NATIONAL OPEN UNIVERSITY OF NIGERIA

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES

COURSE CODE: EHS 305

COURSE TITLE: GENERAL ENTOMOLOGY

COURSE GUIDE

EHS 305 GENERAL ENTOMOLOGY

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COURSE GUIDE

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INTRODUCTION

EHS 305 General Entomology is a two (3) unit course with three (3) modules which contains nine (9) units. This course provides an excellent background in general entomology, including the classification, anatomy, physiology, behavior, ecology, and evolution of insects. There is a large focus on how insects impact human life and ecological interactions between insects and other organisms across diverse ecosystems. The lab focuses on identifying common insects across all orders as well as developing skills in insect collecting, preservation, curation, and imaging. This course is useful for anyone considering a career in entomology, museum based careers, and for any student interested in taxonomy, biodiversity, systematics, evolution, insect morphology, and applied aspects of insect identification.

WHAT YOU WILL LEARN IN THIS COURSE

In this course, you have the course units and a course guide. The course guide will tell you what the course is all about. It is a general overview of the course materials you will be using and instructions on how to use those materials. It also helps you to allocate the appropriate time to each unit so that you can successfully complete the course within the stipulated time limit. The course guide also helps you to know how to go about your Tutor Marked Assignment (TMA) which will form part of your overall assessment at the end of the course. Also, there will be regular tutorial classes that are related to this course, where you can interact with your facilitator and other students. Please, I encourage you to attend these tutorial classes.

Course Aim

The overall aim of this course is to introduce you to general entomology, which is an important branch of environmental biology

Course Objectives

It is expected that at the end of this course, you should be able to:

- Classify and characterize insects with particular reference to vector diseases
- Describe insect ecology
    - Insect anatomy
    - Insect physiology
    - Insect environment and entomology
- Describe methods of insect control,
    - Biological methods of pest control
    - Chemical methods of pest control
    - Physical methods of pest control
- Understand the classes of insecticides, their formulation and application
- Appreciate the health implications of insect handling and safety methods
- Describe the insect sterilization techniques
- Understand the international conventions and policies on insecticide use

Working through this Course

The organization of this course takes cognizance of the fact that this might be the first time the student is being exposed to this specialized area. The subject is therefore

simplified and aided with many illustrations to enable the student understand the important concept and terminologies in the course. Efforts have been made to avoid unnecessary details, especially those meant for medical professionals who have been grounded in clinical sciences in order not to confuse the students. The distinct contents of the course would help deliver the knowledge and skills needed by the student to function effectively either in individual tasks or as a member of a public health team during meat inspection and abattoir management activities.

Although the course has been designed to support independent study, attending tutorial sessions and participating in the practical activities included in this course will greatly enhance understanding of concepts discussed, as it will avail the student the opportunity to seek clarifications on poorly understood sections. Studying the course resources and attending tutorial sessions and practical are therefore vital to enhancing not only student's grade but also their understanding and usability of the knowledge garnered from the course.

COURSE MATERIALS

The course materials are as listed below:

- The Study Guide
- Study Units
- Reference / Further Reading
- Assignments
- Presentation Schedule

STUDY UNITS

The study units in this course are outlined below:

MODULE 1 CLASSIFICATION AND CHARACTERIZATION OF INSECTS AND THEIR ECOLOGY

Unit 1: Introduction to Entomology and insect ecology
Unit 2: Importance of Insects and Taxonomy
Unit 3: Anatomy and physiology

MODULE 2 METHODS OF INSECT CONTROL AND INSECT STERILIZATION TECHNIQUES

Unit 1: Insect handling and biosafety methods
Unit 2: Methods of insect control
Unit 3: Insect sterilization techniques

MODULE 3 INSECTICIDE APPLICATIONS, PROTOCOLS AND USE

Unit 1: Insecticides (Classes and formation)
Unit 2: Insecticide protocol and application
Unit 3: Guidelines and regulations on use of insecticide

There are activities related to the lecture in each unit which will help your progress and comprehension of the unit. You are required to work on these exercises together with the TMAs to enable you achieve the objectives of each unit.

ASSIGNMENT FILE

There are two types of assessments in this course. First are the Tutor- Marked Assessments (TMAs); second is the written examination. In solving the questions in the assignments, you are expected to apply the information, knowledge and experience acquired during the course. The assignments must be submitted to your facilitator for formal assessment in accordance with prescribed deadlines stated in the assignment file.

The work you submit to your facilitator for assessment accounts for 30 percent of your total course mark. At the end of the course, you will be required to sit for a final examination of 1½ hours duration at your study center. This final examination will account for 70 % of your total course mark.

PRESENTATION SCHEDULE

There is a time-table prepared for the early and timely completion and submissions of your TMAs as well as attending the tutorial classes. You are required to submit all your assignments by the stipulated time and date. Avoid falling behind the schedule time.

ASSESSMENT

There are three aspects to the assessment of this course. The first one is the self-assessment exercises. The second is the tutor marked assignments and the third is the written examination or the examination to be taken at the end of the course. Do the exercises or activities in the unit by applying the information and knowledge you acquired during the course. The tutor-marked assignments must be submitted to your facilitator for formal assessment in accordance with the deadlines stated in the presentation schedule and the assignment file. The work submitted to your tutor for assessment will count for 30% of your total course work. At the end of this course, you have to sit for a final or end of course examination of about a three-hour duration which will count for 70% of your total course mark.

TUTOR-MARKED ASSIGNMENTS

This is the continuous assessment component of this course and it accounts for 30% of the total score. You will be given four (4) TMAs by your facilitator to answer. Three of which must be answered before you are allowed to sit for the end of course examination.

These answered assignments will be returned to your facilitator. You're expected to complete the assignments by using the information and material in your readings references and study units. Reading and researching into the references will give you a wider via point and give you a deeper understanding of the subject.

1. Make sure that each assignment reaches your facilitator on or before the deadline given in the presentation schedule and assignment file. If for any reason you are not able to complete your assignment, make sure you contact your facilitator before the assignment is due to discuss the possibility of an extension. Request for extension will not be granted after the due date unless there in exceptional circumstances.

2. Make sure you revise the whole course content before sitting or the examination. The self-assessment activities and TMAs will be useful for this purposes and if you have any comment please do before the examination. The end of course examination covers information from all parts of the course.

COURSE MARKING SCHEME

Assignments	Marks
Assignments 1 - 4	Four assignments, best three marks of the four count at 10% each = 30% of course marks
End of course examination	70% of overall course marks
Total	**100% of course materials**

Table 2: Course Organization

Unit	Title of Work	Weeks Activity	Assessment (End of Unit)
	Course Guide	Week	
1	Introduction to Entomology and insect ecology	Week 1	Assignment 1
2	Importance of Insects and Taxonomy	Week 2	Assignment 2
3	Anatomy and physiology	Week 3	Assignment 3
4	Insect handling and biosafety methods	Week 4	Assignment 4
5	Methods of insect control	Week 5	Assignment 5
6	Insect sterilization techniques	Week 6	Assignment 6
7	Insecticides (Classes and formation)	Week 7	Assignment 7
8	Insecticides (protocol and application)	Week 8	Assignment 8
9	Guidelines and regulations on use of insecticide	Week 9	Assignment 9

HOW TO GET THE MOST OUT OF THIS COURSE

In distance learning, the study units replace the university lecturer. This is one of the huge advantages of distance learning mode; you can read and work through specially designed study materials at your own pace and at a time and place that suit you best. Think of it as reading from the teacher, the study guide tells you what to read, when to read and the relevant texts to consult. You are provided exercises at appropriate points, just as a lecturer might give you an in-class exercise.

Each of the study units follows a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other units and the course as a whole. Next to this is a set of learning objectives. These learning objectives are meant to guide your studies. The moment a unit is finished, you must go back and check whether you have achieved the objectives. If this is made a habit, then you will significantly improve your chances of passing the course.

The main body of the units also guides you through the required readings from other sources. This will usually be either from a set book or from other sources.

Self-assessment exercises are provided throughout the unit, to aid personal studies and answers are provided at the end of the unit. Working through these self-tests will help you to achieve the objectives of the unit and also prepare you for tutor marked assignments and examinations. You should attempt each self-test as you encounter them in the units.

The following are practical strategies for working through this course

1. Read the Course Guide thoroughly.

2. Organize a study schedule. Refer to the course overview for more details. Note the time you are expected to spend on each unit and how the assignment relates to the units. Important details, e.g. details of your tutorials and the date of the first day of the semester are available. You need to gather together all these information in one place such as a diary, a wall chart calendar or an organizer. Whatever method you choose, you should decide on and write in your own dates for working on each unit.

3. Once you have created your own study schedule, do everything you can to stick to it. The major reason that students fail is that they get behind with their course works. If you get into difficulties with your schedule, please let your tutor know before it is too late for help.

4. Turn to Unit 1 and read the introduction and the objectives for the unit.

5. Assemble the study materials. Information about what you need for a unit is given in the table of contents at the beginning of each unit. You will almost always need both the study unit you are working on and one of the materials recommended for further readings, on your desk at the same time.

6. Work through the unit, the content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the unit, you will be encouraged to read from your set books.

7. Keep in mind that you will learn a lot by doing all your assignments carefully. They have been designed to help you meet the objectives of the course and will help you pass the examination.

8. Review the objectives of each study unit to confirm that you have achieved them. If you are not certain about any of the objectives, review the study material and consult your tutor.

9. When you are confident that you have achieved a unit's objectives, you can start on the next unit. Proceed unit by unit through the course and try to pace your study so that you can keep yourself on schedule.

10. When you have submitted an assignment to your tutor for marking, do not wait for its return before starting on the next unit. Keep to your schedule. When the assignment is returned, pay particular attention to your tutor's comments, both on the tutor-

marked assignment form and also that written on the assignment. Consult you tutor as soon as possible if you have any questions or problems.

11. After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in this course guide).

FACILITATORS/TUTORS AND TUTORIALS

Sixteen (16) hours are provided for tutorials for this course. You will be notified of the dates, times and location for these tutorial classes. As soon as you are allocated a tutorial group, the name and phone number of your facilitator will be given to you.

These are the duties of your facilitator: He or she will mark and comment on your assignment. He will monitor your progress and provide any necessary assistance you need. He or she will mark your TMAs and return to you as soon as possible. You are expected to mail your tutored assignment to your facilitator at least two days before the scheduled date.

Do not delay to contact your facilitator by telephone or e-mail for necessary assistance if you do not understand any part of the study in the course material. You have difficulty with the self-assessment activities. You have a problem or question with an assignment or with the grading of the assignment.

It is important and necessary you acted the tutorial classes because this is the only chance to have face to face content with your facilitator and to ask questions which will be answered instantly. It is also period where you can say any problem encountered in the course of your study.

FINAL EXAMINATION AND GRADING

The final examination for EHS 305: General Ecology will be of 1½ hours duration. This accounts for 70 % of the total course grade. The examination will consist of questions which reflect the practice, exercises and the tutor-marked assignments you have already attempted in the past. Note that all areas of the course will be assessed. To revise the entire course, you must start from the first unit to the ninth unit in order to get prepared for the examination. It may be useful to go over your TMAs and probably discuss with your course mates or group if need be. This will make you to be more prepared, since the examination covers information from all aspects of the course.

SUMMARY

Entomology is the study of insects. The study of insects includes their development, anatomy, physiology, life history, behavior, environment, and classification. An insect can be defined simply as a small, six-legged animal. Of the million kinds of animals that scientists have described and named, more than 800,000 are insects. Around 7,000 to 10,000 new kinds of insects are discovered every year. Insects live almost everywhere on earth – from steamy tropical jungles to cold polar regions, from snow-capped mountains to deserts below sea level.

In agriculture, insects are considered harmful and beneficial. Agriculture includes any field involved in growing crops for food and fiber, horticulture (fruits, flowers, and ornamental plants), forestry (managing forests, wood production, and wood products), and animal science (raising and caring for animals whether as pets or for food production). Insects are one of the chief competitors for food and fiber. Each year, insects cause millions of dollars in damage to field crops, vegetables, fruits, and fibers in all stages of growth, production, storage, processing, and distribution.

Insects are not just pests to our society. Many are beneficial to humans. Insects are an important part of the food chain. Birds and fish eat insects directly to survive. Many mammals and reptiles feed on insects as well. The indirect contribution can be seen in the work of bees. Not only do bees make honey, but they also play an important role in pollinating plants. Some insects are helpful to humans by preying on and destroying other insects that are considered harmful. Another example of useful insects is the silkworm, which makes a valuable fiber for clothing and other items. Besides their role in the agricultural fields, insects are very active in breaking down many of the substances in the environment. Many kinds of chemicals, minerals, and organic matter are broken down, recycled, and reused in the environment. Insects play an instrumental part in this degradation process, which is very important to the earth.

In medicine, insects can transmit diseases by many methods. Insects are a very important part of the research to find out about diseases. This includes animal and plant diseases as well as human diseases. Because insects reproduce so efficiently and can be handled so easily in large populations, they have been used extensively in genetic research. This contribution to science has provided researchers with a great wealth of knowledge about heredity, biological growth and development, and the causes and treatments of diseases.

Another large area of insect management is in building construction and maintenance. Knowledge of entomology is important when choosing the type of wood to be used in buildings and other structures. Termites cause much damage to wooden structures and building framing. Soil insects are an important consideration when constructing building foundations, roads, structural supports, and landscaping.

Insects are used in the research and development of many products used in society. Some of the most common products are cosmetics, shampoos, cleaning materials, food preservatives, manufacturing supplies, and medicines. Scientists devote much study to insects that affect plants or animals which are important to man. Scientists who specialize in studying insects are called entomologists. Entomologists are involved in a wide variety of professions, both directly and indirectly. Some careers require an extensive knowledge of entomology, while other careers only require a general knowledge of insects. Many of these career areas overlap one another. One specialty may be used in many different ways in many different fields.

Entomologists can be grouped by their area of insect study. Most professional entomologists are engaged in some branch of economic or applied entomology. This is a very broad category that describes the basic focus of these individuals. They not only want to control the numbers of insects, but to increase those insect populations

that are beneficial and to decrease those that are harmful to people's welfare. Economic and applied entomologists use the study of insects in a practical way. Other entomologists study insects solely to learn more about their life cycles and behaviors.

Review Questions
What is Entomology?
What are the fields in Entomology?
In what way does study of Entomology contribute to society?
In what other fields is the knowledge of Entomology useful?

