Official curriculum for the NCSBA Master Beekeeper Program Certified Level course of instruction

Honey Bee Biology

Social Behaviors and Anatomy

Topics

Honey bee anatomy

3 Major Body Parts

- Head ~ first body segment
- Thorax ~ middle body segment containing two pairs of wings and three pairs of legs
- Abdomen ~ last body segment
- Bilaterally symmetrical body
- Exoskeleton

Honey bee head

- Contains major sensory organs:
  - **Ocelli**
  - **Compound eyes**
  - **Antennae**
  - **Mouth parts**
  - **Body hairs**

Ocelli

- Three sensory organs
- Located on top of head in a triangle
- Exact function unknown, considered to be additional eyes
- Receive and respond to light in some manner

Compound Eyes

- Each eye contains 6,900 facets (worker bee)
- Provides “fair” vision
- Able to detect movement and broken patterns
- Sees colors except part of the red spectrum
- Can see ultraviolet light
- Eyes are hairy

Honey bee vision

Antennae

- Provide
  - **Sense of smell**
  - **Sense of touch**
  - **Sense of taste**

Mouth parts

- Chewing- mouth parts
  - **Mandible**
- Can manipulate solids (Wax mostly)

Mouth parts

- Lapping mouth parts
- Proboscis ~ sucking tube used for extracting nectar and water
  - **Maxilla**
  - **Labium**
  - **Flabellum**

Honey bee thorax

- Contains two pairs of wings
- 1st pair are the largest (fore wing), 2nd pair smaller (hind wing)
- Each wing has numerous veins through which hemolymph circulates
- Hamuli connects wings during flight

Honey bee thorax

Honey bee thorax

- Contains three pairs of legs
- One pair attached to each of the three segments of the thorax
- Legs contain sensory organs for touch, taste, and smell

Honey bee thorax

- Forelegs have antennae cleaner
- Middle legs have a spine for spearing wax scales from abdomen and passing to the mandibles
- Hind legs contain corbicula or pollen basket for storing pollen grain

Honey bee abdomen

- Contains a narrow segment
  - **Wasp-waist**
- Lacks external attachments
- Contains spiracles
  - **Respiratory system openings**
- Constantly moving
  - **Pumping**
  - **Aids breathing**
  - **Digestion**
  - **Excretion**
  - **Circulation**

Honey bee Digestive and Excretory system

Honey bee Circulatory system

Honey bee Respiratory system

Glands in the head

Abdominal glands

- Wax Glands

Abdominal glands

- Nasonov (scent) Gland

Glands associated with the sting

THE BEE'S STING
Plan of sting mechanism
Three plates form a system of levers which are moved by muscles to work the barbs and pump venom
Venom sac
Pivot
Valves control flow of venom
Bulb full of venom
Sting sheath
Sting made up of three barbed rods of which only two are visible. Venom passes along a canal between them
Sting chamber, side view
Backward and forward movement of barbs
Sting sheath
Sting
Anus
Barbs grip the victim's skin
Bees sting only if provoked. The sting is worked by a system of articulated plates which dig the barbs into the victim and pump in venom

Studying by observation

- Glass sided hives have been used for years to study the behaviour of honey bees
- Marking queens, drones and worker bees allows observations through adult life cycle
- The Honey bee is the most studied insect in the world

Complete Metamorphosis

4 stages of life of a honey bee

Life Cycle

How Bees Work Life Cycle
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Queen bee lays egg in a wax cell
Worker bees feed hatched larva
Larva reaches full growth
Workers seal cell with wax
Larva spins cocoon and changes into a pupa
Adult bee leaves cell

Egg stage

- About the size of a pin in thickness
- Fertilized ~ worker (female)
- Unfertilized ~ drone (male)

Cell size

- Worker cell – fertilized egg
- Drone cell – unfertilized egg
- Queen cell – fertilized egg

Larva stage

- Legless, featureless white larva
- Specialized:
  - **To eat**
  - **Grow rapidly**
  - **Increasing 1,500 times its original size**

Larva

- Food placed in the cell not fed directly to larva
- Virtually no external features
  - **Only one opening (a mouth)**
  - **No waste discharge**
- Visited 10,000 times by adult bees (about every 2 minutes)
  - **Feed**
  - **Clean**
  - **Inspect**
- Food will depend on what type of bee they are to become

Pupal stage

- Another name is the capped stage
- Pupa changes (transforms) into adult bees
- “Complete Metamorphosis” ~ the young look like the adults
  - **Gradually assumes the features of the adult**

