	Presentation of Certificates
	Annual Meet and Tea by Academy

Prepared by John R. Pedersen and K. L. Harris Attachment III

REVISED AGENDA (Small Group)

GRAIN SANITATION WORKSHOP

Monday, July 7, 1969

9:00 a.m. - 10:00 a.m.		Registration	
10:00 a.m. - 10:10 a.m.		Presidential Address	H.A.B. Parpia
10:10 a.m. - 10:30 a.m.	(LEC.)	Introduction to the Workshop (Scope and aims of the Workshop with a challenge to participants)	S.K. Majumder
10:30 a.m. - 10:55 a.m.	(LEC.)	Basic Principles of Cereal Product Sanitation (The Food Sanitation Concept)	K.L. Harris
10:55 a.m. - 11:10 a.m.		Tea Break	
11:10 a.m. - 12:00 noon	(LEC.)	Principles of Grain Storage	N.S. Agrawal J.R. Pedersen
12:00 noon - 1:00 p.m.	(LEC.)	Basic Entomology - Classification, Morphology, Ect.	CFTRI
1:00 p.m. - 2:00 p.m.		Lunch Break	
2:00 p.m. - 5:00 p.m.	(LEC.) (LAB.)	Insect Pests of Grain & Cereal Products	S.K. Majumder
		Primary Pests	K.S. Narasimhan
		Secondary Pests	
		Incidental Pests	
		Mites	P.R.P. Pillai
5:00 p.m. - 7:30 p.m.		Dinner	
7:30 p.m. - 9:00 p.m.		Informal Discussion	

Tuesday, July 8, 1969

9:00 a.m. - 10:45 a.m.	(LEC.) (LAB.)	Rodents, Bird and Microbial Pests of Grain and Cereal Products	(S.K. Majumder)
		Rodents	M.K. Krishnakumari
		Birds	CFTRI Staff
		Micro-organisms	A.N. Raghunathan
10:45 a.m. - 11:00 a.m.		Tea Break	
11:00 a.m. - 1:00 p.m.	(LAB.)	Detection of Insect, Rodent and Microbial Contamination in the "Field". (Inspection, Sampling, Etc.)	CFTRI Staff
1:00 p.m. - 2:00 p.m.		Lunch Break	
2:00 p.m. - 5:00 p.m.	(LAB.)	Detection of Insect and Rodent Contamination in Grain	J.R. Pedersen K.L. Harris
7:30 p.m.		Dinner Speaker: Dr. D.W. Parrack Johns Hopkins University Rodents as Vectors of Food Borne Pathogens	

Wednesday, July 9, 1969

9:00 a.m. - 1.00 p.m.	(LAB.)	Detection of Insect and Rodent Contamination in Cereal Products	K.L. Harris J.R. Pedersen K.S. Narasimhan
1:00 p.m. - 2:00 p.m.		Lunch Break	
2:00 p.m. - 5:00 p.m.	(LAB.)	Coordinator - S. K. Majumder Estimation of Uric Acid Estimation of Fungi Estimation of Bacteria Detection of Mycotoxins	H.C. Parvathappa A.N. Raghunathan M.V. Nagamma V. Sreenivasamurthy
5:00 p.m. - 7:30 p.m.		Dinner	
7:30 p.m. - 9:00 p.m.		Informal Discussion	

Thursday, July 10, 1969

9:00 a.m. - 9:30 a.m.	(LEC.)	Pest Control - Relationship to an Integrated Sanitation Program.	S.K. Majumder
9:30 a.m. - 10:00 a.m.	(LEC.)	Pest Control - Inspection and Housekeeping	K. L. Harris
10:00 a.m. - 10.30 a.m.	(LEC.)	Pest Control - Physical and Mechanical Methods	J.R. Pedersen
10:30 a.m. - 10:45 a.m.		Tea Break	
		Pest Control - Chemical Methods	
10:45 a.m. - 11:15 a.m.	(LEC.)	Insecticides - Residual Spraying & Space Fogging	CFTRI Staff
11:15 a.m. - 11:45 a.m.	(LEC.)	Insecticides - Prophylactic or Protectant Treatment of Commodities and Containers	CFTRI Staff
11:45 a.m. - 12:15 p.m.	(LEC.)	Fumigation - Raw Materials and Finished Products	CFTRI Staff
12:15 p.m. - 1:00 p.m.	(LEC.)	Fumigation - Equipment and Food Processing Plants	J.R. Pedersen
1:00 p.m. - 2.00 p.m.		Lunch Break	
2:00 p.m. - 2:30 p.m.	(LEC.)	Pesticide Safety	CFTRI Staff
2:30 p.m. - 3:00 p.m.	(LEC.)	Pesticide Residue Problems	S.K. Majumder
3:00 p.m. - 3:15 p.m.		Tea Break	
3:15 p.m. - 5:00 p.m.		Tour of CFTRI	CFTRI Staff
5:00 p.m. - 7:30 p.m.		Dinner	
7:30 p.m. - 9:00 p.m.		Informal Discussion	

Friday, July 11, 1969

9:00 a.m. - 10:00 a.m.	(LEC.)	Sanitation Problems - Storage and Warehousing of Raw Materials and Finished Food Products.	
10:00 a.m. - 11:00 a.m.	(LEC.)	Sanitation Problems - Flour Mills, Rice Mills, Oil Plants.	
11:00 a.m. - 11:15 a.m.		Tea Break	
11:15 a.m. - 12:00 noon	(LEC.)	Sanitation Problems - Food Processing Plants (Other than Mills).	
12:00 p.m. - 12:30 p.m.	(LEC.)	Sanitation Problems - Restaurants, Hotels and Households.	
12:30 p.m. - 1:00 p.m.	(LEC.)	Sanitation Problems - Transportation	
1:00 p.m. - 2:00 p.m.		Lunch Break	
2:00 p.m. - 3:00 p.m.	(LEC.)	Building Design, Construction and Maintenance.	
3:00 p.m. - 4:00 p.m.	(LEC.)	Development of a Sanitation Program - Panel Discussion	CFTRI Staff AID Staff N.S. Rao - PCI Mill Representative
4:00 p.m. - 5:00 p.m.	(LEC.)	Regulations and Control -- Standards, Grades, Food Laws, Pesticide Regulations, Etc.	CFTRI Staff N.S. Agrawal
5:00 p.m. - 7:30 p.m.		Dinner	
		Free Evening	

Saturday, July 12, 1969

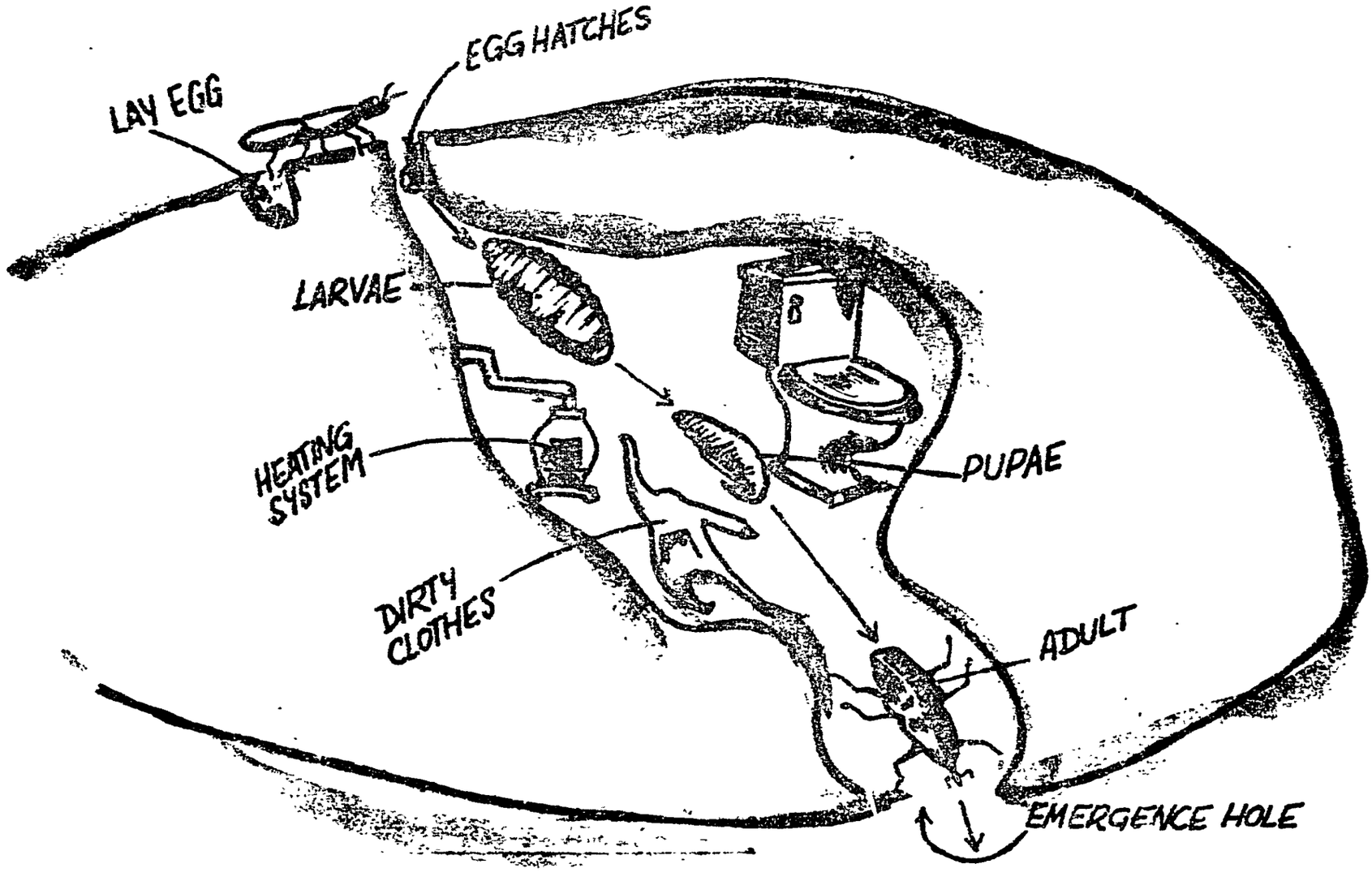
9:00 a.m. - 9:45 a.m.	(LEC.)	Sanitation in India - Past, Present and Future.	S.K. Majumder
9:45 a.m. - 10:00 a.m.		Tea Break	
10:00 a.m. - 10:30 a.m.		Workshop Critique.	
10:30 a.m. - 1:00 p.m.		Presentation of Certificates.	
1:00 p.m. - 2:00 p.m.		Lunch Break	
2:00 p.m. - 4:30 p.m.		Films.	
4:30 p.m. - 6:30 p.m.		Annual Meet and Tea by Academy.	

OUTLINES OF GRAIN SANITATION INSPECTION AND ANALYSIS

GRAIN SANITATION WORKSHOP, MYSORE

John R. Pedersen, Consultant, USAID
Food and Feed Grain Institute
Kansas State University, USA

THE TROUBLE SPOT



INSECT STRUCTURES, GROWTH AND DEVELOPMENT AS THEY RELATE TO STORED GRAIN INSECTS IDENTIFICATION AND CONTROL

Herbert Knutson
DEPARTMENT OF ENTOMOLOGY
KANSAS STATE UNIVERSITY

There are more species (kinds) of insects than all other species of animals combined. Species of insects in the world may total nearly one million. Most species are of no concern to man. A few, such as honeybees, are beneficial. Perhaps one percent of the insects are harmful to man, by competing for his food; by destroying his property; or by annoying him or spreading certain of his diseases.

Since there are so many species of insects, great variation occurs among them. The following discussions pertain primarily to moths and beetles, to which most stored grain insect pests belong, although some other insect characteristics are mentioned to provide a better overall picture.

ADAPTABILITY OF INSECTS. Insects are highly adaptive, so one species or another can live almost anywhere. One female insect of some species may lay thousands of eggs. One species of fly lives in oil pool overflows, yet oil is a commonly-used insecticide! One species of food-infesting insect lives in red pepper, and several additional species live in stored products where the moisture content is very low. Many insects feed on wood and soil and other materials which man cannot eat. Because of their small size, they can gain entrance and hide in small, hard-to-get-to places. Some live in darkness, such as cockroaches; others live in the light. Some live on snow such as "snow fleas"; others in hot surroundings such as "fire brats" on steam pipes.

BASIS FOR INSECT CONTROL. The control of insects is based upon a knowledge of each insect species. First, the different species must be told apart. Then, it must be known how each insect species lives; how, where, when and upon what it feeds; its reproductive rate; what stages of development it undergoes and how long these stages take; where each lives, and its habits and behavior. All these traits govern what control methods are effective, whether it be preventing and avoiding insect infestations or use of chemicals to kill them.

INSECT NAMES. Certain technical terms are necessary in any business in order that people talk about the same thing. People operating elevators, flour mills, or grain storage structures use certain terms which are unfamiliar to those in other businesses.

Insect terms vary from such commonly used names as "head", "abdomen", and "leg", to more unfamiliar terms such as "antenna", "thorax", and "trachea".

Each species of insect also has a "scientific name". For example, Sitophilus granarius is the scientific name for the granary weevil. Scientific names are in Latin and insure that scientists throughout the world are talking about the same species. "Common names", such as "granary weevil", "black beetle", "grain moth", etc. may refer to different species in different localities. However, names of insects attacking stored grain are standarized sufficiently so that only the common names, such as "rice weevil", "granary weevil", "Indian meal moth", etc. will be used during this Conference.

EXTERNAL STRUCTURE OF INSECTS. The insect's body is divided into three regions: the head, the thorax and the abdomen. However, these regions are firmly attached to each other, so that the internal organs are not restricted to any one of these three regions. For example, the digestive and nervous systems extend from one end of the insect's body to the other.

The eyes, antennae (feelers), and mouthparts are located on the head. The wings and legs are attached to the thorax. The abdomen is segmented and generally is without appendages (projections) except for sex organs, hairs, and projections known as cerci.

The skelton of insects (body wall) is on the outside and consists of a tough skin or shell in contrast to internal bones such as in the case of man. The external skeleton of insects is comprised of two principal layers: (1) the living layer, the outer layer of skin of the insect, which secretes the (2) non-living cuticle. In cases where insecticides are designed to kill the insect by contact, the insecticide must penetrate or otherwise destroy this cuticle in order to reach the living tissue of the insect.

The external skeleton is a continuous tube which completely envelops the insect. Minute openings permit breathing, eating and excretion; thin areas in the body wall permit flexibility and movement.

Some of the advantages of an external skeleton are (1) protection from external chemicals, physical blows, etc.; (2) conservation of water in the body by reduction in evaporation; and (3) mechanical advantages for muscle attachment so that insects have agility and power out of proportion to their size.

Disadvantages include (1) rigidity which prevents stretching during growth, so that increase in size can occur only by molting or shedding the cuticle, which is wasteful and is often the most vulnerable period in the insect's life.

Head. The head is essentially a hard, unsegmented capsule with an opening at the front (mouth), and an opening at the back for internal organs to extend into the thorax and abdomen.

The antennae are composed of several segments and include many shapes. Some are thread-like (filiform), clubbed at the tip (capitate), comb-like (pectinate), saw-toothed (serrate), and others are shaped in many other patterns. The number of segments, their shape, and length are important characteristics used in distinguishing between species. The antennae function primarily as sense organs.

Most adult insects have two large "compound eyes", so-called because they are composed of individual eyes fused together. Many insects also have one to three "simple eyes" which are single units, much smaller and located between the compound eyes.

Mouthparts are located either at the front or the bottom of the head. The type of mouthparts is used to help distinguish insects apart and to provide clues as to their feeding habits.

Mouthpart types can be roughly lumped into (1) chewing (such as the grasshopper chewing and swallowing wheat leaves, or the granary weevil chewing and swallowing bits of wheat kernal); (2) rasping (thrips tearing and then sucking plant juices); (3) piercing-sucking (mosquito sucking blood); (4) sponging (house fly sponging up dissolved sugar); and (5) siphoning (butterfly siphoning nectar from flowers). A few species, such as adult Mayflies, have no mouthparts and do not feed.