At the end of this course it is expected that you would have acquired knowledge of Entomology to guide your understanding of insects, their anatomy, collection, control and insecticide use. Hopefully, you could develop interest in advancing yourself as an Entomologist especially as it relates to environmental issues.

We wish you good luck in this course.

MODULE 1 CLASSIFICATION AND CHARACTERIZATION OF INSECTS AND THEIR ECOLOGY

In this module you will study introduction to entomology, the various specialties in entomology, the professional areas that are enhanced by knowledge of entomology, characteristics and classification of entomology and the structure and physiology of insects. The module is made up of 3 units and several sub-units.

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Unit 1 INTRODUCTION TO ENTOMOLOGY AND INSECT ECOLOGY

Content

1.0: INTRODUCTION

This unit on introduction to entomology and insect ecology tells you more about what entomology is all about. What is an insect? An insect can be defined simply as a small, six-legged animal. Of the million kinds of animals that scientists have described and named, more than 800,000 are insects. Around 7,000 to 10,000 new kinds of insects are discovered every year. Insects live almost everywhere on earth – from steamy tropical jungles to cold Polar Regions, from snow-capped mountains to deserts below sea level.

The study of insects is called entomology. The study of insects includes their development, anatomy, physiology, life history, behavior, environment, and classification. Why should we spend time studying insects? Why is entomology important to us? Although some people may think that the study of insects is a small, isolated field, entomology is important to all of us because of the wide range of influence insects have in our lives. Their effect is both direct and indirect, both positive and negative. Entomology gives people a better understanding of the environment, biology, and the world in which they live. An understanding of entomology is also needed to reduce the extensive economic losses in crop damage and health problems caused by insects.

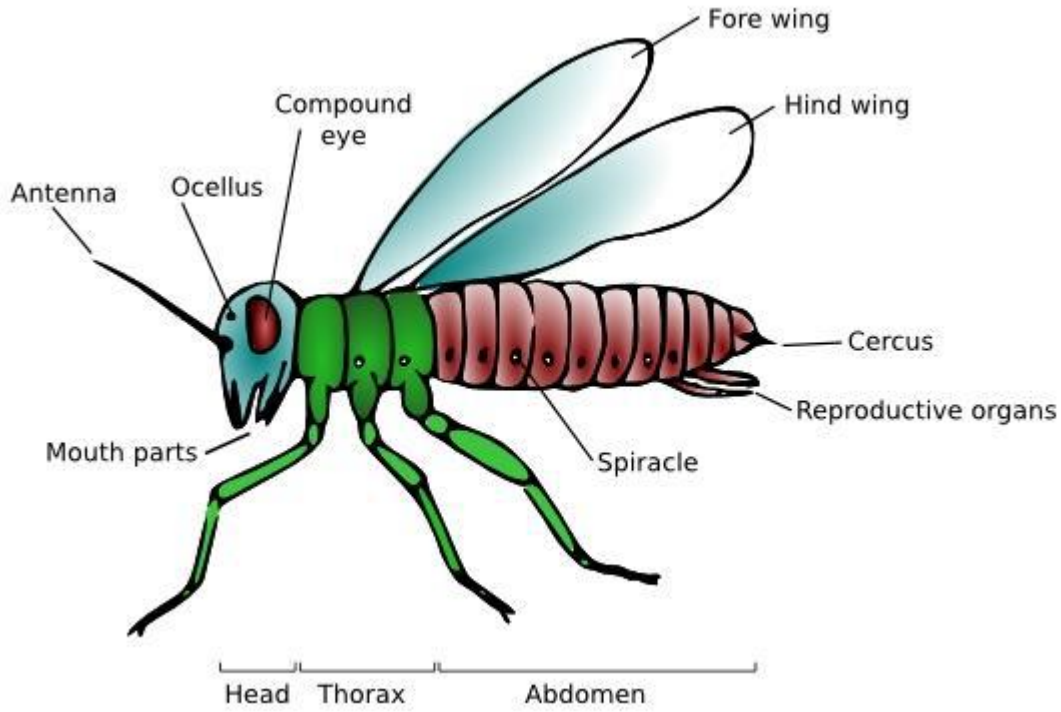

Fig. 1: Diagrammatic illustration of the parts of an insect (Janet Spenser, 2018)

2.0 OBJECTIVES

By the end of this unit, you will be able to: define Entomology and uses of insects, understand the various fields that make up entomology, where entomologists apply their expertise and various disciplines where knowledge of entomology is needed.

3.0 MAIN CONTENT

3.1: Uses of Insects

Agriculture: In agriculture, insects are considered harmful and beneficial. Agriculture includes any field involved in growing crops for food and fiber, horticulture (fruits, flowers, and ornamental plants), forestry (managing forests, wood production, and wood products), and animal science (raising and caring for animals whether as pets or for food production). Insects are one of the chief competitors for food and fiber. Each year insects cause millions of dollars in damage to field crops, vegetables, fruits, and fibers in all stages of growth, production, storage, processing, and distribution.

Insects (Fig. 1) are not just pests to our society. Many are beneficial to humans. Insects are an important part of the food chain. Birds and fish eat insects directly to survive. Many mammals and reptiles feed on insects as well. The indirect contribution can be seen in the work of bees. Not only do bees make honey, but they also play an important role in pollinating plants. Some insects are helpful to humans by preying on and destroying other insects that are considered harmful. Another example of useful insects is the silkworm, which makes a valuable fiber for clothing and other items.

Environmental sciences: Besides their role in the agricultural fields, insects are very active in breaking down many of the substances in the environment. Many kinds of chemicals, minerals, and organic matter are broken down, recycled, and reused in the

environment. Insects play an instrumental part in this degradation process, which is very important to the earth.

Medicine: Insects can transmit diseases by many methods. Insects are a very important part of research to find out about diseases. This includes animal and plant diseases as well as human diseases. Because insects reproduce so efficiently and can be handled so easily in large populations, they have been used extensively in genetic research. This contribution to science has provided researchers with a great wealth of knowledge about heredity, biological growth and development, and the causes and treatments of diseases.

Construction: Another large area of insect management is in building construction and maintenance. Knowledge of entomology is important when choosing the type of wood to be used in buildings and other structures. Termites cause much damage to wooden structures and building framing. Soil insects are an important consideration when constructing building foundations, roads, structural supports, and landscaping.

Product development: Insects are used in the research and development of many products used in society. Some of the most common products are cosmetics, shampoos, cleaning materials, food preservatives, manufacturing supplies, and medicines.

3.2: Careers in Entomology

Scientists devote much study to insects that affect plants or animals which are important to man. Scientists who specialize in studying insects are called entomologists. Entomologists are involved in a wide variety of professions, both directly and indirectly. Some careers require an extensive knowledge of entomology, while other careers only require a general knowledge of insects. Many of these career areas overlap one another. One specialty may be used in many different ways in many different fields.

Entomologists can be grouped by their area of insect study. Most professional entomologists are engaged in some branch of economic or applied entomology. This is a very broad category that describes the basic focus of these individuals. They not only want to control the numbers of insects, but to increase those insect populations that are beneficial and to decrease those that are harmful to people's welfare. Economic and applied entomologists use the study of insects in a practical way. Other entomologists study insects solely to learn more about their life cycles and behaviors.

Agricultural entomologists: Agricultural entomologists study insects that affect the production of foods and other agricultural products. These individuals work in areas of agriculture such as agronomy, animal science, horticulture, floriculture, forestry, and wood processing. Some of the careers as an agricultural entomologist may include

Crop scout – Scouts monitor crop fields and take samples of the types and quantities of insects present. This is important in determining the amount of potential damage which may be done by the insects. From this information, a producer is better able to select an appropriate insect management plan. Usually, attending a training program is

the minimum requirement for a scout. However, experience and education in entomology will enhance an opportunity for a better job in scouting.
Agricultural product dealer – Any background at all in entomology will help one as a product dealer. Dealers must keep up with a wide variety of agricultural products and how they work.

Entomology instructors: Individuals may teach entomology at elementary, secondary, and postsecondary levels. An individual can be an educator in many areas of specialization. Different training levels are required depending on the educational setting and student level. A doctoral degree is frequently needed to teach in a university. High school and vocational teachers need a bachelor's degree. Some states require that high school teachers be certified in pesticide application as well.

Medical and veterinary entomologists: These entomologists are concerned with insects that influence the health of humans and animals. It is largely through the efforts of these scientists that insecticides have been developed to protect crops and to reduce the incidence of insect-borne diseases. Jobs in this area generally require a graduate degree in the area of medical specialization. The degree may or may not be in entomology, but extensive college training in entomology is necessary. It is possible to become a research assistant, laboratory technician, or teaching assistant with a bachelor's degree or perhaps even a 2-year degree. There are a variety of choices and flexibility in this area.

Industrial entomologists: Individuals work in the research and manufacture of many types of products for industrial and domestic use. There are some jobs available for individuals with a high school diploma and some technical training. Many other jobs will require additional training. Knowledge of insects is useful in the testing and development of products. Examples of products are cosmetics, shampoos, cleaning materials, food products, industrial supplies, medicines, and insecticides. Many products contain insecticides as a preservative or as part of the chemical formulation.

Ecological entomologists: These entomologists are concerned with making regulations and enforcing the standards for protecting the environment, public health, and safety. Proper waste disposal and treatment are also included. Usually a bachelor's degree or higher is necessary.

Pest controller – Pest controllers evaluate insect populations and damage, recommend insect management programs, implement these programs, apply insecticides, and dispose of any chemicals. Home care, industrial insect management, and termite control are leading employers in this area. Depending on the particular job responsibilities, individuals may need little or much formal education. Certain types of insecticides require special certification.

Researcher – There are many options in research involving insects. Most university and industrial research positions require a doctoral degree. To be a research assistant, a laboratory technician, or field technician, individuals may need a master's degree, a bachelor's degree, or less depending on the place of employment and the

responsibilities of the position. Consultants may have any level of education, although a graduate degree is frequently required.
Forester– Forest entomologists specialize in studying insects that affect different woods and how to properly treat these woods. A bachelor's degree is usually necessary.

Greenhouse manager – Working in a greenhouse or any similar environment involves insect control. Some fruits and vegetables as well as flowers are grown and shipped to all parts of the country. A bachelor's degree or higher is standard at this management level. Technicians and assistants may be hired with fewer qualifications.

3.3: Career Areas Enhanced by Entomology

There are many careers that do not require a professional degree in entomology, but they are enhanced by a general or working knowledge about insects. The job will determine how much knowledge about insects is required. Some occupations may require special licensing, such as in pesticide application. Occupations that benefit from a working knowledge of entomology include landscaping and turf management, animal and human medical care, food science, and biological science.

Landscaping and turf management: This area involves the care and maintenance of landscaped areas. People in this area take care of lawns and ornamental plants at domestic homes, public grounds, parks, golf courses, etc. Generally, a bachelor's degree or higher is required to be a supervisor. Less education is needed to be a technician or assistant. The job requirements will vary greatly depending on the size of the operation and the responsibilities one has. The area of pest control greatly overlaps here. Workers may need to have a pesticide certification if they apply certain insecticides.

Animal and human medical care: Areas of animal and human health care enhanced by a working knowledge of insects include medical assistants, research assistants, field technicians, horse groomers, livestock workers, and pet shop workers.

Food science: This is a large area involving any aspect of handling food. This includes processing, preservation, storage, packaging, transportation, and distribution of food for people or animals. People involved in food science also work in the development of new foods and serving methods. They work in restaurants or cafeterias and as dieticians. Some individuals work with agencies concerned with the regulation and enforcement of food quality and health and safety standards.

Biological science: This area includes all aspects of agricultural, ecological, and environmental sciences. For example, a conservationist needs to understand how changes in the environment affect insect populations.

4.0 CONCLUSION

You have learned what Entomology and entomologist means and also the various uses of insects. You now understand the various fields that make up entomology, where entomologists apply their expertise and various disciplines where knowledge of entomology is needed.

5.0 Summary

In this unit entomology has been defined as the study of insects and this has a wide range of influence on human and animal lives and their environment. These influences could be positive or negative. Insects are used in various areas including agriculture, environmental science, medicine, construction, product development. Graduates of entomology could build their careers as agricultural entomologists, ecological entomologists, pest controllers, researchers, scientists, foresters and greenhouse managers. Entomology also have influence in other areas such as landscaping and turf management, animal and human medical care, food science, biological sciences etc.

6.0 TMA

1. What is an insect?
2. What areas does study of entomology have influence on?
3. Which career areas are available for entomologists to practice their expertise?

7.0 REFERENCES//FURTHER READING

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UNIT 2: IMPORTANCE OF INSECTS AND TAXONOMY

CONTENT

1.0 INTRODUCTION

This unit teaches the importance of insects and their taxonomy. The various methods for collection and handling of insects are discussed. We also enumerated the different orders that make up the insects kingdom.

2.0 OBJECTIVES

By the end of this unit, you will be able to understand the importance of insects; the different methods applied to collect and preserve insects for studies. You will also learn the different orders which constitute insect kingdom.

3.0 MAIN CONTENT

3.1 Insect Collection, arrangement and care

Insect Collection

Making an insect collection is an ideal way to learn about insects. It opens the doors to the world in which these small creatures live. The collector is able to discover things about insects that he or she may not get from books. It allows insects which are very different to be studied and compared at the same time. Collecting insects is a very interesting hobby as well. Constructing an insect collection is not difficult, but it does require some care and time. There are certain steps and procedures that need to be followed when preparing insects for display. Some standard guidelines are given here.

Collecting Insects

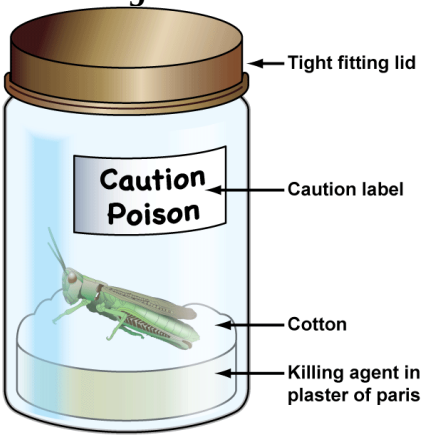

Fig. 2: A sample of a killing jar (source: dese.mo.gov)

Preparing a killing jar: A killing jar is required to enable collection of insects are collected and it could be prepared or purchased. Insects should be killed in a killing jar (Fig. 2) as soon as possible after they are collected. Therefore, the killing jar should be taken along when collecting insects. Killing jars or bottles can either be made or purchased. Wide-mouth jars (6 to 16 oz. size) with airtight lids are the most common. An alternative is to carry a large test tube or slender bottle with a cork or stopper in it. The insects are killed later.