Honey bee Metamorphosis

Stages of growth:

	EGG	LARVA	PUPA	ADULT BEE
QUEEN	Days 1–3	Days 4–9	Days 10–15	Day 16
WORKER	Days 1–3	Days 4–9	Days 10–20	Day 21
DRONE	Days 1–3	Days 4–9	Days 10–23	Day 24

Colony life based on a castes system

2 Female Honey bees

- Queen:
  - **Fertilized egg**
- Larval development:
  - **Biochemical process not completely understood**
  - **Diet of royal jelly**
- Orientation of cell
  - **Queen cups are vertical**

- Workers:
  - **Fertilized egg**
- Larval Development:
  - **2-3 days fed royal jelly**
  - **Mixture of pollen and nectar (progressive provisioning)**
- Orientation of cell
  - **horizontal**

All hail the Queen

- Larger then all other bees in the colony
- Must store millions of sperm in body (spermatheca)
- Last up to three years (potential lifespan)
- Much larger abdomen, especially when laying due to her large ovaries

The Queen

- Fully developed female
- Two Functions:
  - **Lay eggs ~ amazing egg laying machine**
  - **Produce pheromones ~ chemicals that regulate colony cohesion and reproduction**

Royal Princess

- Workers decide who tries out for the royal title
- Require
  - **Larger cell**
  - **More sugar (35%)**
- 3 different cell locations

Virgin Queen

- Newly emerging queens
  - **Killed while still in brood cell**
  - **Kicked out of hive**
  - **Battle to be the remaining queen**
- Winner will spread pheromones (QMP) throughout hive
  - **Via workers**
  - **Alive and well**
  - **Suppress reproductively**

Fight to the death

Fertile Queen

- Mates with 10 or more drones, could be as much as 15 to 20

- All bees in the hive have same mother but different fathers

Over Thrown

- Appears slow or weak
- Workers prep another queen
- Old queen may leave hive with loyal offspring
- Queens have long, curved stingers without barbs, sting multiple times

A queen bee (center) stings an unborn rival to death in her brood cell.

Drones

- Extra large eyes (don’t lose queen in flight)
  - **Eyes touch/meet**
- Bigger then worker bees
- Barrel shaped bodies

Drone

- Male bees
- Develops from an unfertilized egg
- Live about 1 month
- All die in fall

Young Drones

- Helped out of cell by nurse bees
- Don’t work

One Purpose In Life

- Mate with a virgin queen
- Special mating area away from hive
- Up to 100 feet above ground – 20 feet norm

Downside To The Good Life

- Got to go:
  - **When Food supply low**
  - **When Winter approaches**
- Lack a stinger
- Mate with the queen
  - **Pay the Ultimate price**
  - **Guts ripped out and he dies**

The Worker Bee

- Females that don’t have fully developed reproductive organs
- Largest population
- Relative Duties (based on age)
- Usually live about 6 weeks execpt in winter may survive 3-6 months

Young Worker Bees

1 to 12 days old

- In-Hive workers
  - **All inner hive tasks are performed in the dark**
- Duties:
  - **Feeding and capping over larva**
  - **Storing both nectar and pollen**
  - **General hive cleaning**
  - **Tend to the queen**
- Initially stay near brood
- Nurse bees ~ feed older larva mixture of pollen and nectar
- Produce “Royal Jelly” ~ pollen mixed with glands in head, fed to young queens and all larva for 1st few days

Feeding developing larva

Passing Of Food

- All food is passed from one bee to another by mouth (trophallaxis)
- This is why poisons can destroy a whole colony in a few hours

Middle Age Worker Bees

12 to 21 days old

- Duties:
  - **Collect nectar from returning field bees**
  - **Guard duty**
  - **Fan/ventilate the hive**
  - **Build the comb**

- Wax secretion for capping honey and pupal cells starts around 12 days of age
- Orientation flights begin about day 18
- Guard duty 18-21 days of age

Comb Production

- Wax secreted from abdomens
- Build downward from top of hive
- Attach each comb
  - **Two layers of horizontal, hexagonally shaped cells**
  - **Roof and walls**
  - **Leave small passageway for movement between combs**

    (Bee space 3/8)

Comb Cells

- Types: (from top to bottom)
  - **Storing honey**
  - **Pollen-storage**
  - **Brood cells for workers**
  - **Brood cells for drones (off to side)**
  - **Brood cells for infant queens**