Either the adult and/or the larva (worm stage) of all stored grain insects have chewing mouthparts, since only hard and/or dry food is consumed. In cases such as adult weevils, these chewing mouthparts are on the end of a long "snout" or extension of the head.

Thorax. The external skeleton of the thorax is often extended and greatly thickened, to provide room for leg and wing muscles. Two slit-like openings on either side, the "spiracles" are the external "nostrils" of the respiratory system. It is through these openings that fumigants may pass, in order to penetrate the insect's body and kill its tissue. Many insects have valves at these openings, which can temporarily shut out fumigants.

The nature of the wings, both outer (front) and inner (hind) wings, is used to distinguish species, as is the size, shape, color, number of segments, etc. of the legs. There may be two pairs of wings (most adult beetles and moths), one pair (most adult flies), or no wings (such as fleas and lice). Only adult insects have wings.

Abdomen. The abdomen is composed of several segments. Paired spiracles, similar to the two pairs on the thorax, generally occur on each of several abdominal segments.

Genital organs occur at the tip of the abdomen. They may be either exposed or enclosed. Differences in these organs are of great value in distinguishing species of insects which otherwise look alike, but microscopic study is needed and they are of no value in identification from the practical standpoint.

INSECT "METAMORPHOSIS" OR CHANGE DURING DEVELOPMENT. The discussion so far has referred to adult sturctures. The young, or immature, stages are of equal importance but their structural differences are less striking and less understood, although often the greatest grain destruction is produced by immature forms.

Insects undergo three general types of metamorphosis: (1) none; (2) gradual; and (3) complete.

The first type (none) occurs in such insects as lice and silverfish. The egg hatches into a young individual which is smaller but otherwise looks much like the eventual adult insect. It gradually gets larger and larger following each successive shedding of the skin. Food habits of young and adults are similar.

Gradual metamorphosis occurs in such insects as the grasshopper. Here the newly hatched immature insect resembles somewhat the adult, but is out of proportion. Following each successive molt, it gets larger and larger and wings, if present, gradually get longer. The mouthparts and feeding habits remain essentially the same as the adult. The young are called "nymphs".

Complete metamorphosis occurs in such insects as the beetles and moths. Virtually all of the major insect pests of stored grain have this type of metamorphosis. The egg hatches into a worm-like stage called a "larva" if it has legs; and a weevil if it is legless (young of snout beetles). Most larvae with legs have three pairs, located immediately behind the head. Moth larvae may have extra legs on the abdomen. The larva molts several times, each time increasing in size until finally it stops feeding, and transforms into a pupa

or "cocoon" stage. The larva may or may not spin a cocoon before it changes to a pupa. The pupa moves little or not at all and does not feed; inside, tissues are breaking down and reforming into adult itssues. Legs, eyes, wings, and abdominal segments can often be seen forming. Eventually the adult emerges from a rupturing of the pupal skin. Food and feeding habits may or may not be the same for larvae and adults.

No increase in size occurs once adulthood is attained. A small beetle is not a "baby beetle"; it is another species of adult beetle.

The term "instar" refers to a particular individual insect between molts. Hence, a nymph or larva is referred to as a first, second or third instar, etc.

INTERNAL ANATOMY. The digestive tract. The digestive tract is a tube running from one end of the body to the other. Glands, pouches, grinding organs and other structures aid in digestion, depending upon the nature of the food consumed. Insecticides serving as "stomach poisons" are taken into the digestive tract and poison the insect's system. Most insects get water by drinking it or obtaining it from plant juices. Stored grain insects, which live in relatively dry surroundings, conserve and convert for body use that small amount of moisture available.

The circulatory system. The circulatory system is not enclosed within a series of tubes (arteries, capillaries, veins) as in man, but the blood simply flows through open cavities to various parts of the body. A pulsating tube, equipped with valves to prevent backflow, picks up the blood from the hind portion of the body and expells it toward the front. Insect blood functions much like that of man except that the carrying of oxygen and carbon dioxide is of minor importance.

Respiratory system. Air is taken in, through openings or spiracles in the sides of the thorax and abdomen. These are the openings to a system of tubes, known as tracheae and smaller trachioles. These tubes carry the air to the body cells and, in turn, carry away the carbon dioxide. Insecticides such as dry dusts can clog these tubes, and fumigants can penetrate the tubes.

Nervous system. The brain is located in the head but it exerts relatively little influence over the rest of the body when compared to man. Extending backward from the brain is a ventral nerve cord with pairs of nerve centers or ganglia spaced throughout the thorax and abdomen. From these centers go nerves to all parts of the body.

Insecticides coming in contact with the insect, if they penetrate the cuticle of the body wall, may poison these nerves and consequently interfere with the proper function of the various systems of the insect's body.

Muscular system. Some insects have more than 2,000 muscles. They are attached to the body wall in many different positions, providing an extremely effective, powerful, and rapid system.

Reproductive system. Most insects have both males and females, which may be distinguished upon close examination. A few females can reproduce without mating, and, in fact, males of some species do not occur.

A new phase of insect control involves the use of "chemosterilants" which are chemicals which do not kill but sterilize insects so that they cannot reproduce. These chemicals are relatively harmless to man but are not yet studied and developed so as to be of practical use.

INSECT HABITS. Insects are generally creatures of habit. Each generation responds to environment the same as its ancestors. There is no particular intelligence or thinking involved. Egg laying, feeding, migration, etc. of each species generally follows a usual pattern. However, all insects of a species are not identical, and artificial influences such as changes in grain storage practices, may influence their activities as they are forced to adapt to the change. Repeated use of insecticides has resulted in survival of certain individuals within a population; these have lived to reproduce their own kind. The result has been the development of insecticide-resistance, so that a species once controlled by a given insecticide application is no longer effective (resistant house flies, certain mosquitoes, etc.). Luckily, such resistance has not yet developed in stored grain insects so far as is known.

Anyone dealing with control of stored grain insects will do well to observe the habits of these pests, to better devise effective methods of control.

INSECT'S CLOSE RELATIVES. Insects and close relatives, collectively called "Arthropods" all have segmented bodies, projecting structures (appendages) and external skeletons. As a matter of review, the characteristics of insects are again listed, followed by comparative characteristics of their close relatives.

Insects. Body composed of head, thorax and abdomen.
Head has one pair of antennae (feelers); one pair of compound (multiple) eyes; 1 to 3 simple (single) eyes.
Thorax has three pairs of legs and 1, 2, or 0 pairs of wings, and two pairs of spiracles (breathing holes).
Abdomen comprises several segments, many similar in appearance; spiracles one pair per segment, on sides. Genital organs at or near tip of abdomen; and many miscellaneous appendages such as filaments (tails), and cerci (finger-like projections).

Arachnida (spiders, ticks, mites, scorpions, granddaddy long-legs, etc.). Differ from insects by having only two, or one, body regions; four pairs of legs; and no wings, antennae, or compound eyes. Resemble insects by usually having simple eyes and tracheae.

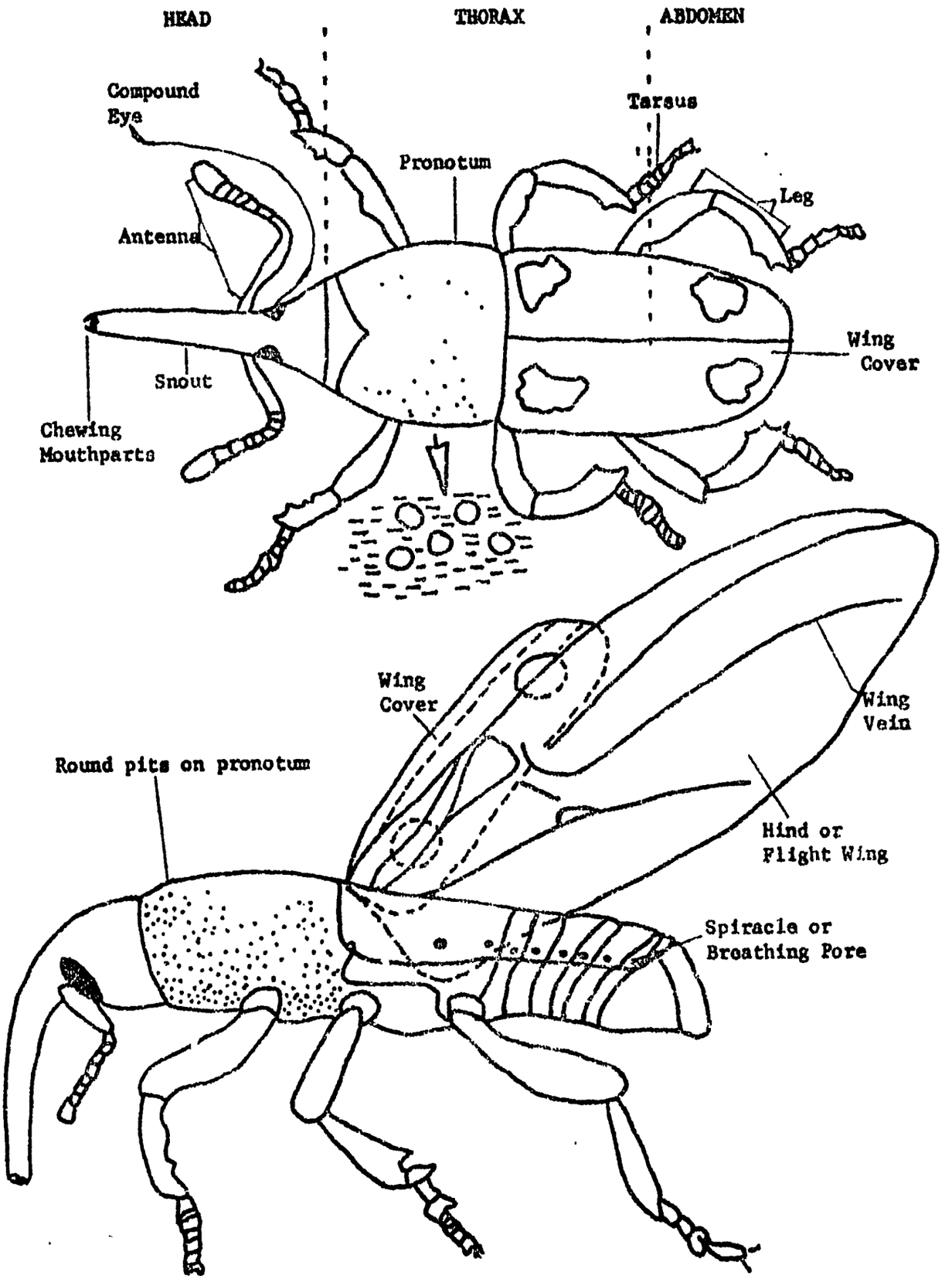
Centipedes. Differ from insects by having only two body regions (head and abdomen); no wings; and one pair of legs per body segment. Resemble insects by having one pair antennae. Legs attached to the sides of the body, in contrast to millipedes.

Millipedes. Differ from insects by having two body regions (head and abdomen: two pairs of legs per segment and no wings. Have pair of short antennae. Legs attached to body close to a mid-line on underside, in contrast to centipedes.

Crustacea (sowbugs, pill bugs, crayfish, lobsters, etc.). Differ from insects by having two body regions (head-thorax and abdomen), five pairs of legs, jointed projections (appendages) on abdomen, two pairs of antennae, and no wings. Live in water or in moist places.

Of these non-insect classes, mites are the most likely to be encountered in stored grain. Grain or flour mites are pale, grayish-white, smooth, soft-bodied creatures, with long hairs on the back and legs. Their body is all in one oval-shaped unit, although the mouthparts at the front may appear to be a head. They are about 1/50 inch long.

RICE WEEVIL, Dorsal and Lateral Views



GRAIN AND MILL INSECTS

OUTLINES FOR DISCUSSIONS AND LABORATORIES

Donald A. Wilbur and Robert B. Mills
Department of Entomology
Kansas State University

INTRODUCTION

1. Structure and habits of insects in general.

   a. Arthropods - insects and their near relatives.

   b. Structure of insects.

   c. Growth and development of insects.

   d. Life cycle of insects.

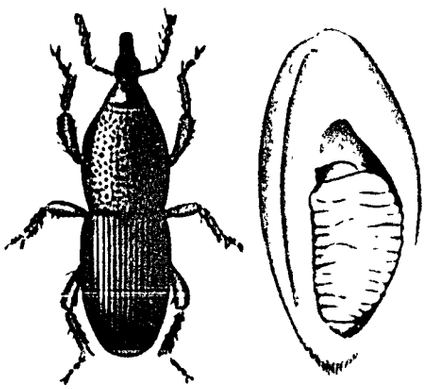
2. Four groups of stored grain insects based on the nature and extent of their association with grain.

   a. Major (primary) pests: 14 species well adapted for living in stored grain and responsible for most of the insect damage to grain in farm or commercial storage.

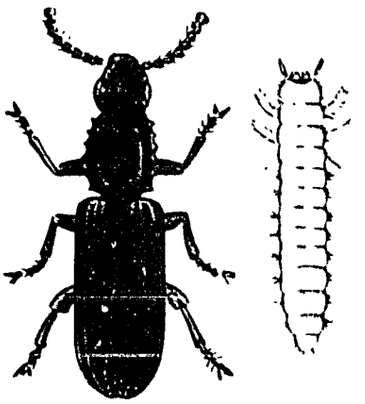
Common name	Scientific name
large rice weevil	Sitophilus zeamais Motsch
lesser rice weevil	Sitohpilus oryzae (L.)
granary weevil	Sitophilus granarius (L.)
lesser grain borer	Rhyzopertha dominica (F.)
saw-toothed grain beetle	Oryzaephilus surinamensis (L.)
merchant beetle	Oryzaephilus mercator (Fauv.)
cadelle	Tenebroides mauritanicus (L.)
confused flour beetle	Tribolium confusum duVal
red flour beetle	Tribolium castaneum (Hbst.)
flat grain beetle	Cryptolestes pusillus (Schonh.)
rusty grain beetle	Cryptolestes ferrugineus (Steph.)
khapra beetle	Trogoderma granarium Everts
Angoumois grain moth	Sitotroga cerealella (Oliv.)
Indian-meal moth	Plodia interpunctella (Hbn.)
Mediterranean flour moth	Anagasta kuhniella

PRINCIPAL STORED GRAIN INSECTS

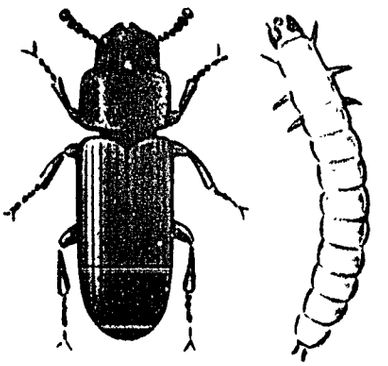
For safe and effective use of insecticides, always identify the problem correctly.