Ethyl acetate, which acts as a fumigant, can be used in making killing jar. It can be obtained from biological or chemical supply companies. It is much safer than other types of killing agents. The ethyl acetate type of killing jar can be made easily by following the procedure listed below.

1. Make a thick mixture of plaster of Paris and water.
2. Pour the mixture into a clean jar to a height of about 1 inch (20–30 millimeters). Allow it to air dry at room temperature (this requires several days) or under low heat (light bulb or lowest oven temperature).

3. When completely dry, add enough ethyl acetate to saturate the plaster of Paris. With the lid on, let it stand for a few minutes. Then, pour back any excess liquid and replace the lid. There should not be any standing liquid. Be careful not to breathe the ethyl acetate fumes.

4. Place enough cotton to cover the plaster of Paris. The insect should not come into direct contact with the plaster of Paris.

5. Tape can be placed on the bottom and lower sides of the jar to reduce the chance of breakage.

6. Label the jar “poison.”

7. Ethyl acetate must be reapplied to the plaster of Paris after several hours of collecting insects depending on how often and for how long the lid was removed. The lid should always be left on unless the collector is actually placing an insect in or removing one from the jar.

Locating insects: Insects can be found almost anywhere in the world. The more places you look; the more kinds of insects you are likely to find. Insects are commonly found in flower and vegetable gardens, grasses in lawns and fields, weeds, bushes, aquatic plants, fruit and shade trees, and animals.

Many insects can be found hiding in plants. Look between the petals in flowers and inside the stem. Leaf damage may indicate the presence of insects. If the stem has holes swellings, or a dead portion, it should be split to locate larvae living there. Soil insects, which feed on roots, are often found near or inside roots. Decaying fruits, nuts, vegetables, bark, logs, and wood piles are homes of many insects. Check tree holes that are filled with water for mosquito larvae and other insects.

Flying insects enjoy sunny, calm days. Certain flies, winged ants, and termites swarm in the spring and fall, especially when it is warm and sunny after rain. Use a net to catch flying insects, or check the radiator or front grill of a car for usable specimens. Certain insects may be found beneath or on top of the water. Mud along water shorelines is also the hiding place for many insects. Like plants on land, water plants are also homes for several kinds of insects.

A lot of insects may be hiding in garden topsoil, mulch, compost piles, and forest litter. To find certain soil insects, dig down about 6 inches under grasses and in garden soil. Since insects are almost everywhere, there are many other places to find them. Outside areas like under stones, logs, plant debris, and picnic trash bins are homes of insects. Household pests may be found in garages, basements, and food storage areas. Parasitic insects live in bird feathers and animal skin and fur. Some insects are not present during the day, but may be found at night.

Collection Arrangement and Care

Once the insects are collected, preserved, pinned, and labeled, they need to be kept in an orderly and safe way. There is no exact way to organize an insect collection. The way the insects are arranged will depend on the size of the collection, the types of insects collected, and the preference of the individual. Whatever way it is done, the collection should be neat and orderly, and the insects easily seen. Specimens are kept in some sort of display for study and storage. There are several different kinds of mounting displays. These mounting containers can be bought at a local supply store or handmade.

Mounting box: The most common type of display for pinned insects is a mounting box. The box is made of wood or heavy cardboard. Boxes can be any size but usually measure about 9 x 12 x 3 inches and have a tight fitting lid. The bottom is lined with a material that is sturdy enough to securely support the pins but soft enough to easily insert the pins. These materials are usually sheet cork, balsa wood, Styrofoam, or corrugated cardboard.

Riker mounting: The Riker mount is a box with one piece of glass on the top. The box is filled with cotton and the insects are mounted on the cotton just under the glass. A small depression is made in the cotton before putting in a thick-bodied insect. Insects in a Riker mount can be seen easily and the mounts handled without damaging the samples. However, only one side of the specimen can be seen. Also, some insects, such as moths, tend to fade after a lot of exposure to the light.

Glass mount: The glass mount is another kind of display. This type has two pieces of glass, one on the top side and one on the bottom side of the box. The size and the materials used for glass mounts are similar to Riker mounts. Glass mounts contain no cotton. This makes it possible to see both sides of an insect specimen. Each glass mount contains only a few insects. They are relatively inexpensive and provide a safe, attractive method for storing and displaying insects.

Plastic mount: Plastic mounts are made of two sheets of thick plastic. The insect is mounted between the plastic. Then, the edges are sealed with acetone or tape. An alternative type of plastic mount is made by embedding an insect in a block of plastic. This is a very involved process, but the end product is very attractive, durable, and permanent.

Slide mount: Insects or parts of insects can be studied in detail by mounting them on slides. Small insects, insects that shrivel up when dried, and soft bodied insects are commonly mounted on slides. Also, parts of insects such as the wings, mouth parts, genitalia, legs, and antennae are mounted on slides for further study. Some specimens have areas that are dark colored. Usually these areas are treated before mounting. The treatment removes some of the dark coloring so that it can be seen well. Samples are mounted on microscope slides using different chemicals. These chemicals have different functions. More information on the purposes of these chemicals can be found in technical books on the subject.
Insect collections need to be protected from beetles and other pests that can attack and damage the specimens. Collections should be examined regularly for signs of damage. Special pest repellents can be bought to treat collections. For a box display, the repellent can be placed in a small pillbox or wrapped in a piece of cloth. It is then placed securely in one corner of the box. For Riker mounts, the repellent can be placed underneath the cotton. Specimens sealed in glass mounts or in plastic need to be treated with repellent before the mount is sealed.

Insect specimens are very brittle when they are dry. They always need to be handled with care. Otherwise, the legs, antennae, wings, and other parts may be broken off. However, if parts do get broken off, use glue or cement to replace them.

3.2 Insect Classification

In order to identify each type of animal, the animal kingdom is divided into many groups. Insects belong to one of the basic divisions of the animal kingdom called Arthropoda. This division also includes centipedes, crabs, lobsters, scorpions, and spiders. Arthropoda is divided into several classes. Insects make up the class Insecta. Insecta is a Latin word that can be broken down into its basic meanings: in = “into” and sect = “cut.” An insect is identified by its segmented body. This class is further divided into orders of insects. The different orders are determined by certain characteristics, such as wing structure, mouth parts, and life cycle. Presently, entomologists agree on 29 orders of insects.

Orders are further divided and sub-divided into other groups. Each of these groups becomes more and more specific until, at last, each insect species can be identified by its own name. Each insect is identified by a scientific name. This name has two parts: the genus name (written capitalized) followed by the species name (written lower case). The genus is like a person’s last name, or family name. The species is like a person’s first name. Insects may also have common names. Insects’ common names would be like nicknames. For example, a person may have his name listed as “Doe, Jonathan,” but his friends call him Johnny. An insect may have the scientific name “Romalea microptera,” but is commonly called a grasshopper.

When learning scientific names, it is very helpful to find out what the name means. This often gives a clue to some part of the insect's life and makes it easier to remember. It is impossible to memorize all the insects and their classification. Books such as field guides or insect keys should be kept close at hand and referred to often. Insect guides contain information such as a description of the insect, distinguishing features of the order, how different insects are related to one another, and the lifestyle and environment of the insect. Each guide is a little different so the introduction on how to use the book should always be read first. Beginners are advised to select a guide that has many clear pictures or drawings. The various parts of the insects should be clearly identified and labeled.

3.3 The Insect Orders

The 29 orders and a brief description of each are summarized in the following paragraphs. The summaries include the scientific name, the meaning of the name, the common name, the number of species in each order, the type of metamorphosis, the type of mouth parts, and the main characteristics that distinguish each order.

1. Collembola • "glue peg" • springtails • 1,500 species • no metamorphosis • chewing mouth parts, withdrawn into head • wingless; long antennae; reduced compound eyes or none; most species can jump using a forked springing organ on the abdomen

2. Protura • "first tail" • Proturans • 170 species • no metamorphosis • piercing-sucking or chewing mouth parts, withdrawn into head • wingless; no eyes; only insects with no antennae; front legs carried upright like antennae and used to sense touch

3. Diplura • "double tail" • campodeids, japygids • 660 species • no metamorphosis • chewing mouth parts, withdrawn into head • wingless; long, slender antennae; no eyes or small eyes shaped like a slit

4. Thysanura • "tassel tail" • bristletails, silver fish • 350 species • no metamorphosis • chewing mouth parts • wingless; long, slender antennae; compound eyes reduced or absent; usually scaly body; two or three bristlelike tails; run swiftly or jump when disturbed

5. Ephemeroptera • "short-lived, wings" • mayflies • 1,000 species • incomplete metamorphosis • chewing mouth parts • usually two pairs of membranous wings that are held flat over body when at rest, hind wings much smaller than front wings; very short antennae; large eyes; two or three long tails; adults do not eat and die soon

6. Odonata • "toothed" • damselflies, dragonflies • 5,000 species • incomplete metamorphosis • chewing mouth parts • two pairs of equal-sized, transparent, and membranous wings that cannot be folded; very small antennae; huge eyes; strong fliers; cannot walk, but legs used to catch prey in air; mate in flight

7. Dermaptera • "skin wings" • earwigs • 1,200 species • incomplete metamorphosis • chewing mouth parts • wingless or two pairs of wings: front wings short and leathery,

hind wings large and membranous, folded under front wings when at rest; forceps on abdomen

8. Grylloblattodea • “cricket cockroach” • rock crawlers, icebugs • 12 species • incomplete metamorphosis • chewing mouth parts • wingless; legs adapted for running; small eyes are long and segmented; antennae are long; live in low-temperature places; active at night; rare
9. Isoptera • “equal wings” • termites • 2,000 species • incomplete metamorphosis • chewing mouth parts • two pairs of similar, membranous wings held flat over the body when at rest; wings shed after mating flight; workers and soldiers are wingless

10. Dictyoptera • “net wings” • cockroaches and mantids • 5,300 species • incomplete metamorphosis • chewing mouth parts • front wings are thick and hind wings are membranous and folded; have short wings or are wingless, fly poorly

11. Phasmida • “phantom” • walking stick or leaf • 2,000 species • incomplete metamorphosis • chewing mouth parts • slow-mowing; some are wingless and look like sticks; wings and legs of others look like broad leaves; can change color

12. Orthoptera • “straight wings” • crickets, locusts, grasshoppers • 20,000 species • incomplete metamorphosis • chewing mouth parts • two pairs of wings: front wings narrow and leathery, hind wings are broad and membranous and folded under front wings when at rest; medium to long antennae; some species wingless, some species make shrill creaking sounds by rubbing special body structures together

13. Embioptera • “lively wings” • web spinners • 140 species • incomplete metamorphosis • chewing mouth parts • females and some males are wingless, most males have two pairs of membranous wings; front legs have organs for spinning silk

14. Plecoptera • “pleated wings” • stone flies • 1,300 species • incomplete metamorphosis • chewing mouth parts • two pairs of membranous wings: folded flat over body when at rest, hind wings larger than front wings; long antennae; small eyes

15. Zoraptera • “pure, wingless” • zorapterans • 16 species • incomplete metamorphosis • chewing mouth parts • have four wings or are wingless: wings have few veins, adults break off wings; compound eyes and small eyes; thread-like, segmented antennae- rare.

16. Psocoptera • “gnawing wings” • bark lice, book lice • 1,700 species • incomplete metamorphosis • piercing-sucking mouth parts • two pairs of membranous wings: roofed over back when at rest, front wings larger than hind wings, some species are wingless.

17. Mallophaga • “to eat wool” • chewing lice • 2,675 species • incomplete metamorphosis • chewing mouth parts • wingless; have reduced eyes or no eyes; parasites of birds and a few mammals, feed on feathers, hair and skin.

18. Anoplura • “unarmed tail” • sucking lice • 2,900 species • incomplete metamorphosis • piercingsucking mouth parts • wingless; short antennae; have reduced eyes or no eyes; parasites that suck the blood of mammals.

19. Thysanoptera • “fringe wings” • thrips • 4,500 species • incomplete or complete metamorphosis • chewing mouth parts • two pairs of wings fringed with long hairs and fold flat over body when at rest, some species are wingless; short antennae; females of many species can reproduce without mating; males are unknown in some species

20. a) Hemiptera • “half wings” • true bugs, chinch bugs • 28,000 species • incomplete metamorphosis • piercing-sucking mouth parts • two pairs of wings: bases of front wings are thick and leathery, hind wings are membranous and fold under front wings when at rest, some species are wingless

b) Homoptera • “same wings” • aphids, cicadas • 32,000 species • incomplete or complete metamorphosis • chewing mouth parts • wingless or one or two pairs of membranous wings, roofed over body when at rest; females of some species can reproduce without mating

21. Neuroptera • “nerve wings” • ant lions, lacewings, alderflies, and dobson flies • 4,500 species • complete metamorphosis • piercing-sucking mouth parts, sucking parts are shaped like a coiled tube when not in use • two pairs of wings: similar, membranous, covered with many vein’s, and roofed over body when at rest; long, slender antennae; larvae and adults are predatory

22. Coleoptera • “sheath wings” • beetles • 350,000 species • complete metamorphosis • chewing or chewing-lapping mouth parts • two pairs of wings: front wings modified into thick, horny wing covers, hind wings membranous and fold under the front wings when at rest, some species are wingless

23. Strepsiptera • “twisted wings” • strepsipterans • 300 species • complete metamorphosis • piercingsucking mouth parts • males have one pair of membranous hind wings, front wings are reduced to clublike parts; females do not have antennae, eyes, wings, or legs; they live in other insects

24. Mecoptera • “long wings” • scorpion flies • 300 species • complete metamorphosis • reduced chewing mouth parts • two pairs of long, slender, and membranous wings, laid flat or roofed over the body when at rest, some species are wingless; long, slender antennae; large eyes; long legs; tip of abdomen of some males are curved like a scorpion’s tail

25. Siphonaptera • “tube, wingless” • fleas • 1,000 species • complete metamorphosis • reduced chewing mouth parts • wingless; body flattened from side to side; simple or no eyes; long hind legs for jumping; parasites that suck blood of birds and mammals

26. Diptera • “two wings” • flies, mosquitoes • 70,000 species • complete metamorphosis • chewing mouth parts • front wings transparent, hind wings replaced by short, knobbed structures; large eyes

27. Trichoptera • “hair wings” • caddis flies • 3,000 species • complete metamorphosis • piercing, sucking or sponging mouth parts • two pairs of hairy, membranous wings, roofed over the body when at rest; long antennae; larvae live in cases of silk and debris near or on water; adults eat little

28. Lepidoptera • “scale wings” • butterflies, moths • 165,000 species • complete metamorphosis • piercing-sucking mouth parts • two pairs of scaly, usually broad, wings, front wings are usually larger than hind wings; long antennae; large eyes
29. Hymenoptera • “membrane wings” • ants, bees, wasps • 110,000 species • complete metamorphosis • chewing or chewing-sucking mouth parts • two pairs of wings: small, stiff, and membranous, interlock during flight, front wings are larger than hind wings, worker ants and a few other insects are wingless

4.0 CONCLUSION

You have learned the importance of insects and their taxonomy. The various methods for collection, handling and killing of insects for the purpose of studying them were also handled. Different orders that make up the insects kingdom, their characteristics and examples were also discussed. However, for particulate images of insects in different orders please consult books, reference materials and also engage in further reading.

