BIO-1070: INSECT BIOLOGY

Cuyahoga Community College

Viewing: BIO-1070 : Insect Biology

Board of Trustees:
October 2022

Academic Term:
Fall 2023

Subject Code
BIO - Biology

Course Number:
1070

Title:
Insect Biology

Catalog Description:
Designed for non-science majors. Considers the use of insects as model organisms to direct learning of biological concepts. Discusses insect form, function, behavior, and evolution. Explores current and historical social and economic dynamics through the study of insect roles such as vectors of human diseases, food and fiber production, nutrition, medical/genetic research, and ethical issues surrounding topics such as pesticide use and genetically modified organisms.

Credit Hour(s):
3

Lecture Hour(s):
3

Requisites

Prerequisite and Corequisite
ENG-0995 Applied College Literacies, or appropriate score on English Placement Test; or departmental approval.

Outcomes

Course Outcome(s):
Use the facts and principles of the scientific method to analyze questions arising in daily life as they relate to theories of modern science, while demonstrating the importance of reproducibility, intrinsic variation, and limitations of data and forming evidence-based conclusions.

Essential Learning Outcome Mapping:
Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):
a. List the steps of the scientific method in sequential order.
b. Explain what objective and subjective means as related to observations.
c. Define hypothesis and differentiate between a hypothesis and prediction.
d. Explain the difference between experimental treatments and control treatments, and differentiate between the types of controls.
e. Define the different types of experimental variables.
f. Evaluate historical and modern entomological experiments that outline the importance of reproducibility, and of intrinsic variations and limitations in gathered data.
g. Demonstrate the use of the scientific method and entomology to solve problems in daily activities.
h. Explain the difference between a primary research article and a secondary article, and the importance of each type.

Course Outcome(s):

Characterize the importance and application of entomology in our daily lives, and explain how scientific principles are formulated, evaluated, and either modified or validated in the context of entomology in our daily lives.

Objective(s):

a. Define entomology.
b. Identify structures specific to arthropods.
c. Identify structures specific to hexapods (insects).
d. Diagram the similarities and differences between insects and non-insect arthropods.
e. Articulate the importance of systematics, taxonomy, and classification of arthropods.
f. Illustrate specific ways insects and entomology affect your daily life.
g. Demonstrate the relationship between structure and function using specific entomological examples.

Course Outcome(s):

Describe the process of evolution by natural selection and explain how the different environmental pressures can lead to specialized function of insect structures by using entomology-specific data and current models and theories to describe, explain, and predict outcomes.

Objective(s):

1. Define evolution by natural selection.
2. Understand how predation, competition, reproduction, nutrition acquisition, and abiotic factors can select for various characteristics of insects.
3. Compare and contrast the different types of insect antennae, wings, mouthparts, and legs.
4. Relate specialized insect structures to environmental pressures with specific examples.

Course Outcome(s):

Understand the internal organization of insects, evaluate how environmental pressures have led to the different growth and development strategies among insects, and use relevant historic studies to demonstrate the reproducibility yet intrinsic variation of scientific data.

Objective(s):

1. Understand the strategies insects use for gas exchange both on land and in an aquatic environment.
2. Explain how insects circulate blood throughout their bodies.
3. Trace the pathway of food through the insect digestive tract.
4. Explain the functions of the excretory system.
5. Describe the components of the insect nervous system.
6. Recognize the structures important for insect reproduction.
7. Describe the process of molting and ecdysis as a model to explain how scientific principles are formulated, evaluated, and either supported or falsified.

Course Outcome(s):

Evaluate the importance of wing development and evolution in insect locomotion and use this information to predict extensive niche distribution/success.

Objective(s):

1. Describe the role of wing development and evolution in the success of insects as a group.
2. Compare and contrast flight in insects that use direct musculature versus indirect musculature.
3. Describe the physiology of insect sight and its importance in flight.
4. Identify the unique locomotion adaptations of different insect groups and relate their adaptations to their ecological roles.
5. Apply insect locomotion adaptations to modern day problems, such as robotics.

Course Outcome(s):

Examine the mechanisms of insect communication and evaluate the need for insects to communicate.

Objective(s):

a. Determine how different senses can be involved in communication, and which are most important for insect communication.
b. Discuss the types of receptors required for insect communication through senses.
c. Assess the role of an insect's exoskeleton in visual communication between species and within a species.
d. Discuss bioluminescence and how it is used in communication.
e. Examine the mechanisms of sound production in insects and evaluate why it is used.
f. Determine why chemical communication is so important to insects, and identify the different types of chemicals produced by insects.
g. Evaluate the importance of insect communication in correlation to insect behavior.