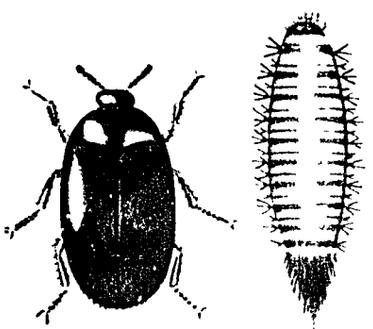
1. Granary weevil



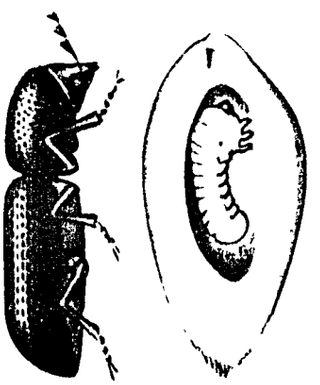
2. Saw-toothed grain beetle



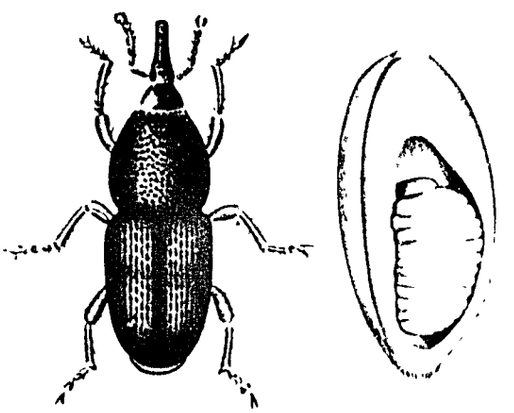
3. Red flour beetle



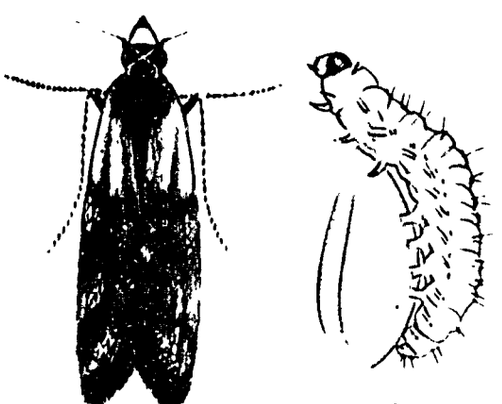
4. Larger cabinet beetle



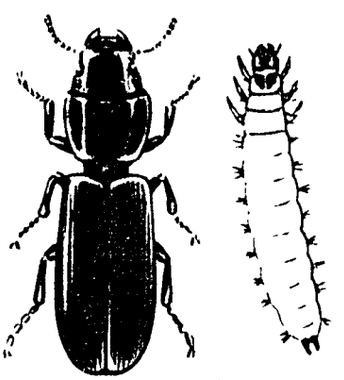
5. Lesser grain borer



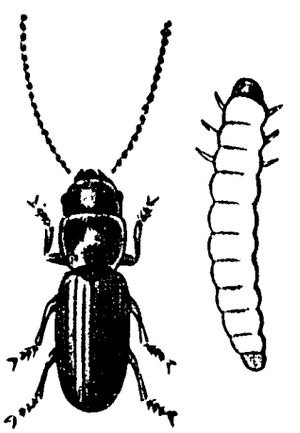
6. Rice weevil



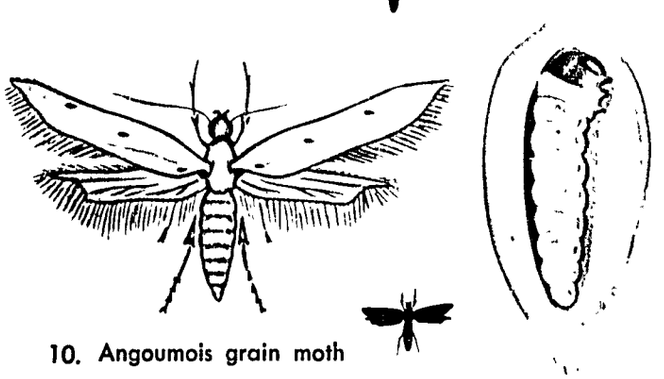
7. Indian-meal moth



8. Cadelle



9. Flat grain beetle



10. Angoumois grain moth

Some of these stored grain insects are also KITCHEN PESTS.

The saw-toothed grain beetle, red flour beetle, larger cabinet beetle, and Indian-meal moth develop in flour, cake mixes, corn meal, breakfast foods and similar products. The Angoumois grain moth infests popcorn.

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U. S. Department of Agriculture

Principal Stored Grain Insects of Kansas

Learn to recognize these tiny harmless looking insects because losses from these pests are estimated to be 60 million bushels of wheat, 234 million bushels of corn, and 17 million bushels of grain sorghum every year in the United States; a sizeable part of this loss is taking place in the grain stored here in our own state. Control measures are available from the Extension office in your county.

1. GRANARY WEEVIL, **Sitophilus granarius** (Linnaeus). This is a small brownish weevil not more than 3/16 of an inch in length. It feeds voraciously on a variety of grains. The female deposits an egg inside the kernel and covers the hole with a gelatinous egg plug. After hatching, the larva feeds entirely within the kernel and is responsible for "hidden" or internal infestations since the kernels usually appear sound from the outside. After several days, when the larva is full grown, it pupates and is transformed into the adult weevil which soon cuts a round hole through the kernel wall and emerges. These circular emergence holes are known as weevil-cut kernels. The period from egg to adult requires about 5 weeks under ideal conditions. Upon close examination, large oval pits can be seen on the plate behind the head of the adult weevil, and the wing covers are uniformly shiny blackish to reddish. Since the granary weevil does not have functional wings, widespread distribution is largely dependent upon movement of infested materials.

2. SAW-TOOTHED GRAIN BEETLE, **Oryzaephilus surinamensis** (Linnaeus). The saw-toothed structure on the thorax makes this insect easily recognized. It infests virtually every kind of foodstuff and is one of the first pests to attack fresh harvested wheat. Female beetles lay up to 285 eggs, deposited loosely in the infested foodstuff. The larvae feed at random on bits of material and pupate in cocoon-like cells constructed of pieces and fragments of the infested material. Development from egg to adult requires 3 to 4 weeks in warm weather. In grain bins, it feeds primarily on cracked grain since it is not able to survive in whole kernel wheat.

3. RED FLOUR BEETLE, **Tribolium castaneum** (Herbst). It is similar to the saw-toothed grain beetle in the habits and life cycle. It is often found in grain and there it feeds on grain dust and particles of broken kernels. The serious damage occurs to grain products, nuts, dried fruits, and other foods. It also imparts a disagreeable odor and taste on the products it infests. This species, and a near relative, the confused flour beetle, are annoying pests in groceries, mills, warehouses and homes.

4. LARGER CABINET BEETLE, **Trogoderma inclusum** (LeConte). This insect is representative of a large group of insects known as dermestids. In general, they are scavengers on dried animal products. In infested products, the larvae are often most plentiful and are easily recognized. They are hairy, sluggish moving, and usually more or less boat-shaped. The presence of excessive amounts of cast skins also indicate the presence of dermestids as each larva sheds its skin from 5 to 16 times in its period of development. The length of the larval period varies depending upon the species, type of food, temperature, and humidity. Some may survive as long as 5 years. The cabinet beetles, larder beetles, and carpet beetles, belong to this group.

5. LESSER GRAIN BORER, **Rhyzopertha dominica** (Fabricius). This is perhaps the most destructive grain pest. Lesser grain borers deposit eggs outside the kernels. Most of the young larvae bore into the kernels where they complete their immature stages. They eventually damage the kernels worse than do weevils. Some infested wheat is reduced to powder. The presence of a peculiar, sweetish, musty odor is also an indication of a lesser grain borer infestation. It is a problem of grain only and does not attack cereal products.

6. RICE WEEVIL, **Sitophilus oryzae** (Linnaeus). This weevil is similar in size and shape to the granary weevil but it is darker in color and usually has four light reddish or yellowish spots on the back. It does have functional wings and the thorax is densely pitted round punctures. The length of life cycle and nature of damage is similar to the granary weevil. It is among the most destructive pests in stored grain.

7. INDIAN-MEAL MOTH, **Plodia interpunctella** (Hubner). The larval stage is responsible for the damage caused by this insect. Infestations are confined to surface layers of grain in storage except in the case of stored ear corn where moths crawl among the ears to lay their eggs. Cereal products such as meal, packaged foods, and dried fruits and nuts are also subject to attack. Female moths lay from 100 to 300 eggs on the food material. It passes through its egg, larval and pupal stages in 6 to 8 weeks during warm weather.

8. CADELLE, **Tenebroides mauritanicus** (Linnaeus). This conspicuous looking insect attacks not only the grain in storage but also the wood of the storage facility as well. The pest is so common it is difficult to find a wooden granary where this insect is not present. The larvae are often referred to as "flour worms." They are white with black heads and black hooks at the end of the body. The adult beetle is about one-third of an inch long and has a noticeable constriction between the first and second pair of legs. Both larvae and adults feed on grain and typically go from kernel to kernel devouring the germ. Adults may live about 2 years. Females lay an average of 1,000 eggs each. Larvae complete their growth in 2 to 14 months, then usually bore into wood timbers to pupate. Both larvae and adults can live for considerable periods without food.

9. FLAT GRAIN BEETLE, **Cryptolestes pusillus** (Schonherr). These are among the smallest beetles that damage stored wheat. They promptly invade newly binned wheat and produce large populations if the moisture content of the grain is high. It also attacks many cereal products under high moisture conditions, but it is not a common pest in the kitchen. Larvae usually feed on the germ under the germ coat and damage may not be noticed.

10. ANGOUMOIS GRAIN MOTH, **Sitotroga cerealella** (Olivier). This insect is particularly destructive to stored ear corn. Field infestations, especially in popcorn, are also occasionally observed. It will attack shelled corn and other grains, but infestations are confined to the surface layer. The adult moth deposits eggs on the grain and upon hatching, the young larva spins a small entrance cocoon to assist it in boring into the hard kernel. It feeds intensely on either the germ or endosperm, until grown, then cuts an exit hole about 3/4 of the circumference of a circle through the shell. Later the newly formed moth emerges by pushing its way through the flap. The life cycle from egg to adult can be completed in 5 weeks, though development is often slower.

H. LEROY BROOKS and DELL E. GATES
Extension Specialists, Entomology

COOPERATIVE EXTENSION SERVICE
Kansas State University, Manhattan

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b. Minor pests: Comprise approximately 175 species of insects and mites that may become abundant and injurious locally. These insects frequently are associated with particular environmental conditions such as high or low moistures or temperatures, poor sanitation, out-of-condition grain. Examples: booklouse, foreign grain beetle, various carpet beetles, spider beetles, cigarette and drugstore beetles, mealworms etc. Occasionally these approach major pest status.

c. Incidental pests: an undetermined number of species that rarely damage grain except by the contamination of their presence.

d. Parasites and predators: an unknown number of insects and mites that prey on the other three groups.

3. A bin of grain as a home for insects.

a. A mountain of concentrated nutrients:

b. A relatively uniform and stable environment.

c. A critical shortage of moisture: few insects are adapted to life in stored grain. Of a potential of possibly two million insect species now inhabiting the earth, only 15, or one in each 133,000 species, are primarily adapted to life in a bin of grain.

4. Sources of water for stored grain insects.

a. Moisture in the air.

b. Moisture in the grain.

c. "Metabolic water" resulting from the breakdown of starches.

5. Damage and losses from stored grain insects (mimeograph on "Damage").

LABORATORY STUDY OF RICE WEEVIL COMPLEX AND GRANARY WEEVIL

Rice Weevil complex: Larger and lesser rice weevil can be identified by their genitalia.

1. Head prolonged into a snout; two light spots on each front wing; body color reddish-brown to black.

2. Small, ROUND, closely-compacted pits on pronotum (large area just behind head and in front of wings).

3. Hind wings function as flight wings; infest corn in the field in southern U. S.

4. Eggs deposited in holes eaten into the kernels and the holes filled with a gelatinous "egg plug".

5. Larvae white, wrinkled and legless; require four molts and growth periods before transforming to adults.

6. Two larvae may live in a single wheat kernel, separated by the crease.

7. Emergence holes smaller, more rounded and neater than those of granary weevil.

Granary weevil:

1. Head with a snout; body and wing color uniformly brownish to black.

2. Large OVAL pits on pronotum, not as closely compacted as with rice weevil.

3. Hind wings not functional as flight wings.

4. Eggs and larvae similar to rice weevil.

5. Only one larva lives in a kernel of wheat.

6. Emergence holes larger and more ragged.

LABORATORY PROCEDURES

1. Identification of adults.

   a. Separate the rice and granary weevil by eye; check your identification using the microscope for the two pale spots on each front wing of rice weevil. Note the variability in color and intensity of the spots on different specimens. These spots are not on granary weevil.

   b. Look for the shallow pits on the pronotum of both species. Describe them.

c. Sex several specimens. Snouts of the males are shorter, broader and rougher than of the females. The tip of the abdomen of males is curved downward when viewed from the side; the tip of the abdomen of females is on a plane with the entire underside of the abdomen.

2. <u>Eggs, larvae and pupae inside the kernels</u>.

a. Kernels of wheat with egg plugs stained by acid fuchsin are available. Look for small cherry-red spots on the kernels by eye and with the microscope. Most of these spots are egg plugs. With care this should expose the excavation, the plug and the egg or larva.

b. Kernels of wheat with mature larvae and pupae are available. Split some kernels having egg plugs by pressing thumb nails into the crease of the kernels. After a few tries you should expose the legless larvae and the pupae with legs, antennae, eyes, snout and other adult characters.

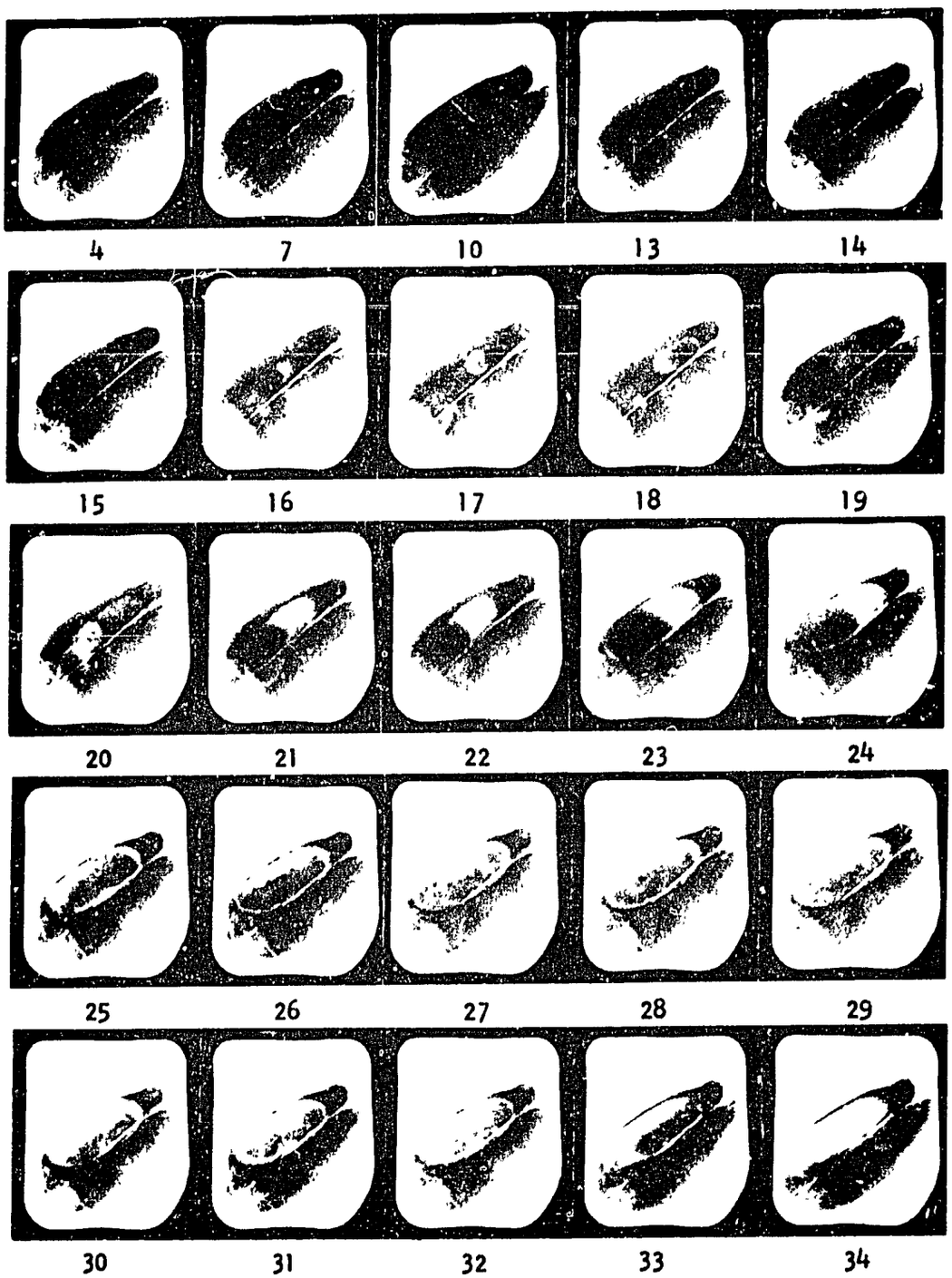
c. Note the shape of the larvae tunnels inside the kernels. The tunnels are partially filled with molted skins and excreta. Examine this carefully under your microscope. Slides will be on demonstration showing larval mandibles obtained from this accumulated frass within a kernel.

d. Note that most rice weevil tunnels do not penetrate the crease while granary weevil tunnels occupy the entire center of the kernels.

e. Note the differences in the emergence holes (weevil-cut kernels) of rice and granary weevil. Rice weevil holes generally are smaller, rounder and neater; granary weevil holes are larger, irregular and frequently with ragged edges.

f. Has the germ, or endosperm, or both been damaged?