5.0 SUMMARY

In this unit making an insect collection has been shown to be an ideal way to learn about insects. It allows insects that are very different to be studied and compared at the same time. Constructing an insect collection involves making a killing jar and locating, preserving, pinning, mounting, labeling, and arranging the insects. The proper techniques should always be followed when making an insect collection. When properly done, a collection can last a very long time. An insect collection is a great adventure into the world of insects. Insects are identified and classified according to common characteristics. Features commonly used are the wings, body shape, mouth parts, and type of metamorphosis. Insects are grouped into 29 orders based on these characteristics. Insect identification guides or keys are very helpful references. They contain a systematic way of finding a great variety of information on many types of insects.

6.0 TUTOR-MARKED ASSIGNMENT

1. State the methods of insect collection.
2. State the procedure for making an insect killing jar.
3. Describe ten (10) insect orders.

7.0 REFERENCES/FURTHER READING

Bland, R.G. How to Know the Insects. Dubuque, IA: Wm. C. Brown Company Publishers, 1978.

Borror, D.J., and R.E. White. A Field Guide to the Insects. Boston, MA: Houghton Mifflin Company, 1970.

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The Random House Encyclopedia. New York: Random House, Inc., 1977.

UNIT 3: ANATOMY AND PHYSIOLOGY OF INSECTS

CONTENTS

1.0 Introduction

In Lesson 2, information on where to look for insects, how to collect them, and how to prepare specimens for a collection were presented. We also discussed the classification of insects. The next step is to learn the details of insects' bodies, the distinguishing features of each order, and how insects are divided into groups.

2.0 OBJECTIVES

By the end of this unit, you will be able to distinguish the different segments of an insect and what they contain. The different developmental stages of insects will also be discussed

3.0 MAIN CONTENT

3.1 Distinguishing Characteristics of an Insect

What exactly is an insect? In Lesson 1, an insect was defined as a small six-legged animal. In this lesson, an insect will be more clearly defined. What determines which animals are put into this class and which are not? There are certain characteristics which set insects apart from other animals. An insect is a small animal without a backbone that has the following external characteristics as an adult.

A hardened external skeleton three distinct body regions: head, thorax, and abdomen; one pair of segmented antennae, three pairs of segmented legs on the thorax segment, one pair of compound eyes (some insects have no eyes) and one or two pairs of wings (some adults are wingless).

Before becoming adults, insects are called immatures. The shape of immatures depends on the species. The best way to study and identify insects is to look at the three main body sections: the head, thorax, and abdomen.

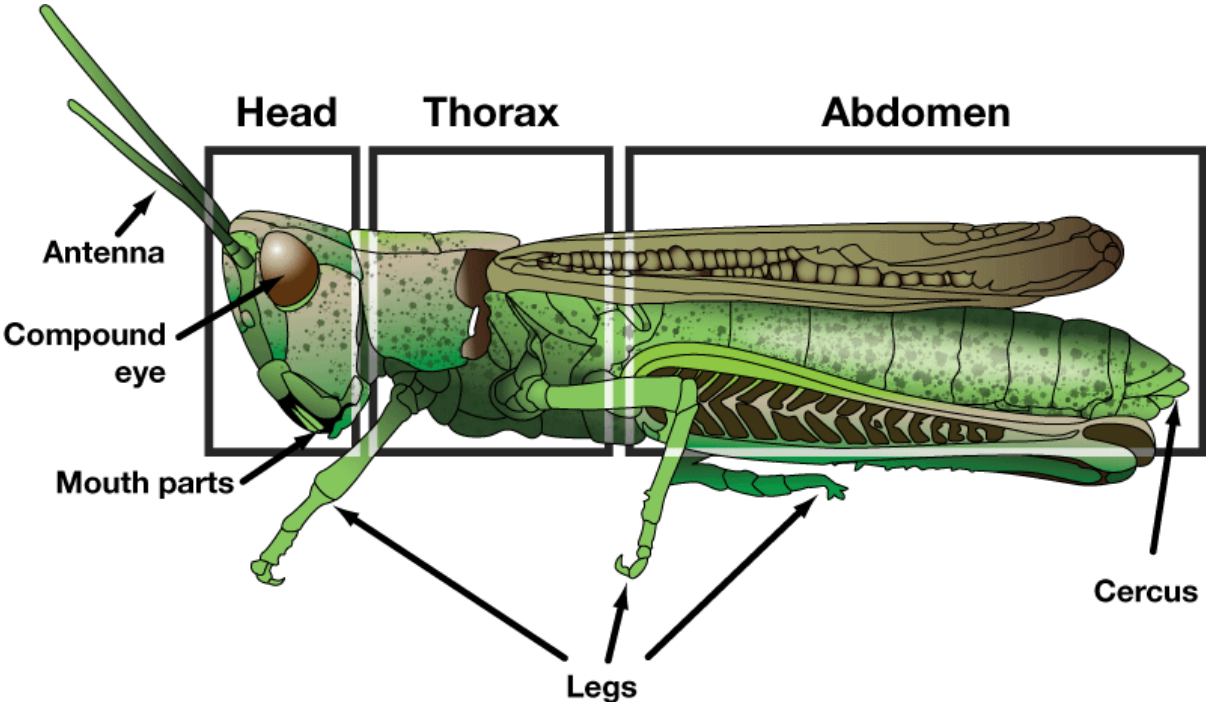

Fig 3. The anatomical sections of an insect

3.2 The Three Main Sections of an Insect

Head: The head is the hardened region at the front of the body, which includes the eyes, antennae, and mouth parts (Fig. 3). There are two types of eyes. Simple eyes are small eyes located on top of the head of adults. Compound eyes are the large eyes found on most adult insects. These eyes contain a few to several thousand individual eye units. Often insects can only see light and dark areas and cannot see objects distinctly.

Insects have one pair of antennae. Antennae are two long, jointed feelers that grow from the insect's head. Antennae are flexible and come in a variety of shapes. Antennae function as sensors to detect the odor, sound, taste, and feel of the surrounding environment. The mouth parts are also in the head region. Chewing and piercing sucking are the two main types of mouth parts. Some insects will have a modification or adaptation of these. Mouth parts determine how the insect feeds.

Chewing mouth parts are strong, curbed, and toothed. They are used for chewing, cutting, crushing, or grinding. Chewing mouth parts crush hard seeds and tear food into pieces. Mouth parts may have other functions as well. Chewing jaws can be used like scissors or tongs. They can also dig like little shovels or plow like tiny bulldozers. Some insects use their strong jaws to squeeze their enemies to death or to cut off their heads. Piercing sucking mouth parts are long and needle-like for piercing leaf surfaces or skin. Special sucking structures suck up the fluids. Examples of mouth parts that are a variation of chewing and piercing sucking are rasping lapping, reduced chewing, chewing sucking, and sponging. How these are used depending on the particular insect species.

Thorax: The thorax is the second section of an insect's body (Fig. 3). This section contains the nerve centers and muscles that control the insect's movement. Wings and

legs are attached to the thorax. Insects have three pairs of legs. Each leg has five parts, although sometimes the parts are hard to see. The legs come in many forms depending on their functions, such as running, jumping, grasping, or swimming.
Adult insects may not have wings. There is a great variety in the shape, size, color, thickness, and vein pattern of insect wings. The shape of the wings and the pattern of the veins are used widely in identification.

Abdomen: The abdomen is the third section of an insect's body (Fig.3). It may be visible or hidden underneath the wings. This section contains the internal organs of the insect. It is the location of the stomach and intestines, where food is digested and absorbed. There is also a place that is used to store food and to carry it back to the nest for other insects. The sexual organs are in the abdomen as well. The abdomen has glands that secrete different types of fluids, such as liquids that mark their trails or drive enemies away. This section may also have a needle-like projection for piercing or stinging.

3.3: Life Stages of Insects

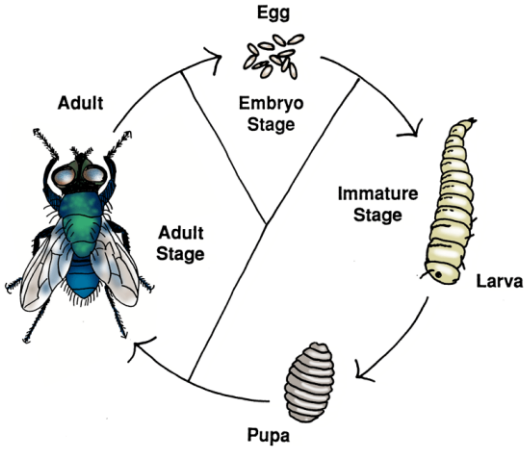

Fig. 4: diagram of the life stages of an insect (source: dese.mo.gov)

The development of insects refers to growth in size and changes in form. There are three stages of development for every insect: the embryo stage, the immature stage, and the adult stage (Fig. 4). Insects begin life as an egg. Insects may lay a few to many thousand eggs at a time. The insect lives as an embryo within the egg. The egg is well supplied with a nutritious yolk and surrounded by a delicate outer shell. It may take days, weeks, or months for the insect to hatch. After hatching, the little insect continues to feed and grow through several more stages until it reaches the adult stage.

After the insect hatches, it is called an immature. The life of an immature insect is divided into growth stages called instars. During each instar, the insect changes in form and size. As the insect grows, it forms an outer layer to protect its body from the environment. This layer is hard and rigid. When the insect grows too big to continue living in this hard layer, it begins to break out of it. The older layer is shed and a new outer layer is formed. The process of shedding the old layer is called molting. The most dramatic changes in the growth and form of an insect are seen when the insect molts.

Insects go through a series of instar growth, molting, instar growth, molting, etc. This continues until it becomes an adult insect. The entire process of development is called metamorphosis. Most insects go through one of two basic types of metamorphosis, incomplete and complete. There are a few primitive species of insects that do not go through metamorphosis at all.

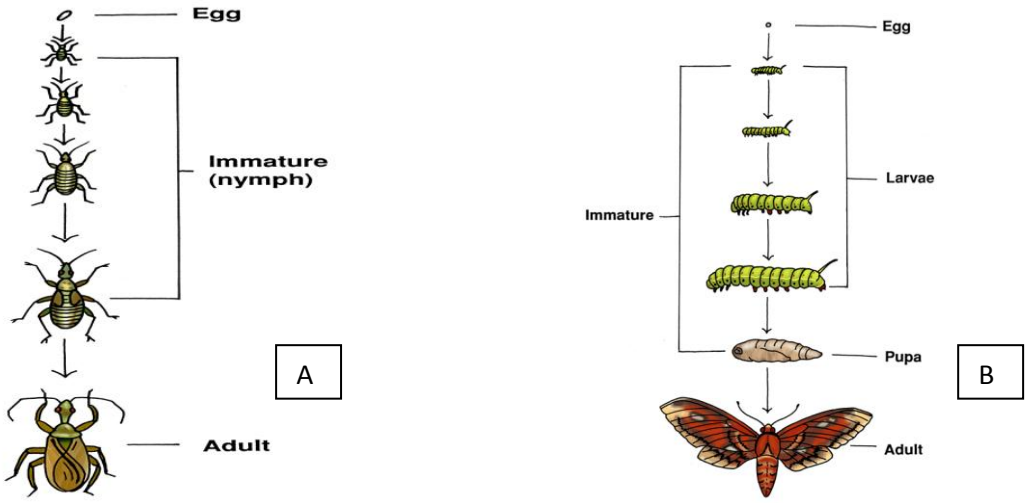

Fig. 5: Different stages of insect metamorphosis. (A) incomplete and (B) complete (source: dese.mo.gov)

Incomplete metamorphosis is the first type of insect development (Fig. 5A). The immature insects look like the adults but only smaller. The immature insects of incomplete metamorphoses are called nymphs. The changes are mainly an increase in size and the development of wings and sexual organs. Nymphs usually eat the same type of food as the adults. Examples of insects having incomplete metamorphoses are the grasshopper, thrip, stink bug, leafhopper, and aphid.

The second type of insect development is complete metamorphosis (Fig. 5B). These insects do not look like the adults when in the immature stage. The immature insects of complete metamorphoses are called larvae. Larvae are small, white forms that do not have eyes or legs. They do have a head and mouth parts. Examples of insects having complete metamorphoses are the lady beetle, weevil, fly, and moth. Insects with complete metamorphoses have also one additional stage of development called the pupa. When the larva becomes mature, it sheds its skin (or molts) one more time and emerges as a pupa. The pupa is shaped like an insect with the legs and antennae folded against its body. The larvae of some insects surround themselves with a cocoon just before they molt and emerge as pupas.

Although it does not eat and barely moves, great changes take place in the body of the pupa. Most of the structural changes take place during the pupa stage. The adult's digestive system and reproductive system are fully formed. The adult's wings, legs, antennae, and mouth parts develop completely. When the adult's body is completely formed, the insect breaks out of the outer, pupal skin. If there is one, the cocoon is left at the same time. Other insects may help the young one break out.

When the insect first emerges as an adult, the wings are crumpled and the body is soft. Within minutes to hours, the adult's body dries, hardens, and develops color. The wings expand as air blows between them and their structure becomes more rigid. The adult starts its normal life. Depending on the species, adults may live from 1 hour to 20 years. In general, adults live only a few weeks.

4.0 CONCLUSION

You have learned the different anatomical parts of an insect and also the developmental stages.