Defending The Home Front

- External Threats
  - **Rely on protective nest**
  - **One entrance to hive heavily guarded**
  - **Guard bees patrolling entrance, attack intruders**
  - **Release alarm pheromone**

- Internal Threats
  - **Garnish interior walls with floral herbicides and fungicides**
  - **Colony specific odor**
  - **“Undertakers” carry out the dead**
  - **On average 100 die each day**

Nectar

- Principals source of carbohydrates
- Stored in honey stomach located in the abdomen
- Regurgitate nectar to pass on to middle age workers

Nectar Ripening Steps

- 1) Receive nectar from field bees
- 2) Regurgitate many times over 20 minute period
  - **Mix with air**
  - **Blows bubbles**
  - **Moisture evaporates**
  - **Mixes enzymes in (Invertase)**
- 3) Ripened droplet of honey is place in empty cell

Honey Production

- Processed by middle aged bees from nectar
- Stored in special honey cells
- Biocidal properties inhibit microbial spoilage (osmotic pressure)

Temperature Control
(Thermo-regulation)

- Cold Days:
  - **Create warm microclimate inside hive**
  - **Warm by exercising flight wings**
  - **Allow only small opening in nest to retain heat**
  - **Clustering into a round mass of bees**
  - **Consume 2 pounds of honey per week**

- Warm Days:
  - **Temp between 91° - 97° ensure proper development of young**
  - **Cool nest by fanning wings**
  - **Spread water on comb to remove heat through evaporation**

Worker Bees

21 to 40 days old

- Foraging workers
  - **Last 2 weeks of life**
  - **Fly over 400 miles**
  - **58% ~ nectar**
  - **25% ~ pollen**
  - **17% ~ nectar, pollen, water, or propolis**

- Duties:
  - **Collect nectar, water and pollen**
  - **Communicate where and how much food is available**

- Influenced by forage conditions/ availability of food source, number of bees involved

Worker Bees

21 to 40 days old

- Facts
  - **Will walk away from hive to die**
  - **Wear out her wings to the point where she can't fly**

Foraging Statistics

- Temperature:
  - **Minimum temp for active foraging is 46-50º F**
  - **Ideal air temp for foraging is 66-86º F**
- Average flight speeds:
  - **Outgoing 12.5 mph**
  - **Returning 15 mph**
- Don’t forage after dark
  - **Must see ground to orient their flight**
- Other Facts:
  - **They can carry 1/3 to 1/5 of their body weight**
  - **Average 15 flights per day**
  - **Average foraging time 30 minutes to 2 hours per flight, depending on weather and foraging conditions**

Foraging Area

- Inexperienced bees forage closer to the hive
- As they age they fly further distances
- Most bees forage within 200-500 yards of the hive
- Most bees forage in a certain part of a field, a particular clump of trees or shrubs, sometimes a single tree or shrub
- Foraging bees do exhibit a preference for certain species of flowers and will fly past other flowers to reach a preferred foraging area

Lifecycle of the colony

Nectar Collection

- Plants secret nectar from many parts of the flower (nectaries)
  - **Even from non-flowering parts (extra floral nectaries)**
- Nectar secretion may only last a few hours or several days
- Its more pronounced on sunny days versus cloudy days

Nectar Collection

- Two important factors in nectar attractiveness:
  - **Abundance**
  - **Sugar concentration**
- Pear flower nectar may be less than 10% sugar while legume nectars more than 40%
- Wind, rain, and damp weather can have a negative effect on nectar
- Dry weather/drought can limit length and quantity of floral production by plants
- Bees prefer sucrose over other sugars, followed by glucose, maltose and fructose
  - **Mixtures with sucrose are highly attractive**
- The major nectars are composed of sucrose, glucose and fructose

Honey Flow

- Period of heaviest nectar secretion
- Characterized by having one or more plants that are reliable nectar producers
- Even the best sources can vary from one year to the next
- Optimum nectar secretion mid-am to mid-pm

Robbing Behavior

- Robbing ~ special type of foraging
  - **Quick way to obtain a rich nectar source**
  - **Honey stored by another colony**

- Most likely to occur
  - **Nectar dearth**
  - **When another hive is vulnerable**
  - **Weakened/disturbed condition**

Bearding - not a swarm or robbing

- Hot and humid days are hard for house bees to thermo-regulate the inside of the colony
- Solid screen inner covers can help