X RAY ANALYSIS OF IMMATURE RICE WEEVIL DEVELOPMENT



Enlarged prints of radiographs taken at daily intervals during the immature development of the rice weevil, Sitophilus oryza (L.) in 13% moisture wheat. Days after start of a three day oviposition period are indicated under each kernel. Egg, larval, prepupal, pupal and pre-emerged adult stages are visible.

LABORATORY STUDY OF LESSER GRAIN BORER, ANGOUMOIS GRAIN MOTH, INDIAN-MEAL MOTH, CONFUSED AND RED FLOUR BEETLES

Lesser grain borer:

1. Cylindrical body appears to be divided into two parts; head cannot be seen from above, covered by pronotum.

2. Front margin of pronotum has numerous projections (tubercules).

3. Eggs are deposited between kernels or in grain dust.

4. Larvae are white with thoracic legs; bodies of older larvae are swollen behind the head.

5. Adults and larvae produce great quantities of dust with a distinctive sweetish, musty odor.

Angoumois grain moth:

1. Moths with light buff-colored front wings; hind wings pointed at tip like an "accusing finger"; hind wings lined posteriorly with a long fringe of hairs.

2. Eggs deposited outside of kernels; newly hatched larvae tunnel into kernels where they live until they have transformed to moths.

3. Larvae are whitish caterpillars with three pairs of legs on thorax and very short prolegs on abdomen.

4. Before pupating the larvae prepare thin escape windows through which the moths emerge.

Indian-meal moth:

1. Basal half of front wings light colored; distal half dark.

2. Caterpillars usually yellowish, greenish or pink; spin large amounts of silk over their food.

3. Caterpillars feed on wide variety of grains, grain products, dried fruits, candies, etc.

Confused flour beetle:

1. Beetles reddish-brown; antennal segments gradually increase in size toward tip.

2. Eyes, viewed from underside, are separated by more than three eye diameters.

3. Eyes, when viewed from above, have a slight ridge on inner margin.

4. Wings non-functioning; beetles do not fly.

5. Larvae white, tinged with yellow; last segment of abdomen with a forked appendage.

6. Adults and larvae feed on whole kernels of high moisture (12.5 to 15.0%) and on cracked kernels of lower moisture.

7. Pupae live on surface of food media.

Red flour beetle:

1. Beetles reddish-brown, slightly smaller than confused flour beetles; antennae with 3 abruptly enlarged segments at tip.

2. Eyes, viewed from underside, are separated by less than two eye diameters.

3. Eyes, viewed from above, are without a ridge on inner margin.

4. Beetles can fly.

5. Larvae and pupae are similar to confused flour beetles.

6. Food of larvae and adults similar to confused flour beetles.

LABORATORY PROCEDURES

1. Lesser grain borer.

   a. Examine beetles under binocular microscope noting size, shape, color, body divisions, tubercules on pronotum.

b. Open infested kernels and remove larvae. Compare their appearance with weevil larvae. Note the legs, "pot belly", etc.

c. Describe damage to wheat kernels by larvae and adults. Has the germ, or endosperm, or both been damaged?

d. Examine under microscope, the fine powder made by these insects. Observe the considerable amount of powder that they make.

e. Shake a rearing jar with an infestation of lesser grain borer and note the characteristic odor. Describe this odor which is unlike the odor made by any other stored-grain insect.

2. Angoumois grain moth.

a. Note the size, shape and color of the moths. The females are appreciably larger than the males when reared on the same food media.

b. Look for the "accusing finger" and the fringe of long hairs on the hind wings.

c. Folded black papers on which eggs have been deposited are available for your inspection. Ovipositing females like to tuck eggs between these folded papers or in the crease of wheat kernels. Newly deposited eggs are white; older eggs turn pinkish.

d. Dissect kernels with caterpillars and pupae. Note the silken cocoon spun by the larvae in which to pupate.

e. Also look for "windows" prepared by mature larvae so that the moths can easily push their way to the outside of the kernels.

3. Indian-meal moth.

a. The basal half of the wings of the moths will be light-colored; the remainder dark, or coppery.

b. Examine the larvae (caterpillars) noting size, color, legs on thorax and prolegs on abdomen.

c. Examine a rearing jar with Indian-meal moth infestation. These cultures usually have a messy appearance due to fecal pellets, webbing, etc.

d. Find some wheat kernels damaged by larval feeding. Has the germ or the endosperm or both been damaged?

4. Confused and red flour beetles.

a. Examine both species and identify them using: (1) shape of antennal club; (2) width between the eyes (underneath); (3) ridge over inner margin of eyes (above).

b. Which species generally is the larger?

c. Find the forked process on the end of the larval abdomen.

d. Shake the rearing jar containing a culture of either species. Note the sharp, acrid odor.

e. Examine damaged kernels. What has been eaten, the germ, the endosperm, or both?

LABORATORY STUDY OF SAW-TOOTHED GRAIN BEETLE AND/OR MERCHANT BEETLE, FLAT GRAIN BEETLE AND/OR RUSTY GRAIN BEETLE, CADELLE, DERMESTIDS, AND OTHERS IF TIME PERMITS

1. Saw-toothed grain beetle and merchant beetle.

a. Reddish-brown beetles; flat with six tooth-like projections on each side of pronotum.

b. Beetles have well developed wings but rarely use them.

c. Eggs deposited singly or in small groups on food.

d. Larvae white without processes on tip of abdomen; yellowish plates on top of each abdominal segment.

e. Food consists of wide varieties of grains, processed grains, dried fruits, etc.

2. Flat grain beetle and rusty grain beetle.

   a. Beetles and larvae of these species are so much alike in behavior and appearance that distinction is rarely made between them by people in the grain industry.

   b. Smallest of the major pests of stored grain (about 1/16 inch long).

   c. Beetles reddish-brown with flattened body; males of flat grain beetle with especially long, slender antennae.

   d. Larvae white with processes at tip of abdomen arising from a definite plate.

3. Cadelle (flour worms).

   a. Black beetles, 1/2 inch or longer, body in two units.

   b. Eggs laid in clusters in protected places.

   c. Larvae white with dark head, dark plates on thoracid segments and dark plate with two dark projections on tip of abdomen.

   d. Larvae (flour worms) 5/8 inch long or longer when full grown.

   e. Larvae migrate out of grain in fall to find wooden structures in which to tunnel and spend the winter. Larvae are true hibernating insects, pupate within their tunnels in early Spring. Wooden binds may be weakened by the tunneling.

   f. Beetles long-lived, sometimes 3 or more years.

4. Dermestids (Khapra beetle, black carpet beetle, etc.).

   a. Most dermestids infest animal products; some are primarily adapted for such vegetable products as stored-grain.

   b. Larvae usually covered with tufts of brown hairs on abdominal segments; some species have tufts of long hairs extending from tip of abdomen.

LABORATORY PROCEDURES

1. Saw-toothed grain beetle and merchant beetle.

   a. Observe the beetles under the microscope noting their flatness, size, color.

   b. Look for the saw-toothed projections on each side of the pronotum. How many?

   c. Examine the larvae. Can you find forked appendages on tip of abdomen?

   d. These species can be distinguished by the shape of the margin of the head behind the eye; on the merchant beetle this margin is pointed; on the saw-toothed grain beetle it is rounded.

2. Flat grain beetle and rusty grain beetle.

   a. Note the color, size, flatness, etc. of the beetles.

   b. How do the larvae differ from saw-toothed grain beetle larvae?

3. Cadelle.

   a. Note size, color, body outline and other characteristics of the beetles.

   b. Describe the color pattern of the larvae including the forked appendages on the tip of the abdomen.

   c. Pieces of wood with holes made by cadelle larvae are available for your observation. You can see why wooden granaries sometimes collapse and ships leak from this type of damage; other grain-infesting insects hide in these tunnels during the winter months.

4. Dermestids.

   a. Several species of dermestids are available for you to see and note the general size, shape, color patterns, etc. Some of these species are difficult to identify except by experts.

   b. Examine larvae under the microscope noting the tufts of hairs, etc.

   c. Khapra beetles from India are available for you to examine.

SOME STRUCTURAL CHARACTERS FOR DISTINGUISHING ADULTS OF THE CONFUSED FLOUR BEETLE FROM THE RED FLOUR BEETLE.

(from Good; U.S. Dept. Agri. Tech. Bul. 498)

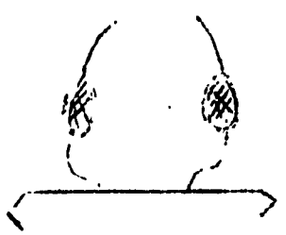
Confused Flour Beetle	Red Flour Beetle
1. The antennae enlarge gradually toward the tip, the ninth joint being only slightly larger than the eighth.	1. The antennae with the three terminal joints suddenly enlarged forming a distinct club, the ninth segment being nearly twice as wide as the eighth.
2. The epicranium is sharply margined immediately above the eye, forming a horizontal carina slightly jutting over the eye.	2. The epicranium not margined above the eye, the front and the eye forming nearly a continuous line.
3. The eyes appear much smaller than on the red flour beetle.	3. The eyes appear larger.
4. Viewed from below the eyes appear rounded.	4. Viewed from below the eyes appear transversely ovate.
5. The width of each eye is about one-third of the space separating the eyes.	5. The width of each eye is equal to or slightly less than the space separating the eyes.
6. The eyes are emarginate, the emargination extending backward to the middle of the eye.	6. The eyes are emarginate, the emargination extending backward for about one-third the length of the eye.

STRUCTURAL CHARACTERS FOR DISTINGUISHING PUPAE

1. The eyes are nearly, but not completely divided by the genae.	1. The eyes are only slightly emarginated.
2. The lateral abdominal processes are provided with three hairs, one rather long hair arising from the anterior lobe and two shorter hairs from very small median lobes.	2. The lateral abdominal processes are provided with two hairs, one hair arising from the large anterior lobe and a shorter hair at a point one-third from the posterior serrate margin.

SAW-TOOTHED GRAIN BEETLE AND MERCHANT BEETLE, Cucujidae

SAW-TOOTHED GRAIN BEETLE *Oryzaephilus surinamensis* (L.)	MERCHANT BEETLE, *O. mercator* (Fauvel)
1. About 1/8 inch long.	1. Same
2. Rather long and narrow in appearance	2. Same
3. Six distinct, rather sharp "saw teeth" along each edge of the pronotum.	3. Same
4. All of dorsal surface heavily pitted.	4. Same
5. Antennae slightly shorter than head and prothorax combined.	5. Same
6. Area directly behind eye curved and wider (See illustrations).	6. Area directly behind eye pointed and more narrow.



CIGARETTE BEETLE and DRUG-STORE BEETLE, Anobiidae

CIGARETTE BEETLE

Lasioderma serricorne (F.)

1. Small, stout, oval, reddish-yellow or brownish-red beetle.
2. Elytra smooth (not striated).
3. Antenae with segments 4-10 serrate.
4. Head bent down under pronotum; body with a humped appearance when viewed from the side.
5. 2 - 2.5 mm

DRUG-STORE BEETLE

Stegobium paniceum (L.)

1. Small, uniformly light-brown beetle with the body more elongate in proportion than with the cigarette beetle.
2. Elytra striated.
3. Antennae with a loose 3-segmented club.
4. Body more elongate than the cigarette beetle.
5. 2 - 3 mm.

CORN SAP BEETLE and DRIED FRUIT BEETLE, Nitidulidae

CORN SAP BEETLE

Carpophilus dimidiatus (F.)

1. Ovate beetles with distinct 3-segmented club.
2. Body brownish-yellow to black with reddish tinge, appendages lighter.
3. Elytra paler than body and without spots.
4. Elytra shortened and truncated showing two abdominal segments from above.
5. Feebly shining.
6. 2.0 - 3.5 mm.

DRIED FRUIT BEETLE

Carpophilus himipterus (L.)

1. Ovate beetles with distinct 3-segmented antennal club.
2. Body dark brown or blackish, appendages amber or reddish.
3. Each elytron with a prominent amber-brown spot at apex and a smaller spot at the side of the base.
4. Elytra shortened and truncated showing two abdominal segments.
5. Feebly shining.
6. 2.0 - 4.0 mm.

FLAT GRAIN BEETLE AND RUSTY GRAIN BEETLE, Cucujidae

FLAT GRAIN BEETLE

Cryptolestes (Laemophloeus) pusillus (Schonherr)

1. Minute, flattened, oblong, reddish-brown beetles.
2. Male antennae 2/3 length of body
3. Pronotum clearly transverse, 1.5 times as wide as long.
4. Males without external manibular tooth.
5. Frontoclypeal suture bulging away from mouthparts.
6. Sexual dimorphism: Males with antennae almost as long as body; hind tarsus 4-segments; Females with antennae about ½ length of body hind tarsus 5-segments

Cryptolestes turcicus (Grouvelle)

1. Minute, flattened, oblong reddish-brown beetles.
2. Male antennae as long as body.
3. Pronotum quadrate or narrowing slightly basically, hind angles distinct.
4. Males without external mandibular tooth.
5. Frontoclypeal suture bulging toward the mouthparts.
6. Sexual dimorphism: Males with antennae about as long as body, hind tarsus 4-segments; Females with antennae about ½ length of body; hind tarsus 5-segments.

RUSTY GRAIN BEETLE

C. (Laemophloeus) ferrugineous Steph.)

1. Same as flat grain beetle
2. Male antennae not longer than female antennae, reaching the basal third of the elytra.
3. Pronotum slightly transverse
4. Males with external mandibular tooth.
5. Same as for pusillus
6. Sexual dimorphism: Males with 4-segmented hind tarsus; Females 5-segmented hind tarsus.

YELLOW AND DARK MEALWORMS, Tenebrionidae

YELLOW MEALWORM, *Tenebrio molitor* L.	DARK MEALWORM, T. *obscurus* F.
1. Antennal apical segment as long as broad	1. Antennal apical segment broader than long
2. Third antennal segment only slightly longer than 4th	2. Third antennal segment nearly twice as long as the 4th
3. Dorsal surface feebly shining	3. Dorsal surface not shining
4. Pronotum longer than broad	4. Pronotum as broad as long
5. Body with less punctures	5. Body with abundant dense punctures
6. Polished dark brown or black color	6. Dull pitchy black color
7. Elytra longitudinally striated	7. Same as *molitor*
8. 15 mm long	8. 14-18 mm long
9. Larvae yellowish to yellow-brown or honey color	9. Larvae dark

LESSER MEALWORM AND BLACK FUNGUS BEETLE, Tenebrionidae

LESSER MEALWORM, *Alphitobius diaperinus* (Panz.)	BLACK FUNGUS BEETLE, *Alphitobius laevigatus* (F.)
1. Considerably smaller than yellow and dark mealworms	1. Same as lesser mealworm
2. Similar in appearance to black fungus beetle	2. Similar in appearance to the lesser mealworm
3. Black or very dark reddish-brown	3. Same as lesser mealworm
4. Eyes only partly divided	4. Eyes completely or nearly completely divided
5. Sides of thorax nearly straight with the surface finely and sparcely punctured	5. Sides of the thorax curved with the surface coarsely and profusely punctured

LESSER MEALWORM, *Alphitobius diaperinus* (Panz.) (cont.)