5.0 SUMMARY

In this unit you were informed that the body of an insects is made up of three parts which includes the head, thorax and abdomen. The head carries the antennae which has the sensory for odour, sound, taste and feel. The mouth parts also found in the head are used for chewing and piercing. The thorax is the nerve centre of the insect and has the legs and wings attached to it. The abdomen carries the internal organs of the insect and the sex organs. The insect has a three life stages which includes he embryo, immature and adult stages.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe the different segments of an insect.
2. Describe the different life stages of an insect
3. State the difference between the two types of insect metamorphosis

7.0 REFERENCES/FURTHER READING

Bland, R.G. How to Know the Insects. Dubuque, IA: Wm. C. Brown Company Publishers, 1978.

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MODULE 2 METHODS OF INSECT CONTROL AND INSECT STERILIZATION TECHNIQUES

Unit 1: Insect handling and biosafety methods
Unit 2: Methods of insect control
Unit 3: Insect sterilization techniques

UNIT 1: INSECT HANDLING AND BIOSAFETY METHODS

CONTENTS

1.0 INTRODUCTION

This unit on insect handling and biosafety methods involved in handling insects. You will be learning different methods involved in handling insects.

2.0 OBJECTIVES

By the end of this unit, you will know how to handle insects which includes catching, killing, pinning and preserving insects.

3.0 MAIN CONTENT

3.1 Catching, Killing and Preserving Insects

Catching insects: The simplest way to catch insects is by hand. Place them in a killing jar or container. Gloves are recommended for catching insects. Many beginners may be hesitant to reach out and grab an insect because they are afraid that it might bite or sting. Although this is a common fear, it is not very likely to occur with most insects. Insects which bite do so by moving their jaws sideways and pinching, or by piercing with their beak. Actually, there are very few pinching insects capable of causing pain or breaking skin. Most biting insects cannot bite if they are grasped firmly by the sides of their body. Insects which sting do this by using a structure located at the back end of their body. Only female bees, wasps, and some ants can sting.

A net, envelopes, small boxes, forceps, a hand lens, flash lights, and killing jars are useful when gathering insects. A net is used by swinging it at insects as they go by or swinging it through vegetation or along the surface of water. To prevent the insect from escaping, quickly turn the net handle so that the bag folds over the rim. Insects should be removed from the net as gently and carefully as possible to prevent damage.

To remove insects from the net, you can;
1. Remove them directly by gently grasping them with fingers or a tool,

2. Insert a box or bottle into the net and ease the insect into this container, or
3. Work the insect into a fold in the net and place this fold into a killing jar to stun the insect directly. If the insect is one that stings, it can be worked into a fold in the net and stunned by pinching the thorax before removal.

Killing insects: Place insects immediately into the killing jar after they are captured. If the killing jar is in use, the insects can be placed into another container with a lid. It is important to kill the insects as soon as possible so that they do not damage their body parts.

Preserving insects: Specimens are kept in killing jars until it is time to preserve them. Most insects are normally preserved by "pinning." Pinning is a way to mount and preserve insects indefinitely. Insects should be pinned immediately after they are killed. Otherwise, they become very brittle after drying and can easily break if mounted later. Soft-bodied insects, larvae, and nymphs need to be preserved in liquid. The bodies of these insects will shrivel when dried. The most common liquid used for killing and preserving these insects is an alcohol solution.

Another method for preserving insects is to keep them in envelopes. This works best for insects that have relatively slender and fragile bodies, such as dragonflies, damselflies, and crane flies. Using envelopes saves a lot of space and protects these types of insects better than mounting on pins. Envelopes can be made of paper or plastic. Label information is either written on the outside of the envelope or written on a piece of paper and placed inside the envelope.

3.2 Labeling and Pinning of insects

Labeling of insects: Locality and ecological labels: Labeling is a very important part of an insect collection. The information should be accurate and written clearly. Without data a specimen is useless. The first label, which is the locality label, must include the date when the insect was found and the place where it was caught. It may include the collector's name. A second label, called the ecological label, may be used. The ecological label would contain information or observations about the insect's environment or habitat.

These labels are made of fairly stiff white paper. They are about 1/4 by 3/4 inches or smaller in size. The labels are mounted on the pin at the proper heights and parallel with the insect (or point). The insects and labels could be mounted using a pinning block at the following marks: insects at the 1-inch mark, locality labels at the 5/8-inch mark, and ecological labels at the 3/8-inch mark. They can be mounted so that they are read from either the right or left. Just make sure that all labels are read from the same direction. This helps keep the collection neat and orderly. For specimens mounted on microscope slides, the information is written on a slide label.

Identification labels: An insect collection should contain some identification labels. Specimens in a collection should be arranged into groups according to insect orders. One label is used to identify each group. If the insects are labeled to the scientific level of species, an identification label is used for each individual specimen. A piece of paper about an inch square is used for the identification label. This is placed alongside a group of insects or at the base of the pin for individual insects. These

types of labels contain the order of the group of insects or the scientific name of the insect, the name of the person identifying it, and the month and year when the identification was made.

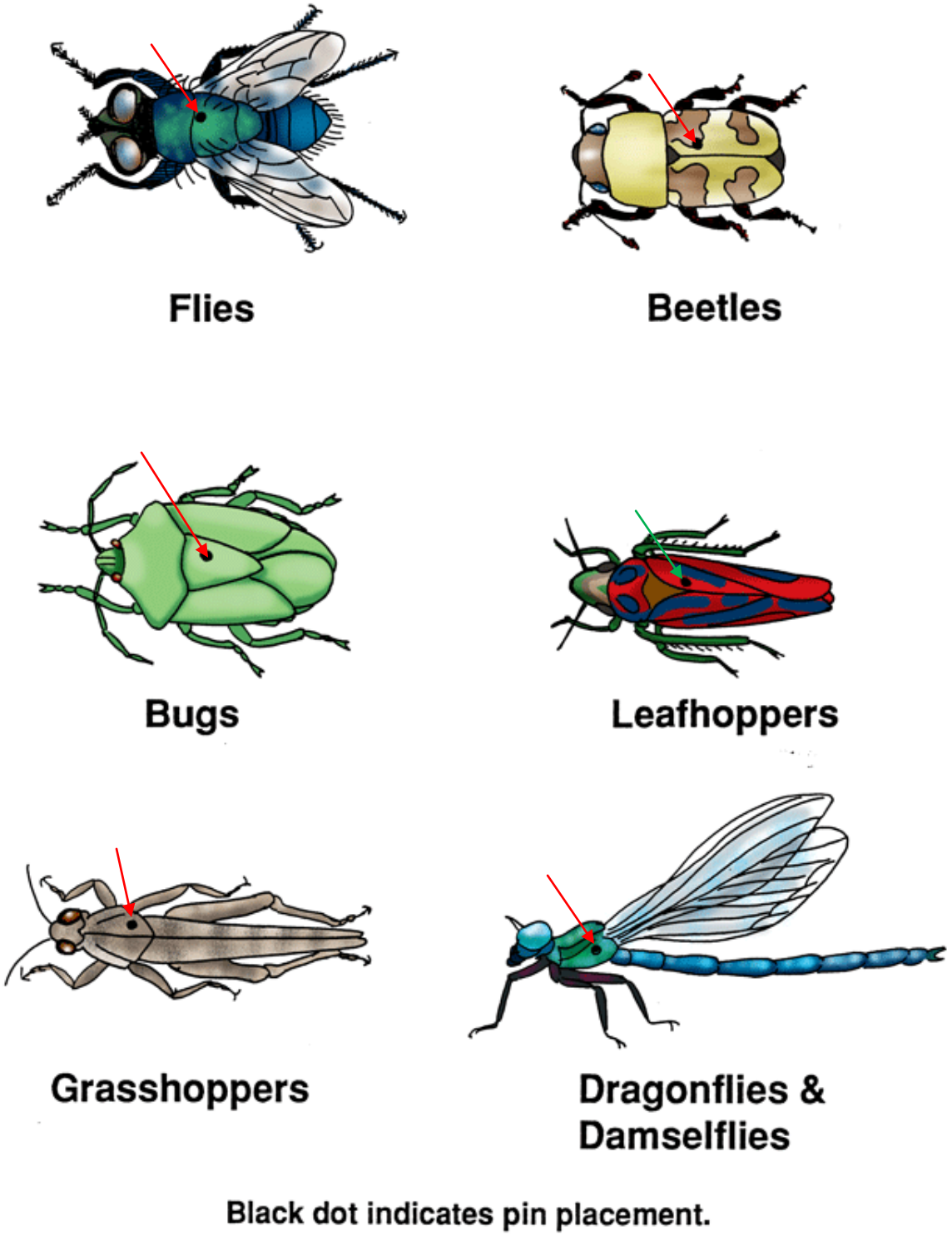

Fig. 6: Image showing pinning position for some insects (source: dese.mo.gov)

Pinning of insects

A special system has been developed for pinning insects. The procedures should be followed as closely as possible. Pinning is done with special insect pins, pins which are made especially for this purpose. They are sold in several sizes. The most common are Number 1 (very thin), Number 2 (thin), and Number 3 (thick, for larger insects).

The simplest way to handle an insect for pinning is to hold the insect between the thumb and forefinger of one hand and insert the pin with the other hand.

Different insect types are pinned in different places (Fig. 6). Most insects are pinned through the thorax vertically. Beetles and hoppers are pinned through the front part of the right wing. Make sure the pin does not damage a leg as it comes through on the underside of the body. True bugs are pinned through the scutellum, if they are large enough. The scutellum is the triangular area between the bases of the wings. Otherwise, they are pinned like beetles through the right wing. Grasshoppers and crickets are pinned through the thorax between the bases of the front wings and just to the right of the midline.

Dragonflies and damselflies can be pinned in two ways. The best way is to pin them sideways. The left side should face up with the wings together above the body. The pin goes through the thorax below the wing bases. If the wings are not together when the insect is removed from the killing jar, place the specimen in an envelope with the wings together above the body for a day or two. The specimen is ready to pin when it has dried enough for the wings to stay in position. The other way is to pin the insect through the thorax with the wings placed horizontally.

When mounted, all of the insects and labels on pins should be the same height. The easiest way to do this is to use a pinning block. A pinning block is usually made of wood. The block can be shaped as a solid rectangle or like stair steps. Holes are drilled to 1, 5/8, and 3/8 inches in depth. The following procedure should be followed when using a pinning block.
1. After placing a specimen on a pin, insert the pin in the 1-inch hole.
2. Then, add the first label and insert the pin in the 5/8-inch hole.
3. Finally, add the second label, if there is one, and insert the pin in the 3/8-inch hole.

Pinned specimens can be temporarily stored on a sheet of cork, balsa wood, or other soft material until placement into the collection.
The abdomen of some insects, such as dragonflies, may sag when pinned. One of the following techniques can be used to prevent this. The insects should be allowed to dry completely before they are placed in the collection.
1. Stick the pinned insect onto a vertical surface with the abdomen hanging down.
2. Place a small piece of cardboard on the pin just under the insect so that the abdomen is supported.
3. Insert two pins so that they cross under the abdomen. They will support the sagging abdomen.

Some insects may be too small to put a pin through. These are usually mounted on a small triangular piece of cardboard called a point. Points are about 3/8 inch (8 millimeters) long and 3/16 inch (3– 4 millimeters) wide at the base. The insect is glued to the tip of the triangle and the pin is put through the wide base. The entire setup is then mounted on the block as described before. Be careful to glue the insect so that the body parts you want to examine are not hidden. The suggested way is to glue the insect on the right side with the head facing away from the pin. A household cement or glue should be used.

3.3 Spreading Butterflies and Moths

For most insects, the exact position of the legs and wings is not generally important as long as all of the body parts can be seen. Insects such as butterflies and moths need to have their wings spread before being put into the collection. Insects can be spread on a spreading board or on a flat surface. To "spread" an insect on a spreading board follow the steps below. If a spreading board is not available, spread the specimen upside-down on a flat surface.

Step 1: Hold the specimen by grasping it by the thorax, the middle section of an insect. Holding it right side up, insert a pin through the middle of the thorax. Move it to the 1-inch position on the pin. The pinned specimen is then lowered onto the spreading board. The pin should go into, and maybe even through, the bottom of the groove. Push the pin through the board until the underside of the wings is even with the top piece of the spreading board. Pin narrow strips of paper over the wings on each side.

Step 2: Remove the pin on one side at the lower end of the strip of paper. Raise the front wing until the rear edge is at a right angle to the body. Forceps, a pin, or some other tool may be helpful in doing this. Be careful not to tear or puncture the wing. When the wing is in place, insert a pin through the strip of paper just in front of the tip of the wing. Pin the lower edge of the paper strip back into place.

Step 3: Repeat this procedure with the other front wing.

Step 4: Use forceps, a pin, or some other tool to raise the hind wing on one side until the space between the two wings is reduced. The front and hind wings of theses insects will overlap at the base with the front edge of the hind wing under the rear edge of the front wing. Move the pin in the lower part of the paper strip until it is just below the tip of the hind wing.

Step 5: Repeat this procedure with the hind wing on the other side.

Step 6: Now, position the antennae so that they appear balanced. Put pins alongside of the antennae to hold them in place.

Step 7: Fasten the legs close to the body at right angles to the body. This is done by placing a strip of paper across the entire body.

After spreading the wings, the insect is left in position until it dries. How long it takes the insect to dry completely depends on the size of the insect, the temperature, and makes it possible to see both sides of an insect specimen. Each glass mount contains only a few insects. They are relatively inexpensive and provide a safe, attractive method for storing and displaying insects.

Plastic mount: Plastic mounts are made of two sheets of thick plastic. The insect is mounted between the plastic. Then, the edges are sealed with acetone or tape. An alternative type of plastic mount is made by embedding an insect in a block of plastic.

This is a very involved process, but the end product is very attractive, durable, and permanent.

Slide mount: Insects or parts of insects can be studied in detail by mounting them on slides. Small insects, insects that shrivel up when dried, and soft bodied insects are commonly mounted on slides. Also, parts of insects such as the wings, mouth parts, genitalia, legs, and antennae are mounted on slides for further study. Some specimens have areas that are dark colored. Usually these areas are treated before mounting. The treatment removes some of the dark coloring so that it can be seen well. Samples are mounted on microscope slides using different chemicals. These chemicals have different functions. More information on the purposes of these chemicals can be found in technical books on the subject.

Insect collections need to be protected from beetles and other pests that can attack and damage the specimens. Collections should be examined regularly for signs of damage. Special pest repellents can be bought to treat collections. For a box display, the repellent can be placed in a small pillbox or wrapped in a piece of cloth. It is then placed securely in one corner of the box. For Riker mounts, the repellent can be placed underneath the cotton. Specimens sealed in glass mounts or in plastic need to be treated with repellent before the mount is sealed.