Course Outcome(s):

Discuss the strategies predators, prey, parasites, and parasitoids use to acquire nutrients and examine their evolutionary significance.

Objective(s):

1. Understand the roles of predators, parasites, and parasitoids in ecosystems.
2. Explain how insect populations are naturally regulated.
3. Examine, classify, and discuss the evolutionary significance of strategies insects use to avoid being eaten by predators.
4. Explain the difference between a predator, parasite, and parasitoid.
5. Describe the strategies parasitoids use to acquire nutrients.
6. Evaluate the medical significance of parasites.

Course Outcome(s):

Illustrate the evolutionary significance of plant-insect interactions as they apply to the overall diversity of both groups.

Objective(s):

1. Explain the types of relationships that exist between insects and plants.
2. Explain the advantages and disadvantages of utilizing a generalist versus a specialist feeding strategy.
3. Connect insect feeding habits with agricultural insect pest characteristics.
4. Define coevolution and how it applies to both beneficial and detrimental plant-insect relationships.
5. Describe strategies plants use to prevent phytophagy.
6. Describe strategies insects use to overcome plant defenses.
7. Explain the relationship between insect pollinators and flowering plants.
8. Examine the strategies plants use to attract insect pollinators.

Course Outcome(s):

Explain the different insect reproductive strategies and their evolutionary significance.

Objective(s):

1. Understand the structural terminology of the insect reproductive system.
2. Compare and contrast indirect versus direct reproductive strategies.
3. Explain how sexual selection is the main driver for the variety of reproduction strategies seen in insects.
4. Compare and contrast male-driven and female-driven sexual selection.
5. Describe how sexual conflict can occur between genders of an insect species, and how it can lead to sexually antagonistic coevolution.
6. Explain the pressures that lead to parthenogenesis.

Course Outcome(s):

Understand the levels of sociality in certain insects and formulate hypotheses as to why social behavior may have evolved in different groups.

Objective(s):

1. Describe reasons why solitary insects interact.
2. List the three characteristics of eusociality and describe the evolutionary trends from primitive to advanced eusocial groups.
3. Compare and contrast the sociality of termites, honeybees, and ants in relation to the three characteristics of eusociality and the caste system.
4. Define polyethism and polymorphism within the worker caste.

Course Outcome(s):

Explain the adaptations possessed by aquatic insects that allow them to live in freshwater environments.

Objective(s):

1. Explain why aquatic insects mostly live in freshwater habitats but not marine habitats.
2. Describe the adaptations possessed by marine aquatic insects.
3. Compare and contrast adaptations of aquatic insects living in lotic versus lentic water.
4. Identify the strategies aquatic insects use to breathe underwater.
5. Outline the importance of aquatic insects as water quality indicators.

Course Outcome(s):

Understand the medical impact insects and other arthropods have on humans and other animals, and predict the ramifications of climate change on pathogen distribution.

Objective(s):

1. List ways arthropods act as indirect agents of medical and veterinary importance and provide examples.
2. Describe the difference between poison, toxin, and venom, and how these terms relate to medically important arthropods.
3. Describe the different forms of myiasis.
4. Explain the difference between mechanical and biological disease transmission.
5. List ways arthropods act as direct agents of medical and veterinary importance and provide examples.
6. Examine current distributions of insect vectors and their associated pathogens, and predict how climate change will alter them.

Course Outcome(s):

Determine how forensic entomology developed historically, the characteristics of forensic entomology, and explain how abiotic and biotic factors are critical to determining time of death.

Objective(s):

1. Define forensic entomology.
2. Explain the historical context and scope of forensic entomology.
3. List the abiotic factors that must be considered in forensic entomology.
4. Define death at the organismal and cellular levels and evaluate the physiology at each level.
5. List the stages of decay and their association with tissue invasion by insects.
6. Predict how the environmental factors will affect time of death in examples.