6. Antennae with inner apex of 5th segment feebly produced

7. Anterior tibia with apex strongly broadened

8. 5.5-7 mm long

9. Larvae yellowish brown, resembling yellow mealworm larvae

BLACK FUNGUS BEETLE, *Alphitobius laevigatus* (F.) (cont.)

6. Antennae with 5th segment subparallel, inner apex not produced

7. Anterior tibia with apex only feebly broadened

8. 4.5-6 mm long

9. Same as lesser mealworm

SMALL-EYED FLOUR BEETLE and DEPRESSED FLOUR BEETLE, Tenebrionidae

SMALL-EYED FLOUR BEETLE *Palorus ratzeburgi* (Wissm.)	DEPRESSED FLOUR BEETLE, *Palorus subdepressus* (Woll.)
1. Flattened, shiny, reddish-brown beetles	1. Similar in appearance to small-eyes flour beetles
2. Head with anterior sides not strongly explanate or flexed upwards	2. Sides of the front of head strongly explanate
3. Ridge above eyes feeble and indistinct	3. Ridge above eye extends backwards covering anterior part of the eye
4. Eyes small, round	4. Eyes large, vertical diameter slightly but distinctly larger than horizontal
5. 2.5 - 3 mm	5. 2.5 mm

BROAD-HORNED FLOUR BEETLE and SLENDER-HORNED FLOUR BEETLE, Tenebrionidae

BROAD-HORNED FLOUR BEETLE *Gnathocerus cornutus* (F.)	SLENDER-HORNED FLOUR BEETLE *Gnathocerus maxillosus* (F.)
1. Mandibles of male with broad stout dorsal teeth (horns), the teeth being as broad at base extending forwards and upwards) as the distance between them	1. Mandibles of male with slender dorsal teeth (horns) which only slightly narrow from base to apex; Teeth less than half as broad as the space between them
2. Clypeus with anterior margin strongly rounded	2. Clypeus with anterior margin truncate
3. Sides of head very broadly explanate and strongly flexed upwards.	3. Sides of head less strongly explanate, and then, only anterior to instead of opposite eyes
4. Female with broadest point of head before eyes	4. Female with broadest point of head across posterior parts of eyes
5. Stout reddish-brown beetles	5. Same as with broad-horned flour beetle
6. 3.5 - 4.5 mm	6. 3-4 mm

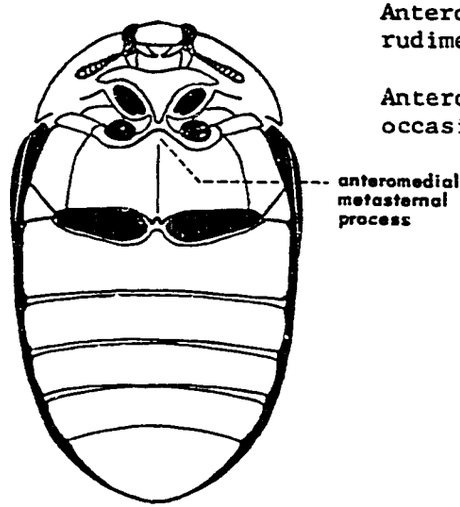
BROAD-HORNED FLOUR BEETLE
Gnathocerus cornutus (F.)
(cont.)

7. Sexual dimorphism: Males with mandibular tooth greatly enlarged; two prominent tubercules in center of head. Females with mandibles normal

8. Larvae yellowish brown with head and posterior segments a pronounced brown

A SUPPLEMENTAL CHARACTER FOR SEPARATING ADULT TROGODERMA GRANARIUM EVERTS, KHAPRA BEETLE, FROM OTHER NEARCTIC TROGODERMA SPECIES

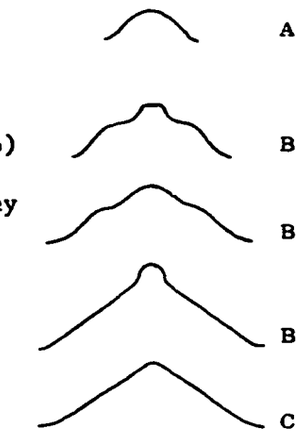
by
George T. Okumura
Bureau of Entomology
California Department of Agriculture, Sacramento, California



Trogoderma granarium ♀ (ventral view)

Anteromedial metasternal process rounded (A) (rarely rudimentary nipple present)...Trogoderma granarium Everts

Anteromedial metasternal process with nipple (B) or occasionally pyramidal (C)....Trogoderma angustum (Solier)
Trogoderma anthrenoides (Sharp)
Trogoderma ballfinchae Beal
Trogoderma fasciferum Blatchley
Trogoderma glabrum (Herbst)
Trogoderma grassmani Beal
Trogoderma inclusum LeConte
Trogoderma okumurai Beal
Trogoderma ornatum (Say)
Trogoderma parabile Beal
Trogoderma paralia Beal
Trogoderma primum (Jayne)
Trogoderma simplex Jayne
Trogoderma sinistrum Fall
Trogoderma sternale Jayne
Trogoderma teukton Beal



Of the foreign species only Trogoderma versicolor (Creutzer), T. boganense Armstrong, T. irroratum Reitter were available for examination. All have nipples.

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FOOD AND FEED GRAIN INSTITUTE
KANSAS STATE UNIVERSITY

Contaminant Analysis

Laboratory Guide - Insect Fragments and Rodent Hairs.

I. Purpose:

The objective of this laboratory session is to acquaint the participants with the basic reasons for analyzing food products for insect fragments and rodent hairs, sources of contamination, recognition and identification of fragments and methods for recovering fragments and rodent hairs from cereal food products.

II. Background:

Contaminant analysis of cereal products can provide an indication of the sanitary conditions under which the raw materials have been stored or produced, sanitary conditions under which the foods were produced and sanitary conditions under which the cereal foods were stored.

By being able to identify the insects contributing the fragments to food products, the source of contamination can many times be pinpointed so that proper corrective or preventive measures can be taken to eliminate the source of contamination.

This aspect of food product sanitation has given rise to a relatively new field--Analytical Entomology. Analytical entomology is an important and necessary implement in assuring that foods contain an irriducible level of contamination that might be injurious to health.

Analytical entomologists must be able to isolate and identify insects, their fragments, eggs and excrement from food products. Isolation is necessary so that correct identification can be made if contaminants are present. Identification not only establishes that the food is contaminated but can also indicate whether the contamination took place during normal production of the crop or during some later stage of processing or storage. Insect fragment and rodent hair counts serve also as indices of the sanitary handling of the food.

Proper identification of contaminants requires a thorough knowledge of insect morphology--the anatomical structure of a given insect and the body parts, sculpturing, markings or other physical characteristics that make positive identification possible.

With this brief introduction, we shall now proceed to take the first step toward becoming "analytical entomologists."

III. Laboratory Exercise

A. EXTERNAL STRUCTURE OF INSECTS.

Most of the insects which are pests of grain and grain products are microscopic in size and as such do not lend themselves to convenient study of structures common to all insects. For this reason, a rather large insect has been chosen as a demonstration insect. It is large enough to easily see the various structures and is fairly easy to handle.

Each participant will be supplied an insect specimen, several insect pins, a soft piece of wood and a binocular microscope.

Examine your specimen closely. You will see lines extending across the head and body segments. These lines are called sutures and in many places on the insect body indicate lines of flexibility. The hardened areas between sutures are called sclerites.

Notice also that the insect is divided into three general body regions: head, thorox and abdomen. Each of these regions will be examined briefly and certain landmarks discussed. Figure 1.

1. HEAD. The head of an insect is a hardened, shell-like capsule located on the anterior (front) end of the body. Attached to it are two sets of appendages -- the mouthparts and antennae (singular antenna).

a. Antennae. The antennae are sensory organs of touch and smell. In relation to contamination analysis, they are an excellent source of fragments. Antennae of many insects differ in their appearance and as such, are valuable in insect identification. Although whole antennae may not commonly be found in cereal products, individual segments or groups of segments are often found. See figure 2 for diagrams of various types of antennae.

(1) Remove an antenna from the point of attachment on the head. This may be accomplished by pinning the specimen, bottom-side up on the wooden block using insect pins. Place one pin through the abdomen and the other through the back part of the head. With another pin, probe the area at the base of the antenna until the antenna is loosened and removed.

Observe the socket-like structure where the antenna was attached.

(2) Count the number of segments and compare the general appearance with other antennae shown in figure 2 and on other laboratory specimens.

(3) Remove a few of the individual segments and note how the segments are joined together, their surface sculpturing and setae (hairs).

b. Mouthparts. With few exceptions, stored product insects have simple chewing mouthparts. These are the most primitive type. The structures involved are recognizable as a group and are found in adults of several orders and in all larvae of insects.

The mouthparts consist of five major structures. The labrum, a flap-like lobe hinged to the front of the head, overlies the cutting edges of the mandibles. The mandibles are dark, heavily sclertized structures used for chewing food materials. They are hinged at the outer edge of the head by a ball and socket arrangement. A fleshy lobe lying beneath the mandibles on the mid-line is called the hypopharynx. Two flat, flap-like appendages called maxillae (singular maxilla) are situated, just below the mandibles. Each of these is made up of several individual parts and bears a segmented palpus (plural palpi). A toothed inner lobe (lacinia) of the maxilla is used for manipulating bits of food. The soft, flap-like outer lobe is the galea. The central plate to which each is attached is the stipes. A single basal plate (the labium) closes the "mouth" cavity from below. The labium is a single structure resulting from the fusion of a pair of structures. Palpi on the labium are sensory.

(1) With the specimen pinned in the inverted position, probe with an insect pin across the head about midway from the front. This should loosen the labium and maxillae and allow them to be removed. Separate the structures and observe the various parts indicated in the preceeding paragraph.

(2) Using the insect pin, force the mandibles toward the sides and remove them. Notice the general structures, the sharp teeth and the dark knob which is the point of articulation for mandible movement in chewing. Compare the appearance of this mandible with those shown in figure 3.

(3) Observe the flap-like lobe (labrum) that remains attached to the head. Notice the hairs (setae) and their points of attachment to the labrum.

Mouthparts, especially mandibles, are common fragments found in cereal products. They are very hard and are able to resist much of the rough treatment encountered in processing. Another reason many "mandibles" are found in cereal products is that the larvae of internal infesting insects are often processed with the grain and because the early stages of development are very small the mandibles are able to pass through the final sieving in processing. In systems where adequate steps are taken to clean grain before it is processed and where the systems themselves are reasonably free of infestation the internal infesting insects are responsible for contributing nearly all of the fragments in the finished food.

c. Compound eyes. Also located on the head capsule are compound eyes made up of many six-sided units or lenses. Each lens represents a separately functioning unit. Fragments of compound eyes are easily recognized in analysis plates.

2. THORAX. The thorax of the insect is a comparatively short box-like region specialized to serve efficiently in a locomotor capacity. Legs and wings are the organs of locomotion attached to the thorax.

This body region has three subdivisions or body segments included: by position these are the prothorax (in front); mesothorax (in the middle); and the metathorax (behind or last). A pair of legs is found on each segment; these are referred to as prothoracic, mesothoracic, and metathoracic legs, respectively. Wings, if present, usually may be found on the mesothoracic segment (mesothoracic or front wings), and on the metathoracic segment (metathoracic or hind wings). Wings are never present on the prothorax.

The prothorax (the PRONOTUM) is generally greatly enlarged and is a very important landmark on the insect. The mesonotum and metanotum are squeezed in on top between the bases of the wings; they usually are small and covered by the wings when the latter are not in use.

a. Legs. The legs of insects, as in all anthropods, consist of a series of segments separated by joints. The basal segment (closest to the body) is called the coxa; this rotates in a cavity in the thorax, forming a partial ball-and-socket joint. The second segment, the trochanter, is usually a smaller, more or less tubular or triangular piece which articulates with the coxa. The third portion of the leg is the large femur (plural femora), which is attached by a knee-like joint to the next segment, the tibia (plural tibiae). The remainder of the leg, beyond the tibia, constitutes the tarsus (plural tarsi) which consists of several small segments, which are numbered 1, 2, 3, etc. from the base (next to the tibia) outward. The primitive number of tarsal segments in insects is five, and none has more than five. Attached to the tip of the tarsus are the claws.

(1) Remove one each of the pro-thoracic, meso-thoracic and meta-thoracic legs by probing with a pin at the point of attachment to the body. Compare the legs with respect to shape, size and numbers of segments.

(2) Note the general texture, sculpturing spines, and jointing of segments of a leg.

(3) Break one of the segments of the tibia or femur and note the tubular construction.

b. Wings. Stored product adult insects, in general, have two pair of wings. Wings of insects aremot modified legs but entirely separate structures, formed as flap-like extensions of the body wall. The front wings of the beetles are scleritized structures called elytra (singular elytron) and are attached to the meso-thoracic segment. They are not used for flight but are covers for the hind wings (flight wings in some cases). The elytra will produce fragments similar to sclerites on other parts of the insect body but are not readily used for identification except by the highly trained expert.

The hind wings are membranous and fragments of them might easily be overlooked. Veins and spiny texture of some wings are recognizable landmarks.

(1) Turn your specimen over from its inverted position and remove the elytra. Notice the striations (longitudinal lines) the general sculpturing of the surface, and the reinforcing construction along the edges and at the point of attachment to the thorax.

(2) Remove one of the membranous flight wings and notice the veins (strengthening structures) and the general texture of the membranous portion of the wing.

3. Abdomen. This is an elongate, plainly segmented body region which in the adult insect bears no legs or leg-like appendages. It is the center of the reproductive organs of both male and female insects. Reproductive structures are often used in specific identification of insects and from the standpoint of fragment analysis could be valuable. In general, however, the adult abdomen contributes primarily non-descript fragments. In certain of the larvae, abdominal cerci (structures located at the tip of the abdomen) are very valuable in determining species identification based on fragments.

(1) Crush the tip of the abdomen with your pin and remove the reproductive structures. Notice the scleritized plates.

(2) Break some of the abdominal sclerites and notice the texture, sculpturing and color away from the rest of the insect body.

B. LARVAE

The general configuration of larvae is similar to that of adult insects in that they are made up of three sections -- head, thorax and abdomen.

1. HEAD. The head is structurally similar to the adult insect with the exception of lacking compound eyes. Mouthparts are of the chewing type with mandibles and labrum providing the best potential for identifiable fragments. The other appendages are minute and quite delicate.

Since the head capsule is generally more heavily scleritized and structurally reinforced to allow feeding it provides the primary source of recognizable fragments. Identifiable features include: mouth parts, antennae, sutures, setal pits and setae and reinforcing ridges.

2. THORAX. The thorax bears only legs as appendages. Wings are not present.

3. ABDOMEN. The most valuable fragments obtained from the abdomen would be the cerci.

C. Fragments from Specific Insects. (If time permits).

1. Select one or more species of adult insects and grind them, individually, with a mortar and pestle. (Make certain the specimens have been dired to remove body fluids).