Insect specimens are very brittle when they are dry. They always need to be handled with care. Otherwise, the legs, antennae, wings, and other parts may be broken off. However, if parts do get broken off, use glue or cement to replace them.
A large butterfly may take several days at room temperature or an hour with heat. Ovens or electric lamps are used as sources of heat. A specimen is dry when the abdomen is stiff when gently touched with a pin. If the abdomen is still flexible, the insect is not dry enough.

4.0 CONCLUSION

You have learned the handling methods for insects and the mounting, pinning and preservation methods for ease of studying insects

5.0 SUMMARY

In this unit handling insects has been shown to be very vital to the study of Entomology. To understand the features of an insect or to confirm the species of a pest, catching an insect is necessary. This could involve grabbing the insect with hand, net, envelope, boxes etc and killing the insect in a jar. The insect is then preserved, pinned, spread, mounted and labeled appropriately.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe the procedures for preserving and labeling an insect
2. Describe the procedures for pinning an insect.
3. Describe the steps involved in spreading butterflies.

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UNIT 2: METHODS OF CONTROL OF INSECTS

CONTENTS

1.0 INTRODUCTION

In this unit on methods of control of insects, you will learn that insects can be controlled by several different methods. Each of these methods has its own advantages and disadvantages. The methods of control are grouped as biological, cultural, physical and mechanical, and chemical. Usually, an effective insect control program uses a combination of methods, depending on the needs of the individual.

2.0 OBJECTIVES

By the end of this unit, you will be able to understand how to control insects especially pests and the various methods that can be employed to adequately control pests.

3.0 MAIN CONTENT

3.1 Biological and Cultural Control of Insects

Biological Control of Insects: The biological control of pests is the oldest control method available. All creatures in nature have natural enemies that repel, kill, and consume them. If these natural enemies were not here, the world would be overrun with insects. Biological control is the use of naturally occurring bacteria, diseases, fungi, viruses, insects, nematodes, birds, fish, toads and frogs, lizards, snakes, rodents, weeds, and others to control insects.

These methods require that the individual has an extensive knowledge about the insect's life cycle, habitat, and response to environmental conditions. Individual insect types cannot be selectively controlled. Biological control requires a lot of time to become effective and then may be only partially effective. It also requires a knowledge of how the environment will be affected by any particular method. The effects on the environment cannot be very well predicted. Although not all biological control methods are costly, they can be very expensive and labor intensive. At this time, these methods are not practical for commercial agriculture. There are four general areas of biological control.

Natural enemies of the insect: This involves selectively increasing the population of the enemies that destroy a particular insect. Insects, such as the ladybug and the praying mantis, are valued because they prey upon a variety of insects that are

considered harmful to producers. This method can also involve releasing a virus or disease that infects and kills a particular insect.
Resistant plant varieties: Plant varieties resistant to insect attacks are developed both in nature and through research programs. These host plants are resistant to insects and diseases.

Crop rotations: Crop rotation is an effective biological control method that is used against certain insects. It involves rotating the type of crop grown in a particular spot so that the same crop is not grown year after year. By changing the host species and the environment, insects are less able to build up their populations. Crop rotation is especially effective where insects are not very mobile. This method works because it disrupts the life cycle of the insect and the alternate crop is not suitable for the insect's growth and development.

Sterilization: Radiation or chemicals can be used to sterilize or to genetically alter insects so that they cannot reproduce. These insects can be released into the environment. The particular insect population is then reduced, because it cannot reproduce. This method seems promising but is not yet practical for normal field conditions.

Cultural control of insects: Cultural control is the management of insect populations by modifying the environment. A thorough knowledge of the insect's life cycle, habitat, and response to the environment is essential for these practices to be successful. Usually, the goal is the make the environment less attractive or agreeable for insects by using standard agricultural practices. These methods are based on disrupting the physical conditions that favor insect life. It is essential to know which conditions to disturb and when to disturb them.

Cultural control methods are only partially effective and individual insect types cannot be selected out. These methods do not require special machinery or equipment and most are not labor intensive. Common cultural methods include tillage, crop rotation, sanitation, timing of harvesting and planting, and water management.

Tillage: How the soil is prepared affects the temperature, moisture, and physical conditions of the soil. Insects may be killed directly by tillage or indirectly. Insects brought to the surface are unprotected and can easily die due to exposure or from being eaten. Often, immature insects living in the soil are killed before they can complete their life cycle.

Crop rotation: This is considered a means of cultural control as well as biological control.

Sanitation: This means removing weeds or crop residues where insects might live. Weeds may attract insects that spread to crop plants. Also, weeds and crop residues may keep insects alive between crop plantings. Plowing under or shredding weeds and crop residues can reduce many insect problems.

Timing of harvest and planting: Insects may be active in large numbers only for a brief period of the season. If it is possible, time the planting and harvesting of crops so that crops are not growing when insects are most active.
Water management: Many insects depend on water or soil moisture for proper growth and development. Regulating water sources can help control insects.

3.2 Physical and Mechanical Control of Insects
The goal of physical and mechanical control methods is to destroy insects directly or to modify the environment so that it is unsuitable for insect pests. Physical methods destroy insects by using the physical properties of the environment. Mechanical methods require machinery or manual operations to destroy insects. Often these methods are used together. These methods are different from cultural methods because special equipment or operations are used in addition to regular agricultural practices.

Physical and mechanical methods can give immediate and noticeable results. However, they may be expensive and labor intensive. Also, they are only partially effective. There is limited application in commercial agriculture and large field operations. A good knowledge of the insect's life cycle and habitat is necessary when using these techniques. Determining the type of physical and mechanical control methods that can be used depends on how an insect respond to temperature, humidity, odors, and light. Physical and mechanical control methods include cold storage of fruits and vegetables, applying heat, flooding insects out with a wash, treating agricultural products with protective gases, burning crop stubble and field edges, and insect traps used with an attractant (such as roach motels, or sticky insect strips).
Physical control refers to non-chemical, non-biological methods that destroy pests or make the environment unsuitable for the entry or survival of pests. Most of these control methods may be classified as passive (e.g. fences, trenches, traps, inert dusts, and oils) or active (e.g. mechanical, impact, and thermal treatments). Physical control measures generally are limited to confined environments such as glasshouses, food storage structures (e.g. silos), and domestic premises, although certain methods, such as exclusion barriers or trenches, can be employed in fields of crops. The best-known mechanical method of pest control are the domestic fly swatter and the sifting and separating procedure used in flour mills to remove insects. An obvious method is physical exclusion such as packaging of food products, semi-hermetic sealing of grain silos, or provision of mesh screens on glasshouses. In addition, products may be treated or stored under controlled conditions of temperature (low or high), atmospheric gas composition (e.g. low oxygen or high carbon dioxide), or low relative humidity, which can kill or reduce reproduction of insect pests. Ionizing radiation can be used as a quarantine treatment for insects inside exported fruit, and hot-water immersion of mangoes has been used to kill immature tephritid fruit flies. The use of certain physical control methods are increasing and often replacing methyl bromide (also called bromomethane), which is used as a fumigant for many stored and exported products, but is meant to be phased out because it depletes ozone in the atmosphere. Traps that use long-wave ultraviolet light (e.g. "insect-o-cutors" or "zappers" that lure flying insects towards an electrified metal grid) or adhesive surfaces can be effective in domestic or food retail buildings or in glasshouses, but should not be used outdoors because of the likelihood of catching native or introduced beneficial insects. In one study designed to catch insect using electric traps in

suburban yards in the USA showed that insects from more than a hundred non-target families were killed. About half of the insects caught were non-biting aquatic insects with over 13% being predators and parasites. Only about 0.2% was the target nuisance biting flies.

3.3 Chemical Control of Insects

This section will focus on chemical insect control. The purpose of insect control is to reduce the damage that can result from insect pest activity. Most producers want a level of control that is effective as well as economical. Chemical control is the most widely used type of insect control because it is direct, very effective, target specific, usually economical, practical for commercial production, and easy to buy and apply.

Chemical control primarily involves the use of insecticides. Chemical insecticides work very quickly and effectively. Insect control can be managed better with chemicals than any of the other methods. Insecticides can be extremely dangerous to people, animals, and the environment, if they are not applied properly. They may destroy beneficial insects as well as harmful ones, but it is possible to control a particular insect without harming other beneficial insects, humans, plants, or animals. Some harmful insects develop a resistance to insecticides after a few generations, thus causing the insecticide to be useless in their control. Only a general knowledge of the insect's life cycle, habitat, and response to the environment is needed. Chemical control is usually not labor intensive.

Chemical control is a common part of insect management. It is important to know how to work safely with these materials. When using any type of pesticide, it is very important to always read and follow instructions in the label exactly. Although the following information applies to any kind of pesticide, this lesson will be referring specifically to insecticides.

The insecticide label: The insecticide label contains important information. Always read and follow the label directions exactly. It is unlawful to use an insecticide in any manner or for any other purpose than those specified on its label. By reading the label, the individual will be able to determine the type of insecticide being used, the target insects, application techniques, the effects of the product on different plants and insects, the toxicity level, signal words, safety guidelines, disposal methods, and first aid procedures.

4.0 CONCLUSION

You have learned the different methods used to control insects in various operational areas.

5.0 SUMMARY

Insect control is very important in our society. There are several different methods for controlling insects. These control methods are classed as biological, cultural, chemical, and physical and mechanical. Each of these methods has its own advantages and limitations. Usually, an effective insect control program uses a combination of the methods, depending on the needs of the individual.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe crop rotation as a biological method and cultural method of pest control.
2. Describe physical method of pest control.
3. Discuss the chemical methods of controlling insects in a farm.

7.0 REFERENCES/FURTHER READING

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UNIT 3: INSECT STERILIZATION TECHNIQUES

CONTENTS

1.0 INTRODUCTION

There are many alternatives to pesticides when it comes to protecting crops from pests. One alternative way that stands out from the rest is called the Sterile Insect Technique (SIT). The SIT is used in situations, where one specific, insect is overwhelming a crop. The females of the insects are the ones who cause the damage to the crops by laying eggs in them. The SIT was developed to extinguish the problem of the female insects before they can lay their eggs and harm the crop. SIT is used by first using X-ray radiation to sterilize the male insects so they are not able to produce. Once the male insects are sterilized, they are then released in a large number to go out and mate with their female counterparts who are causing damage to the crops. Once the males are released and mate with the females, the females will not be able to reproduce, and thus will eventually die, not enlarging the population. If the females are only able to mate with sterile males, then the population will diminish and the targeted specie of insect may even cease to exist in the specific area where the sterile males were released.

2.0 OBJECTIVES

By the end of this unit, you will learn the method of control of insects through sterilization of male insects and releasing them to mate with females

3.0 MAIN CONTENT

3.1 Chemical Sterilization

Chemical sterilization of insects involves the use of a compound to render insects sterile. This has been recommended as the method of choice to sterilize insects. In practice, only the late developmental stages and adult stage are suitable for chemosterilization. Some chemsterilants are species specific and could require optimization for other insects. In most cases only minimal sterilizing dose of the chemical must be applied and as uniformly as possible to a large number of insects by a safe and economically acceptable procedure. The dose must not kill the insects or change their mating behavior. The compound must not be toxic and hazardous to the environment. The insect must be free from the residues or may carry only a tolerable amount of it.

Some examples of chemosterilants includes:

1. Triethylenephosphoramide
2. Busulfan
3. Mechlorethamine
4. Aminopterin
5. 5-Fluorouracil
6. Hexametapol
7. Benzeneboronic acid
8. Captothecin
9. Anthramycin
10. hexamethylmelamine

chemosterilants are best used in low insect density populations. While irradiation has been associated with loss of fitness for the males, chemosterilisation can deliver insects with effective fitness required. One drawback to chemical sterilization is the issue of toxicity and environmental pollution but recent research have developed chemosterilants capable of addressing these issues.

3.2 Sterilization by Ionizing Radiation

Exposing the insects to ionizing radiation is the current method of choice, when it comes to sterilizing insects so they may no longer produce. Isotopic sources such as cobalt-60 or cesium-137 are used to produce gamma radiation for sterilizing the insects. X-rays and high energy elections are other useful ways in which insects may be exposed to radiation. The most important factor when radiating insects for sterilization, is the amount of radiation that is absorbed by the insect. This factor is extremely important, and must be controlled very closely, in order for the insects to be unable to reproduce, but still be strong enough to mate and compete with other wild insects. Insects range when it comes to the amount of radiation that is absorbed by each particular insect. The range is from as little as below 5 Gy all the way up to and some even beyond 300 Gy. Each insect species has its own Gy value that is needed in order for it to be sterilized, what is tricky is that factors such as the age or the oxygen levels of the insect come into play when determining how radiation each insect species will absorb.

Ionizing radiation or chemosterilants induce chromosomal aberrations and abnormalities in subsequent nuclear divisions. The exposed germ cells produce viable sperms or ova with dominant lethal mutations. Timing and dose of the treatment determines the relative effect on both germ and somatic cells. Timing and dose can be controlled in order to maximize the effect without affecting sperm motility, concomitantly minimizing the effect on survival, motility, mating ability and competitiveness of the treated insects. The desired outcome is an insect that searches and finds mates, copulates and transfers sperm successfully. As the sperm is defective, such fertilized eggs fail to develop.

Insect sterilization by irradiation has been the most developed, cost effective and widely used sterile insect technique but has some limitations. Irradiation may require precision which could be time consuming and expert dependent. There is also the issue of loss of fitness associated with irradiation making the released males not able to compete with unsterilized ones in mating the females.

3.3 Effectivity of Male Sterilization

Sterile insect technique (SIT) seems to be more effective when only sterile males are released for the following reasons:

1. Males are more efficient carriers of the sterility trait, as they often copulate more than once, whereas females may be restricted in the number of their matings.
2. When only males are released, assortative mating amongst the laboratory-reared insects can be avoided, increasing the exploitation of the sterile sperm.
3. When no females are released, males disperse more rapidly in the native (wild) population.
4. Female insects might damage crops even if they are sterile, as they could cause oviposition wounds.
5. Rearing only males reduces the cost of mass-rearing, provided females can be eliminated early during the rearing process.

SIT has successfully been used to eradicate tse tse flies in Zanzibar; Aedes mosquitos in Caymans Island and Brazil; Cattle screw worm in North and Central America; fruit flies from Mexico, Chile, Peru, Isreal, South Africa, Spain, Croatia and Argentina. It has also been used to control Codling moth in Canada and Onion flies in the Netherlands.