Methods of Evaluation:

1. Examinations
2. Quizzes
3. Creative project
4. Group activities and homework assignments

Course Content Outline:

a. Introduction to Entomology
   i. Recurring biological concepts in entomology
      1. Evolution by natural selection
         a. Definition
         b. Insect examples
      2. Structure reflects function
         a. What a structure does can be determined by what it looks like
         b. Insect examples
   ii. Arthropods
      1. Characteristics
         a. Exoskeleton with internal musculature
         b. Segmented body that is bilaterally symmetrical
         c. Jointed appendages
         d. Ventral nerve cord
         e. Dorsal heart
      2. Importance
         a. Diversity
         b. Abundance
         c. Pollination
         d. Decomposition
         e. Food
         f. Medical importance (bites, stings, pathogen transmittance)
      3. Classification
         a. Taxonomy, systematics, classification
         b. Binomial nomenclature
         c. Examples
         d. Importance of common vs. scientific names
   iii. Insects
      1. Characteristics
         a. Three distinct body regions
            i. Head
               1. Contains senses and sensory processing tools
               2. Directs muscles for mouthparts and antennae
            ii. Thorax
               1. Attachment for all appendages used for locomotion
               2. Contains all musculature for legs/wings
            iii. Abdomen
               1. Contains most digestive and reproductive organs
               2. Also primary tool for respiration
         b. Three pairs of legs
         c. Usually two pairs of wings
            i. Ancestor of all insects had wings
            ii. Some have secondarily lost their wings (fleas, lice)
         d. One pair of antennae
         e. One pair each of complex mouthpart appendages
         f. External opening of reproductive organ on posterior end of abdomen
b. Insect Locomotion and Flight
   i. Major Evolutionary Changes in Insects
      1. Advancing to land
      2. Complete Metamorphosis
      3. Development of wings
      4. Wing folding
   ii. Direct Flight
      1. Primitive strategy
      2. Precise control and maneuverability
   iii. Indirect Flight
      1. Derived/advanced strategy
      2. Compression and expansion of thoracic sclerites indirectly moves wings
   iv. Vision and Flight

1. Insects that are good fliers have good vision
    a. More ommatidia in compound eyes e.g. dragonflies have 10,000
    b. Insects that do not fly or live in dark might have no compound eyes with ommatidia
2. Insects cannot see red, but can see UV light
3. Very high flicker-fusion frequency allows insects to respond quickly to movement

v. Mechanics of cursorial insects
1. Cockroaches used as model for robot movement
    a. Speed
    b. Climbing ability
    c. Suspension
    d. Tarsal claws
2. Unique adaptations
    a. Elateridae (click beetles)
    b. Saltatorial legs (Orthoptera)
    c. Issidae (leaf hoppers)
    d. Siphonaptera (fleas)
    e. Carabidae (tiger beetle larvae)

vi. Migration
1. Dragonflies
    a. Due to mating reasons
2. Monarch butterflies
    a. Due to overwintering strategies

c. Insect Senses and Communication Strategies
i. Short Distance Visual Signals
1. Mating cues
    a. Can be used to verify species
    b. Help locate mates
2. Warning signals
    a. Aposematic coloration
    b. Startle markings such as eyespots
3. Color production in exoskeleton
    a. Pigments
    b. Structure causing diffraction of light

ii. Long Distance Visual Signals
1. Bioluminescence
    a. Fireflies
        i. Luciferin and luciferase
        ii. Mating cues
    b. Glowworms
        i. Luciferin
        ii. Lure for prey
        iii. Aposematic coloring

iii. Sound Production and Signaling
1. Mechanoreceptors
    a. Trichoid sensilla
    b. Chordotonal sensilla
2. Sound production
    a. Stridulation and stridulatory organ
    b. File and scraper method
        i. Rubbing wings together (katydids, crickets)
        ii. Rubbing leg on wing (grasshopper)
    c. Tympanum (cicadas, some Lepidoptera)
    d. Hitting body part of surface (stoneflies)

iv. Chemical communication
1. Chemoreceptors
    a. Most detect chemicals in the air
    b. Usually concentrated on antennae
2. Main types of chemicals
    a. Pheromones
        i. Within species communication
        ii. Usually beneficial to all that contact

iii. Types
1. Sex
2. Aggregation
3. Alarm
4. Spacing
5. Primer
6. Trail-marking

b. Allomones
i. Between species communication
ii. ii. Benefits emitter, modifies receiver's behavior
iii. Often used as defense by plants against herbivores, or by prey against predators

c. Kairomones
i. Between species communication
ii. Benefits receiver and disadvantageous to emitter
iii. E.g. terpene is released by ponderosa pine when damaged, causes nearby trees to increase defenses