2. Flush the fragmented parts of the insect onto a white filter paper with alcohol.

3. Examine the fragments with a binocular miscroscope and pick out fragments you recognize as:

a. Mandibles
b. Antennae or segments
c. Other mouth parts
d. Legs
e. Non-descript fragments

D. Rodent Hairs

1. Rodent hairs can be incorporated into food products in several ways.

a. Free rodent hairs may be present in grain as a result of shedding by rodents in contact with the grain.

b. Rodent hairs may be dislodged from rodent pellets if they are incorporated into the food product.

c. Air-borne rodent hairs may be incorporated into the food product during processing by contaminated conveying air.

d. Finished cereal products may be contaminated with rodent hairs by direct contact with rodents.

2. Identification. A food analyst must be able to differentiate between animal hairs and other fibrous materials that may resemble hairs. He is also often interested in knowing whether a given hair or hair fragments came from a rodent or some other species of animal. In most cases, identification of hairs must be made on the basis of fragments or pieces of hairs. This

requires that microscopic characteristics visible in the internal hair structure be used, i.e. structure of individual medullary segments, air spaces, pigment granules, cortex and cuticle. See figure 4.

It is possible to differentiate between rat and mice hairs, however, since the significance of their presence is the same they are generally considered together. The two types of hairs most likely to be encountered in food products are guard hairs and fur hairs.

"Guard hairs of rodents have multiple-rowed, discontinuous medullas; that is, the medulla is broken into several rows of block-like sections. Mouse hairs usually have 2 to 4 rows of segments but rat hairs may have as many as 9 or 10 rows. Between these segments are air spaces. When the air is driven out, the appearance of the medulla is somewhat changed: The blocks or segments are no longer in rows but are staggered to form a mosaic."

"In the fur hairs of rats and mice there are prominent constrictions or spots in which the diameter of the hair decreases markedly, usually from 1 to 4 in a hair."

"In rodent fur hairs the medullary segments, if colored, are compactly pigmented so that the pigmented area looks solid and substantial. Usually one end of the segment is pigmented and the other end is clear."

As a rule the cortex is not heavily pigmented.

E. METHODS FOR RECOVERING FRAGMENTS FROM CEREAL FOOD PRODUCTS.

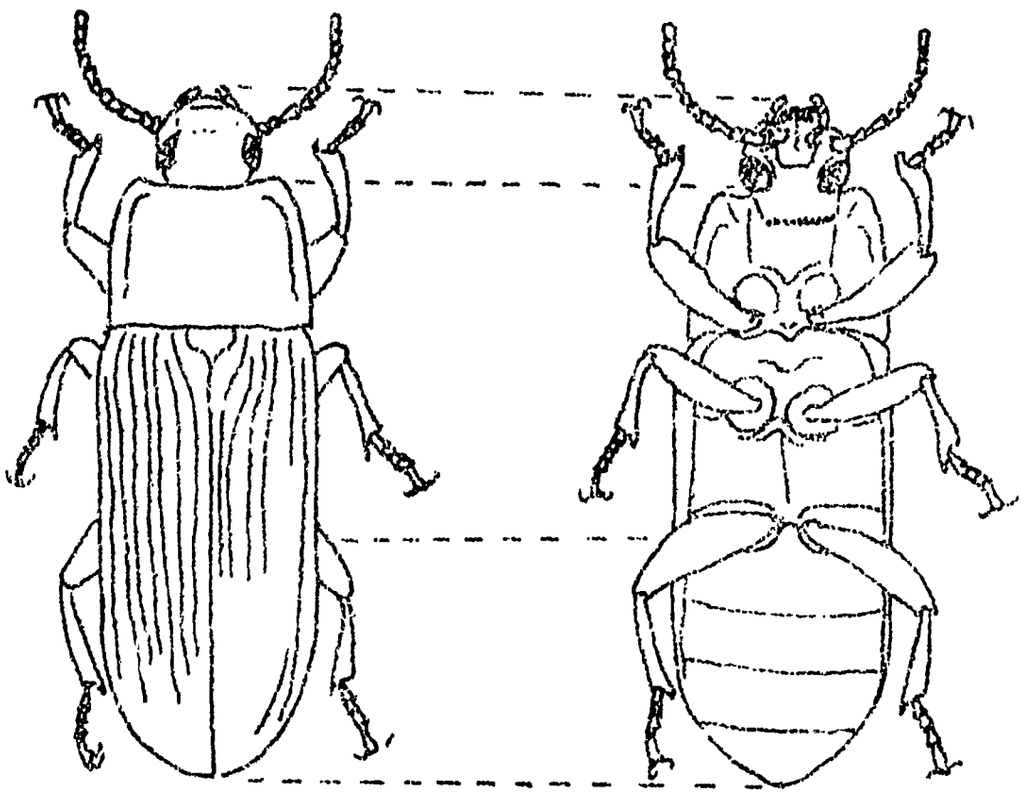
1. Demonstration of Acid Hydrolysis Method for Insect Fragments and Rodent Hairs.

2. Demonstration of Tween-Versene Method for Insect Fragments and Rodent Hairs

3. Examination of prepared plates to detect insect fragments and rodent hairs.

FIGURE 1

MEALWORM (*Tenebrio molitor*) ADULT
Dorsal and Ventral Views



MOUTHPARTS
(General)

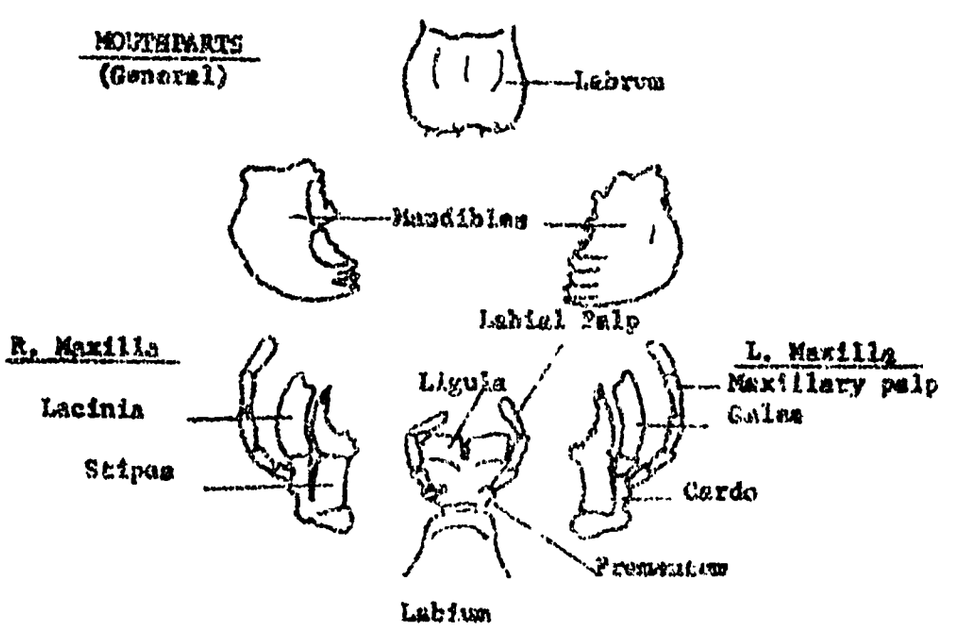


FIGURE 2

ANTENNAE EXAMPLES

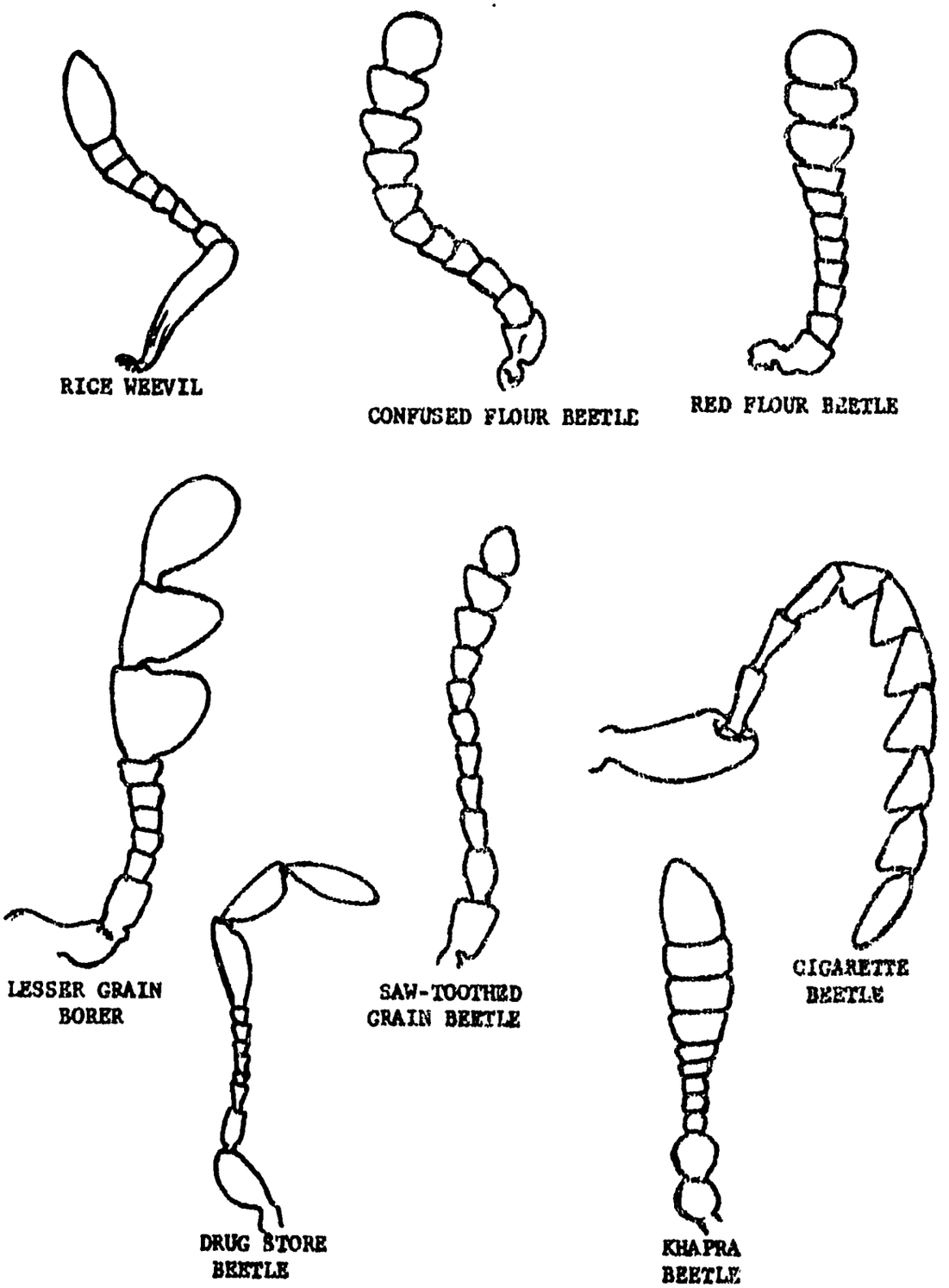


FIGURE 3

MANDIBLE EXAMPLES

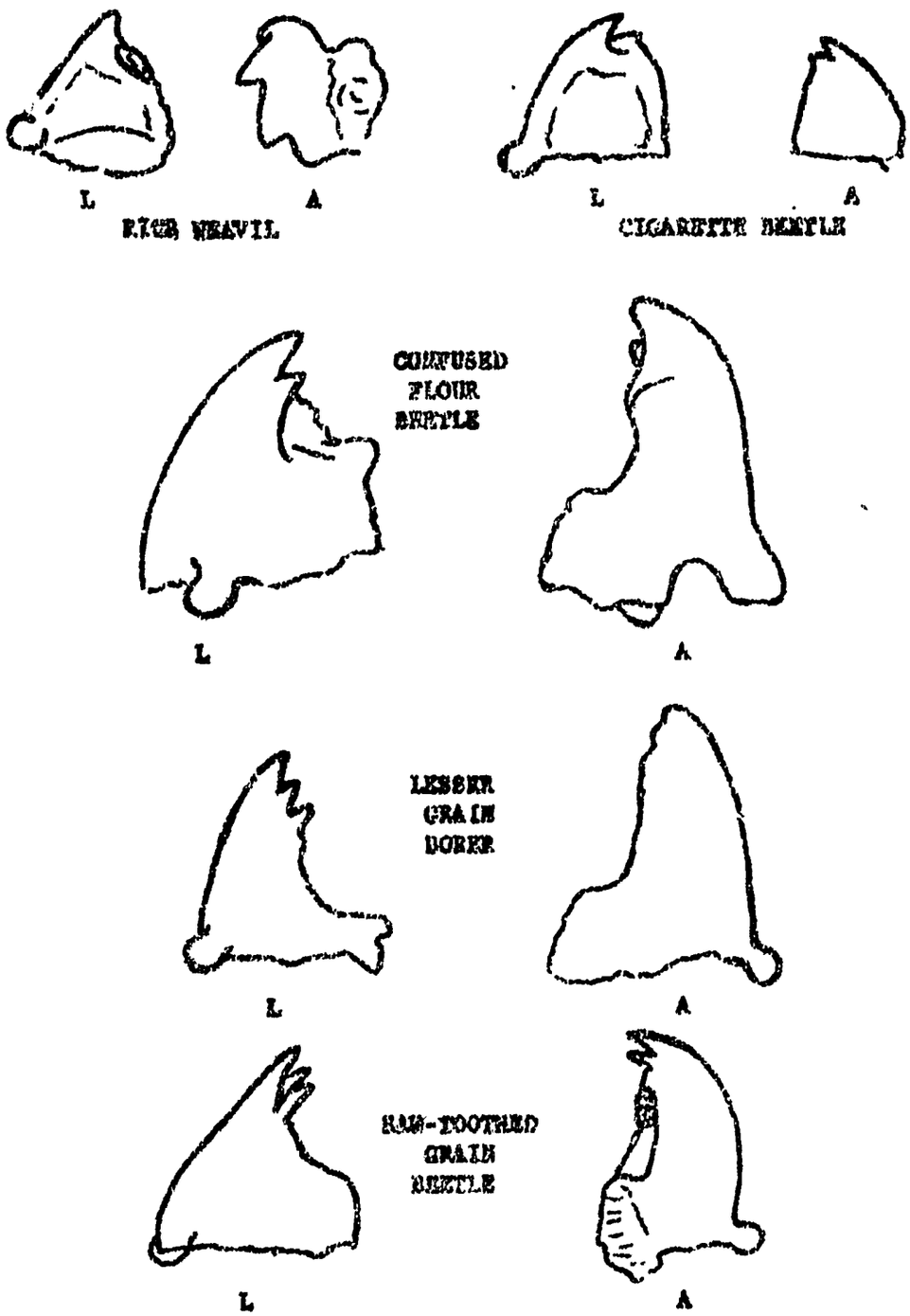
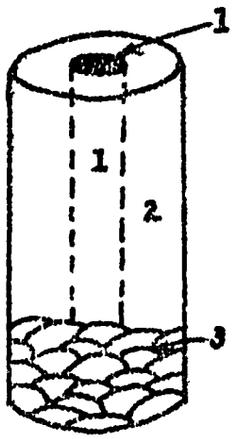


FIGURE 4



A

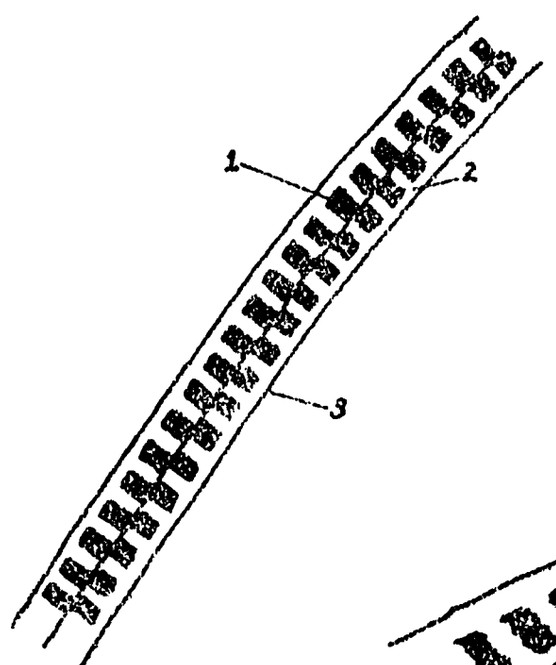
SCHEMATIC DIAGRAMS OF HAIRS

A. Generalized Hair Cross-Section

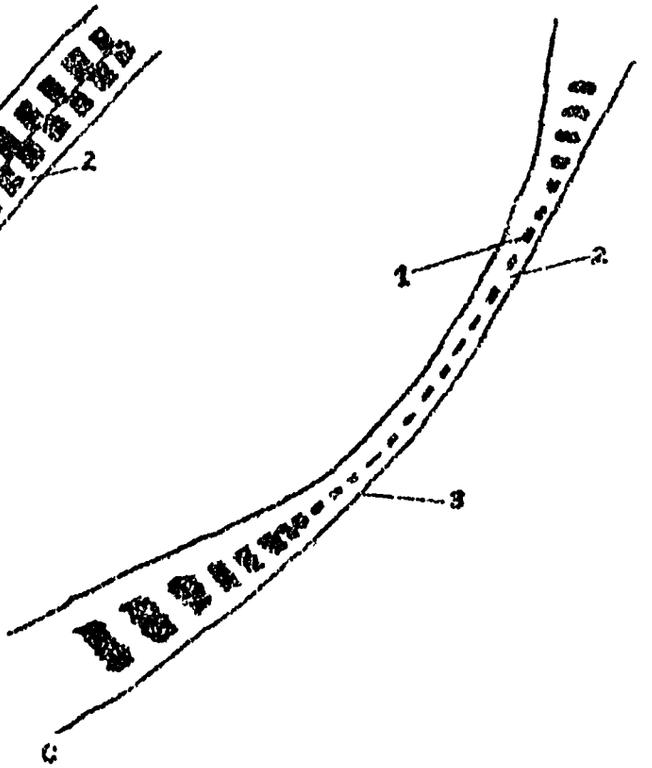
1. Central Medulla
2. Cortex
3. Cuticle-Scales

B. Rodent Guard Hair

C. Rodent Fur Hair



B



C

FOOD AND FEED GRAIN INSTITUTE

CONTAMINATION ANALYSIS

Determination of Extraneous Material (Light filth) in flour --
Acid Hydrolysis Method

These instructions outline a procedure for determining insect fragments and rodent hairs in flour.