4.0 CONCLUSION

You have learned the methods of control of insects by sterilization which involves two main methods –the use of irradiation and chemosterilants. The strengths and drawbacks of both methods were highlighted.

5.0 SUMMARY

In this unit you have learnt that one alternative to the use of pesticides in the control of insects is the application of sterile insect technique, to stop the female insects that are responsible for destruction of crops from multiplying, the males are made sterile principally by radiation use of chemosterilants and released back to the field. Without mating, the females cannot lay eggs thereby reducing destruction of crops and reduction of the population of inseccts.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is SIT and how is it achieved?
2. Why is the sterilization of male insects more effective than that of females?
3. What are the limitations associated with sterilization of insects by irradiation?

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MODULE 3 INSECTICIDE APPLICATIONS, PROTOCOLS AND USE
Unit 1: Insecticides (Classes and formation)
Unit 2: Insecticide protocol and application
Unit 3: Guidelines and regulations on use of insecticide

UNIT 1: INSECTICIDES (CLASSES AND FORMATION)

CONTENTS

1.0 Introduction
Insecticides are agents that are specifically made for controlling insects. The term pesticide is a general term for insecticides used to kill any pests. They are designed to kill, control, or prevent pests from causing damage. A pest can be any living thing that competes with humans for food and fiber, or that attacks people directly.

Insects are considered pests when they compete with humans for food and fiber, or attack people directly. Insects are pests when they feed on leaves; tunnel or bore in stems, stalks, and branches; feed on and tunnel in roots; suck the sap from leaves, stems, roots, fruits, and flowers; carry plant and animal diseases or disease agents; feed on and/or feed in seeds and nuts; and feed on and/or feed in humans and animals.

2.0 Objectives
At the end of this unit you would have learnt about insecticides. The different types of insecticides, modes of action and formations will be discussed.

3.0 Main content

3.1 Types of Pesticide
Pesticides are classified by the types of pests they are designed to control. The pest for which a pesticide is intended is called the target pest. Any type of pesticide may effectively control pests other than the desired target group. Most pesticides can kill organisms that are biologically similar to the target pest as well as the target pest. For example, insecticides may kill beneficial insects as well as pest insects.

Table 1: Types of pesticides and their target pest (source: dese.mo.gov)

Type of Pesticide	Target Pest
Acaricide	mites, ticks

Avicide	birds
Bactericide	bacteria
Fungicide	fungi
Herbicide	weeds
Insecticide	insects
Miticide	mites
Molluscicide	snails, slugs
Nematicide	nematodes
Piscicide	fish
Rodenticide	rodents (rats, mice)

3.2 Mode of Action of Pesticides

Pesticides function in different ways. Attractants attract pests. Repellents keep pests away. Desiccants and defoliants remove or kill leaves and stems. Plant growth regulators stop, speed up, or otherwise change normal plant processes. How a pesticide works is called the mode of action. Common modes of action for insecticides are given below.

Contacts – Once an insect comes into contact with a contact poison, it dies.

Systemics – Systemics are applied to the animal or plant on which the insects are feeding. Once the insects feed on the treated host, they die.

Fumigants – Fumigants are gases that kill when they are inhaled or otherwise absorbed by the insect.

Protectants – Once applied to plants, animals, structures, and/or products, protectants prevent entry or damage by insects.

Sterilants – Sterilants make insects unable to reproduce.

Selective insecticides – Selective insecticides kill a particular type of insect without harming other insects.

Growth regulators – Growth regulators prevent immature insects from reaching adulthood.

Biologicals – Living microorganisms, such as viruses, bacteria, and fungi, are applied to a host to cause a disease in the insect feeding on that host.

3.3 Chemical insecticides

Chemical insecticides are usually classified by how they are made. The main groups are known as organic, inorganic, botanical, and bacterial.

Organic: These are manufactured materials that consist mainly of carbon, hydrogen, and oxygen. They are the most widely used type. Numerous organics are available. Organic insecticides are classified in three groups.

1. *Chlorinated Hydrocarbon* – These insecticides, which are also called organic chlorines, are considered long-lasting because once they are used, they affect living

things for several years. They do not break down easily in the environment. Examples are DDT, chlordane, and lindane. Chlorinated Hydrocarbon is slowly being replaced by other kinds.

2. *Organic Phosphate* – These insecticides contain phosphorus. They can be used on food crops because they do not leave harmful deposits on or in foods. They must be handled carefully because they are highly poisonous to man. Parathion and malathion are examples.

3. *Carbamate* – Carbamates contain groups of nitrogen and hydrogen and can be used to kill most insects. They do not leave harmful deposits on food, but some are harmful to warm-blooded animals. Aldicarb, bendiocarb, carbaryl, and carofuran are examples.

Inorganic: These are usually made from minerals. Many inorganics are used to protect cotton, fruit trees, vegetables, and livestock. Since several of these do not break down easily in the environment, they are being replaced by substances that break down more quickly. Lead, arsenate, boric acid, and sulfur powder are examples of inorganic insecticides.

Botanical: These are made from plants. Plant parts are processed and used as either the active killing ingredient or as an attractant. Nicotine, potenome, and dried pyrethrum flowers are examples.

Bacterial: Bacteria are used to infect insects with diseases. Most insecticides work on a general class of insects, whereas a bacterial insecticide specifically kills one kind of insect. They are used on Japanese beetles and caterpillars.

4.0 CONCLUSION

You have learned the types, modes of action and formations of different pesticides and the species of pests they are applied to.

5.0 SUMMARY

Insecticides are used for the control of insects. Insecticides become pesticides when they are used for the control of pests. There are different types of pesticides and they are classified by the type of pests they control eg. acaricides; their mode of action eg. systemics and their source eg. biological.

6.0 TUTOR-MARKED ASSIGNMENT

1. Name five pesticides classification and the pests they control.
2. Describe the source of inorganic pesticides and the crop they protect.
3. Describe the mode of action of pesticides.

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UNIT 2: INSECTICIDES (PROTOCOL AND APPLICATION)

CONTENTS

1.0 INTRODUCTION

This unit on insecticides (protocol and application) describes for you methods of uses of insecticides. Insecticide applicators are responsible for the correct application and disposal of insecticides. This includes applications on the ground or by air, privately or commercially, and on domestic or public grounds. Usually, the applicator needs to attend a special training course to be certified.

2.0 OBJECTIVES

By the end of this unit, you will be able to acquire knowledge of how to apply insecticides and how they are applied to different areas.

3.0 MAIN CONTENT

3.1 Methods of Insecticide Application

The key to using insecticides effectively without injuring plants, animals, or agricultural products is to follow the directions on the label. Do not use any insecticide product for any purpose for which it was not specified. The methods of insecticide application are described by special terms.

Pre-emergence – Insecticide is applied before crops or weeds emerge.
Pre-plant – Insecticide is applied before the crop is planted.
Band – Insecticide is applied to a strip over or along each crop row.
Broadcast – Insecticide is applied uniformly to an entire, specific area.
Dip – Dip refers to the complete or partial immersion of a plant, animal, or object in an insecticide.
Directed – In directed application, the insecticide is aimed at a portion of a plant, animal, or structure.
Drench – Drench can mean saturating the soil with an insecticide or the oral treatment of an animal with a liquid insecticide.
Foliar – Foliar refers to applying insecticide to the leaves of plants.
In-furrow – Applying insecticide to or in the furrow in which a plant is planted is the in-furrow application technique.
Over-the-top – Insecticide is applied over the top of a growing crop.
Pour-on – Insecticide is poured along the midline of the back of livestock.
Sidedress – Insecticide is applied along the side of a crop row.

Soil incorporation – Insecticide is applied and incorporated into the soil using tillage implements.
Spot treatment – Spot treatment means to apply insecticide to a small area.

3.2 Insecticide Formulations

An insecticide formulation refers to the specific way the product is made. Insecticide formulations have two parts:
1. The active ingredient, which is the chemical that does the work, and
2. The inert or inactive ingredients are the materials that make the active ingredient easier to apply.

There are several common formulations. They are usually made and applied as a liquid, gas, or solid. Each of these has a specific letter abbreviation, frequently used on labels and in recommendations.

Liquid formulations: An emulsifiable concentrate (EC or E) can be mixed with water to form an emulsion in a spray tank. An emulsion is a mixture in which one liquid is suspended as tiny drops in another liquid (such as oil in water). A flowable (F or L) can be mixed with water to form a suspension in a spray tank. A suspension is made by mixing finely divided solid particles in a liquid. A solution (S) is a mixture of one or more substances that are completely dissolved. These ready-to-use formulations are often used on livestock and in barns.

Ultra-low-volume solutions (ULV) are formulations that may contain only the active ingredient itself. They require special application equipment. Aerosols (A) are low concentrate solutions, which are usually applied as a fine spray or mist indoors. Some come in pressurized cans. Liquified gases are fumigant formulations that turn into a gas when applied. Some have to be packaged in pressurized containers.

Dry formulations: Dusts (D) are made by adding the active ingredient to a fine inactive powder. Dusts must be used dry. Granules (G) are made by adding the active ingredient to coarse particles, or granules, of some inactive material.

Granule particles are much larger than dust particles. Soluble powders (SP) are made from an active ingredient that dissolves when added to water. Wettable powders (WP or W) are made by combining the active ingredient with a fine powder and a wetting agent. A wetting agent is a chemical that causes a liquid to cover a surface more thoroughly. Wettable powders look like dusts, but they are made to be mixed with water. Wettable powders need continuous agitation to maintain in suspension. Baits (B) are made by adding the active ingredient to a substance that attracts insects or is eaten by insects.

The following should be considered when selecting the insecticide formulations for a given job:
Life cycle and habitat of the insect type and density of plants, type of coverage needed, type and condition of the target plant or animal, type of insecticide, formulation, weather conditions, equipment used, cost of the insecticide product and the best and safest method of control.

3.3 Applying Insecticides

Weather conditions play an important part in using insecticides. Although some air movement is helpful, it is not wise to spray in winds. Winds can cause an insecticide dust or spray to be unevenly distributed on the plants and to drift away from target areas. Be cautious about spraying if rain is predicted. The effectiveness of an insecticide treatment may be reduced if rain falls soon after spraying. Cold weather may have the same effect. Check the label for any precautions concerning the weather.
The equipment used to apply an insecticide is very important to the success of the insect control job. The type of application equipment selected depends on the insecticide formulation. Insecticides may be sprayed, dusted, used in a dipping tank, injected, or mixed with insect food. Liquids are generally applied using some kind of sprayer. Sprayers are chosen according to the size of the area being sprayed and the insecticide formulation. There are several sprayer types.

Hand sprayers: Hand sprayers are best for small jobs around the home or farm. They can be used in restricted areas where a power sprayer is not suitable. They are economical, simple, and easy to use, clean, and store. However, hand sprayers may give an uneven application rate because of hand operation. They do not usually have the agitation and screening needed for wettable powder formulations. They must be shaken often to provide agitation.

Low-pressure field sprayers: These sprayers are usually used for treating field and forage crops, pastures, and fence rows. They are also used to apply fertilizer-pesticide mixtures. These sprayers are equipped with medium to large tanks. This sprayer is more versatile and flexible than the hand sprayer. It can be operated at a low cost. A high volume of insecticide is usually needed to make the most effective use of these sprayers. Low pressure will limit penetration. Agitation is also limited.

High-pressure sprayers: High-pressure sprayers are also called hydraulic sprayers. They are designed to handle high volumes (100 or more gallons per acre) at high pressure (above 100 psi). They are usually used on fruits, vegetables, landscape plants, and livestock. These sprayers are well built for extended use. Mechanical agitation keeps the insecticide mixed. They are expensive to operate because large amounts of water, power, and fuel are needed. With high pressure, the spray drifts easily.

Air-blast sprayers: The output from the nozzle is broken up into fine drops by a high-speed airstream. The insecticide moves with the airstream to the target. These sprayers provide good coverage and penetration. Only low pump pressure is required. They usually have mechanical agitation. The sprayer may be difficult to control in small areas. If not properly operated, they may cause an over application of insecticide.
Ultra-low-volume (ULV) sprayers: These sprayers deliver special ultra-low-volume insecticide formulations. High-speed airstreams are used to break up and direct the spray. No water is needed for these sprayers and less insecticide is used. Since no water is used during application, there is a danger of an over application. Care must be taken when applying high-concentration insecticides. Few insecticides can be sprayed this way.
There are five basic nozzle types. Each of these has a special spray pattern. The type of nozzle selected depends on the type of job.

Solid stream: A solid stream is used in handguns to spray a distant target (Fig. 7). It is also fixed in a nozzle body to apply a narrow band or inject it into the soil. There is little drift with these types.

Flat fan: There are different kinds of flat fan nozzles (Fig. 7). The regular flat fan nozzle makes a narrow oval pattern with lighter edges. It is used on booms for broadcast spraying. The nozzles are mounted on the boom so that the spray overlaps 30–50 percent for even distribution.

Solid cone: The solid cone nozzle forms a circular pattern (Fig. 7). The spray is well-distributed throughout the pattern. It is used for spraying insecticides at high pressure and flow rates.

Hollow cone: This nozzle forms a circular pattern with tapered edges (Fig. 7). Little or no spray is in the center. It is used for spraying foliage. There are two types of hollow cone nozzles: the core and disk nozzle and the whirl chamber nozzle.

Broadcast: This nozzle forms a wide "flat fan" pattern (Fig. 7). It is used on sprayers with or without a boom. When attached to the end of a boom, it expands the width of the area sprayed. This provides good coverage for a wide pattern.
Nozzles are made of brass, stainless steel, plastic, aluminum, tungsten carbide, and ceramic. Each type has advantages and limitations.

