

# The Mathematics of Bees and Beekeeping

Perspectives of a Hobby Apiarist

Robert Pruvencok

Perimeter College at Georgia State University

# Overview

- Importance of Honeybees
- Economics and Experiences
- Math, Science, History, and Future

# Importance of Honeybees

- Pollination Services (Industrial Scale)
  - Partial list of commercial crops at [honeylove.org](http://honeylove.org) [1]
- Bees Collect
  - Pollen, nectar, propolis, water
- And Produce
  - Honey, bee bread, beeswax, royal jelly
- That we use for
  - Food, allergy prevention, medicine, beauty, candles, etc.

# Economics & Experiences

- **Preparation**

- Family history
- Reading
- YouTube
- Networking
- Purchasing supplies
- Setting up
- Assisting the pros

- **Time Required**

- 3-5 hours per hive body (x8)
- Several days assisting pros
- Purchasing runs
- Hive inspections (2-3/mo.)
- Association meetings (1/mo.)
- Honey harvest! (3 days)

# Economics & Experiences

- Expenses (2 hives)
  - One 3 lb package bees \$100
  - One nuc bees \$150
  - 2 Bottom boards \$23/ea
  - 4 Deep bodies \$28/ea
  - 4 Medium bodies \$22/ea
  - 80 Frames \$112
  - Deep foundation \$63/50 sheets
  - Medium foundation \$52/5 lb
  - 2 Inner covers \$13/ea
  - 2 Outer covers \$23/ea
  - 2 Boardman feeders \$5/ea
  - 6 Pollen substitute patties \$60
  - Refractometer, calibration oil \$30
  - Wood glue \$7
  - Hive, frame, and other nails (?)
  - Frame wire, eyelets & tool \$8
  - Bee suit \$64
  - Bee jacket \$30
  - Smoker \$42
  - Hive tool \$12
  - J-tool (?)
  - Bee brush \$6
  - Association membership \$30/yr
  - 2 Queen excluders \$15/ea
  - Fishing line (?)
  - Chest freezer \$400
  - Miticide (?)

# Economics & Experiences

- Income (honey harvest!)
  - 2 hives
  - September 2.25 gal
  - November 7.25 gal
    - Bees left
    - No miticide treatment
  - Total harvest **9.5 gallons = 38 quarts = 76 pints**
  - Sells for \$80/gal (but we ate some...)
  - Local, raw, unfiltered (800 micron) wildflower honey!

# Economics & Experiences

- HONEY

- 15-20% water
  - Measured with refractometer
  - USDA max 18.6%
  - Crystallizes if too little water (14%)
  - Ferments if too much water (22%)
- Sugar, enzymes, pollen, other good stuff
- Local, raw, unfiltered (800 micron) wildflower honey!
- Store bought honey can have
  - Bee diseases (viruses)
  - Pasteurization (destroys enzymes)

# Math, Science, History, and Future

- Fun facts about bees
  - Five eyes
  - 3 million hairs
  - can see in UV



# Math, Science, History, and Future

- Queen
  - 16 days to mature
  - Adult lifespan 2-5 years
  - Only one mating flight (up to 6 miles away)
  - Seeks a Drone Congregating Area
  - Mates aurally with up to 20 drones
  - One per hive
  - Replaced by collective decision of the workers

# Math, Science, History, and Future

## • Workers

- 21 days to mature
- Nurses, incubators (108 °F), foragers (up to 2 miles)
- Adult lifespan
  - 2-6 weeks (summer)
  - 3-11 months (winter)
- decide when to swarm or supersede queen

# Math, Science, History, and Future

## • Drones

- 24 days to mature
- Welcome in any hive (disease vector)
- Never visit flowers
- Sole known function is to mate
- Gather in “drone congregating areas”
- Lifespan up to 8 weeks or until mating

# Math, Science, History, and Future

- Bees understand “zero” [[2](#)]
- Bees can add and subtract! [[3](#)]
  - Their 1 million vs. our 85 billion neurons
- Flight turns with ~constant centrifugal force (30% of body weight) [[4](#)]

# Math, Science, History, and Future

- Waggle Dance ( $> 100$  m)
  - Distant food, 1973 Nobel Prize for Karl von Frisch [[5](#)]
- Round Dance ( $< 25$  m)
  - Local food
- Foraging
  - Up to 2 miles, 8000+ acres, old workers
- Nursing
  - Young workers

# Math, Science, History, and Future

- Hive population
  - 1 queen
  - workers < 10,000 (late winter) to > 100,000 (late summer)
  - Several hundred drones
  - 20,000 – 30,000 bees per hive body
- Homeostatic at 95 °F
- Bee space ( $\frac{3}{8}$ " ) between combs

# Math, Science, History, and Future

- Bearding
- Washboarding [[6](#)]
- Festooning [[8](#)]
- Robbing
- Swarming (colony reproduction)
- Super swarming (Africanized) [[7](#)]
- Invading (new territory and each other)

# Math, Science, History, and Future

- 7-10 species of honeybees (?)
  - European, Dwarf (2), Giant, East Asian (3)
- **Groups**
  - African, Near East, southeastern Europe, northwestern Europe
- **Races**
  - Italian (most common in US), Carniolan, German, Caucasian, others
- **Hybrids**
  - Cordovan, Russian, Africanized, others
- **Not native to the Americas**
  - First imported by Pilgrims in 1622 for a cheap sweetener



# Math, Science, History, and Future

- Africanized honeybees (“killer bees”)
  - Hybrid of European and African bees
  - Result of scientific breeding experiment in Brazil in 1956
  - Smaller, faster, more defensive, more likely to swarm, invasive
  - Saturate South America, Central America, and Mexico
  - Range is still expanding [[5](#)]
  - Texas in 1990, Florida in 2005, south Georgia in 2010

# Math, Science, History, and Future

- The Sting

- Modified ovipositor (females only)
- Barbed, remains in victim with venom sac
- Workers sting once then die
- Queen stings repeatedly but only other queens
- Local reaction lasts several days
- Non-allergic lethal dose is ~5-10 stings per pound of body weight
- Systemic reaction
- Hypersensitivity (increases with each sting, varying rates)
- Immunity (regular doses of venom)

# Math, Science, History, and Future

- Colony Collapse Disorder (CCD)
  - > 40% colony death annually in US
  - Pests
    - Small hive beetle, wax moth, Varroa mite, tracheal mite, Japanese hornets, etc.
  - Diseases
    - American and European foulbrood, etc.)
  - Pesticides
    - Neonicotinoids, etc.
  - Crop monoculture