I. Materials, Reagents and Solutions.
   A. Materials.
      1. Balance.
      2. Beakers - 800 or 1000 ml.
      3. Stirring rods - with rubber policemen.
      4. Electric burners or hot plates.
      5. Separatory funnels - 1000 ml. equipped with rubber drain tubes fitted with pinch clamps.
      6. Buchner funnel and filtering flask.
      7. Petri dishes.
      8. Ruled analytical filter paper.
      9. Microscope. 30x or 45x wide field binocular.
      10. Logbook.
   B. Reagents and solutions.
      1. Hydrochloric acid solution - 5% (1000 ml. made up to 20 liters).
      2. Light mineral oil.
      3. Tween 80 Alcohol solution (one part polyoxyethylene sorbitan monooleate to 5 parts 60% alcohol).
      4. Kerosine or any lead-free gasoline.
      5. Detergent solution. (2 ml. liquid detergent to 500 ml. hot water).
      6. Glycerine solution - 1 part glycerine to 1 part water.

II. Procedure.
   A. Method.
      1. The sample should be registered in a contaminant analysis logbook and a laboratory number assigned to it.
      2. Weigh 50 grams of flour into an 800 ml. beaker.
      3. Add, with stirring, about 400 ml. of 5% HCl solution.
      4. Optional. Add, with stirring, 30 ml. of the Tween-80/alcohol solution.
      5. Add 20 ml. of light mineral oil.
      6. Heat to boiling, with intermittant stirring to prevent the flour from scorching. boil for 6-10 minutes.
      7. Remove beaker from burner and allow to cool. Cold water (about 200 ml. may be added to help cooling).

8. Pour 30 ml. of kerosene or lead-free gasoline into the 1000 ml. separatory funnel.
9. Quantitatively transfer the digested sample from the beaker to the separatory funnel. Rinse the beaker and stirring rod with hot water.
10. Allow the sample to settle for 30-45 minutes. Drain off the sediment so the oil-gas layer is about 1½ to 2 inches from the bottom.
11. Fill the separatory funnel with water and let settle for 30-45 minutes. Drain off the sediment retaining the oil-gas layer in the separatory funnel.
12. Filter the material remaining in the funnel through ruled analytical filter paper using the Buchner funnel.
13. Transfer the filter paper to a petri dish to which has been added several drops of glycerine solution.

B. Results.

1. Examine filter paper using binocular microscope.
2. Record adult insect fragments, larval fragments and rodent hairs and fragments in the logbook.
3. Make notations as to identifiable fragments (if desired) and any other contaminants found.

Reference: AOAC (1965) Official Methods of Analysis of the Association of Official Agricultural (Analytical) Chemists, Tenth Edition, 957 p. Chapter 36, paragraph 36.029.

FOOD AND FEED GRAIN INSTITUTE
KANSAS STATE UNIVERSITY

Determination of Extraneous Material (light filth) in flour --Tween-Versene Method

I. Materials, Reagents and Solutions
   A. Materials
      1. Erlenmeyer trap flask - 1000 ml.
      2. Buchner funnel
      3. Filtering flask
      4. Ruled filter paper
      5. Petri dishes
      6. Balance
      7. Widefield binocular microscope
   B. Reagents and Solutions
      1. Alcohol - 60% isopropyl
      2. Tween 80 - Alcohol solution (40 ml. polyoxyethylene sorbitan mono-oleate added to 210 ml. 60% isopropyl alcohol, mix and filter).
      3. EDTA 60% alcohol solution (Versene solution - Tetrasodium salt of ethylene-diamine tetraacetic acid. Dissolve 5 g. salt in 100 ml. water, add 150 ml. isopropyl alcohol, mix and filter).
      4. Gasoline

II. Method
   A. Procedure
      1. Weigh 50 grams flour into a 1 liter trap flask.
      2. Add 300 ml 60% alcohol and mix.
      3. Add 250 ml. Tween 80-60% alcohol solution and mix.
      4. Add 250 ml. EDTA - 60% alcohol solution.
      5. Add 70 Ml. gasoline and mix.
      6. Fill flask so that gasoline layer is in neck of flask.
      7. Stir gently at 5 min. intervals for 20 minutes.
      8. Let stand for 1 hour.
      9. Trap off gasoline layer using Buchner funnel and ruled filter paper.
      10. Add 40 ml. gasoline and allow 1.5 hour standing period before trapping off second extraction on separate ruled filter paper.
   b. Results:
      1. Examine ruled filter papers using widefield, binocular microscope.
      2. Record insect fragments and rodent hairs.

Reference: AOAC (1965) Official Methods of the Association of Official Agricultural (Analytical) Chemists, Tenth Edition. Association of Official Agricultural Chemists Chapter 36, paragraph 36.034.

B. Results.

1. Using the binocular microscope, examine the filter plate.
2. Record whole insects, major insect parts, whole larvae, cast larval skins and larval head capsules.

Reference: AOAC (1965) Official Methods of Analysis of the Association of Official Agricultural (Analytical) Chemists, Tenth Edition, 957 p. Chapter 36, paragraph. 36.035.

SAMPLING OF GRAIN AND CEREAL PRODUCTS

A. Sampling Equipment

1. Double-tube, separate compartment grain probe for sampling carload lots of bulk grain (with extensions).

2. Spout sampler or "Pelican" for sampling bulk grain from a falling stream of grain.

3. Automatic sampling device fitted into spout, on belt or in scale, to sample flowing grain.

4. Sack probe (trier) for sampling sacked lots of grain.

5. Sampling canvas 63 inches long by 29½ wide.

6. Airtight containers for preserving samples for moisture tests.

7. Identification tags or labels.

B. Procedures.

1. Identification. Full identification of the lot sampled and other information obtained at the time of sampling should be recorded at the time the sample is taken.

   a. Example of the type of information needed.

      (1) Date sampled.
      (2) Commodity sampled
      (3) Quantity of commodity sampled.
      (4) Commodity identification (lot, shipment, transport vehicle, etc.).
      (5) Type of storage (bag, bulk, ship, rail, truck).
      (6) Sampler's initials or name.

   b. Special remarks - reason sampled, special sampling techniques, etc.

2. Representative Sample.

   a. The taking of a representative sample of a lot of grain or cereal product for sanitation inspection is important and essential. If the sample obtained is not representative, no amount of care in making determinations of contaminants will establish the true condition of the commodity involved.

   b. Sample size may vary depending on the type of commodity being sampled and the total quantity of product represented.

(1) Grain, the sample size should not be less than - two (2) quarts (1.94 liters).

(2) Flour, the sample size should not be less than five (5) pounds.

3. Sampling Bulk Grain in Cars and Trucks.. Bulk grain in cars, trucks, wagons or anyother conveyance should be sampled in a manner that will produce a representative sample of the grain.

a. Samples may be taken using,

(1) Compartmented grain probe, or
(2) Automatic stream sampling devices, or
(3) By use of a device called a "Pelican" spout sampler.

b. Samples should be taken from at least five (5) positions in carlot or trucklot shipments when using a grain probe.

(1) Probe samples when emptied from the probe should be grossly examined for insects, rodent pellets, mold, heating, etc.

(2) Samples should be placed in containers which will preserve the moisture content at time of sampling.

(3) Samples should be examined thoroughly at the laboratory using laboratory methods.

c. Representative samples taken by automatic stream samplers or "Pelican" spout samples should be obtained as the conveyance is unloaded and before the grain is comingled with other lots of grain.

(1) The grain stream should be regularly and frequently sampled.

(2) Individual samples should be grossly examined for insects, rodent pellets, mold, heating, etc. at the site of sampling.

(3) Samples should be taken to the laboratory for thorough examination.

4. Sampling Bulk Grain in Ships.

a. Where grain is discharged from a boat, barge or other vessel, representative samples should be taken from the running stream as the grain is unloaded.

(1) "Pelican" spout samplers may be used to collect samples.

(2) The grain stream should be sampled at regular and frequent intervals to provide a representative sample.

b. Where grain is to be sampled at rest in the vessel, samples should be taken by means of compartmented probe by probing at regular intervals.

(1) When a ship is divided into compartments probe samples from at least five (5) places from each compartment should be taken.

(2) If the ship is not compartmented, then probe samples should be taken, generally, as follows:

20,000 bu (about 550 M.T.)- 20 places
60,000 bu (about 1600 M.T.)-30 places.

Samples should be evenly spaced.

(3) Each probe sample should be grossly examined for presence of insects, rodent pellets, mold, heating, etc.

(4) Samples should be placed in containers to maintain moisture until examined at the laboratory.

(5) Samples should be examined thoroughly at the laboratory using laboratory methods.

5. <u>Sampling Bulk Grain in Bins.</u>

a. Bulk grain in flat storage warehouses should be sampled using a compartmented probe where depth permits.

(1) Numbers of probes should follow the schedule established for ships holds.

(2) Samples should be grossly examined and subjected to laboratory examination as indicated previously.

f. Bulk grain in silo or elevator storage where depth prevents probe sampling, should be moved from one bin to another and the flowing stream sampled.

(1) The "Pelican" spout sampler or automatic stream sampler may be used to obtain a representative sample.

(2) Samples should be grossly examined and examined in the laboratory as indicated previously.

6. <u>Sampling Sacked Grain.</u>

a. Sacked or bagged grain should be sampled using a bag trier or probe sufficient in length to reach the center of the bag.

b. Samples should be taken from individual sacks, at random, to provide a representative sample.

(1) In cases where bagged grain is stacked in warehouses, on docks, etc. and all bags are not accessible for sampling, obtain a representative sample by probing bags on top, front, back and sides of the stack at random.

(2) One rule of thumb in obtaining a representative sample is to take samples from bags equal to the square root of the total bags in the shipment.

(a) No more than 20 bags should be sampled.

(b) If the shipment is larger than 400 bags, divide the shipment into lots approximating 400 bag lots.

7. Sampling of Cereal Products

a. The sampling procedure outlined in 6 above may be used.

b. If large numbers of shipments are being analyzed the following procedure may be used for cereal products.

(1) Take one pound samples from the center of the number of bags that is equivalent to one half the square root of the total number of the shipment, but not less than 5 bags.

Example:

36 bags shipment - sample 3 bags
100 bags shipment - sample 5 bags
400 bags shipment - sample 10 bags
900 bags shipment or more - 15 bags

(2) Composite these small samples into a large sample and mix thoroughly.

(3) Take a one pound sample of the mixed composite as the sample for laboratory analysis.

c. The analysis can be no better than the sample. It must be realized also that smaller numbers of individual samples and compositing reduce the reliability of the analysis.

FOOD AND FEED GRAIN INSTITUTE
KANSAS STATE UNIVERSITY

GRAIN STORAGE WAREHOUSE SANITATION CHECK LIST

WAREHOUSE:_____Date:_____

LOCATION:_____INSPECTOR:_____

WAREHOUSE CONSTRUCTION AND UTILIZATION

1. Storage capacity_____M.T.;_____Sq. Ft._____
2. Grains in Storage_____
   _____
3. Type of Storage: Bulk (flat)_____;Bagged_____
   Bag bulk head_____.

CONDITION OF WAREHOUSE PERIMETER

1. Railroad tracks:	a. debris present	Yes___	No___
	b. grain accumulations	Yes___	No___
2. Truck loading docks:	a. debris present	Yes___	No___
	b. grain accumulations	Yes___	No___
3. Weeds, brush or tall grass on grounds		Yes___	No___
4. Trash piles on grounds or near warehouse		Yes___	No___
5. Rodent signs on warehouse grounds (Explain) _____		Yes___	No___
6. Birds nesting, or roosting under canopies		Yes___	No___

MAINTENANCE OF WAREHOUSE EXTERIORS

1. Canopies in need of repair	Yes___	No___
2. Holes in walls through which birds can enter	Yes___	No___
3. Holes in walls at floor level giving access to rodents	Yes___	No___
4. Doors are not tight fitting to exclude rodents	Yes___	No___
5. Broken windows or sky lights	Yes___	No___
6. Windows or doors in need of screens	Yes___	No___
7. Roof or walls leak when it rains	Yes___	No___

MAINTENANCE OF WAREHOUSE INTERIORS

1. Do floor areas require cleaning — Yes___ No___
2. Do walls require cleaning — Yes___ No___
3. Do overhead areas require cleaning — Yes___ No___
4. Accumulations of debris in warehouse — Yes___ No___
5. Are there cracks in floors or walls which accumulate grain — Yes___ No___

GRAIN INSPECTION PROCEDURES

1. Is grain sampled and inspected before receiving it in the warehouse — Yes___ No___
   a. moisture is determined — Yes___ No___
   b. grain is graded — Yes___ No___
   c. grain checked for insects — Yes___ No___
      Method_____
   d. grain is checked for evidence of rodents (pellets_____; urine_____) — Yes___ No___
   e. grain is checked for "off-odors" — Yes___ No___
2. Is grain in storage routinely inspected — Yes___ No___
   a. for moisture (frequency_____) — Yes___ No___
   b. for temperature (frequency_____) — Yes___ No___
   c. for insects (frequency_____) — Yes___ No___
3. Standards are established for maximum insect and/or rodent evidence — Yes___ No___
4. Grain is fumigated if insects noted — Yes___ No___

GRAIN STORAGE PRACTICES

1. Bagged grain is stored on pallets — Yes___ No___
2. Bagged grain is stored in orderly fashion — Yes___ No___
3. Stacks of bagged grain no more than 20 bags high - (6 meters) and 6 meters wide — Yes___ No___
4. Stacks of bagged grain are at least 1 meter below overhead structures — Yes___ No___
5. Stacks of bagged grain are stored at least 1 meter from all walls and at least 1 meter between stacks — Yes___ No___
6. Broken bags of grain in stacks <u>not</u> noted — Yes___ No___
7. Is grain cleaned when received — Yes___ No___