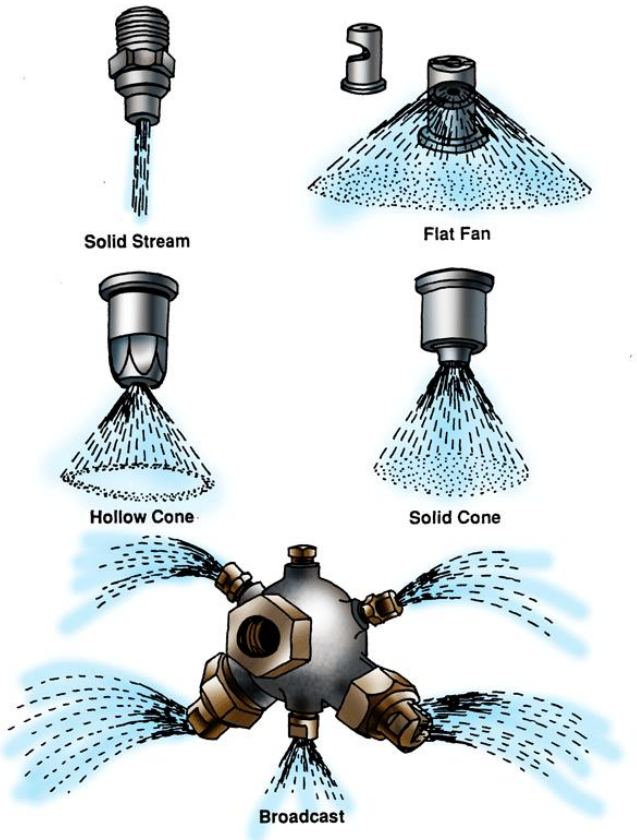

Fig. 7: Shapes of different nozzles for application of insecticides (source: dese.mo.gov)

Sprayer calibration: For all spraying applications, there are some standard procedures that should always be followed. Always read the operator's manual supplied by the manufacturer. Choose the speed, pumping pressure, and nozzles that you want to use. For thorough and accurate coverage, the insecticide must be applied evenly and accurately. To do this, the sprayer must move at a constant speed when in use. The insecticide must be pumping out at a constant pressure. Each nozzle in the system must deliver the correct amount of insecticide. The nozzles must be of the correct type and size. All of the nozzles need to be the same kind. Each nozzle must be clean and mounted at the right height.

Calibrating a sprayer simply means to adjust the equipment so that the desired rate of insecticide can be applied. This is very important to make sure that each insecticide is used as directed on the label. Too much insecticide is dangerous, costly, and wasteful. Too little insecticide will not do an effective job. The best results are safely obtained by calibrating correctly. There are many ways to calibrate a sprayer. The methods selected will depend on the equipment used and personal preference.

4.0 CONCLUSION

You have learned the different methods of application of insecticides and the field areas where they are being used

5.0 SUMMARY

In this unit, pesticides have been defined as chemicals designed to kill, control, or prevent pests from causing damage. A pest can be any living thing that competes with humans for food and fiber, or that attacks people directly. Selection of a particular insecticide depends on the needs of the producer, the type of insect, the mode of action, and the formulation of the insecticide. There are a variety of sprayers and nozzles available for applying insecticides. Equipment is selected depending on the formulation and application instructions of an individual chemical.

Calibrating a sprayer is very important for safe and effective use of insecticides. It is very important to make sure that each insecticide is used as directed on the label. There are several ways to calibrate a sprayer, depending on the chemical formulation, the equipment used, and the preference of the applicator.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the forms of pesticide application?
2. Describe different types of pesticide formulations.
3. What are the methods of applying pesticides?

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UNIT 3: GUIDELINES AND REULATIONS ON USE OF INSECTICIDES

CONTENTS

1.0 INTRODUCTION

This unit will deal with regulations and guidelines on the use of insecticides. It will also teach you to the recommendations for dealing with emergencies in case of poisoning and exposure to insecticides

2.0 OBJECTIVES

By the end of this unit, you will be able to understand the regulations and guidelines required for the use of insecticides. The methods of handling emergencies and first aid requirements are also highlighted.

3.0 MAIN CONTENT

3.1 Insecticide Toxicity and Pesticide Certification

Insecticide Toxicity: Insecticide toxicity levels are usually established by government agencies regulates all stages of pesticide use, manufacture, registration, and transportation.

LD50: Insecticide toxicity is measured by a standard test called the LD50 Test. The "LD" stands for "lethal dose" of a chemical. The lethal dose is determined as the amount of the chemical necessary to kill half (50%) of a test population, such as mice. The LD50 is expressed in milligrams per kilogram of body weight. The lower the LD50 number, the greater the chemical toxicity and the less it takes to kill. For example, an insecticide with an LD50 rating of 5 would be much more poisonous than an insecticide with an LD50 rating of 300. This does not imply that pesticides with less toxicity should be used unwisely.

Signal words: Signal words indicate how toxic the chemical is. They are located on the front panel of insecticide labels just below the statement "Keep Out of Reach of Children." There are three categories of signal words. Class I insecticides are labeled "Danger" or "Danger – Poison" with an accompanying drawing of a skull and crossbones. The letters are printed in red. Insecticides in this category are extremely toxic when taken into the body through the mouth, through the skin, and/or through breathing. In addition, these insecticides will cause severe eye and skin burning.

Insecticides in Class I have an oral LD50 rating of 0–50. Some of the Class I insecticides are so highly poisonous that even a taste could kill an adult human. Class

II insecticides are labeled with the signal word "Warning." Insecticides in this category are moderately poisonous to humans and have an oral LD50 rating of 50–500. As little as a teaspoon taken by mouth of some of these pesticides could be deadly. Class III insecticides have the signal word "Caution." These insecticides are slightly toxic to humans and have an oral LD50 rating of 500–5,000. As little as one ounce of certain of these chemicals taken internally could be fatal.

The insecticide label also contains warning statements such as "fatal if swallowed" or "may irritate eyes, nose, throat, or skin." These warning statements are meant to get your attention, not to indicate the only method of entry for the insecticide. Many insecticides could be harmful to the body if any contact at all is made. It is crucial to wear proper protective clothing whenever applying insecticides.

Pesticide Certification: Applicators may or may not need to be certified in order to handle a particular pesticide. Certification depends on the way the pesticide is used. Pesticides are classified as 100 percent general use, 100 percent restricted use, or a mixture of the two. This information will be clearly stated on the label of the container. A general use pesticide is defined as one not likely to harm people, wildlife, and/or the environment when used according to label instructions. Certification is not required in order to apply general use pesticides. Some examples of these pesticides are Malathion, Sevin, and Pyronone.

A restricted use pesticide can cause serious injury to people, wildlife, or the environment. These pesticides must be applied by someone who is well-trained, competent, and certified, or under the direct supervision of a certified pesticide applicator. Certification is required for handling restricted use pesticides. Some examples of these pesticides are Lannate, Nicotine, and Thiodan.

Pesticide certification is given to people who take a special training course set up by the regulatory authorities. After completing the instructional process, applicants must then pass a test in the safe handling and use of pesticides. Finally, a license is issued to each person who successfully completes the pesticide training session.

There are two types of licenses for certified pesticide applicators: private applicator and commercial applicator. Private applicators administer restricted use pesticides onto their own land, onto land they rent, or onto the property of another person with whom they trade services. A certified private pesticide applicator's license usually has validity period for example (valid for 5 years) after which they must be renewed.

Commercial applicators are hired to apply restricted use pesticides on the property of others. Commercial applicators are trained and tested like private applicators, but receive additional instruction to specialize in various areas. A certified commercial pesticide applicator's license is valid for 3 years and then must be renewed.

3.2 Symptoms of Insecticide Poisoning and First Aid Procedures

Symptoms of Insecticide Poisoning: Since different insecticides affect people differently, there are no standard symptoms of insecticide poisoning. Symptoms will

vary depending on the type of insecticide, amount and length of exposure, the time interval between exposures, and the general health of the victim.
Insecticide poisoning may be divided into external irritants, internal poisons, or a combination of both. External irritant insecticides may cause swelling, stinging, redness, blisters, and/or rash when splashed on the skin or external body tissues, such as eyes, ears, and mouth. Insecticides causing internal poisoning are dangerous when swallowed, inhaled, or absorbed through the skin.

These may cause such symptoms as headache, nausea, vomiting, and diarrhea. Some insecticides can cause both external irritation and internal poisoning at the same time.
Insecticide poisoning symptoms may be similar to symptoms of other illnesses, such as the flu. However, flu medicine should not be used to relieve these symptoms as they may make insecticide poisoning much worse. Therefore, it is important to talk with a doctor who can diagnose the difference and prescribe proper treatment.

First Aid Procedures for Insecticide Poisoning: When you think an insecticide poisoning has occurred, always act immediately. The amount of time between the insecticide poisoning and getting to the doctor may make the difference between life and death for the poisoning victim. It is extremely important to stay calm and take quick action. Follow these steps:
1. Protect yourself from contamination. Wear protective clothing and/or equipment. You won't be able to assist anyone else if you are not protected yourself.
2. Without endangering yourself, remove the victim from the contaminated area.
3. Remove contaminated clothing from the victim.
4. Flood the affected area with a generous amount of water.
5. Contact the Poison Control Center or a doctor and administer first aid procedures as indicated. Keep the insecticide label handy for reference.

3.3 Safety Guidelines for Using Insecticides

Since insecticides may be absorbed through the skin, eyes, and ears, inhaled and/or swallowed, insecticides must be handled very carefully. First and foremost, always read and follow insecticide label directions exactly. Label directions will not only indicate the application procedures, but the pre-harvest interval and safe re-entry time as well. The pre-harvest interval is the time required between applying the insecticide and the date when the crop can be safely harvested for human consumption. Safe re-entry refers to the time needed between the time an insecticide is applied to an area and the time you need to wait before the area can safely be entered again. Before applying an insecticide, all people, pets, and foodstuffs need to be removed from the area. Never smoke, eat, or drink when applying insecticides.

Protective clothing: Protective clothing should always be worn and protective equipment always used to prevent exposure to external irritant insecticides. The following are standard safety clothing and procedures:
Wear clean long trousers and a long-sleeved shirt, or coveralls made of closely woven cloth.
Wear unlined rubber gloves and rubber boots made of neoprene.
Wear shirt sleeves outside of the gloves and wear pant legs outside of the boots to prevent insecticides from entering.

Wear close-fitting eye goggles or a face shield.
Wear a wide-brimmed waterproof hat, one that is easy to clean or is disposable.
Wear a respiratory device that prevents internal poisoning whenever applying an insecticide.
Clean clothing and equipment as directed by the insecticide label or by the poison control center recommendations.
Respiratory devices: Insecticides give off fumes and some quickly become gases. This poses a great threat of injury or death by inhalation to insecticide applicators. Respiratory devices cover the mouth and nose and filter the air of harmful substances. Although they are recommended whenever using insecticides, they are especially important when working in confined or closed areas. Be sure that every respirator carries a seal of approval for insecticide use from the regulatory authorities. Carefully read the accompanying instructions for the use and care of each respirator. There are several different types available depending on the spraying conditions.

Cartridge respirator – used for occasional exposure to most insecticides.
Gas mask or canister respirator – used when the applicator is exposed to an insecticide for a relatively long period of time or is exposed to high concentrations of insecticides for a short period of time, and working in a confined or closed area.
Self-contained breathing apparatus – used if the oxygen supply is low or the insecticide vapor concentration is high.
Precautions should always be taken to avoid insecticide drift. Insecticide drift occurs when the insecticide tends to drift away from the target area. This can be avoided by always following the label directions, using the proper equipment for the job, and not spraying when it is windy.

After applying insecticides, remove clothing and take a shower with plenty of soapy water; shampoo and rinse the hair well. Wash insecticide exposed clothing separately from other clothing. If disposable clothing is worn, dispose of it properly.

If insecticides are applied on a regular basis, a health watch program should be established with a physician. Inform the doctor about the type of insecticides being used. Then the doctor can review the chemical formulations, poisoning symptoms, and treatments. In addition, the physician can stock a supply of the necessary drugs needed for treatment. Being prepared in case insecticide poisoning occurs is important because there are no drugs to prevent it.
Applicators who work regularly with carbamate or organophosphate insecticides should set up a cholinesterase testing program with their physicians. Cholinesterase is a biological enzyme that is part of the body's nervous system. Carbamate and organophosphate insecticides can cause serious health hazards by interfering with the availability of cholinesterase in the body. Therefore, the doctor should perform a cholinesterase test in January to establish a "base line level" for each applicator. Then periodic retests must be taken to check cholinesterase levels.

If the applicator's cholinesterase level falls too low, then the doctor will limit or stop the patient's contact with these two types of insecticides.

Disposal of Insecticides and Containers: Always try to mix the correct amount of insecticide solution for each application to avoid the need to dispose of any extra chemical. Any extra insecticide solution must be disposed of safely to avoid harming people, animals, or the environment. Governments of different countries set up specific guidelines for disposal of insecticides and insecticide containers. In Nigeria, information could be obtained from Federal Ministry of Agriculture and natural Resources and their state offices nationwide.

Carefully read and follow the instructions for precautions and/or disposal methods on the insecticide container label. Never flush insecticides down the drain or into sewers. If there are additional areas having the same insect problem, apply the extra insecticide on those areas as well. If this is not possible, then take the excess insecticide and/or insecticide containers to a landfill that has a permit for toxic waste disposal. This should also be done for outdated or unwanted insecticides. Keep in mind that many solid waste landfills do not have this special permit and, therefore, are not legally able to handle insecticides. Federal regulations require that organic insecticides be disposed of by burial or by burning.

Do not leave insecticides or insecticide containers at the place where the chemicals were applied. Never reuse insecticide containers. Keep all insecticide containers out of the reach of children. Any insecticides leftover should be kept in tightly closed containers in a storage facility.

First Aid Kit: First aid supplies should always be near any place where insecticides are handled. The container used for the first aid supplies should keep the supplies clean and be easily accessible. A first aid kit should contain items such as the following:
Adhesive tape, assorted adhesive and gauze, bandages, blanket – enclosed in plastic to keep clean and dry, merthiolate Syrup of ipecac, teaspoon, two quarters – taped to the inside cover of the first aid kit for phone calls. The contact phone number of the nearest or most accessible medical center should be provided for easy access. Medical professionals will ask questions about the victim and about the insecticide. It is important to have the insecticide label or container close by when contacting medical personnel.

4.0 CONCLUSION

You have learned the regulations and guidelines for the use of insecticides. How to detect insecticide poisoning and the first aid requirements were also explained. With the knowledge acquired, you can act as pest controller and adviser on issues related to pest control subject to certification.

5.0 SUMMARY

In this unit it has been shown that to avoid toxic chemical injury to humans, animals, and/or the environment, it is crucial to read and follow all label directions for the insecticide being applied. Depending on the insecticides to be applied, the applicator may be required to have a certified pesticide applicator’s license.

Appropriate clothing and protective equipment should always be worn when applying insecticides. Insecticides should always be handled with care and disposed of properly.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the first aid procedures for insecticide poisoning and what the content of a first aid kit?
2. What are the safety guidelines for using insecticides?
3. Explain fully the requirements for disposal of insecticides and their containers.

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