Pollen

- Carried in special pollen “baskets” located on hind legs
- Provides
  - **Amino acids**
  - **Vitamins**
  - **Fat**
  - **Proteins**
- Stored in pollen cells near brood cells
- Feed to developing larvae as bread

Pollen Foraging

- Honeybees require the stimulus of brood rearing to collect pollen
- As the brood area increases so does pollen foraging
- Scabbling ~ act of gathering pollen
  - **Bees actively use their mandibles to dislodge pollen from anthers**
- Bees can also incidentally collect pollen as they brush against anthers while they forage for nectar
- Bees recognize pollen as a food source because of its odor
- Pollen is often released by flowers early and late in the day

Locating Flowers

- Bees use two major senses:
  - **Sight**
  - **Smell**
- Flowers show both colors and patterns
- Visual clues are important for long range orientation and scent is more critical for short-range orientation
- Many flowers have nectar guides that give a "Bulls-eye" pattern of different colors and textured lines
  - **Some patterns are only visible to the UV sensitive eyes of honeybees**
- Floral sent is also a powerful attractant

Poisonous And Toxic Nectars

- Few nectars are poisonous to bees/larva
  - **Carolina Jessamine**
- Few nectars are toxic to bees and humans
  - **In cool, wet springs if the honey is consumed before it is fully ripened**
  - **Rhododendron**
  - **Azalea**
  - **Oleander**

Water

- Used to dilute honey to feed to brood
- Used to cool the hive on hot days
- Fewer than 1% of foragers collect water
- Prefer water with an odor, closer to hive

Propolis

- A resinous substance that bees collect from tree buds or other botanical sources
- Used as a sealant for unwanted open spaces
  - **Used as cement**
- Sanitize the hive

- Believed to:
  - **reinforce the structural stability of the hive**
  - **reduce vibration**
  - **make the hive more defensible by sealing alternate entrances**
  - **prevent diseases and parasites from entering the hive**

Propolis

- Bees bite the glue-like resin secreted from some plants
- Work it like taffy
- Place it in their pollen baskets
- Take it to a place needed in the hive

Other Use For Propolis

- Small animal enters hive
  - **Bees attack animal**
  - **Animal dies inside hive**
  - **Bees can’t remove dead animal**
- Use propolis to cover the animal
  - **Mummification of body**
  - **Odorless**
  - **Harmless**
- Prevent putrefaction within hive

Scouting Bees

- Find a field of flowers by two methods:
  - **Scout for them (search them out)**
  - **Be recruited/directed by a dancing bee**
- Critical to colony survival:
  - **5-35% of foraging field bees can be involved in scouting at any one time**
  - **With information from a dancing scout other field bees can fly toward the nectar source and home in by using scent cues from the dancing bee**

Sense of direction and ability to calculate distance

- Upon finding a food source, returns to hive to report on nectar source
- Shakes its body and dances in the direction of the nectar source with reference to sun’s position
- Duration and number of vibrations tell the exact distance to flowers
- Studies show that the bee, with its sesame seed-sized brain, calculates the most efficient route speedier than computers.

Interpretative Dance
(not all of the dances)

Waggle Dance

- Location of nectar source 88 yards or more

Round Dance

- Location of nectar closer than 88 yards

Shake Dance

- More foragers are needed

Tremble Dance

- Too much nectar, needs to be processed

Dance Moves

Waggle Dance

(also known as the wag-tail dance)

- Inform other foragers of nectar source
- Get other bees to go to nectar source
- Performed near entrance for easy exit of foraging bees
- Length of waggle:
  - Typically between 1-100 waggles per dance
  - Farther the flower, longer the dance
- Source richness:
  - How long
  - How vigorously

Waggle Dance

- Determined by sun
  - **Straight line drawn from dance floor to the sun at its current position**
  - **If source lies in the exact direction of the sun, bee walks facing exactly straight up**
  - **If source 30º to the left, the angle of the bee's walk is 30º to the left of vertical**

Round Dance

- Less than 80 meters
- Influenced by source richness

Other Dances

- Shake:
  - **When more foragers are needed**
  - **Will shake abdomen back and forth before non-foraging workers to encourage them to move to the dance floor**
  - **1-20 beats per minute**

- Tremble Dance:
  - **Too much nectar**
  - **Bees are needed to process nectar into honey**
  - **Walking slowly around hive**
  - **Quivers legs, causing body to tremble forward and backward and from side to side**
  - **Can go on for over 1 hour**

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