INSECT CONDITIONS

1. Moths noted flying in warehouse — Yes___ No___
2. Adult insects or larvae noted:
   a. on floors or walls — Yes___ No___
   b. on outsides of bags of grain — Yes___ No___
   c. in accumulations of spilled grain — Yes___ No___
   d. in samples taken from stacks of grain (on separate sheet list lots of grain sampled and insects present if any). — Yes___ No___
3. Insect tracks in dust on walls, floors overhead areas — Yes___ No___

Explain any "yes" above_____

_____

RODENT, BIRD AND/OR MICROBIAL CONDITIONS

1. Live or dead rodents noted in warehouse — Yes___ No___
2. Rodent pellets noted in warehouse or on bags of grain — Yes___ No___
3. Rodent urine stains on bags — Yes___ No___
4. Rodent chewed bags — Yes___ No___
5. Rodent tracks noted in dust — Yes___ No___
6. Birds noted in warehouse — Yes___ No___
7. Bird droppings on bags, floors overhead — Yes___ No___
8. Molded or sprouted grain noted — Yes___ No___

Explain any "yes" above_____

_____

PEST CONTROL

Insect

1. Regularly scheduled residual spraying of warehouse practiced — Yes___ No___
   a. frequency_____
   b. insecticide used_____
2. Regularly scheduled fogging of warehouse — Yes___ No___
   a. frequency_____
   b. insecticide used_____
3. Grain fumigated when received — Yes___ No___
   Fumigant used_____
4. Protective treatment applied when received — Yes___ No___
   a. Applied to bags_____
   b. Applied to grain_____
   c. Material applied_____
5. Grain fumigated as required — Yes___ No___

Rodent

1. Rodent bait stations maintained on warehouse exterior Yes___ No___
2. Rodent bait stations maintained on warehouse interior Yes___ No___
3. Rodent traps maintained on warehouse interior Yes___ No___
4. Bait stations serviced with fresh bait regularly Yes___ No___
   a. Type of bait used_____
   b. Frequency of service_____

Birds

1. Baits in use (Type_____) Yes___ No___
2. Traps in use Yes___ No___

MANAGEMENT

1. Do warehouse employees report presence of insects, rodents, birds, and molds Yes___ No___
2. Is a sanitation program written out for the warehouse Yes___ No___
3. Are personnel adequately informed about sanitation
   a. Management Yes___ No___
   b. Employees Yes___ No___
4. Does warehouse manager make routine inspection of warehouse Yes___ No___
   Frequency_____

RECOMMENDATIONS/REMARKS

FOOD PRODUCT WAREHOUSE
SANITATION INSTRUCTIONS

Not only are millions of dollars worth of human food products destroyed annually due to contamination by insects, rodents, birds, etc., but in addition, Federal Food and Drug (FDA) regulations are violated when food for human consumption is stored under insanitary conditions whereby it may become contaminated or is contaminated.

The following warehouse sanitation practices are recommended as an aid in protecting the product from contamination, and thus reducing the loss in quality, quantity and revenue.

1. Inspect all incoming product for possible insect, rodent, and other forms of contamination.

   Look for these signs of possible contamination:

   a. Live insects crawling on product containers.
   b. Insect "trails" in the dust on bags or cases.
   c. Mouse or rat pellets on product containers.
   d. Rodent gnawed bags.
   e. Undesirable odors.
   f. Stains on product containers.

2. Product storage conditions.

   a. Store product on clean pallets. Do not store directly on floor. All emptied storage bays should be swept clean before being refilled with palletized product.

   b. Leave an 18" floor space between pallets of product and the wall. Do not store pallets directly against wall.

   c. Segregate animal feed from food for human consumption. Do not store dog food, etc. adjacent to flour, cake mix, etc. Do not store flour, bakery mixes, cake mixes, etc. adjacent to such odorous items as onions, spices, kerosene, cresote, etc.

   d. Practice stock rotation. Use older stocks first. Frequently restack older stocks and carefully examine exterior of containers for signs of possible contamination.

e. Remove to rework room daily all warehouse and/or railroad damaged product. Any torn contaminers should be taped or otherwise closed to prevent the entrance of any contamination.

3. Stored product insect control.

a. Warehouse fogging:

During the warm summer months, fog the warehouse weekly using an approved pyrethrin type insecticide diluted with an odorless, stainless oil.

Caution: Do not use more than one gallon of material per 50,000 cubic feet of space.

b. Spraying:

At least three times during the summer months, spray all floor areas (including floor area when storage bays become empty) and wall surfaces with an approved malathion insecticide diluted with water.

Caution: Do not allow insecticide to come in contact with product or product containers.

Insect control service may be secured from a local licensed pest control company if trained personnel, equipment or material are not available. Precautions must be taken to see that pest control operators adhere to safe pesticide practices.

4. Rodent control.

a. Keep weeds and high grass from growing on the property immediately adjacent to the warehouse perimeter.

b. Do not allow scrap wood or other debris to collect on outside perimeter of premises.

c. Place an adequate number of rodent bait boxes, containing anticoagulant type rodenticide, on the exterior and interior perimeter of the warehouse. Service these boxes at least each month.

d. Place an adequate number of snap type and/or wind-up type rodent traps at strategic locations throughout the warehouse.

e. Rodent proof the building as much as possible by sealing holes through which rodents may enter.

Rodent control service may be secured from a local licensed pest control company if trained personnel, materials and equipment are not available.

5. General sanitation practices.

a. Near the close of each operating day, sweep or dust mop floor area, paying particular attention to floor space between wall and pallets of product and other "hidden corners".

b. Do not allow scrap wood, paper, and other debris to accumulate.

c. A thorough sanitation inspection of the entire premises should be made at least weekly by a responsible employee.

d. Instruct all employees to be sanitation conscious.

e. When "grocery return" products are received, segregate such products in an area walled off from the main warehouse or in a separate building. Careful inspection should be made for any contamination of the product and disposition made in accordance with existing applicable Food and Drug regulations.

f. Keep doors closed as much as possible in order to exclude birds. Destroy any bird nests found on the premises.

6. Fumigation

Since any material used for fumigation is highly dangerous to human life, a local licensed pest control company should be contacted if the need arises for fumigation of any commodity.

FOOD PRODUCT WAREHOUSE SANITATION CHECK LIST

NAME OF WHSE.:_____ DATE:_____

ADDRESS:_____ CITY:_____ STATE:_____

MANAGER OR SUPERINTENDENT:_____ INSPECTOR(S):_____

WAREHOUSE CONSTRUCTION AND UTILIZATION

1. Type of warehouse:
   a. Single Level_____; Multiple Level_____;(No. of Levels)___,
   b. Construction: Brick_____: Concrete _____; Wood_____; Other_____.
2. Storage space (area) assigned to food products (if changed since previous inspection) _____.

CONDITION OF WAREHOUSE PERIMETER

1.	Railroad tracks: (a) debris present	Yes___	No___
	(b) waste flour or cereal products present	Yes___	No___
2.	Truck loading docks: (a) debris present	Yes___	No___
	(b) waste flour or cereal present	Yes___	No___
3.	Weeds, brush or high grass on premises	Yes___	No___
4.	Trash piles on premises or near warehouse	Yes___	No___
5.	Rodent signs on exterior of warehouse (explain) _____	Yes___	No___
6.	Birds nesting, resting, roosting under canopies	Yes___	No___

MAINTENANCE OF BLDG. EXTERIOR

1.	Canopies in need of repair	Yes___	No___
2.	Holes in walls through which birds can enter	Yes___	No___
3.	Holes in walls at floor level giving easy access to rodents	Yes___	No___
4.	When doors are closed are the cracks between doors and sills at least one-half inch in height	Yes___	No___
5.	Broken window panes or skylight noted	Yes___	No___
6.	Windows and/or skylight in need of screens	Yes___	No___
7.	Does the roof leak when it rains	Yes___	No___

MAINTENANCE OF BLDG. INTERIOR

1. Do floor areas require cleaning (aisleways, storage bags, along walls) Yes___ No___
2. Accumulations of debris along wall-floor junctures Yes___ No___
3. Do walls require cleaning Yes___ No___
4. Are there accumulations of spilled rodent bait or broken glass on the warehouse interior Yes___ No___

PRODUCT STORAGE

1. Products are stacked against walls Yes___ No___
2. Products are stacked in aisleways Yes___ No___
3. Products are stacked on the floor (case goods without pallet sheets) Yes___ No___
4. Products are stacked adjacent to dry dog food or other animal feeds Yes___ No___
5. Products are stored adjacent to oils, fertilizer, chemicals or other strong odor materials Yes___ No___
6. Unusual odors were noted near food products Yes___ No___
7. Broken and/or crushed containers with exposed products noted in the stacks (How Much) Yes___ No___
8. Stock is not being adequately rotated Yes___ No___
9. Old products. List the products and codes (If any)_____

_____

_____

INSECT CONDITIONS

1. Moths were noted flying about the warehouse Yes___ No___
2. Insects or Larvae noted: (a) crawling on the floors and walls Yes___ No___
   (b) crawling on the outside of bales, bags, cases Yes___ No___
   (c) under loose portions of flaps on bales Yes___ No___
   (d) observed in piles of whse, damaged product Yes___ No___
3. Insect trails observed in dust on cases, on bales, bags, pallets or floors Yes___ No___
4. Explain any "yes" above _____

_____

_____

RODENT AND/OR BIRD CONDITIONS

1. Rodent pellets noted along walls, around roof supporting columns or stacks of pallets — Yes___ No___
2. Rodent tracks noted on pallets and/or floor — Yes___ No___
3. Evidence of rodents in track wells — Yes___ No___
4. Rodent pellets noted on bags, bales or pallets of product — Yes___ No___
5. Evidence of rodent chewed bags — Yes___ No___
6. Bird droppings noted on floor, beams or on bags or cases — Yes___ No___
7. Birds were seen in the warehouse — Yes___ No___
8. Explain any "yes" above _____

_____

_____

HANDLING PRACTICES

1. Prior to loading cars and/or trucks are
   a. inspected for signs of insects, rodent, odors, etc. — Yes___ No___
   b. properly cleaned and, when applicable, sprayed, fogged or fumigated — Yes___ No___
2. All incoming cars and/or trucks are inspected for evidence of contamination (insects, rodents, odors, etc): — Yes___ No___
   a. prior to unloading — Yes___ No___
   b. during unloading — Yes___ No___
3. Contaminated carriers:
   a. products are isolated and salvaged in best possible manner? — Yes___ No___
   b. Contaminated carriers fumigated? — Yes___ No___
4. Warehouse personnel can distinguish between cereal infesting insects and night flying insects. — Yes___ No___
5. Blacklight is available for detection of rodent urine stains — Yes___ No___
6. Whse, personnel know how to blacklight products — Yes___ No___
7. Whse, employees report evidence of rodent, birds, insects and/or odors to whse. management — Yes___ No___
8. Damaged product is removed from stacks and/or exposed product covered by taping — Yes___ No___
9. Damaged product is removed from whse. every two weeks or more often — Yes___ No___
10. Contaminated products handled in accordance with "Sanitation Instructions" — Yes___ No___

PEST CONTROL

1. Pest control company is employed to handle:
   a. rodent control — Yes___ No___
   b. bird control — Yes___ No___
   c. insect control — Yes___ No___

   Name of pest control company_____

   _____

   If answer to a., b., or c. is "no" explain

   _____

   _____

   _____

2. Rodent bait stations in use:
   a. on interior of warehouse — Yes___ No___
   b. on exterior of warehouse — Yes___ No___
3. Rodent bait stations properly maintained — Yes___ No___
   (if "no" explain) _____

   _____

4. Properly set and baited traps used in whse.: — Yes___ No___
   Type traps used: Ketch-All___, expanded trigger___, regular snap___.
5. Insecticide usage in whse.:
   a. fogging-frequency and by whom_____ — Yes___ No___

   _____

   b. spraying-frequency and by whom_____ — Yes___ No___

   _____

6. What insecticide is used:
   a. whse. fogging_____
   b. warehouse spraying_____
   c. boxcar spraying and/or fogging_____

   _____

7. Is record of pest control maintained:
   a. rodent control — Yes___ No___
   b. insect control — Yes___ No___

GENERAL

1. Whse. management makes regular whse, inspection (written) How often_____ — Yes___ No___
2. Current manual of sanitation instruction readily available — Yes___ No___
3. Understanding of and adherence to housekeeping and sanitation principles:
   a. employees — Yes___ No___
   b. management — Yes___ No___

RECOMMENDATIONS

Attachment V

GRAIN SANITATION WORKSHOP PARTICIPANTS

Shri A.N. Thite
Demonstrator
Department of Botany
Shivaji University,
Kolhapur, Maharashtra State

Shri M.R. Bajikar
c/o Pest Control (India) Ltd.,
10, Chowringhee Road
Calcutta 13 (W.B.)

Shri H. Satish
c/o Pest Control (India) Pvt. Ltd.,
F 47, N.D.S.E. Part I
Ring Road, New Delhi 49

Shri A.K. Shrivastav
S IX - 370
Ramakrishna Puram
New Delhi 22

Shri R.K. Chopra
J.7/53, Rajouri Gardens
New Delhi 27

Shri M. Vishakantaiah
Asst. Plant Protection Specialist (PP)
Directorate of Extension
University of Agricultural Sciences
Bangalore 24

Mr. P.S. Ramaseamy
Industrial Consultant
c/o Century Flour Mills Ltd.,
330, Thambu Chetty Street
P.O.B. 1558, Madras 1

Shri V.J. Sundaravadivelu
Scientific Assistant
Bureau of Nutrition
Directorate of Health Services
Bangalore 9

Shri K.S.R.K. Murthy
Senior Research Fellow
Dept. of Entomology
University of Udaipur
Jobner, Jaipur

Shri A.P. Kalia
Chemist
c/o Jawala Flour Mills
Amritsar

Shri Man Mohan Saran
Analyser, Central Grain Analysis
Laboratory
Min. of Food, Agri., CD & Cooperation
(Department of Food), Krishi Bhavan
New Delhi

Mr. Suresh S. Kulkarni
c/o Pest Control (India) Pvt. Ltd.,
Yusuf Building, Mahatma Gandhi Road
P.B.No. 1510, Bombay 1

Shri S.C. Bhardwaj
Dept. of Agric. Zoology and Entomology
College of Agriculture
University of Udaipur
Udaipur, Rajasthan

Shri A.S. Junnarkar
c/o The Wallace Flour Mills Co. Ltd.,
Hancock Bridge, Chinch Bunder
Bombay 9

Shri Narendra Kumar Jain
c/o Kishan Flour Mills
Railway Road
Meerut City (U.P.)

Miss Amrita H. Patel
Nutrition Officer
Quality Control Laboratory
Cattle Feed Factory,
Kanjari, Anand, Gujarat State.

Shri T.N. Parthasarathy
c/o Flour and Food Ltd.,
27, Mahatma Gandhi Road
Indore M.P.

Shri S. K. Kutty
c/o Dr. Sarup's Pest Control Pvt. Ltd.,
216/2A Lower Circular Road
Calcutta 17

Shri M.T. Santwani
Asst. Director (AFD)
Indian Standards Institution
9 Bahadur Shah Zafar Marg
New Delhi 1

Shri Goyal Ruli Chand
c/o Sahuwala Flour Mills
38, Strotten Muthia Mudali St.,
Madras 1.

Dr. N.S. Agrawal
Deputy Director (Storage & Inspection)
Ministry of Food & Agriculture
New Delhi

Mr. R. B. Rao
Pest Control (India) Pvt. Ltd.,
Madras

Mr. Anand Swaroop Goel
Pest Control A.S. Goel
Delhi

Mr. Harcharan Chawla
Pestirides Spray Co.
New Delhi