d. Synomones
i. Between species communication
ii. Benefits both the emitter and receiver
iii. E.g. chemicals released by a damaged tree can attract a parasitoid to the organism that is damaging the tree, benefiting both the tree and parasitoid

d. Strategies for Acquiring Nutrients
i. Predator/prey Relationship
1. Importance
2. Methods

a. Adventitious coloration
i. Definition
ii. Examples

b. Camouflage
i. Types
1. Coloration
2. Behavioral
ii. Examples

c. Warning coloration
i. Types
1. Aposematic
2. Startle markings
ii. Examples

d. Mimicry
i. Types
1. Batesian
2. Mullerian
3. Wasmannian
ii. Examples

e. Mass emergence
i. Phase polymorphism
1. Definition
2. Contributing factors
ii. Periodicity

f. Allomones/defensive secretions
i. Distasteful to predators
ii. Harmful to predators
iii. Provide protection

g. Sound
i. Definition
ii. Examples

h. Autotomy
i. Definition
ii. Examples

i. Attack

- i. Predatory hungers and trappers
- ii. Defensive attacks

ii. Parasitoids
1. Characteristics
   a. Development
   b. Host type
      i. Solitary
      ii. Gregarious
   c. Effect on host development
2. Hyperparasitoids

iii. Parasites
1. Vectors
2. Pathogens
   a. Mechanical transmission
   b. Biological transmission
3. Examples

e. Plant-Insect Interactions
i. Phytophagy
1. Strategies
   a. Generalist feeding strategy
      i. Advantages
      ii. Disadvantages
   b. Specialist feeding strategy
      i. Advantages
      ii. Disadvantages
2. Agricultural pests
   a. Native
   b. Invasive
3. Plant defensive strategies
   a. Physical
   b. Symbionts
   c. Chemical
4. Insect strategies to overcome plant defenses
   a. Behavioral resistance
   b. Chemical resistance
   c. Excretion
   d. Detoxification
   e. Sequester

ii. Pollination
1. Generalist versus specialist strategy
2. Plant-provided pollinator rewards
   a. Nectar
   b. Pollen
   c. Oil
3. Plant/pollinator conflict
   a. Deceit pollination

f. Insect Reproduction Strategies
i. Indirect Fertilization
1. Spermatophore
2. Nuptial gift

ii. Direct Fertilization
1. Definition
2. Examples

iii. Sexual Selection
1. Female-driven
   a. Egg-laying strategies
      i. Oviparity
      ii. Ovoviviparity
      iii. Viviparity

b. Male sound production in courtship
c. Bioluminescence in courtship
2. Male-driven
a. Allows for male mate preference
b. Examples
3. Male-male competition
a. Fighting
b. Territoriality
c. Sperm competition

iv. Sexual Conflict
1. Definition
2. Sexually antagonistic coevolution
3. Examples
4. Male/female bed bug system

v. Parthenogenesis
1. Definition
2. Examples

g. Social Insects
i. Solitary Insect Interactions
ii. Semi-social species
iii. Eusociality
1. Reproductive division of labor (caste system)
a. Queen
i. Founds colony
ii. Lays eggs
b. King
i. Found in termites
ii. Mates with queen over lifetime
c. Alates
i. New winged reproductive
ii. Produced from healthy colonies
iii. Find new mates and new locations to begin colonies
d. Drone
i. Found in honeybees
ii. Male, mates then dies
e. Worker
i. Male and female in termites
ii. Only females in ants and honeybees
iii. Perform tasks of the colony such as raising young and finding food.
f. Soldier
i. Found in termites
ii. Defends against colony invaders
2. Cooperative care of young
a. Job performed by workers
b. Male and female in termites, female only in honeybees and ants
3. Overlapping of adult generations

iv. Honeybee Eusociality
1. Structure of colony
2. Swarming
3. Development of queen
4. Age polyethism

v. Ant Eusociality
1. Structure of colony
2. Monomorphic and polymorphic workers
3. Alate production

vi. Termite Eusociality
1. Structure of colony
2. Defense of colony

h. Aquatic Insects

i. Types of Aquatic Environments
    1. Marine
        a. Adaptations
        b. Evolutionary significance
    2. Lentic
    3. Lotic
ii. Gas Exchange
    1. Open tracheal system
        a. Importance of diffusion
        b. Plastron
        c. Examples
            i. Culicidae
            ii. Coleoptera
            iii. Other Diptera
    2. Closed tracheal system
        a. Gills
        b. Examples
            i. Ephemeroptera
            ii. Odonata
            iii. Plecoptera
iii. Water Quality Indicators
    1. Biodiversity in healthy water
    2. Biodiversity in polluted water

i. Medical and Veterinary Entomology
    i. Possible Medical Effects of Insects
        1. Annoyance
        2. Fear and mental stress
            a. Delusory parasitosis
            b. Irritation/allergies
            c. Poison/toxin/venom
        3. Myiasis
            a. Accidental
            b. Facultative
            c. Obligatory
        4. Parasitism
            a. Blood-feeding
            b. Infections
        5. Pathogen transmission
    ii. Modes of Pathogen Transmission
        1. Mechanical
            a. General pathogen transmission
            b. Bacterial types
        2. Biological
            a. Vector usually has specialized relationship with pathogen
            b. Pathogen often requires time inside vector and inside host to properly reproduce.
    iii. Medically Important Arthropod Groups
        1. Siphonaptera
            a. Life cycle
            b. Pathogen examples
                i. Black plague
                    1. Symptoms
                    2. Life cycle
                    3. Impact on fleas
                ii. Murine typhus
                iii. Tapeworms
            c. Historical impact
                i. Pandemics
                ii. Feudal system
                iii. Religious influence
                iv. Ring around the rosies nursery song

2. Culicidae
    a. Life cycle and selection pressures
    b. Pathogen examples
        i. Malaria
            1. Symptoms
            2. Distribution
            3. Life cycle and effect of selection pressures
            4. Human resistance
        ii. Yellow fever
            1. Distribution
            2. Symptoms
            3. Historical impact
        iii. Dengue
        iv. Filariasis
            1. Symptoms
        v. Encephalitis
3. Phthiraptera
    a. Species
    b. Life cycle
    c. Historical impact
    d. Sociological changes that caused better control
    e. Epidemic typhus
        i. Historical impact
        ii. Napoleon

iv. Effect of Climate Change on Medically-Important Arthropods

j. Forensic Entomology
    i. Specialties of Discipline
        1. Urban
        2. Stored-Product
        3. Medicolegal
    ii. History
    iii. Definitions of Death
        1. Somatic
        2. Cellular
    iv. Stages of Decomposition
        1. Initial decay
        2. Putrefaction
        3. Black putrefaction
        4. Butyric fermentation
        5. Dry decay
    v. Insect Succession During Decomposition
        1. Necrophagous insects
            a. Calliphoridae
            b. Sarcophagidae
            c. Muscidae
        2. Predators/parasites of necrophagous insects
            a. Silphidae
            b. Staphylinidae
        3. Omnivorous insects
        4. Environment extension
    vi. Using Insects to Estimate Time of Death
        1. Influencing factors
            a. Abiotic factors at collection site
            b. Species identification
            c. Temperature rearing
                i. Degree days
                ii. Base temperature
                iii. Examples

2. Determining homicides
3. Entomotoxicology

Resources

Whitney Cranshaw and Richard Redak. *Bugs Rule!: An Introduction to the World of Insects*. New Jersey: Princeton University Press, 2013.

Gene Kritsky and Frank N. Young, Jr. (2011) *A Survey of Entomology*, iUniverse, Incorporated.

Jeffrey A. Lockwood. (2010) *Six-Legged Soldiers: Using Insects as Weapons of War*, Oxford: Oxford University Press.

Jason H. Byrd. (2010) *Forensic Entomology: The Utility of Arthropods in Legal Investiations*, Boca Raton: CRC Press.

Norman F. Johnson and Charles A. Triplehorn. (2004) *Borror and DeLong's Introduction to the Study of Insects*, Singapore: Cengage Learning.

Donald J. Borror and Richard E. White. (1998) *A Field Guide to Insects: America North of Mexico*, New York: Houghton Mifflin Company.

Dunn, Robb. (2018) *Never Home Alone: From Microbes to Millipedes, Camel Crickets, and Honeybees, the Natural History of Where We Live.* , New York, NY: Hachette Book Group.

Embry, Paige. (2018) *Our Native Bees: North America's Endangered Pollinators and the Fight to Save Them*, Amazon Digital Sercies LLC.

Engel, Michael S. and Tom Baione. (2018) *Innumerable Insects: The Story of the Most Diverse and Myriad Animals on Earth (Natural Histories)*, New York, NY: Sterling Publishing Co.

Instructional Services

OAN Number:

Ohio Transfer 36 TMNS

Top of page

Key: 5016